Multiprotocol Label Switching (MPLS) Configuration Guide, Cisco IOS XE Amsterdam 17.2.x (Catalyst 9400 Switches)

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CHAPTER 1

Configuring Multiprotocol Label Switching (MPLS)

Multiprotocol Label Switching

This module describes Multiprotocol Label Switching and how to configure it on Cisco switches.

Restrictions for Multiprotocol Label Switching

- Multiprotocol Label Switching (MPLS) fragmentation is not supported.
- MPLS maximum transmission unit (MTU) is not supported.

Information about Multiprotocol Label Switching

Multiprotocol label switching (MPLS) combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing. MPLS enables you to meet the challenges of explosive growth in network utilization while providing the opportunity to differentiate services without sacrificing the existing network infrastructure. The MPLS architecture is flexible and can be employed in any combination of Layer 2 technologies. MPLS support is offered for all Layer 3 protocols, and scaling is possible well beyond that typically offered in today's networks.

Functional Description of Multiprotocol Label Switching

Label switching is a high-performance packet forwarding technology that integrates the performance and traffic management capabilities of data link layer (Layer 2) switching with the scalability, flexibility, and performance of network layer (Layer 3) routing.

Label Switching Functions

In conventional Layer 3 forwarding mechanisms, as a packet traverses the network, each switch extracts all the information relevant to forwarding the packet from the Layer 3 header. This information is then used as an index for a routing table lookup to determine the next hop for the packet.

In the most common case, the only relevant field in the header is the destination address field, but in some cases, other header fields might also be relevant. As a result, the header analysis must be done independently at each switch through which the packet passes. In addition, a complicated table lookup must also be done at each switch.

In label switching, the analysis of the Layer 3 header is done only once. The Layer 3 header is then mapped into a fixed length, unstructured value called a *label* .

Many different headers can map to the same label, as long as those headers always result in the same choice of next hop. In effect, a label represents a *forwarding equivalence class* --that is, a set of packets which, however different they may be, are indistinguishable by the forwarding function.

The initial choice of a label need not be based exclusively on the contents of the Layer 3 packet header; for example, forwarding decisions at subsequent hops can also be based on routing policy.

Once a label is assigned, a short label header is added at the front of the Layer 3 packet. This header is carried across the network as part of the packet. At subsequent hops through each MPLS switch in the network, labels are swapped and forwarding decisions are made by means of MPLS forwarding table lookup for the label carried in the packet header. Hence, the packet header does not need to be reevaluated during packet transit through the network. Because the label is of fixed length and unstructured, the MPLS forwarding table lookup process is both straightforward and fast.

Distribution of Label Bindings

Each label switching router (LSR) in the network makes an independent, local decision as to which label value to use to represent a forwarding equivalence class. This association is known as a label binding. Each LSR informs its neighbors of the label bindings it has made. This awareness of label bindings by neighboring switches is facilitated by the following protocols:

- Label Distribution Protocol (LDP)--enables peer LSRs in an MPLS network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network
- Border Gateway Protocol (BGP)--Used to support MPLS virtual private networks (VPNs)

When a labeled packet is being sent from LSR A to the neighboring LSR B, the label value carried by the IP packet is the label value that LSR B assigned to represent the forwarding equivalence class of the packet. Thus, the label value changes as the IP packet traverses the network.

For more information about LDP configuration, see the see MPLS: LDP Configuration Guide at http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mpls/config_library/xe-3s/mp-xe-3s-library.html

Note As the scale of label entries is limited in, especially with ECMP, it is recommended to enable LDP label filtering. LDP labels shall be allocated only for well known prefixes like loopback interfaces of routers and any prefix that needs to be reachable in the global routing table.

MPLS Layer 3 VPN

A Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) consists of a set of sites that are interconnected by means of an MPLS provider core network. At each customer site, one or more customer edge (CE) routers attach to one or more provider edge (PE) routers.

Before configuring MPLS Layer 3 VPNs, you should have MPLS, Label Distribution Protocol (LDP), and Cisco Express Forwarding (CEF) installed in your network. All routers in the core, including the PE routers, must be able to support CEF and MPLS forwarding.

Classifying and Marking MPLS QoS EXP

The QoS EXP Matching feature allows you to classify and mark network traffic by modifying the Multiprotocol Label Switching (MPLS) experimental bits (EXP) field in IP packets.

The QoS EXP Matching feature allows you to organize network traffic by setting values for the MPLS EXP field in MPLS packets. 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. Setting the MPLS EXP value allows you to:

- **Classify traffic:** The classification process 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.
- **Police and mark traffic**: Policing causes traffic that exceeds the configured rate to be discarded or marked to a different drop level. Marking traffic 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.

Restrictions

Following is the list of restrictions for classifying and marking MPLS QoS EXP:

- Only Uniform mode and Pipe mode are supported; Short-pipe mode is not supported.
- Support range of QoS-group values range between 0 and 30. (Total 31 QoS-groups).
- EXP marking using QoS policy is supported only on the outer label; inner EXP marking is not supported.

How to Configure Multiprotocol Label Switching

This section explains how to perform the basic configuration required to prepare a switch for MPLS switching and forwarding.

Configuring a Switch for MPLS Switching

MPLS switching on Cisco switches requires that Cisco Express Forwarding be enabled.

> **Note** **ip unnumbered** command is not supported in MPLS configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef distributed**
4. **mpls label range** *minimum-value maximum-value*
5. **mpls label protocol ldp**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip cef distributed** **Example:** `Device(config)# ip cef distributed`	Enables Cisco Express Forwarding on the switch.
Step 4	**mpls label range** *minimum-value maximum-value* **Example:** `Device(config)# mpls label range 16 4096`	Configure the range of local labels available for use with MPLS applications on packet interfaces.
Step 5	**mpls label protocol ldp** **Example:** `Device(config)# mpls label protocol ldp`	Specifies the label distribution protocol for the platform.

Configuring a Switch for MPLS Forwarding

MPLS forwarding on Cisco switches requires that forwarding of IPv4 packets be enabled.

Note **ip unnumbered** command is not supported in MPLS configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot/subslot /port*
4. **mpls ip**
5. **mpls label protocol ldp**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot/subslot /port* **Example:** `Device(config)# interface gigabitethernet 1/0/0`	Specifies the Gigabit Ethernet interface and enters interface configuration mode. For Switch Virtual Interface (SVI), the example is `Device(config)# interface vlan 1000`
Step 4	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 packets along routed physical interfaces (Gigabit Ethernet), Switch Virtual Interface (SVI), or port channels.
Step 5	**mpls label protocol ldp** **Example:** `Device(config-if)# mpls label protocol ldp`	Specifies the label distribution protocol for an interface. **Note** MPLS LDP cannot be enabled on a Virtual Routing and Forwarding (VRF) interface.
Step 6	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying Multiprotocol Label Switching Configuration

This section explains how to verify successful configuration of MPLS switching and forwarding.

Verifying Configuration of MPLS Switching

To verify that Cisco Express Forwarding has been configured properly, issue the **show ip cef summary** command, which generates output similar to that shown below:

SUMMARY STEPS

1. **show ip cef summary**

DETAILED STEPS

show ip cef summary

Example:

```
Device# show ip cef summary

IPv4 CEF is enabled for distributed and running
VRF Default
 150 prefixes (149/1 fwd/non-fwd)
 Table id 0x0
 Database epoch:        4 (150 entries at this epoch)
Device#
```

Verifying Configuration of MPLS Forwarding

To verify that MPLS forwarding has been configured properly, issue the **show mpls interfaces detail** command, which generates output similar to that shown below:

Note The MPLS MTU value is equivalent to the IP MTU value of the port or switch by default. MTU configuration for MPLS is not supported.

SUMMARY STEPS

1. **show mpls interfaces detail**
2. **show running-config interface**
3. **show mpls forwarding**

DETAILED STEPS

Step 1 **show mpls interfaces detail**

Example:

```
For physical (Gigabit Ethernet) interface:
Device# show mpls interfaces detail interface GigabitEthernet 1/0/0

        Type Unknown
        IP labeling enabled
        LSP Tunnel labeling not enabled
        IP FRR labeling not enabled
        BGP labeling not enabled
        MPLS not operational
        MTU = 1500

For Switch Virtual Interface (SVI):
Device# show mpls interfaces detail interface Vlan1000

        Type Unknown
        IP labeling enabled (ldp) :
          Interface config
        LSP Tunnel labeling not enabled
        IP FRR labeling not enabled
        BGP labeling not enabled
        MPLS operational
        MTU = 1500
```

Step 2 **show running-config interface**

Example:

```
For physical (Gigabit Ethernet) interface:
Device# show running-config interface interface GigabitEthernet 1/0/0

Building configuration...


Current configuration : 307 bytes
!
interface TenGigabitEthernet1/0/0
no switchport
ip address xx.xx.x.x xxx.xxx.xxx.x
mpls ip
mpls label protocol ldp
end

For Switch Virtual Interface (SVI):
Device# show running-config interface interface Vlan1000

Building configuration...


Current configuration : 187 bytes
!
interface Vlan1000
ip address xx.xx.x.x xxx.xxx.xxx.x
mpls ip
mpls label protocol ldp
end
```

Step 3 **show mpls forwarding**

Example:

```
For physical (Gigabit Ethernet) interface:
Device# show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
500        No Label   l2ckt(3)         0             Gi3/0/22   point2point
501        No Label   l2ckt(1)         12310411816789 none       point2point
502        No Label   l2ckt(2)         0             none       point2point
503        566        15.15.15.15/32   0             Po5        192.1.1.2
504        530        7.7.7.7/32       538728528     Po5        192.1.1.2
505        573        6.6.6.10/32      0             Po5        192.1.1.2
506        606        6.6.6.6/32       0             Po5        192.1.1.2
507        explicit-n 1.1.1.1/32       0             Po5        192.1.1.2
556        543        19.10.1.0/24     0             Po5        192.1.1.2
567        568        20.1.1.0/24      0             Po5        192.1.1.2
568        574        21.1.1.0/24      0             Po5        192.1.1.2
574        No Label   213.1.1.0/24[V]  0             aggregate/vpn113
575        No Label   213.1.2.0/24[V]  0             aggregate/vpn114
576        No Label   213.1.3.0/24[V]  0             aggregate/vpn115
577        No Label   213:1:1::/64     0             aggregate
594        502        103.1.1.0/24     0             Po5        192.1.1.2
595        509        31.1.1.0/24      0             Po5        192.1.1.2
596        539        15.15.1.0/24     0             Po5        192.1.1.2
597        550        14.14.1.0/24     0             Po5        192.1.1.2
633        614        2.2.2.0/24       0             Po5        192.1.1.2
634        577        90.90.90.90/32   873684        Po5        192.1.1.2
635        608        154.1.1.0/24     0             Po5        192.1.1.2
636        609        153.1.1.0/24     0             Po5        192.1.1.2
Device# end
```

Additional References for Multiprotocol Label Switching

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	

Feature History for Multiprotocol Label Switching

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	Multiprotocol Label Switching	Multiprotocol Label Switching combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 2

Configuring MPLS Layer 3 VPN

An MPLS Virtual Private Network (VPN) consists of a set of sites that are interconnected by means of a Multiprotocol Label Switching (MPLS) provider core network. At each customer site, one or more customer edge (CE) devices attach to one or more provider edge (PE) devices. This module explains how to create an MPLS Layer 3 VPN.

MPLS Layer 3 VPNs

An MPLS Virtual Private Network (VPN) consists of a set of sites that are interconnected by means of a Multiprotocol Label Switching (MPLS) provider core network. At each customer site, one or more customer edge (CE) devices attach to one or more provider edge (PE) devices. This module explains how to create an MPLS VPN.

Prerequisites for MPLS Virtual Private Networks

- Make sure that you have installed Multiprotocol Label Switching (MPLS), Label Distribution Protocol (LDP), and Cisco Express Forwarding in your network.
- All devices in the core, including the provider edge (PE) devices, must be able to support Cisco Express Forwarding and MPLS forwarding. See the “Assessing the Needs of the MPLS Virtual Private Network Customers” section.
- Enable Cisco Express Forwarding on all devices in the core, including the PE devices. For information about how to determine if Cisco Express Forwarding is enabled, see the “Configuring Basic Cisco Express Forwarding” module in the *Cisco Express Forwarding Configuration Guide*.
- The **mpls ldp graceful-restart** command must be configured to enable the device to protect LDP bindings and MPLS forwarding state during a disruption in service. We recommend you to configure this command (even if you do not want to preserve the forwarding state) to avoid device failure during SSO in a high availability setup with scale configurations.

Restrictions for MPLS Virtual Private Networks

When static routes are configured in a Multiprotocol Label Switching (MPLS) or MPLS virtual private network (VPN) environment, some variations of the **ip route** and **ip route vrf** commands are not supported. Use the following guidelines when configuring static routes.

Supported Static Routes in an MPLS Environment

The following **ip route** command is supported when you configure static routes in an MPLS environment:

- **ip route** *destination-prefix mask interface next-hop-address*

The following **ip route** commands are supported when you configure static routes in an MPLS environment and configure load sharing with static nonrecursive routes and a specific outbound interface:

- **ip route** *destination-prefix mask* **interface1 next-hop1**
- **ip route** *destination-prefix mask* **interface2 next-hop2**

Unsupported Static Routes in an MPLS Environment That Uses the TFIB

The following **ip route** command is not supported when you configure static routes in an MPLS environment:

- **ip route** *destination-prefix mask next-hop-address*

The following **ip route** command is not supported when you configure static routes in an MPLS environment and enable load sharing where the next hop can be reached through two paths:

- **ip route** *destination-prefix mask next-hop-address*

The following **ip route** commands are not supported when you configure static routes in an MPLS environment and enable load sharing where the destination can be reached through two next hops:

- **ip route** *destination-prefix mask* **next-hop1**
- **ip route** *destination-prefix mask* **next-hop2**

Use the *interface* an *next-hop* arguments when specifying static routes.

Supported Static Routes in an MPLS VPN Environment

The following **ip route vrf** commands are supported when you configure static routes in an MPLS VPN environment, and the next hop and interface are in the same VRF:

- **ip route vrf** *vrf-name destination-prefix mask next-hop-address*
- **ip route vrf** *vrf-name destination-prefix mask interface next-hop-address*
- **ip route vrf** *vrf-name destination-prefix mask* **interface1 next-hop1**
- **ip route vrf** *vrf-name destination-prefix mask* **interface2 next-hop2**

The following **ip route vrf** commands are supported when you configure static routes in an MPLS VPN environment, and the next hop is in the global table in the MPLS cloud in the global routing table. For example, these commands are supported when the next hop is pointing to the Internet gateway.

- **ip route vrf** *vrf-name destination-prefix mask next-hop-address* **global**

- **ip route vrf** *vrf-name destination-prefix mask interface next-hop-address* (This command is supported when the next hop and interface are in the core.)

The following **ip route** commands are supported when you configure static routes in an MPLS VPN environment and enable load sharing with static nonrecursive routes and a specific outbound interface:

- **ip route** *destination-prefix mask* **interface1 next-hop1**
- **ip route** *destination-prefix mask* **interface2 next-hop2**

Unsupported Static Routes in an MPLS VPN Environment That Uses the TFIB

The following **ip route** command is not supported when you configure static routes in an MPLS VPN environment, the next hop is in the global table in the MPLS cloud within the core, and you enable load sharing where the next hop can be reached through two paths:

- **ip route vrf** *destination-prefix mask next-hop-address* **global**

The following **ip route** commands are not supported when you configure static routes in an MPLS VPN environment, the next hop is in the global table in the MPLS cloud within the core, and you enable load sharing where the destination can be reached through two next hops:

- **ip route vrf** *destination-prefix mask* **next-hop1 global**
- **ip route vrf** *destination-prefix mask* **next-hop2 global**

The following **ip route vrf** commands are not supported when you configure static routes in an MPLS VPN environment, and the next hop and interface are in the same VRF:

- **ip route vrf** *vrf-name destination-prefix mask* **next-hop1** *vrf-name destination-prefix mask* **next-hop1**
- **ip route vrf** *vrf-name destination-prefix mask* **next-hop2**

Supported Static Routes in an MPLS VPN Environment Where the Next Hop Resides in the Global Table on the CE Device

The following **ip route vrf** command is supported when you configure static routes in an MPLS VPN environment, and the next hop is in the global table on the customer edge (CE) side. For example, the following command is supported when the destination prefix is the CE device's loopback address, as in external Border Gateway Protocol (EBGP) multihop cases.

- **ip route vrf** *vrf-name destination-prefix mask interface next-hop-address*

The following **ip route** commands are supported when you configure static routes in an MPLS VPN environment, the next hop is in the global table on the CE side, and you enable load sharing with static nonrecursive routes and a specific outbound interface:

- **ip route** *destination-prefix mask* **interface1 nexthop1**
- **ip route** *destination-prefix mask* **interface2 nexthop2**

Information About MPLS Virtual Private Networks

This section provides information about MPLS Virtual Private Networks:

MPLS Virtual Private Network Definition

Before defining a Multiprotocol Label Switching virtual private network (MPLS VPN), you must define a VPN in general. A VPN is:

- An IP-based network delivering private network services over a public infrastructure
- A set of sites that communicate with each other privately over the Internet or other public or private networks

Conventional VPNs are created by configuring a full mesh of tunnels or permanent virtual circuits (PVCs) to all sites in a VPN. This type of VPN is not easy to maintain or expand, because adding a new site requires changing each edge device in the VPN.

MPLS-based VPNs are created in Layer 3 and are based on the peer model. The peer model enables the service provider and the customer to exchange Layer 3 routing information. The service provider relays the data between the customer sites without the customer's involvement.

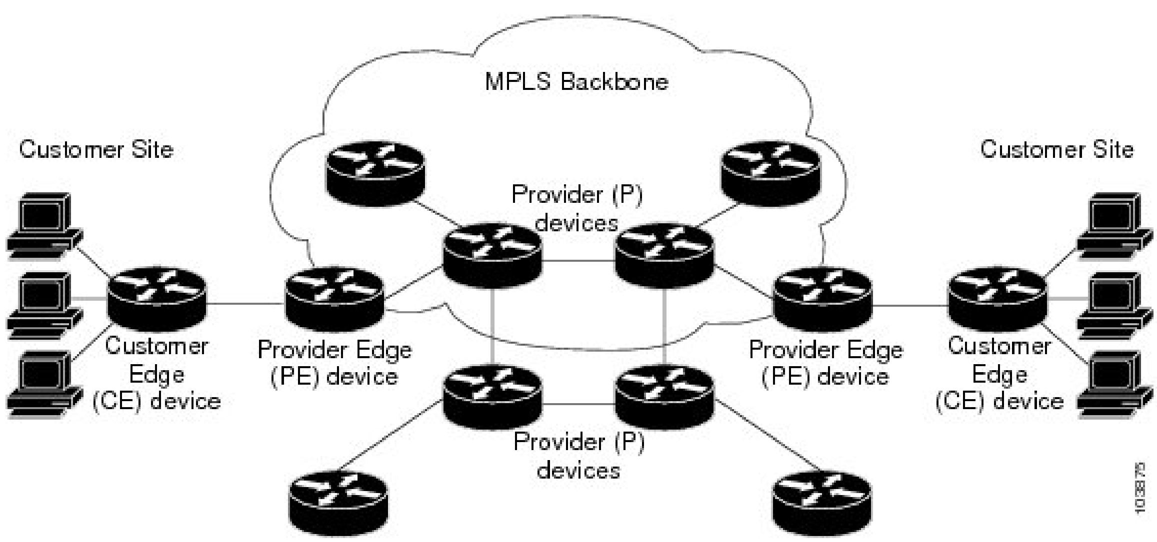
MPLS VPNs are easier to manage and expand than conventional VPNs. When a new site is added to an MPLS VPN, only the service provider's edge device that provides services to the customer site needs to be updated.

The different parts of the MPLS VPN are described as follows:

- Provider (P) device—Device in the core of the provider network. P devices run MPLS switching, and do not attach VPN labels to routed packets. The MPLS label in each route is assigned by the provider edge (PE) device. VPN labels are used to direct data packets to the correct egress device.
- PE device—Device that attaches the VPN label to incoming packets based on the interface or subinterface on which they are received. A PE device attaches directly to a customer edge (CE) device.
- Customer (C) device—Device in the ISP or enterprise network.
- CE device—Edge device on the network of the ISP that connects to the PE device on the network. A CE device must interface with a PE device.

The figure below shows a basic MPLS VPN.

Figure 1: Basic MPLS VPN Terminology



How an MPLS Virtual Private Network Works

Multiprotocol Label Switching virtual private network (MPLS VPN) functionality is enabled at the edge of an MPLS network. The provider edge (PE) device performs the following:

- Exchanges routing updates with the customer edge (CE) device.
- Translates the CE routing information into VPNv4 routes.
- Exchanges VPNv4 routes with other PE devices through the Multiprotocol Border Gateway Protocol (MP-BGP).

The following sections describe how MPLS VPN works:

Major Components of an MPLS Virtual Private Network

A Multiprotocol Label Switching (MPLS)-based virtual private network (VPN) has three major components:

- VPN route target communities—A VPN route target community is a list of all members of a VPN community. VPN route targets need to be configured for each VPN community member.
- Multiprotocol BGP (MP-BGP) peering of VPN community provider edge (PE) devices— MP-BGP propagates virtual routing and forwarding (VRF) reachability information to all members of a VPN community. MP-BGP peering must be configured on all PE devices within a VPN community.
- MPLS forwarding—MPLS transports all traffic between all VPN community members across a VPN service-provider network.

A one-to-one relationship does not necessarily exist between customer sites and VPNs. A given 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 available to the site from the VPNs of which it is a member.

Benefits of an MPLS Virtual Private Network

Multiprotocol Label Switching virtual private networks (MPLS VPNs) allow service providers to deploy scalable VPNs. They build the foundation to deliver value-added services, such as the following:

Connectionless Service

A significant technical advantage of MPLS VPNs is that they are connectionless. The Internet owes its success to its basic technology, TCP/IP. TCP/IP is built on a packet-based, connectionless network paradigm. This means that no prior action is necessary to establish communication between hosts, making it easy for two parties to communicate. To establish privacy in a connectionless IP environment, current VPN solutions impose a connection-oriented, point-to-point overlay on the network. Even if it runs over a connectionless network, a VPN cannot take advantage of the ease of connectivity and multiple services available in connectionless networks. When you create a connectionless VPN, you do not need tunnels and encryption for network privacy, thus eliminating significant complexity.

Centralized Service

Building VPNs in Layer 3 allows delivery of targeted services to a group of users represented by a VPN. A VPN must give service providers more than a mechanism for privately connecting users to intranet services. It must also provide a way to flexibly deliver value-added services to targeted customers. Scalability is critical, because you want to use services privately in their intranets and extranets. Because MPLS VPNs are seen as private intranets, you may use new IP services such as:

- Multicast
- Quality of service (QoS)
- Telephony support within a VPN
- Centralized services including content and web hosting to a VPN

You can customize several combinations of specialized services for individual customers. For example, a service that combines IP multicast with a low-latency service class enables video conferencing within an intranet.

Scalability

If you create a VPN using connection-oriented, point-to-point overlays, Frame Relay, or ATM virtual connections (VCs), the VPN's key deficiency is scalability. Specifically, connection-oriented VPNs without fully meshed connections between customer sites are not optimal. MPLS-based VPNs, instead, use the peer model and Layer 3 connectionless architecture to leverage a highly scalable VPN solution. The peer model requires a customer site to peer with only one provider edge (PE) device as opposed to all other customer edge (CE) devices that are members of the VPN. The connectionless architecture allows the creation of VPNs in Layer 3, eliminating the need for tunnels or VCs.

Other scalability issues of MPLS VPNs are due to the partitioning of VPN routes between PE devices. And the further partitioning of VPN and Interior Gateway Protocol (IGP) routes between PE devices and provider (P) devices in a core network.

- PE devices must maintain VPN routes for those VPNs who are members.
- P devices do not maintain any VPN routes.

This increases the scalability of the provider's core and ensures that no one device is a scalability bottleneck.

Security

MPLS VPNs offer the same level of security as connection-oriented VPNs. Packets from one VPN do not inadvertently go to another VPN.

Security is provided in the following areas:

- At the edge of a provider network, ensuring packets that are received from a customer are placed on the correct VPN.
- At the backbone, VPN traffic is kept separate. Malicious spoofing (an attempt to gain access to a PE device) is nearly impossible because the packets that are received from customers are IP packets. These IP packets must be received on a particular interface or subinterface to be uniquely identified with a VPN label.

Ease of Creation

To take full advantage of VPNs, customers must be able to easily create new VPNs and user communities. Because MPLS VPNs are connectionless, no specific point-to-point connection maps or topologies are required. You can add sites to intranets and extranets and form closed user groups. Managing VPNs in this manner enables membership of any given site in multiple VPNs, maximizing flexibility in building intranets and extranets.

Flexible Addressing

To make a VPN service more accessible, customers of a service provider can design their own addressing plan. This addressing plan can be independent of addressing plans for other service provider customers. Many customers use private address spaces, as defined in RFC 1918. They do not want to invest the time and expense of converting to public IP addresses to enable intranet connectivity. MPLS VPNs allow customers to continue to use their present address spaces without Network Address Translation (NAT) by providing a public and private view of the address. A NAT is required only if two VPNs with overlapping address spaces want to communicate. This enables customers to use their own unregistered private addresses, and communicate freely across a public IP network.

Integrated QoS Support

QoS is an important requirement for many IP VPN customers. It provides the ability to address two fundamental VPN requirements:

- Predictable performance and policy implementation
- Support for multiple levels of service in an MPLS VPN

Network traffic is classified and labeled at the edge of the network. The traffic is then aggregated according to policies defined by subscribers and implemented by the provider and transported across the provider core. Traffic at the edge and core of the network can then be differentiated into different classes by drop probability or delay.

Straightforward Migration

For service providers to quickly deploy VPN services, use a straightforward migration path. MPLS VPNs are unique because you can build them over multiple network architectures, including IP, ATM, Frame Relay, and hybrid networks.

Migration for the end customer is simplified because there is no requirement to support MPLS on the CE device. No modifications are required to a customer’s intranet.

How to Configure MPLS Virtual Private Networks

The following section provides the steps to configure MPLS Virtual Private Networks:

Configuring the Core Network

The following section provides the steps to configure the core network:

Assessing the Needs of MPLS Virtual Private Network Customers

Before you configure a Multiprotocol Label Switching virtual private network (MPLS VPN), you need to identify the core network topology so that it can best serve MPLS VPN customers. Perform this task to identify the core network topology.

SUMMARY STEPS

1. Identify the size of the network.
2. Identify the routing protocols in the core.
3. Determine if you need MPLS VPN High Availability support.

4. Determine if you need Border Gateway Protocol (BGP) load sharing and redundant paths in the MPLS VPN core.

DETAILED STEPS

	Command or Action	Purpose
Step 1	Identify the size of the network.	Identify the following to determine the number of devices and ports that 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?
Step 2	Identify the routing protocols in the core.	Determine which routing protocols you need in the core network.
Step 3	Determine if you need MPLS VPN High Availability support.	MPLS VPN Nonstop Forwarding and Graceful Restart are supported on select devices and Cisco software releases. Contact Cisco Support for the exact requirements and hardware support.
Step 4	Determine if you need Border Gateway Protocol (BGP) load sharing and redundant paths in the MPLS VPN core.	For configuration steps, see the “Load Sharing MPLS VPN Traffic” feature module in the *MPLS Layer 3 VPNs Inter-AS and CSC Configuration Guide*.

Configuring MPLS in the Core

To enable Multiprotocol Label Switching (MPLS) on all devices in the core, you must configure either of the following as a label distribution protocol:

- MPLS Label Distribution Protocol (LDP). For configuration information, see the “MPLS Label Distribution Protocol (LDP)” module in the *MPLS Label Distribution Protocol Configuration Guide*.

Connecting the MPLS Virtual Private Network Customers

The following section provides information about Connecting the MPLS Virtual Private Network Customers:

Defining VRFs on the PE Devices to Enable Customer Connectivity

Use this procedure to define a virtual routing and forwarding (VRF) configuration for IPv4. To define a VRF for IPv4 and IPv6, see the “Configuring a Virtual Routing and Forwarding Instance for IPv6"section in the “IPv6 VPN over MPLS" module in the *MPLS Layer 3 VPNs Configuration Guide*.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*

5. **address-family** *ipv4* | *ipv6*
6. **route-target** {**import** | **export** | **both**} *route-target-ext-community*
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**vrf definition** *vrf-name* **Example:** `Device(config)# vrf definition vrf1`	Defines the virtual private network (VPN) routing instance by assigning a virtual routing and forwarding (VRF) name and enters VRF configuration mode. • The *vrf-name* argument is the name assigned to a VRF.

Step 4	**rd** *route-distinguisher*
	Example:
	`Device(config-vrf)# rd 100:1`
		Creates routing and forwarding tables.
		• The *route-distinguisher* argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter a route distinguisher (RD) in either of these formats:
		  • 16-bit AS number:your 32-bit number, for example, 101:3
		  • 32-bit IP address:your 16-bit number, for example, 10.0.0.1:1

Step 5	**address-family** *ipv4* | *ipv6* **Example:** `Device(config-vrf)# address-family ipv6`	Enters IPv4 or IPv6 address family mode
Step 6	**route-target** {**import** | **export** | **both**} *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target both 100:1`	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 **both** keyword imports routing information from and exports routing information to the target VPN extended community.

	Command or Action	Purpose
		• The *route-target-ext-community* argument adds the route-target extended community attributes to the VRF's list of import, export, or both route-target extended communities.
Step 7	**exit** **Example:** `Device(config-vrf)# exit`	(Optional) Exits to global configuration mode.

Configuring VRF Interfaces on PE Devices for Each VPN Customer

To associate a virtual routing and forwarding (VRF) instance with an interface or subinterface on the provider edge (PE) devices, perform this task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **vrf forwarding** *vrf-name*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface GigabitEthernet 0/0/1`	Specifies the interface to configure and enters interface configuration mode. • The *type* argument specifies the type of interface to be configured. • The *number* argument specifies the port, connector, or interface card number.
Step 4	**vrf forwarding** *vrf-name* **Example:**	Associates a VRF with the specified interface or subinterface.

	Command or Action	Purpose
	`Device(config-if)# vrf forwarding vrf1`	• The *vrf-name* argument is the name that is assigned to a VRF.
Step 5	**end** **Example:** `Device(config-if)# end`	(Optional) Exits to privileged EXEC mode.

Configuring Routing Protocols Between the PE and CE Devices

Configure the provider edge (PE) device with the same routing protocol that the customer edge (CE) device uses. You can configure the Border Gateway Protocol (BGP), Routing Information Protocol version 2 (RIPv2), EIGRP, Open Shortest Path First (OSPF) or static routes between the PE and CE devices.

Verifying the Virtual Private Network Configuration

A route distinguisher must be configured for the virtual routing and forwarding (VRF) instance. Multiprotocol Label Switching (MPLS) must be configured on the interfaces that carry the VRF. Use the **show ip vrf** command to verify the route distinguisher (RD) and interface configured for the VRF.

SUMMARY STEPS

1. **show ip vrf**

DETAILED STEPS

show ip vrf

Displays the set of defined VRF instances and associated interfaces. The output also maps the VRF instances to the configured route distinguisher.

Verifying Connectivity Between MPLS Virtual Private Network Sites

To verify that the local and remote customer edge (CE) devices can communicate across the Multiprotocol Label Switching (MPLS) core, perform the following tasks:

Verifying IP Connectivity from CE Device to CE Device Across the MPLS Core

SUMMARY STEPS

1. **enable**
2. **ping** [*protocol*] {*host-name* | *system-address*}
3. **trace** [*protocol*] [*destination*]
4. **show ip route** [*ip-address* [*mask*] [**longer-prefixes**]] | *protocol* [*process-id*]] | [**list** [*access-list-name* | *access-list-number*]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode.

Step 2 **ping** [*protocol*] {*host-name* | *system-address*}

Diagnoses basic network connectivity on AppleTalk, Connectionless-mode Network Service (CLNS), IP, Novell, Apollo, Virtual Integrated Network Service (VINES), DECnet, or Xerox Network Service (XNS) networks. Use the **ping** command to verify the connectivity from one CE device to another.

Step 3 **trace** [*protocol*] [*destination*]

Discovers the routes that packets take when traveling to their destination. The **trace** command can help isolate a trouble spot if two devices cannot communicate.

Step 4 **show ip route** [*ip-address* [*mask*] [**longer-prefixes**]] | *protocol* [*process-id*]] | [**list** [*access-list-name* | *access-list-number*]

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.

Verifying That the Local and Remote CE Devices Are in the PE Routing Table

SUMMARY STEPS

1. **enable**
2. **show ip route vrf** *vrf-name* [*prefix*]
3. **show ip cef vrf** *vrf-name* [*ip-prefix*]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode.

Step 2 **show ip route vrf** *vrf-name* [*prefix*]

Displays the IP routing table that is associated with a virtual routing and forwarding (VRF) instance. Check that the loopback addresses of the local and remote customer edge (CE) devices are in the routing table of the provider edge (PE) devices.

Step 3 **show ip cef vrf** *vrf-name* [*ip-prefix*]

Displays the Cisco Express Forwarding forwarding table that is associated with a VRF. Check that the prefix of the remote CE device is in the Cisco Express Forwarding table.

Configuration Examples for MPLS Virtual Private Networks

The following section provides the configuration examples for MPLS Virtual Private Networks:

Example: Configuring an MPLS Virtual Private Network Using RIP

PE Configuration

```
 vrf vpn1
 rd 100:1
 route-target export 100:1
 route-target import 100:1
!
ip cef
mpls ldp router-id Loopback0 force
mpls label protocol ldp
!
interface Loopback0
 ip address 10.0.0.1 255.255.255.255
!
interface GigabitEthernet 1/0/1
 vrf forwarding vpn1
 ip address 192.0.2.3 255.255.255.0
 no cdp enable
interface GigabitEthernet 1/0/1
ip address 192.0.2.2 255.255.255.0
mpls label protocol ldp
mpls ip
!
router rip
version 2
timers basic 30 60 60 120
!
address-family ipv4 vrf vpn1
version 2
redistribute bgp 100 metric transparent
network 192.0.2.0
distribute-list 20 in
no auto-summary
exit-address-family
!
router bgp 100
no synchronization
bgp log-neighbor changes
neighbor 10.0.0.3 remote-as 100
neighbor 10.0.0.3 update-source Loopback0
no auto-summary
!
address-family vpnv4
 neighbor 10.0.0.3 activate
 neighbor 10.0.0.3 send-community extended

 bgp scan-time import 5
 exit-address-family
!
address-family ipv4 vrf vpn1
 redistribute connected
 redistribute rip
 no auto-summary
 no synchronization
 exit-address-family
```

CE Configuration

```
ip cef
mpls ldp router-id Loopback0 force
mpls label protocol ldp
!
interface Loopback0
 ip address 10.0.0.9 255.255.255.255
!
interface GigabitEthernet 1/0/1
 ip address 192.0.2.1 255.255.255.0
 no cdp enable
router rip
 version 2
 timers basic 30 60 60 120
 redistribute connected
 network 10.0.0.0
 network 192.0.2.0
 no auto-summary
```

Example: Configuring an MPLS Virtual Private Network Using Static Routes

<table>
<tr><th>PE Configuration</th><th>CE Configuration</th></tr>
<tr><td>
<pre>
vrf vpn1
 rd 100:1
 route-target export 100:1
 route-target import 100:1
!
ip cef
mpls ldp router-id Loopback0 force
mpls label protocol ldp
!
interface Loopback0
 ip address 10.0.0.1 255.255.255.255
!
interface GigabitEthernet 1/0/1
 vrf forwarding vpn1
 ip address 192.0.2.3 255.255.255.0
 no cdp enable
!
interface GigabitEthernet 1/0/1
ip address 192.168.0.1 255.255.0.0
mpls label protocol ldp
mpls ip
!
router ospf 100
network 10.0.0. 0.0.0.0 area 100
network 192.168.0.0 255.255.0.0 area 100
!
router bgp 100
 no synchronization
 bgp log-neighbor changes
 neighbor 10.0.0.3 remote-as 100
 neighbor 10.0.0.3 update-source Loopback0
no auto-summary
 !
address-family vpnv4
 neighbor 10.0.0.3 activate
 neighbor 10.0.0.3 send-community extended
 bgp scan-time import 5
 exit-address-family
 !
address-family ipv4 vrf vpn1
 redistribute connected
 redistribute static
 no auto-summary
 no synchronization
 exit-address-family
!
ip route vrf vpn1 10.0.0.9 255.255.255.255
192.0.2.2
ip route vrf vpn1 192.0.2.0 255.255.0.0
192.0.2.2
</pre>
</td><td>
<pre>
ip cef
!
interface Loopback0
 ip address 10.0.0.9 255.255.255.255
!
interface GigabitEthernet 1/0/1
 ip address 192.0.2.2 255.255.0.0
 no cdp enable
!
ip route 10.0.0.9 255.255.255.255 192.0.2.3
3
ip route 198.51.100.0 255.255.255.0 192.0.2.3
 3
</pre>
</td></tr>
</table>

Example: Configuring an MPLS Virtual Private Network Using BGP

PE Configuration	CE Configuration

	<pre>router bgp 5000
	bgp log-neighbor-changes
	neighbor 5.5.5.6 remote-as 5001
	neighbor 5.5.5.6 ebgp-multihop 2
	neighbor 5.5.5.6 update-source Loopback5
	neighbor 35.2.2.2 remote-as 5001
	neighbor 35.2.2.2 ebgp-multihop 2
	neighbor 35.2.2.2 update-source Loopback1
	neighbor 3500::1 remote-as 5001
	neighbor 3500::1 ebgp-multihop 2
	neighbor 3500::1 update-source Loopback1
	!
	address-family ipv4
	  redistribute connected
	  neighbor 5.5.5.6 activate
	  neighbor 35.2.2.2 activate
	  no neighbor 3500::1 activate
	exit-address-family
	!
	address-family ipv6
	  redistribute connected
	  neighbor 3500::1 activate
	exit-address-family
	Device-RP(config)#</pre>

PE Configuration	CE Configuration

router bgp 5001
bgp log-neighbor-changes
bgp graceful-restart
bgp sso route-refresh-enable
bgp refresh max-eor-time 600
redistribute connected
neighbor 102.1.1.1 remote-as 5001
neighbor 102.1.1.1 update-source Loopback1
neighbor 105.1.1.1 remote-as 5001
neighbor 105.1.1.1 update-source Loopback10
neighbor 160.1.1.2 remote-as 5002
!
address-family vpnv4
  neighbor 102.1.1.1 activate
  neighbor 102.1.1.1 send-community both
  neighbor 105.1.1.1 activate
  neighbor 105.1.1.1 send-community extended
exit-address-family
!
address-family vpnv6
  neighbor 102.1.1.1 activate
  neighbor 102.1.1.1 send-community extended
  neighbor 105.1.1.1 activate
  neighbor 105.1.1.1 send-community extended
exit-address-family
!
address-family ipv4 vrf full
  redistribute connected
  neighbor 20.1.1.1 remote-as 5000
  neighbor 20.1.1.1 ebgp-multihop 2
  neighbor 20.1.1.1 update-source Loopback2
  neighbor 20.1.1.1 activate
  neighbor 20.1.1.1 send-community both
exit-address-family
!
address-family ipv6 vrf full
  redistribute connected
  neighbor 2000::1 remote-as 5000
  neighbor 2000::1 ebgp-multihop 2
  neighbor 2000::1 update-source Loopback2
  neighbor 2000::1 activate
exit-address-family
!
address-family ipv4 vrf orange
  network 87.1.0.0 mask 255.255.252.0
  network 87.1.1.0 mask 255.255.255.0
  redistribute connected
  neighbor 40.1.1.1 remote-as 7000
  neighbor 40.1.1.1 ebgp-multihop 2
  neighbor 40.1.1.1 update-source Loopback3
  neighbor 40.1.1.1 activate
  neighbor 40.1.1.1 send-community extended
  neighbor 40.1.1.1 route-map orange-lp in
  maximum-paths eibgp 2
exit-address-family
!
address-family ipv6 vrf orange
  redistribute connected
  maximum-paths eibgp 2
  neighbor 4000::1 remote-as 7000
  neighbor 4000::1 ebgp-multihop 2
  neighbor 4000::1 update-source Loopback3	

PE Configuration	CE Configuration

<pre> neighbor 4000::1 activate
exit-address-family
!
address-family ipv4 vrf sona
  redistribute connected
  neighbor 160.1.1.2 remote-as 5002
  neighbor 160.1.1.2 activate
  neighbor 160.1.1.4 remote-as 5003
  neighbor 160.1.1.4 activate
exit-address-family</pre>	

Additional References

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	See the MPLS Commands section of the *Command Reference (Catalyst 9400 Series Switches)*
Configuring Cisco Express Forwarding	"Configuring Basic Cisco Express Forwarding" module in the *Cisco Express Forwarding Configuration Guide*
Configuring LDP	"MPLS Label Distribution Protocol (LDP)" module in the *MPLS Label Distribution Protocol Configuration Guide*

Feature History for MPLS Virtual Private Networks

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	MPLS Virtual Private Networks	An MPLS Virtual Private Network (VPN) consists of a set of sites that are interconnected by means of a Multiprotocol Label Switching (MPLS) provider core network. At each customer site, one or more customer edge (CE) devices attach to one or more provider edge (PE) devices.
Cisco IOS XE Gibraltar 16.11.1	BGP PE-CE support for MPLS Layer 3 VPNs	Support for BGP as a routing protocol between the provider edge (PE) device and the customer edge (CE) device was introduced.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 3

Configuring eBGP and iBGP Multipath

BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

The BGP Multipath Load Sharing for eBGP and iBGP feature allows you to configure multipath load balancing with both external BGP (eBGP) and internal BGP (iBGP) paths in Border Gateway Protocol (BGP) networks that are configured to use Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs). This feature provides improved load balancing deployment and service offering capabilities and is useful for multi-homed autonomous systems and Provider Edge (PE) routers that import both eBGP and iBGP paths from multihomed and stub networks.

Prerequisites for BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

Cisco Express Forwarding (CEF) or distributed CEF (dCEF) must be enabled on all participating devices.

Restrictions for BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

Address Family Support

This feature is configured on a per VPN routing and forwarding instance (VRF) basis. This feature can be configured under both IPv4 and IPv6 VRF address families.

Memory Consumption Restriction

Each BGP multipath routing table entry will use additional memory. We recommend that you do not use this feature on a device with a low amount of available memory and especially if the device carries full Internet routing tables.

Number of Paths Limitation

The number of paths supported are limited to 2 BGP multipaths. This could either be 2 iBGP multipaths or 1 iBGP multipath and 1 eBGP multipath.

Unsupported Commands

ip unnumbered command is not supported in MPLS configuration.

Information About BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

Multipath Load Sharing Between eBGP and iBGP

A BGP routing process will install a single path as the best path in the routing information base (RIB) by default. The **maximum-paths** command allows you to configure BGP to install multiple paths in the RIB for multipath load sharing. BGP uses the best path algorithm to select a single multipath as the best path and advertise the best path to BGP peers.

Note The valid values for the **maximum-paths** command range from 1 to 32. However, the maximum value that can be configured is 2.

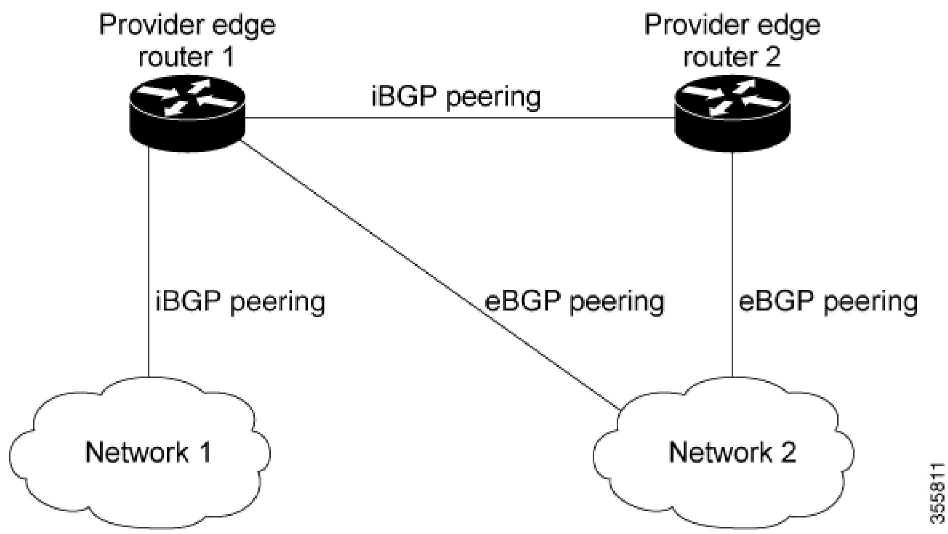
Load balancing over the multipaths is performed by CEF. CEF load balancing is configured on a per-packet round robin or on a per session (source and destination pair) basis. For information about CEF, see IP Switching Cisco Express Forwarding Configuration Guide. The BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN feature is enabled under the IPv4 VRF address family and IPv6 VRF address family configuration modes. When enabled, this feature can perform load balancing on eBGP and/or iBGP paths that are imported into the VRF. The number of multipaths is configured on a per VRF basis. Separate VRF multipath configurations are isolated by unique route distinguisher.

Note The BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN feature operates within the parameters of configured outbound routing policy.

eBGP and iBGP Multipath Load Sharing in a BGP MPLS Network

The following figure shows a service provider BGP MPLS network that connects two remote networks to PE router 1 and PE router 2. PE router 1 and PE router 2 are both configured for VPNv4 unicast iBGP peering. Network 2 is a multihomed network that is connected to PE router 1 and PE router 2. 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 2: Service Provider BGP MPLS Network



PE router 1 can be configured with the BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN feature so that both iBGP and eBGP paths can be selected as multipaths and imported into the VRF . The multipaths will be used by CEF to perform load balancing. IP traffic that is sent from Network 1 to Network 2, PE router 1 will Load Share with eBGP paths as IP traffic & iBGP path will be sent as MPLS traffic.

Note

- eBGP session between local CE & local PE is not supported.
- eBGP session from a local PE to a remote CE is supported.
- eiBGP Multipath is supported in per prefix label allocation mode only. It is not supported in other label allocation modes.

Benefits of Multipath Load Sharing for Both eBGP and iBGP

The BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN feature allows multihomed autonomous systems and PE routers to be configured to distribute traffic across both eBGP and iBGP paths.

How to Configure BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

This section contains the following procedures:

Configuring Multipath Load Sharing for Both eBGP an iBGP

SUMMARY STEPS

1. **enable**
2. **configure** { **terminal** | **memory** | **network** }
3. **router bgp as-number**
4. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name* }
5. **address-family ipv4 vrf***vrf-name*
6. **address-family ipv6 vrf***vrf-name*
7. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name* } **update-source** *interface-type interface-name*
8. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name* } **activate**
9. **maximum-paths eibgp** [*import-number*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure** { **terminal** | **memory** | **network** } **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router bgp as-number** **Example:** `Device(config)# router bgp 40000`	Enters router configuration mode to create or configure a BGP routing process.
Step 4	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name* } **Example:** `Device(config-router)# neighbor group192`	Accepts and attempts BGP connections to external peers residing on networks that are not directly connected.
Step 5	**address-family ipv4 vrf***vrf-name* **Example:** `Device(config-router)# address-family ipv4 vrf RED`	Places the router in address family configuration mode. • Separate VRF multipath configurations are isolated by unique route distinguisher.
Step 6	**address-family ipv6 vrf***vrf-name* **Example:** `Device(config-router)# address-family ipv6 vrf RED`	Places the router in address family configuration mode. • Separate VRF multipath configurations are isolated by unique route distinguisher.
Step 7	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name* } **update-source** *interface-type interface-name* **Example:**	Specifies the link-local address over which the peering is to occur.

	Command or Action	Purpose
	Device(config-router)# **neighbor FE80::1234:BFF:FE0E:A471 update-source Gigabitethernet 1/0/0**	
Step 8	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name* } **activate** **Example:** (config-router)# **neighbor group192 activate**	Activates the neighbor or listen range peer group for the configured address family.
Step 9	**maximum-paths eibgp** [*import-number*] **Example:** (config-router-af)# **maximum-paths eibgp 2**	Configures the number of parallel iBGP and eBGP routes that can be installed into a routing table.

Verifying Multipath Load Sharing for Both eBGP an iBGP

SUMMARY STEPS

1. **enable**
2. **show ip bgp neighbors**
3. **show ip bgp vpnv4 vrf***vrf name*
4. **show ip route vrf***vrf-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Device> **enable**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip bgp neighbors** **Example:** Device# **show ip bgp neighbors**	Displays information about the TCP and BGP connections to neighbors.
Step 3	**show ip bgp vpnv4 vrf***vrf name* **Example:** Device# **show ip bgp vpnv4 vrf RED**	Displays VPN address information from the BGP table. This command is used to verify that the VRF has been received by BGP.
Step 4	**show ip route vrf***vrf-name* **Example:** Device# **show ip route vrf RED**	Displays the IP routing table associated with a VRF instance. The show ip route vrf command is used to verify that the VRF is in the routing table.

Configuration Examples for the BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN Feature

The following examples show how to configure and verify this feature:

eBGP and iBGP Multipath Load Sharing Configuration Example

This following configuration example configures a router in IPv4 address-family mode to select two BGP routes (eBGP or iBGP) as multipaths:

```
Device(config)# router bgp 40000
Device(config-router)# address-family ipv4 vrf RED
Device(config-router-af)# maximum-paths eibgp 2
Device(config-router-af)# end
```

This following configuration example configures a router in IPv6 address-family mode to select two BGP routes (eBGP or iBGP) as multipaths:

```
Device(config)#router bgp 40000
Device(config-router)# address-family ipv6 vrf RED
Device(config-router-af)# maximum-paths eibgp 2
Device(config-router-af)# end
```

Feature Information for BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 1: Feature Information for BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN

Feature Name	Releases	Feature Information
BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS-VPN	Cisco IOS XE Everest 16.6.1	The BGP Multipath Load Sharing for eBGP and iBGP feature allows you to configure multipath load balancing with both external BGP (eBGP) and internal BGP (iBGP) paths in Border Gateway Protocol (BGP) networks that are configured to use Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs). This feature provides improved load balancing deployment and service offering capabilities and is useful for multi-homed autonomous systems and Provider Edge (PE) routers that import both eBGP and iBGP paths from multihomed and stub networks.

CHAPTER 4

Configuring EIGRP MPLS VPN PE-CE

Prerequisites for MPLS VPN Support for EIGRP Between PE and CE

- Configure MPLS Layer 3 VPNs.
- Configure the Border Gateway Protocol (BGP) in the network core.

Information About MPLS VPN Support for EIGRP Between PE and CE

How to Configure MPLS VPN Support for EIGRP Between PE and CE

This section provides information about how to configure MPLS VPN support for EIGRP bbetween PE and CE:

Configuring EIGRP as the Routing Protocol Between the PE and CE Devices

To configure PE-to-CE routing sessions that use EIGRP, perform this task.

Before you begin

Configure the PE device with the same routing protocol that the CE device uses.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp** *as-number*
4. **no synchronization**
5. **neighbor** *ip-address* **remote-as** *as-number*
6. **neighbor** *ip-address* **update-source loopback** *interface-number*
7. **address-family vpnv4**
8. **neighbor** *ip-address* **activate**
9. **neighbor** *ip-address* **send-community extended**
10. **exit-address-family**
11. **address-family ipv4 vrf** *vrf-name*
12. **redistribute eigrp** *as-number* [**metric** *metric-value*] [**route-map** *map-name*]
13. **no synchronization**
14. **exit-address-family**
15. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *as-number* **Example:** `Device(config)# router bgp 10`	Enters router configuration mode, and creates a BGP routing process.
Step 4	**no synchronization** **Example:** `Device(config-router)# no synchronization`	Configures BGP to send advertisements without waiting to synchronize with the IGP.
Step 5	**neighbor** *ip-address* **remote-as** *as-number* **Example:**	Establishes peering with the specified neighbor or peer group.

	Command or Action	Purpose
	`Device(config-router)# neighbor 10.0.0.1 remote-as 10`	• In this step, you are establishing an iBGP session with the PE device that is connected to the CE device at the other CE site.
Step 6	**neighbor** *ip-address* **update-source loopback** *interface-number* **Example:** `Device(config-router)# neighbor 10.0.0.1 update-source loopback 0`	Configures BGP to use any operational interface for TCP connections. • This configuration step is not required. However, the BGP routing process will be less susceptible to the effects of interface or link flapping.
Step 7	**address-family vpnv4** **Example:** `Device(config-router)# address-family vpnv4`	Enters address family configuration mode for configuring routing sessions that use standard IPv4 address prefixes, such as BGP, RIP, and static routing sessions.
Step 8	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.0.0.1 activate`	Establishes peering with the specified neighbor or peer group. • In this step, you are activating the exchange of VPNv4 routing information between the PE devices.
Step 9	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 10.0.0.1 send-community extended`	Configures the local device to send extended community attribute information to the specified neighbor. • This step is required for the exchange of EIGRP extended community attributes.
Step 10	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits address family configuration mode and enters router configuration mode.
Step 11	**address-family ipv4 vrf** *vrf-name* **Example:** `Device(config-router)# address-family ipv4 vrf RED`	Configures an IPv4 address family for the EIGRP VRF and enters address family configuration mode. • An address-family VRF needs to be configured for each EIGRP VRF that runs between the PE and CE devices.
Step 12	**redistribute eigrp** *as-number* [**metric** *metric-value*] [**route-map** *map-name*] **Example:** `Device(config-router-af)# redistribute eigrp 101`	Redistributes the EIGRP VRF into BGP. • The autonomous system number from the CE network is configured in this step.
Step 13	**no synchronization** **Example:**	Configures BGP to send advertisements without waiting to synchronize with the IGP.

	Command or Action	Purpose
	`Device(config-router-af)# no synchronization`	
Step 14	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits address family configuration mode and enters router configuration mode.
Step 15	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode and enters privileged EXEC mode.

Configuring EIGRP Redistribution in the MPLS VPN

Perform this task on every PE device that provides VPN services to enable EIGRP redistribution in the MPLS VPN.

Before you begin

The metric must be configured for routes from external EIGRP autonomous systems and non-EIGRP networks before these routes can be redistributed into an EIGRP CE device. The metric can be configured in the redistribute statement using the **redistribute** (IP) command or can be configured with the **default-metric** (EIGRP) command. If an external route is received from another EIGRP autonomous system or a non-EIGRP network without a configured metric, the route will not be advertised to the CE device.

Note Redistribution between native EIGRP VRFs is not supported. This is designed behavior.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router eigrp** *as-number*
4. **address-family ipv4** [**multicast** | **unicast** | **vrf** *vrf-name*]
5. **network** *ip-address wildcard-mask*
6. **redistribute bgp** {*as-number*} [**metric** *bandwidth delay reliability load mtu*] [**route-map** *map-name*]
7. **autonomous-system** *as-number*
8. **exit-address-family**
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Device> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router eigrp** *as-number* **Example:** `Device(config)# router eigrp 1`	Enters router configuration mode and creates an EIGRP routing process. • The EIGRP routing process for the PE device is created in this step.
Step 4	**address-family ipv4** [**multicast** | **unicast** | **vrf** *vrf-name*] **Example:** `Device(config-router)# address-family ipv4 vrf RED`	Enters address-family configuration mode and creates a VRF. • The VRF name must match the VRF name that was created in the previous section.
Step 5	**network** *ip-address wildcard-mask* **Example:** `Device(config-router-af)# network 172.16.0.0 0.0.255.255`	Specifies the network for the VRF. • The network statement is used to identify which interfaces to include in EIGRP. The VRF must be configured with addresses that fall within the wildcard-mask range of the network statement.
Step 6	**redistribute bgp** {*as-number*} [**metric** *bandwidth delay reliability load mtu*] [**route-map** *map-name*] **Example:** `Device(config-router-af)# redistribute bgp 10 metric 10000 100 255 1 1500`	Redistributes BGP into the EIGRP. • The autonomous system number and metric of the BGP network are 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 and is configured in this step.
Step 7	**autonomous-system** *as-number* **Example:** `Device(config-router-af)# autonomous-system 101`	Specifies the autonomous system number of the EIGRP network for the customer site.
Step 8	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits address family configuration mode and enters router configuration mode.
Step 9	**end** **Example:**	Exits router configuration mode and enters privileged EXEC mode.

	Command or Action	Purpose
	`Device(config-router)# end`	

Verifying Connectivity Between MPLS Virtual Private Network Sites

To verify that the local and remote customer edge (CE) devices can communicate across the Multiprotocol Label Switching (MPLS) core, perform the following tasks:

Verifying IP Connectivity from CE Device to CE Device Across the MPLS Core

SUMMARY STEPS

1. **enable**
2. **ping** [*protocol*] {*host-name* | *system-address*}
3. **trace** [*protocol*] [*destination*]
4. **show ip route** [*ip-address* [*mask*] [**longer-prefixes**]] | *protocol* [*process-id*]] | [**list** [*access-list-name* | *access-list-number*]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode.

Step 2 **ping** [*protocol*] {*host-name* | *system-address*}

Diagnoses basic network connectivity on AppleTalk, Connectionless-mode Network Service (CLNS), IP, Novell, Apollo, Virtual Integrated Network Service (VINES), DECnet, or Xerox Network Service (XNS) networks. Use the **ping** command to verify the connectivity from one CE device to another.

Step 3 **trace** [*protocol*] [*destination*]

Discovers the routes that packets take when traveling to their destination. The **trace** command can help isolate a trouble spot if two devices cannot communicate.

Step 4 **show ip route** [*ip-address* [*mask*] [**longer-prefixes**]] | *protocol* [*process-id*]] | [**list** [*access-list-name* | *access-list-number*]

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.

Verifying That the Local and Remote CE Devices Are in the PE Routing Table

SUMMARY STEPS

1. **enable**
2. **show ip route vrf** *vrf-name* [*prefix*]
3. **show ip cef vrf** *vrf-name* [*ip-prefix*]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode.

Step 2 **show ip route vrf** *vrf-name* [*prefix*]

Displays the IP routing table that is associated with a virtual routing and forwarding (VRF) instance. Check that the loopback addresses of the local and remote customer edge (CE) devices are in the routing table of the provider edge (PE) devices.

Step 3 **show ip cef vrf** *vrf-name* [*ip-prefix*]

Displays the Cisco Express Forwarding forwarding table that is associated with a VRF. Check that the prefix of the remote CE device is in the Cisco Express Forwarding table.

Configuration Examples for MPLS VPN Support for EIGRP Between PE and CE

This section provides the configuration examples for MPLS VPN support for EIGRP between PE and CE:

Example: Configuring an MPLS VPN Using EIGRP

<table>
<tr><th>PE Configuration</th><th>CE Configuration</th></tr>
<tr><td>

```
ip vrf vpn1

 rd 100:1
 route-target export 100:1
 route-target import 100:1
!
ip cef
mpls ldp router-id Loopback0 force
mpls label protocol ldp
!
interface Loopback0
 ip address 10.0.0.1 255.255.255.255
interface FastEthernet0/0/0
 ip vrf forwarding vpn1
 ip address 34.0.0.2 255.0.0.0
 no cdp enable
interface FastEthernet1/1/0
ip address 30.0.0.1 255.0.0.0
mpls label protocol ldp
mpls ip
router eigrp 1000
 auto-summary
!
address-family ipv4 vrf vpn1
 redistribute bgp 100 metric 10000 100 255 1 1500

 network 34.0.0.0
 distribute-list 20 in
 no auto-summary
 autonomous-system 1000
 exit-address-family
!
router bgp 100
no synchronization
bgp log-neighbor changes
neighbor 10.0.0.3 remote-as 100
neighbor 10.0.0.3 update-source Loopback0
no auto-summary
 !
address-family vpnv4
 neighbor 10.0.0.3 activate
 neighbor 10.0.0.3 send-community extended
 bgp scan-time import 5
 exit-address-family
 !
address-family ipv4 vrf vpn1
 redistribute connected
 redistribute eigrp
 no auto-summary
 no synchronization
 exit-address-family
```

</td><td>

```
ip cef

mpls ldp router-id Loopback0 force
mpls label protocol ldp
!
interface Loopback0
 ip address 10.0.0.9 255.255.255.255
!
interface FastEthernet0/0/0
 ip address 34.0.0.1 255.0.0.0
 no cdp enable
!
router eigrp 1000
 network 34.0.0.0
 auto-summary
```

</td></tr>
</table>

Feature Information for MPLS VPN Support for EIGRP Between PE and CE

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 2: Feature Information for MPLS VPN Support for EIGRP Between PE and CE

Feature Name	Releases	Feature Information
MPLS VPN Support for EIGRP Between PE and CE	Cisco IOS XE Fuji 16.9.1	The MPLS VPN Support for EIGRP Between PE and CE feature allows service providers to configure the Enhanced Interior Gateway Routing Protocol (EIGRP) between provider edge (PE) and customer edge (CE) devices in a Multiprotocol Label Switching (MPLS) virtual private network (VPN) and offer MPLS VPN services to those customers that require native support for EIGRP.

CHAPTER 5

Configuring Ethernet-over-MPLS (EoMPLS)

Prerequisites for Ethernet-over-MPLS

Before you configure EoMPLS, ensure that the network is configured as follows:

- Configure IP routing in the core so that the provider edge (PE) devices can reach each other through IP.
- Configure MPLS in the core so that a label switched path (LSP) exists between the PE devices.
- Configure the **no switchport**, **no keepalive**, and **no ip address** commands before configuring Xconnect on the attachment circuit.
- For load-balancing, configuring the **port-channel load-balance** command is mandatory.
- Subinterfaces must be supported to enable EoMPLS VLAN mode.
- The **mpls ldp graceful-restart** command must be configured to enable the device to protect LDP bindings and MPLS forwarding state during a disruption in service. We recommend you to configure this command (even if you do not want to preserve the forwarding state) to avoid device failure during SSO in a high availability setup with scale configurations.

Restrictions for Ethernet-over-MPLS

The following sections list the restrictions for EoMPLS port mode and EoMPLS VLAN mode.

Restrictions for Ethernet-over-MPLS Port Mode

- Ethernet Flow Point is not supported.

- Quality of Service (QoS): Customer differentiated services code point (DSCP) re-marking is not supported with virtual private wire service (VPWS) and EoMPLS.
- Virtual Circuit Connectivity Verification (VCCV) ping with explicit null is not supported.
- Layer 2 Protocol Tunneling CLI is not supported.
- Flow-Aware Transport (FAT) Pseudowire Redundancy is supported only in Protocol-CLI mode. Supported load-balancing parameters are Source IP, Source MAC address, Destination IP, and Destination MAC address.
- MPLS QoS is supported only in pipe and uniform mode. Default mode is pipe mode.
- Both legacy Xconnect and Protocol-CLI (interface pseudowire configuration) modes are supported.
- Xconnect and MACSec cannot be configured on the same interface.
- MACSec should be configured on CE devices and Xconnect should be configured on PE devices.
- A MACSec session should be available between CE devices.
- By default, EoMPLS PW tunnels all the protocols such as Cisco Discovery Protocol and Spanning Tree Protocol (STP). EoMPLS PW cannot perform selective protocol tunneling as part of L2 Protocol Tunneling CLI.
- Link Aggregation Control Protocol (LACP) and Port Aggregation Protocol (PAgP) packets are not forwarded over Ethernet-over-MPLS Pseudowire, as these are processed by the local PE.

Restrictions for EoMPLS VLAN Mode

- Virtual circuit will not work if the same interworking type is not configured on PE devices.
- Untagged traffic is not supported as incoming traffic.
- Xconnect mode cannot be enabled on Layer 2 subinterfaces because multiplexer user-network interface (MUX UNI) is not supported.
- Xconnect mode cannot be configured on subinterfaces if it is enabled on the main interface for port-to-port transport.
- FAT can be configured on Protocol CLI mode only.
- In VLAN mode EoMPLS, only those packets encrypted with the dot1q in clear by the CE device will be processed by the PE device.
- QoS: Customer DSCP Remarking is not supported with VPWS and EoMPLS.
- MPLS QoS is supported in pipe and uniform mode. Default mode is pipe mode.
- In VLAN mode EoMPLS, Cisco Discovery Protocol packets from the CE will be processed by the PE, but will not be carried over the EoMPLS virtual circuit, whereas in port mode, Cisco Discovery Protocol packets from the CE will be carried over the virtual circuit.
- Only Ethernet and VLAN interworking types are supported.
- L2 Protocol Tunneling CLI is not supported.

- Link Aggregation Control Protocol (LACP) and Port Aggregation Protocol (PAgP) packets are not forwarded over Ethernet-over-MPLS Pseudowire, as these are processed by the local PE.

Information About Ethernet-over-MPLS

EoMPLS is one of the Any Transport over MPLS (AToM) transport types. EoMPLS works by encapsulating Ethernet protocol data units (PDUs) in MPLS packets and forwarding them across the MPLS network. Each PDU is transported as a single packet.

The following modes are supported:

- Port mode: Allows all traffic on a port to share a single virtual circuit across an MPLS network. Port mode uses virtual circuit type 5.
- VLAN mode: Transports Ethernet traffic from a source 802.1Q VLAN to a destination 802.1Q VLAN through a single virtual circuit over an MPLS network. VLAN mode uses virtual circuit type 5 as the default (does not transport dot1q tag); however, uses virtual circuit type 4 (transports dot1 tag) if the remote PE does not support virtual circuit type 5 for subinterface-based (VLAN-based) EoMPLS.

Interworking between EoMPLS port mode and EoMPLS VLAN mode: If EoMPLS port mode is configured on a local PE and EoMPLS VLAN mode on a remote PE, then the customer edge (CE) Layer 2 switchport interface must be configured as an *access* on the port mode side and the Spanning Tree Protocol must be disabled on the VLAN mode side of the CE device.

The maximum transmission unit (MTU) of all the intermediate links between PEs must be able to carry the largest Layer 2 packet received on ingress PE.

How to Configure Ethernet-over-MPLS

EoMPLS can be configured in the port mode or VLAN mode.

Configuring Ethernet-over-MPLS Port Mode

EoMPLS port mode can be configured using either the Xconnect mode or protocol CLI method.

Xconnect Mode

To configure EoMPLS port mode in Xconnect mode, perform the following task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **no switchport**
5. **no ip address**
6. **no keepalive**
7. **xconnect** *peer-device-id vc-id* **encapsulation mpls**

8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/36`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Enters Layer 3 mode for physical ports only.
Step 5	**no ip address** **Example:** `Device(config-if)# no ip address`	Ensures that no IP address is assigned to the physical port.
Step 6	**no keepalive** **Example:** `Device(config-if)# no keepalive`	Ensures that the device does not send keepalive messages.
Step 7	**xconnect** *peer-device-id vc-id* **encapsulation mpls** **Example:** `Device(config-if)# xconnect 10.1.1.1 962 encapsulation mpls`	Binds the attachment circuit to a pseudowire virtual circuit (VC). The syntax for this command is the same as for all other Layer 2 transports.

	Command or Action	Purpose
Step 8	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Protocol CLI Method

To configure EoMPLS port mode in protocol CLI mode, perform the following task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **port-channel load-balance dst-ip**
4. **interface** *interface-id*
5. **no switchport**
6. **no ip address**
7. **no keepalive**
8. **exit**
9. **interface pseudowire** *number*
10. **encapsulation mpls**
11. **neighbor** *peer-ip-addr vc-id*
12. **l2vpn xconnect context** *context-name*
13. **member** *interface-id*
14. **member pseudowire** *number*
15. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**port-channel load-balance dst-ip** **Example:** `Device(config)# port-channel load-balance dst-ip`	Sets the load distribution method to the destination IP address.
Step 4	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/21`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 5	**no switchport** **Example:** `Device(config-if)# no switchport`	Enters Layer 3 mode for physical ports only.
Step 6	**no ip address** **Example:** `Device(config-if)# no ip address`	Ensures that no IP address is assigned to the physical port.
Step 7	**no keepalive** **Example:** `Device(config-if)# no keepalive`	Ensures that the device does not send keepalive messages.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 9	**interface pseudowire** *number* **Example:** `Device(config)# interface pseudowire 17`	Establishes a pseudowire interface with a value that you specify and enters pseudowire configuration mode.
Step 10	**encapsulation mpls** **Example:**	Specifies the tunneling encapsulation.

	Command or Action	Purpose
	`Device(config-if)# encapsulation mpls`	
Step 11	**neighbor** *peer-ip-addr vc-id* **Example:** `Device(config-if)# neighbor 10.10.0.10 17`	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.
Step 12	**l2vpn xconnect context** *context-name* **Example:** `Device(config-if)# l2vpn xconnect context vpws17`	Creates an L2VPN cross connect context and enters Xconnect context configuration mode.
Step 13	**member** *interface-id* **Example:** `Device(config-if-xconn)# member TenGigabitEthernet1/0/21`	Specifies interface that forms an L2VPN cross connect.
Step 14	**member pseudowire** *number* **Example:** `Device(config-if-xconn)# member pseudowire 17`	Specifies the pseudowire interface that forms an L2VPN cross connect.
Step 15	**end** **Example:** `Device(config-if-xconn)# end`	Exits Xconnect interface configuration mode and returns to privileged EXEC mode.

Configuring Ethernet-over-MPLS VLAN Mode

EoMPLS VLAN mode can be configured using either the Xconnect mode or protocol-CLI method.

Xconnect Mode

To configure EoMPLS VLAN mode in Xconnect mode, perform the following task:

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface** *interface-id*
4. **no switchport**
5. **no ip address**
6. **no keepalive**
7. **exit**
8. **interface** *interface-id.subinterface*
9. **encapsulation dot1Q** *vlan-id*
10. **xconnect** *peer-ip-addr vc-id* **encapsulation mpls**
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/36`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Enters Layer 3 mode, for physical ports only.
Step 5	**no ip address** **Example:** `Device(config-if)# no ip address`	Ensures that there is no IP address assigned to the physical port.
Step 6	**no keepalive** **Example:**	Ensures that the device does not send keepalive messages.

	Command or Action	Purpose
	`Device(config-if)# no keepalive`	
Step 7	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 8	**interface** *interface-id.subinterface* **Example:** `Device(config)# interface TenGigabitEthernet1/0/36.1105`	Defines the subinterface to be configured, and enters subinterface configuration mode.
Step 9	**encapsulation dot1Q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1Q 1105`	Enables IEEE 802.1Q encapsulation of traffic on the subinterface.
Step 10	**xconnect** *peer-ip-addr vc-id* **encapsulation mpls** **Example:** `Device(config-subif)# xconnect 10.0.0.1 1105 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC. The syntax for this command is the same as for all other Layer 2 transports.
Step 11	**end** **Example:** `Device(config-subif-xconn)# end`	Returns to privileged EXEC mode.

Protocol CLI Method

To configure EoMPLS VLAN mode in protocol-CLI mode, perform the following task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **port-channel load-balance dst-ip**
4. **interface** *interface-id*
5. **no switchport**
6. **no ip address**

7. **no keepalive**
8. **exit**
9. **interface** *interface-id.subinterface*
10. **encapsulation dot1Q** *vlan-id*
11. **exit**
12. **interface pseudowire** *number*
13. **encapsulation mpls**
14. **neighbor** *peer-ip-addr vc-id*
15. **l2vpn xconnect context** *context-name*
16. **member** *interface-id.subinterface*
17. **member pseudowire** *number*
18. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**port-channel load-balance dst-ip** **Example:** `Device(config)# port-channel load-balance dst-ip`	Sets the load-distribution method to the destination IP address.
Step 4	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/36`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 5	**no switchport** **Example:** `Device(config-if)# no switchport`	Enters Layer 3 mode, for physical ports only.

	Command or Action	Purpose
Step 6	**no ip address** **Example:** `Device(config-if)# no ip address`	Ensures that there is no IP address assigned to the physical port.
Step 7	**no keepalive** **Example:** `Device(config-if)# no keepalive`	Ensures that the device does not send keepalive messages.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 9	**interface** *interface-id.subinterface* **Example:** `Device(config)# interface TenGigabitEthernet1/0/36.1105`	Defines the subinterface to be configured, and enters subinterface configuration mode.
Step 10	**encapsulation dot1Q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1Q 1105`	Enables IEEE 802.1Q encapsulation of traffic on the subinterface.
Step 11	**exit** **Example:** `Device(config-subif)# exit`	Exits subinterface configuration mode and returns to interface configuration mode.
Step 12	**interface pseudowire** *number* **Example:** `Device(config)# interface pseudowire 17`	Establishes a pseudowire interface with a value that you specify and enters pseudowire configuration mode.
Step 13	**encapsulation mpls** **Example:**	Specifies the tunneling encapsulation.

	Command or Action	Purpose
	`Device(config-if)# encapsulation mpls`	
Step 14	**neighbor** *peer-ip-addr vc-id* **Example:** `Device(config-if)# neighbor 10.10.0.10 17`	Specifies the peer IP address and VC ID value of a L2VPN pseudowire.
Step 15	**l2vpn xconnect context** *context-name* **Example:** `Device(config-if)# l2vpn xconnect context vpws17`	Creates a L2VPN cross connect context, and enters Xconnect context configuration mode.
Step 16	**member** *interface-id.subinterface* **Example:** `Device(config-if-xconn)# member TenGigabitEthernet1/0/36.1105`	Specifies the subinterface that forms a L2VPN cross connect.
Step 17	**member pseudowire** *number* **Example:** `Device(config-if-xconn)# member pseudowire 17`	Specifies pseudowire interface that forms a L2VPN cross connect.
Step 18	**end** **Example:** `Device(config-if-xconn)# end`	Exits Xconnect configuration mode and returns to privileged EXEC mode.

Configuration Examples for Ethernet-over-MPLS

Figure 3: EoMPLS Topology

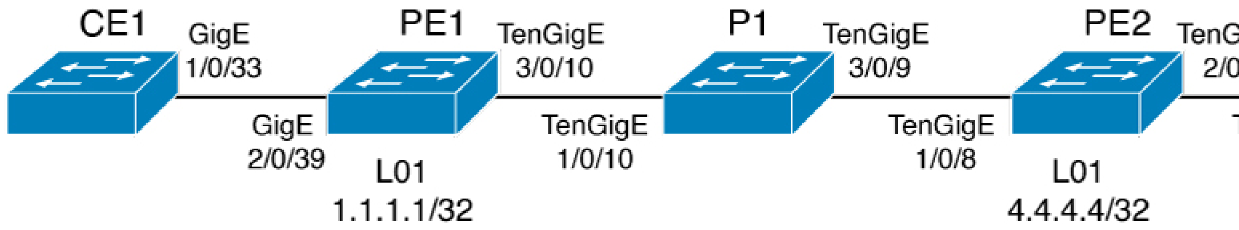


Table 3: EoMPLS Port Mode Configuration

PE Configuration	CE Configuration
mpls ip mpls label protocol ldp mpls ldp graceful-restart mpls ldp router-id loopback 1 force interface Loopback1 ip address 10.1.1.1 255.255.255.255 ip ospf 100 area 0 router ospf 100 router-id 10.1.1.1 nsf system mtu 9198 port-channel load-balance dst-ip ! interface gigabitethernet 2/0/39 no switchport no ip address no keepalive ! interface pseudowire101 encapsulation mpls neighbor 10.10.10.10 101 load-balance flow ip dst-ip load-balance flow-label both l2vpn xconnect context pw101 member pseudowire101 member gigabitethernet 2/0/39 ! interface tengigabitethernet 3/0/10 switchport trunk allowed vlan 142 switchport mode trunk channel-group 42 mode active ! interface Port-channel42 switchport trunk allowed vlan 142 switchport mode trunk ! interface Vlan142 ip address 10.11.11.11 255.255.255.0 ip ospf 100 area 0 mpls ip mpls label protocol ldp !	interface gigabitethernet 1/0/33 switchport trunk allowed vlan 912 switchport mode trunk spanning-tree portfast trunk ! interface Vlan912 ip address 10.91.2.3 255.255.255.0 !

Table 4: EoMPLS VLAN Mode Configuration

PE Configuration	CE Configuration
interface tengigabitethernet 1/0/36 no switchport no ip address no keepalive exit ! interface tengigabitethernet 1/0/36.1105 encapsulation dot1Q 1105 exit ! interface pseudowire1105 encapsulation mpls neighbor 10.10.0.10 1105 exit ! l2vpn xconnect context vme1105 member tengigabitethernet 1/0/36.1105 member pseudowire1105 end !	interface fortygigabitethernet 1/9 switchport switchport mode trunk switchport trunk allowed vlan 1105 mtu 9216 end !

Table 5: Interworking Between EoMPLS Port Mode and EoMPLS VLAN Mode Configuration

PE Configuration: Port Mode	CE Configuration: Port Mode
interface tengigabitethernet 1/0/37 no switchport no ip address no keepalive exit ! interface pseudowire1105 encapsulation mpls neighbor 10.11.11.11 1105 exit ! l2vpn xconnect context vme1105 member tengigabitethernet 1/0/37 member pseudowire1105 end !	interface fortygigabitethernet1/10 switchport switchport mode access switchport access vlan 1105 end no spanning-tree vlan 1105 !

PE Configuration: VLAN Mode	CE Configuration: VLAN Mode
interface tengigabitethernet 1/0/36 no switchport no ip address no keepalive exit ! interface tengigabitethernet 1/0/36.1105 encapsulation dot1Q 1105 exit ! interface pseudowire1105 encapsulation mpls neighbor 10.10.0.10 1105 exit ! l2vpn xconnect context vme1105 member tengigabitethernet 1/0/36.1105 member pseudowire1105 end !	interface fortygigabitethernet 1/9 switchport switchport mode trunk switchport trunk allowed vlan 1105 mtu 9216 end no spanning-tree vlan 1105 !

Another scenario for interworking between EoMPLS port mode and EoMPLS VLAN mode is to configure the following commands on both CE devices:

- **switchport mode trunk**
- **switchport trunk allowed vlan** *vlan-id*
- **spanning-tree vlan** *vlan-id*

Data traffic will flow through by disabling STP on both CE devices, if the traffic sent is not double VLAN tagged.

The following is a sample output of the **show mpls l2 vc vcid** *vc-id* **detail** command:

```
Device# show mpls l2 vc vcid 1105 detail
Local interface: TenGigabitEthernet1/0/36.1105 up, line protocol up, Eth VLAN 1105 up
  Interworking type is Ethernet
  Destination address: 10.0.0.1, VC ID: 1105, VC status: up
    Output interface: Po10, imposed label stack {33 10041}
    Preferred path: not configured
    Default path: active
    Next hop: 10.10.0.1
  Create time: 00:04:09, last status change time: 00:02:13
    Last label FSM state change time: 00:02:12
  Signaling protocol: LDP, peer 10.0.0.1:0 up
    Targeted Hello: 10.0.0.10(LDP Id) -> 10.0.0.1, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: not configured and not enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
     Last local PW i/f circ status rcvd: No fault
```

```
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 124, remote 10041
    Group ID: local 336, remote 352
    MTU: local 9198, remote 9198
    Remote interface description:
    MAC Withdraw: sent:1, received:0
  Sequencing: receive disabled, send disabled
  Control Word: On (configured: autosense)
  SSO Descriptor: 10.0.0.1/1105, local label: 124
  Dataplane:
    SSM segment/switch IDs: 9465983/446574 (used), PWID: 109
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

The following is a sample output of the **show l2vpn atom vc vcid** *vc-id* **detail** command:

```
Device# show l2vpn atom vc vcid 1105 detail
pseudowire100109 is up, VC status is up PW type: Ethernet
  Create time: 00:04:17, last status change time: 00:02:22
    Last label FSM state change time: 00:02:20
  Destination address: 10.0.0.1 VC ID: 1105
    Output interface: Po10, imposed label stack {33 10041}
    Preferred path: not configured
    Default path: active
    Next hop: 10.10.0.1
  Member of xconnect service TenGigabitEthernet1/0/36.1105-1105, group right
    Associated member TenGigabitEthernet1/0/36.1105 is up, status is up
    Interworking type is Ethernet
    Service id: 0x1f000037
  Signaling protocol: LDP, peer 10.0.0.1:0 up
    Targeted Hello: 10.0.0.10(LDP Id) -> 10.0.0.1, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: not configured and not enabled
    PWid FEC (128), VC ID: 1105
    Status TLV support (local/remote)         : enabled/supported
      LDP route watch                         : enabled
      Label/status state machine              : established, LruRru
      Local dataplane status received         : No fault
      BFD dataplane status received           : Not sent
      BFD peer monitor status received        : No fault
      Status received from access circuit     : No fault
      Status sent to access circuit           : No fault
      Status received from pseudowire i/f     : No fault
      Status sent to network peer             : No fault
      Status received from network peer       : No fault
      Adjacency status of remote peer         : No fault
  Sequencing: receive disabled, send disabled
  Bindings
    Parameter    Local                          Remote
    ------------ ------------------------------ ------------------------------
    Label        124                            10041
    Group ID     336                            352
    Interface
    MTU          9198                           9198
    Control word on (configured: autosense)     on
    PW type      Ethernet                       Ethernet
    VCCV CV type 0x02                           0x02
                   LSPV [2]                       LSPV [2]
    VCCV CC type 0x06                           0x06
                   RA [2], TTL [3]               RA [2], TTL [3]
```

```
    Status TLV   enabled                        supported
  SSO Descriptor: 10.0.0.1/1105, local label: 124
  Dataplane:
    SSM segment/switch IDs: 9465983/446574 (used), PWID: 109
  Rx Counters
    0 input transit packets, 0 bytes
    0 drops, 0 seq err
    0 MAC withdraw
  Tx Counters
    0 output transit packets, 0 bytes
    0 drops
    1 MAC withdraw
```

The following is a sample output of the **show mpls forwarding-table** command:

```
Device# show mpls forwarding-table 10.0.0.1

Local      Outgoing   Prefix           Bytes Label   Outgoing        Next Hop
Label      Label      or Tunnel Id     Switched      interface
2049       33         10.0.0.1/32      38540         Hu2/0/30/2.1   10.0.0.2
           33         10.0.0.1/32      112236        Hu2/0/30/2.2   10.0.0.6
           33         10.0.0.1/32      46188         Hu2/0/30/2.3   10.0.0.8
```

Feature Information for Ethernet-over-MPLS (EoMPLS)

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	Ethernet-over-MPLS and Pseudowire Redundancy	Ethernet-over-MPLS is one of the Any Transport over MPLS (AToM) transport types. The Layer 2 VPN pseudowire redundancy feature enables you to configure your network to detect a failure in the network and reroute the Layer 2 service to another endpoint that can continue to provide service.
Cisco IOS XE Gibraltar 16.12.1	VLAN mode support for Ethernet-over-MPLS	VLAN mode transports Ethernet traffic from a source 802.1Q VLAN to a destination 802.1Q VLAN through a single virtual circuit over an MPLS network.
Cisco IOS XE Amsterdam 17.1.1	Macsec over EoMPLS	In VLAN mode, the switch (PE device) can now process packets in which the 802.1Q tag is not encrypted by the CE device.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 6

Configuring IPv6 Provider Edge over MPLS (6PE)

Prerequisites for 6PE

Redistribute PE-CE IGP IPv6 routes into core BGP and vice-versa

Restrictions for 6PE

eBGP as CE-PE is not supported. Static Routes, OSPFv3, ISIS, RIPv2 are supported as CE-PE.

Information About 6PE

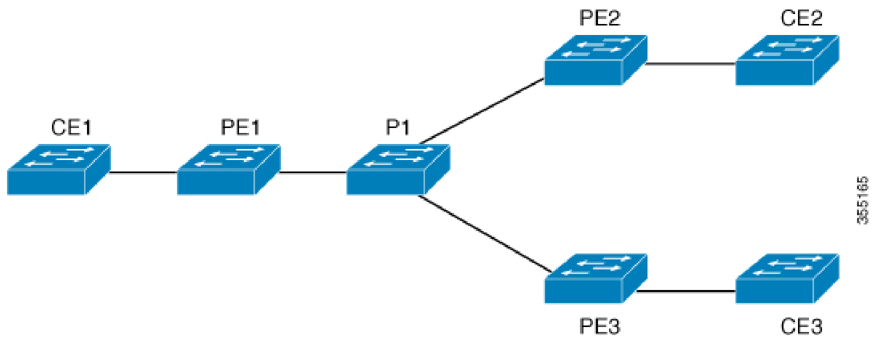
6PE is a technique that provides global IPv6 reachability over IPv4 MPLS. It allows one shared routing table for all other devices. 6PE allows IPv6 domains to communicate with one another over the IPv4 without an explicit tunnel setup, requiring only one IPv4 address per IPv6 domain.

While implementing 6PE, the provider edge routers are upgraded to support 6PE, while the rest of the core network is not touched (IPv6 unaware). This implementation requires no reconfiguration of core routers because forwarding is based on labels rather than on the IP header itself. This provides a cost-effective strategy for deploying IPv6.The IPv6 reachability information is exchanged by PE routers using multiprotocol Border Gateway Protocol (mp-iBGP) extensions.

6PE relies on mp-iBGP extensions in the IPv4 network configuration on the PE router to exchange IPv6 reachability information in addition to an MPLS label for each IPv6 address prefix to be advertised. PE routers are configured as dual stacks, running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange. The next hop advertised by the PE router for 6PE and 6VPE prefixes is still the IPv4 address that is used for IPv4 L3 VPN routes. A value of ::FFFF: is prepended to the IPv4 next hop, which is an IPv4-mapped IPv6 address.

The following figure illustrates the 6PE topology.

Figure 4: 6PE Topology



Configuring 6PE

Ensure that you configure 6PE on PE routers participating in both the IPv4 cloud and IPv6 clouds.

BGP running on a PE router should establish (IPv4) neighborhood with BGP running on other PEs. Subsequently, it should advertise the IPv6 prefixes learnt from the IPv6 table to the neighbors. The IPv6 prefixes advertised by BGP would automatically have IPv4-encoded-IPv6 addresses as the nexthop-address in the advertisement.

To configure 6PE, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 unicast-routing**
4. **router bgp** *as-number*
5. **bgp router-id interface** *interface-id*
6. **bgp log-neighbor-changes**
7. **bgp graceful-restart**
8. **neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **remote-as** *as-number*
9. **neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **update-source** *interface-type interface-number*
10. **address-family ipv6**
11. **redistribute** *protocol as-number* **match** { **internal** | **external 1** | **external 2**
12. **neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **activate**
13. **neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **send-label**
14. **exit-address-family**
15. **end**

DETAILED STEPS

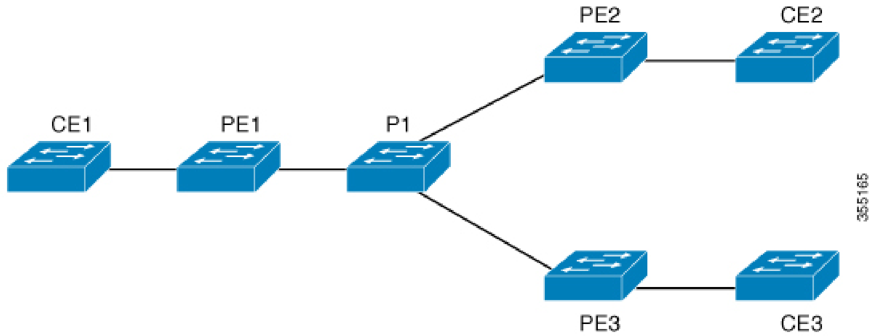
	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Device> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 unicast-routing** **Example:** `Device(config)# ipv6 unicast-routing`	Enables the forwarding of IPv6 unicast datagrams.
Step 4	**router bgp** *as-number* **Example:** `Device(config)# router bgp 65001`	Enters the number that identifies the autonomous system (AS) in which the router resides. *as-number*—Autonomous system number. Range for 2-byte numbers is 1 to 65535. Range for 4-byte numbers is 1.0 to 65535.65535.
Step 5	**bgp router-id interface** *interface-id* **Example:** `Device(config-router)# bgp router-id interface Loopback1`	Configures a fixed router ID for the local Border Gateway Protocol (BGP) routing process.
Step 6	**bgp log-neighbor-changes** **Example:** `Device(config-router)# bgp log-neighbor-changes`	Enables logging of BGP neighbor resets.
Step 7	**bgp graceful-restart** **Example:** `Device(config-router)# bgp graceful-restart`	Enables the Border Gateway Protocol (BGP) graceful restart capability globally for all BGP neighbors.
Step 8	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 33.33.33.33 remote-as 65001`	Adds an entry to the BGP or multiprotocol BGP neighbor table. • *ip-address*—IP address of a peer router with which routing information will be exchanged. • *ipv6-address*—IPv6 address of a peer router with which routing information will be exchanged. • *peer-group-name*—Name of the BGP peer group. • *remote-as*—Specifies a remote autonomous system.

	Command or Action	Purpose
		• *as-number*—Number of an autonomous system to which the neighbor belongs, ranging from 1 to 65535.
Step 9	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 33.33.33.33 update-source Loopback1`	Configures BGP sessions to use any operational interface for TCP connections.
Step 10	**address-family ipv6** **Example:** `Device(config-router)# address-family ipv6`	Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard IPv6 address prefixes.
Step 11	**redistribute** *protocol as-number* **match** { **internal** | **external 1** | **external 2** **Example:** `Device(config-router-af)# redistribute ospf 11 match internal external 1`	Redistributes routes from one routing domain into another routing domain.
Step 12	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **activate** **Example:** `Device(config-router-af)# neighbor 33.33.33.33 activate`	Enables the exchange of information with a BGP neighbor.
Step 13	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **send-label** **Example:** `Device(config-router-af)#  neighbor 33.33.33.33 send-label`	Sends MPLS labels with BGP routes to a neighboring BGP router.
Step 14	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits BGP address-family submode.
Step 15	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Configuration Examples for 6PE

Figure 5: 6PE Topology



PE Configuration

```
router ospfv3 11
ip routing
ipv6 unicast-routing
address-family ipv6 unicast
redistribute bgp 65001
exit-address-family
!
router bgp 65001
bgp router-id interface Loopback1
bgp log-neighbor-changes
bgp graceful-restart
neighbor 33.33.33.33 remote-as 65001
neighbor 33.33.33.33 update-source Loopback1
!
address-family ipv4
neighbor 33.33.33.33 activate
!
address-family ipv6
redistribute ospf 11 match internal external 1 external 2 include-connected
neighbor 33.33.33.33 activate
neighbor 33.33.33.33 send-label
neighbor 33.33.33.33 send-community extended
!
```

The following is a sample output of **show bgp ipv6 unicast summary** :

```
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 34, main routing table version 34
4 network entries using 1088 bytes of memory
4 path entries using 608 bytes of memory
4/4 BGP path/bestpath attribute entries using 1120 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 2816 total bytes of memory
BGP activity 6/2 prefixes, 16/12 paths, scan interval 60 secs
```

```
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
  State/PfxRcd
2.2.2.2         4          100      21      21       34    0    0 00:04:57
        2

sh ipv route
IPv6 Routing Table - default - 7 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP
external
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect

       RL - RPL, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       la - LISP alt, lr - LISP site-registrations, ld - LISP dyn-eid lA
 - LISP away
C   10:1:1:2::/64 [0/0]
     via Vlan4, directly connected
L   10:1:1:2::1/128 [0/0]
     via Vlan4, receive
LC  11:11:11:11::11/128 [0/0]
     via Loopback1, receive
B   30:1:1:2::/64 [200/0]
     via 33.33.33.33%default, indirectly connected
B   40:1:1:2::/64 [200/0]
     via 44.44.44.44%default, indirectly connected
```

The following is a sample output of **show bgp ipv6 unicast** command :

```
BGP table version is 112, local router ID is 11.11.11.11
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f
RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
              t secondary path,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
     Network          Next Hop            Metric LocPrf Weight Path
 *>   10:1:1:2::/64    ::                       0         32768 ?
 *>i  30:1:1:2::/64    ::FFFF:33.33.33.33
                                                0    100      0 ?
 *>i  40:1:1:2::/64    ::FFFF:44.44.44.44
                                                0    100      0 ?
 *>i  173:1:1:2::/64   ::FFFF:33.33.33.33
                                                2    100      0 ?
```

The following is a sample output of **show ipv6 cef 40:1:1:2::0/64 detail** command :

```
40:1:1:2::/64, epoch 6, flags [rib defined all labels]
  recursive via 44.44.44.44 label 67
    nexthop 1.20.4.2 Port-channel103 label 99-(local:147)
```

Feature History for IPv6 Provider Edge over MPLS (6PE)

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 7

Configuring IPv6 VPN Provider Edge over MPLS (6VPE)

Configuring 6VPE

This section provides information about Configuring 6VPE on the switch.

Restrictions for 6VPE

- Inter-AS and carrier supporting carrier (CSC) is not supported.
- VRF Route-Leaking is not supported.
- eBGP as CE-PE is not supported.
- EIGRP, OSPFv3, RIP, ISIS, Static Routes are supported as CE-PE.
- MPLS Label Allocation modes supported are Per-VRF and Per-Prefix. Per-Prefix is the default mode.
- IP fragmentation is not supported in the Per-Prefix mode of Layer 3 VPN.
- DHCPv6 is not supported on a 6VPE topology with per-port trust enabled.

Information About 6VPE

6VPE is a mechanism to use the IPv4 backbone to provide VPN IPv6 services. It takes advantage of operational IPv4 MPLS backbones, eliminating the need for dual-stacking within the MPLS core. This translates to savings in operational costs and addresses the security limitations of the 6PE approach. 6VPE is more like a regular IPv4 MPLS-VPN provider edge, with an addition of IPv6 support within VRF. It provides logically separate routing table entries for VPN member devices.

Components of MPLS-based 6VPE Network

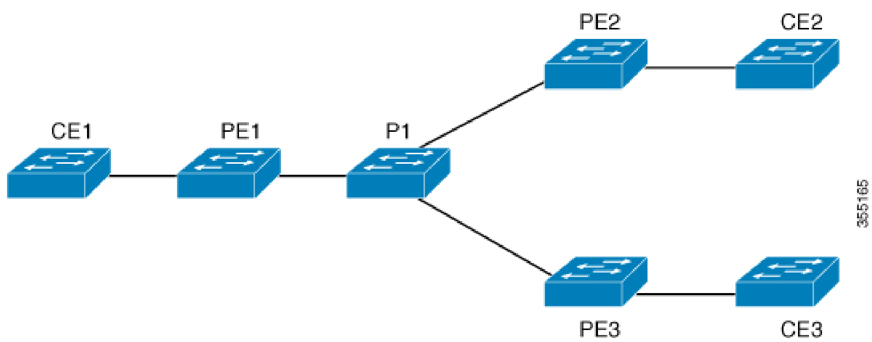
- VPN route target communities – A list of all other members of a VPN community.

- Multiprotocol BGP (MP-BGP) peering of VPN community PE routers – Propagates VRF reachability information to all members of a VPN community.
- MPLS forwarding – Transports all traffic between all VPN community members across a VPN service-provider network.

In the MPLS-VPN model a VPN is defined as a collection of sites sharing a common routing table. A customer site is connected to the service provider network by one or more interfaces, where the service provider associates each interface with a VPN routing table–known as the VRF table.

Configuration Examples for 6VPE

Figure 6: 6VPE Topology



PE Configuration

PE Configuration	C

```
vrf definition 6VPE-1
 rd 65001:11
 route-target export 1:1
 route-target import 1:1
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
interface TenGigabitEthernet1/0/38
 no switchport
 vrf forwarding 6VPE-1
 ip address 10.3.1.1 255.255.255.0
 ip ospf 2 area 0
 ipv6 address 10:111:111:111::1/64
 ipv6 enable
 ospfv3 1 ipv6 area 0
!
router ospf 2 vrf 6VPE-1
 router-id 1.1.11.11
 redistribute bgp 65001 subnets
!
router ospfv3 1
nsr
graceful-restart
!
address-family ipv6 unicast vrf 6VPE-1
redistribute bgp 65001
exit-address-family
!
router bgp 65001
bgp router-id interface Loopback1
bgp log-neighbor-changes
bgp graceful-restart
neighbor 33.33.33.33 remote-as 65001
neighbor 33.33.33.33 update-source Loopback1
!
 address-family ipv4 vrf 6VPE-1
  redistribute ospf 2 match internal external 1 external 2
 exit-address-family
 address-family ipv6 vrf 6VPE-1
  redistribute ospf 1 match internal external 1 external 2 include-connected
 exit-address-family
!
address-family vpnv4
neighbor 33.33.33.33 activate
neighbor 33.33.33.33 send-community both
neighbor 44.44.44.44 activate
neighbor 44.44.44.44 send-community both
neighbor 55.55.55.55 activate
neighbor 55.55.55.55 send-community both
exit-address-family
!
address-family vpnv6
neighbor 33.33.33.33 activate
neighbor 33.33.33.33 send-community both
neighbor 44.44.44.44 activate
neighbor 44.44.44.44 send-community both
neighbor 55.55.55.55 activate
```

PE Configuration
neighbor 55.55.55.55 send-community both exit-address-family !

The following is a sample output of **show mpls forwarding-table vrf** :

```
Local Outgoing Prefix Bytes Label Outgoing Next Hop
Label Label or Tunnel Id Switched interface
29 No Label A:A:A:565::/64[V] \ 0 aggregate/VRF601
32 No Label A:B5:1:5::/64[V] 2474160 Vl601 FE80::200:7BFF:FE62:2636
33 No Label A:B5:1:4::/64[V] 2477978 Vl601 FE80::200:7BFF:FE62:2636
35 No Label A:B5:1:3::/64[V] 2477442 Vl601 FE80::200:7BFF:FE62:2636
36 No Label A:B5:1:2::/64[V] 2476906 Vl601 FE80::200:7BFF:FE62:2636
37 No Label A:B5:1:1::/64[V] 2476370 Vl601 FE80::200:7BFF:FE62:2636
```

The following is a sample output of **show vrf counter** command :

```
Maximum number of VRFs supported: 256
Maximum number of IPv4 VRFs supported: 256
Maximum number of IPv6 VRFs supported: 256
Maximum number of platform iVRFs supported: 10
Current number of VRFs: 127
Current number of IPv4 VRFs: 6
Current number of IPv6 VRFs: 127
Current number of VRFs in delete state: 0
Current number of platform iVRFs: 1
```

The following is a sample output of **show ipv6 route vrf** command :

```
IPv6 Routing Table - VRF1 - 8 entries Codes: C - Connected, L - Local, S
 - Static, U - Per-user Static route B - BGP, R - RIP, I1 - ISIS L1, I2
- ISIS L2 IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP
external ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr -
Redirect RL - RPL, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1 OE2
 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2 la - LISP
alt, lr - LISP site-registrations, ld - LISP dyn-eid lA - LISP away

B 1:1:1:1::1/128 [200/1] via 1.1.1.11%default, indirectly connected
O 2:2:2:2::2/128 [110/1] via FE80::A2E0:AFFF:FE30:3E40,
TenGigabitEthernet1/0/7
B 3:3:3:3::3/128 [200/1] via 3.3.3.33%default, indirectly connected
B 10:1:1:1::/64 [200/0] via 1.1.1.11%default, indirectly connected
C 10:2:2:2::/64 [0/0] via TenGigabitEthernet1/0/7, directly connected
L 10:2:2:2::1/128 [0/0] via TenGigabitEthernet1/0/7, receive
B 10:3:3:3::/64 [200/0] via 3.3.3.33%default, indirectly connected
L FF00::/8 [0/0] via Null0, receive
```

Feature History for IPv6 VPN Provider Edge over MPLS (6VPE)

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	IPv6 VPN Provider Edge over MPLS (6VPE)	IPv6 VPN Provider Edge over MPLS (6VPE) is a mechanism to use the IPv4 backbone to provide VPN IPv6 services. It takes advantage of operational IPv4 MPLS backbones, eliminating the need for dual-stacking within the MPLS core.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 8

Configuring MPLS VPN InterAS Options

Information About MPLS VPN InterAS Options

The MPLS VPN InterAS Options provide various ways of interconnecting VPNs between different MPLS VPN service providers. This allows sites of a customer to exist on several carrier networks (autonomous systems) and have seamless VPN connectivity between these sites.

ASes and ASBRs

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, 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.

An AS boundary router (ASBR) is a device in an AS that is connected by using more than one routing protocol, and exchanges routing information with other ASBRs by using an exterior routing protocol (for example, eBGP), or use static routes, or both.

Separate ASes from different service providers communicate by exchanging information in the form of VPN IP addresses and they use the following protocols to share routing information:

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

  iBGP distributes network layer information for IP prefixes within each VPN and each AS.

- 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.

MPLS VPN InterAS Options configuration is supported and can include an inter provider VPN, which is MPLS VPNs that include two or more ASes, connected by separate border edge routers. The ASes exchange routes using eBGP, and no iBGP or routing information is exchanged between the ASes.

MPLS VPN InterAS Options

The following options defined in RFC4364 provide MPLS VPN connectivity between different ASes:

- InterAS Option A – This option provides back-to-back virtual routing and forwarding (VRF) connectivity. Here, MPLS VPN providers exchange routes across VRF interfaces.
- InterAS Option B – This option provides VPNv4 route distribution between ASBRs.

InterAS Option A

In terms of configuration, interAS Option A is the simplest of all available options.

A typical AS consists of these devices – Provider Edge(PE), Customer Edge(CE) and an Autonomous System Boundary Router(ASBR). The target is to enable VRF connectivity between CE devices (also referred to as VPN sites) in a network. In order to facilitate interAS option A, you have to perform the following for each VPN site:

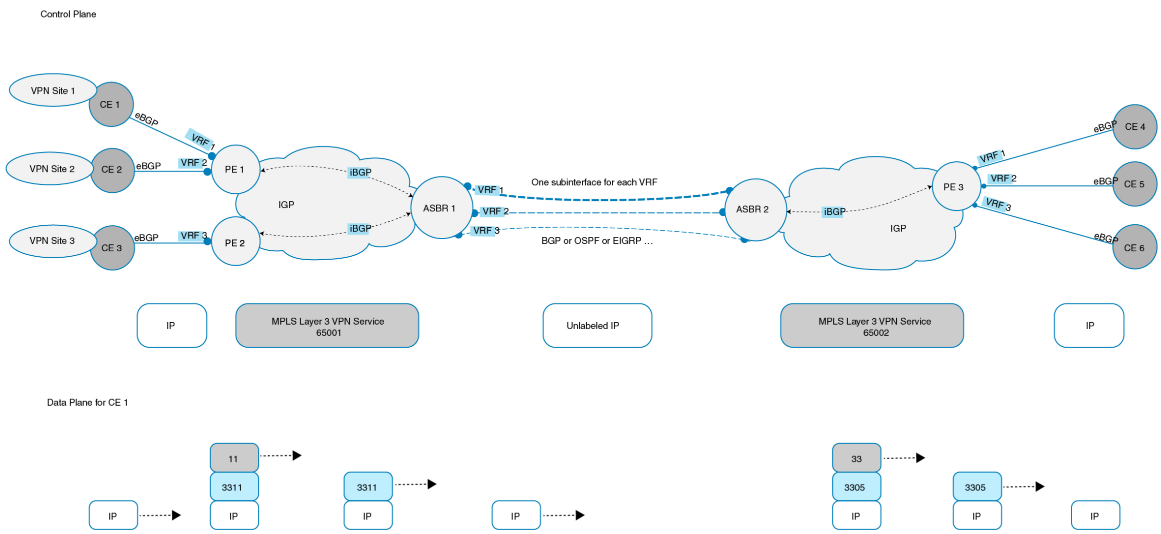
- Assign a VRF interface to each VPN site
- Define an interface or sub-interface for each VRF interface. (If multiple VPN sites are involved, they cannot all be associated with a single interface, and therefore, a sub-interface must be configured for each VRF). Optionally, a dedicated QoS policy may be applied to each subinterface.
- Create a BGP (or other routing protocol) session for each VRF.

With the above configuration in place, traffic flow with option A is as follows: Within the AS, data packets travel like regular Layer 3 VPN traffic. Traffic flow between ASBRs when traversing ASes is in the form of unlabeled IP packets on a VRF interface. Any routing protocol may be used to exchange routing information between the ASBRs in the different ASes.

While this option provides certain advantages (flexibility in terms of the routing protocol that can be used within an AS and between ASBRs, and security by means of a QoS policy on a subinterface), the scale for interAS option A is limited by the scale numbers for subinterfaces and VRFs. This option is therefore suited only to scenarios where the number of VPNs and the number of routes to transfer, is limited (and not likely to increase).

The figure below shows the data packet flow from CE 1, CE 2, CE 3 to CE 4, CE 5, CE 6 respectively. The explanation below takes the instance of the route advertisement and data packet flow from CE1 in AS-65001 to CE 4 in AS-65002.

Figure 7: MPLS VPN InterAS Option A Topology

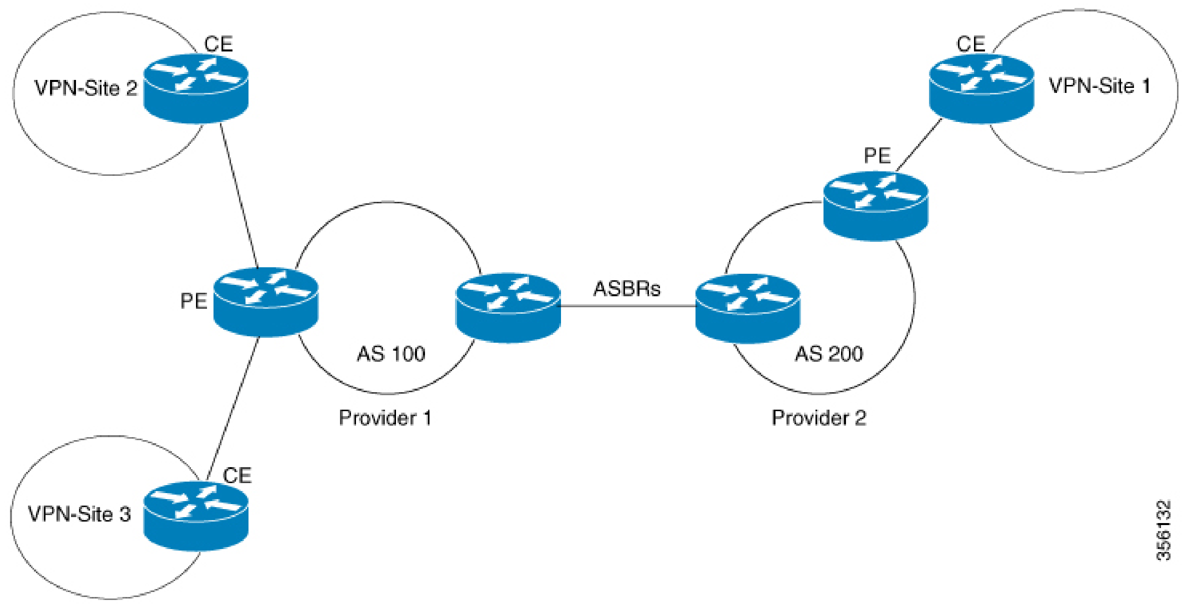


The IP traffic between CE 1 and PE 1 is sent over a VRF sub-interface by using eBGP. Once the packet reaches PE 1 it is sent to ASBR 1 as a two-label MPLS stack. The outermost label is the Interior Gateway protocol (IGP) label and the inner label is the VPN label. Layer 3 VPN traffic is sent from PE 1 to ASBR 1 in AS-65001 and from ASBR 2 to PE 3 in AS-65002 over a MPLS cloud. At ASBR 1, both the labels (IGP and VPN) are popped (removed). From ASBR 1 to ASBR 2 traffic flows as an unlabelled IP packet on a VRF interface. In this example, the routing protocol used between the two ASBRs is eBGP. The two label MPLS stack is pushed once the IP packet reaches ASBR 2. After the packet reaches PE 3, the VPN label is removed. The IGP label is also popped in case of explicit NULL IGP. The VPN packet is sent to CE4 through a VRF interface.

InterAS Option B

In an interAS option B network, ASBR ports are connected by one or more interfaces that are enabled to receive MPLS traffic. With this option, the ASBRs peer with each other using eBGP session. The ASBR also functions as a PE router and peers with every PE router in their AS. The ASBR does not hold any VRFs but holds all or a subset of VPNv4 routes from PE router that need to be passed to the other AS. VPNv4 routes are kept unique in ASBR using route-distinguisher and are filtered using route targets. The ASBRs exchange VPNv4 routes and VPN labels using eBGP.

Figure 8: Topology for InterAS Option B



Two methods are supported to distribute the next hop for VPNv4 routes between ASBRs. There is no requirement for LDP or any IGP to be enabled on the link connecting the two ASBRs. The MP-eBGP session between directly connected interfaces on the ASBRs enables the interfaces to forward labeled packets. To ensure this MPLS forwarding for directly connected BGP peers, you must configure mpls bgp forwarding command on the interface connecting to ASBR. This command is implemented in the IOS for directly connected interfaces. Upto 200 BGP neighbors can be configured.

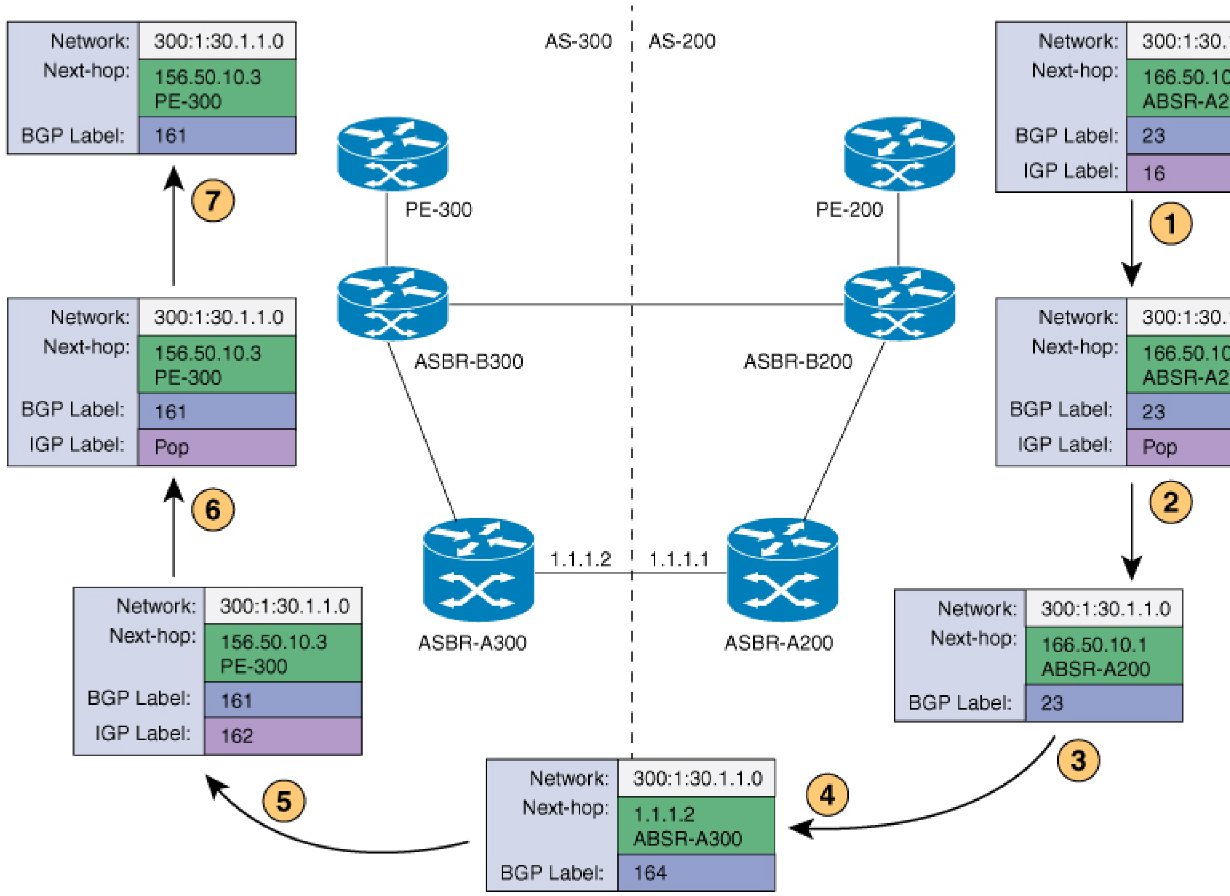
- **Next-hop-self Method:** Changing next-hop to that of the local ASBR for all VPNv4 routes learnt from the other ASBR.
- **Redistribute Connected Subnets Method:** Redistributing the next hop address of the remote ASBR into the local IGP using redistribute connected subnets command , i.e., the next hop is not changed when the VPNv4 routes are redistributed into the local AS.

Note In case of multiple equal paths - ECMP towards remote AS, you have to configure MPLS static label bindings towards remote Loopback on ASBR. Otherwise, you may experience packet loss.

The label switch path forwarding sections described below has AS200 configured with the Next-hop-self method and the AS300 is configured with Redistribute-subnet method.

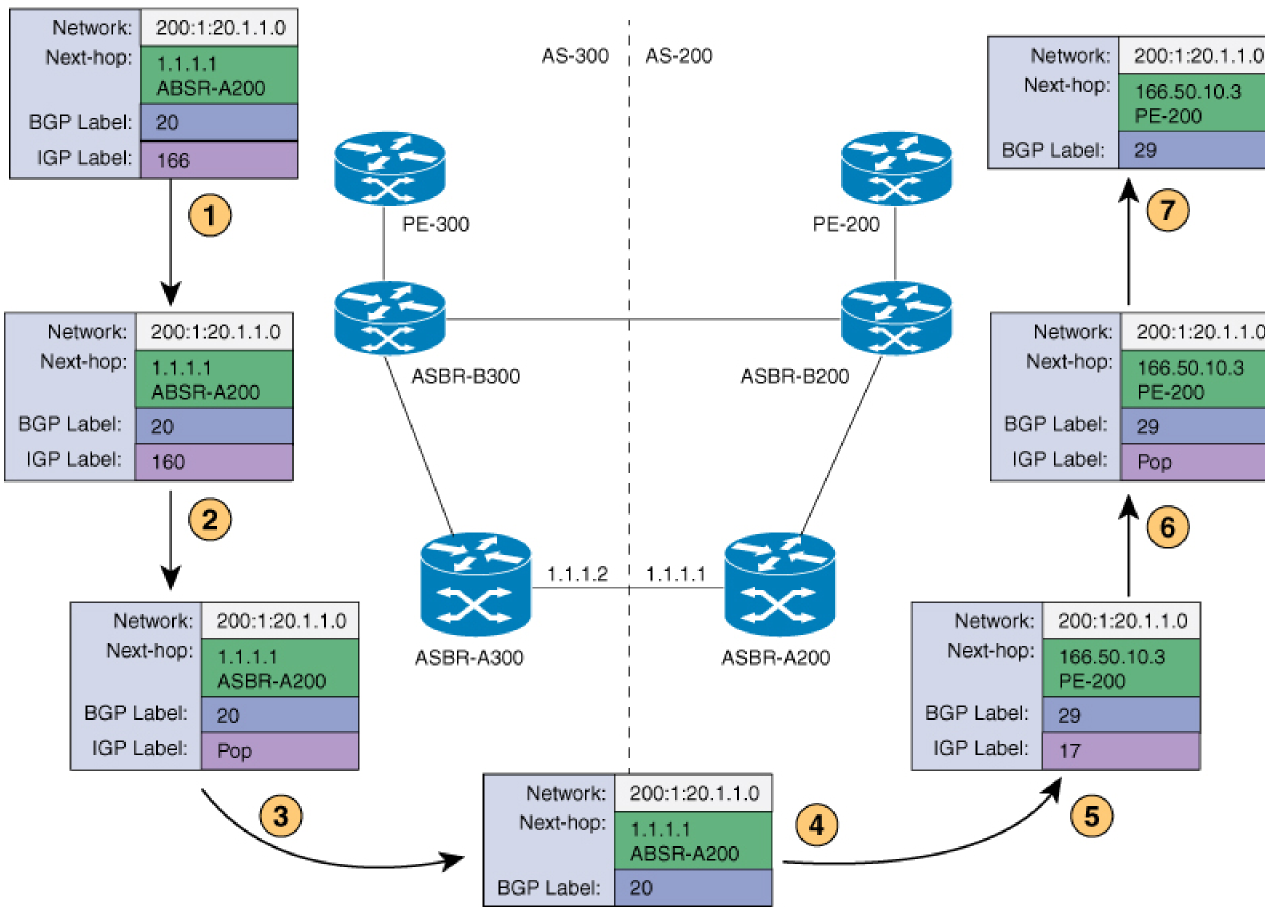
Next-Hop Self Method

The following figure shows the label forwarding path for next-hop-self method. The labels get pushed, swapped and popped on the stack as packet makes its way from PE-200 in AS 200 to PE-300 in AS 300. In step 5, ASBR-A300 receives labeled frame, replaces label 164 with label 161 pushes IGP label 162 onto the label stack.



Redistribute Connected Subnet Method

The following figure shows the label forwarding path for Redistribute connected subnets method. The labels get pushed, swapped and popped on the stack as packet travels from PE- 300 in AS 300 to PE-200 in AS 200. In step 5, ASBR-A200 receives frame with BGP label 20, swaps it with label 29 and pushes label 17.



How to Configure MPLS VPN InterAS Options

The following section provides information about how to configure MPLS VPN InterAS Options.

Configuring MPLS VPN InterAS Option A

Sending AS: Configuring PE

Complete the following tasks to configure the PE which is in the AS sending data to another AS.

Sending AS: Configuring a VRF for a PE

Beginning in user EXEC mode complete the following steps to configure a VRF for a PE which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*
5. **address-family ipv4**
6. **route−target export** *route-target-ext-community*
7. **route−target import** *route-target-ext-community*
8. **exit−address−family**
9. **address−family ipv6**
10. **route−target export** *route-target-ext-community*
11. **route−target import** *route-target-ext-community*
12. **exit-address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:1`	Creates routing and forwarding tables for a VRF instance.

Step 5	**address-family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.

Step 6	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:1`	Creates a list of export route target communities for the specified VRF.

	Command or Action	Purpose
Step 7	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:2`	Creates a list of import route target communities for the specified VRF.

Step 8	**exit−address−family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to VRF configuration mode.

Step 9	**address−family ipv6** **Example:** `Device(config-vrf)# address-family ipv6`	Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.
Step 10	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:101`	Creates a list of export route target communities for the specified VRF.
Step 11	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:102`	Creates a list of import route target communities for the specified VRF.

Step 12	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to VRF configuration mode.

Sending AS: Configuring a PE-CE Interface

Beginning in privileged EXEC mode complete the following steps to configure a PE-CE interface which is in the sending AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]
6. **exit**

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface Gi1/1/0/13.1`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-if)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-if)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-if)# ip address 140.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Step 6	**exit**
	Example:
	`Device(config-if)# exit`
	`Device(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Sending AS: Configuring BGP

Beginning in user EXEC mode complete the following steps to configure a BGP session for a PE which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp** *autonomous-system-number*
4. **neighbor** *ip-address* **remote-as** *as-number*
5. **address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]

6. **neighbor** *ip-address* **activate**
7. **exit address-family**
8. **address-family** *vpnv4*
9. **neighbor** *ip-address* **activate**
10. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send-community** [**both** | **standard** | **extended**]
11. **exit address-family**
12. **address-family** *vpnv6*
13. **neighbor** *ip-address* **activate**
14. **neighbor** *ip-address* **send-community extended**
15. **exit address-family**
16. **address-family ipv4 vrf** *vrf-name*
17. **redistribute** *protocol*
18. **neighbor** *ip-address* **remote-as** *as-number*
19. **neighbor** *ip-address* **activate**
20. **exit address-family**
21. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**router bgp** *autonomous-system-number*
	Example:
	`Device(config)# router bgp 65001`
	`Device(config-router)#`
		Configures a BGP routing process.

Step 4	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 2.2.2.2 remote-as 65001`	Configures an entry to the BGP neighbor table.
Step 5	**address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*] **Example:**	Enters address family configuration mode for configuring BGP routing sessions that use standard IPv4 address prefixes.

	Command or Action	Purpose
	`Device(config-router)# address-family ipv4` `Device(config-router-af)#`	
Step 6	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 2.2.2.2 activate`	Enables the exchange of information with a BGP neighbor.

Step 7	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 8	**address-family** *vpnv4*
	Example:
	`Device(config-router)# address-family vpnv4`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 9	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 2.2.2.2 activate`	Enables the exchange of information with a BGP neighbor.
Step 10	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send-community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 2.2.2.2 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 11	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 12	**address-family** *vpnv6*
	Example:
	`Device(config-router)# address-family vpnv6`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

Step 13	**neighbor** *ip-address* **activate** **Example:**	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 2.2.2.2 activate`	
Step 14	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 2.2.2.2 send-community extended`	Specifies that a community attribute should be sent to a BGP neighbor.

Step 15	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 16	**address-family ipv4 vrf** *vrf-name*
	Example:
	`Device(config-router)# address-family ipv4 vrf cu1`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IPv4 address prefixes.

Step 17	**redistribute** *protocol* **Example:** `Device(config-router-af)# redistribute connected`	Redistributes routes from one routing domain into another routing domain.
Step 18	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 140.1.1.2 remote-as 65002`	Configures an entry to the BGP neighbor table.
Step 19	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 140.1.1.2 activate`	Enables the exchange of information with a BGP neighbor.

Step 20	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 21	**exit** **Example:**	Exits router BGP mode.

	Command or Action	Purpose
	`Device(config-router)# exit`	

Sending AS: Configuring a PE-P Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a PE-P interface and IGP which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
4. **no switchport**
5. **ip address** *ip-address mask*
6. **ip ospf** *process-id* **area** *area-id*
7. **mpls ip**
8. **exit**
9. **router ospf** *process-id*
10. **router-id** *ip-address*
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface po91`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Sets the interface to the routed-interface status and erases all Layer 2 configurations.
Step 5	**ip address** *ip-address mask* **Example:**	Sets a primary or secondary IP address for an interface.

	Command or Action	Purpose
	`Device(config-if)# ip address 91.1.1.1 255.255.255.248`	
Step 6	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.
Step 9	**router ospf** *process-id* **Example:** `Device(config)# router ospf 2`	Configures an OSPF routing process and assigns a process number.
Step 10	**router-id** *ip-address* **Example:** `Device(config-router)# router-id 1.1.1.1`	Specifies a fixed router ID.
Step 11	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode and returns to privileged EXEC mode.

Sending AS: Configuring P

Complete the following tasks to configure the P which is in the AS sending data to another AS.

Sending AS: Configuring P-PE Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a P-PE interface and IGP which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
4. **no switchport**
5. **ip address** *ip-address mask*
6. **ip ospf** *process-id* **area** *area-id*
7. **mpls ip**

8. **exit**
9. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
10. **no switchport**
11. **ip address** *ip-address mask*
12. **ip ospf** *process-id* **area** *area-id*
13. **mpls ip**
14. **exit**
15. **router ospf** *process-id*
16. **router-id** *ip-address*
17. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface Port-channel91`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Sets the interface to the routed-interface status and erases all Layer 2 configuration.
Step 5	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 91.1.1.2 255.255.255.248`	Sets a primary or secondary IP address for an interface.
Step 6	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.

	Command or Action	Purpose

Step 8	**exit**
	Example:
	`Device(config-if)# exit`
	`Device(config)#`
		Exits interface configuration mode.

Step 9	**interface** {*interface-id* | *subinterface-id* | *vlan-id*} **Example:** `Device(config)# interface Port-channel92`	Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.
Step 10	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.
Step 11	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 92.1.1.2 255.255.255.248`	Sets a primary or secondary IP address for an interface.
Step 12	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 13	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 14	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.

Step 15	**router ospf** *process-id*
	Example:
	`Device(config)# router ospf 2`
	`Device(config-router)#`
		Configures an OSPF routing process and assign a process number.

Step 16	**router-id** *ip-address* **Example:** `Device(config-router)# router-id 5.5.5.5`	Specifies a fixed router ID.
Step 17	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode, and returns to privileged EXEC mode.

Sending AS: Configuring ASBR

Complete the following tasks to configure the ASBR which is in the AS sending data to another AS.

Sending AS: Configuring VRF for ASBR

Beginning in user EXEC mode complete the following steps to configure a VRF for a ASBR which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*
5. **address-family ipv4**
6. **route-target export** *route-target-ext-community*
7. **route-target import** *route-target-ext-community*
8. **exit-address-family**
9. **address-family ipv6**
10. **route-target export** *route-target-ext-community*
11. **route-target import***route-target-ext-community*
12. **exit-address-family**
13. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:2`	Creates routing and forwarding tables for a VRF instance.

	Command or Action	Purpose

Step 5	**address-family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		The address-family ipv4 command places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv4 address prefixes.

Step 6	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:2`	Creates a list of export route target communities for the specified VRF.
Step 7	**route-target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:1`	Creates a list of import route target communities for the specified VRF.

Step 8	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Leaves the address family configuration mode and returns to router configuration mode.

Step 9	**address-family ipv6** **Example:** `Device(config-vrf)# address-family ipv6`	Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.
Step 10	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:102`	Creates a list of export route target communities for the specified VRF.
Step 11	**route-target import***route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:101`	Creates a list of import route target communities for the specified VRF.

Step 12	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to router configuration mode.

Step 13	**exit** **Example:**	Exits the router configuration mode and returns to global configuration mode.

	Command or Action	Purpose
	`Device(config-vrf)# exit`	

Sending AS: Configuring Interface Towards the Receiving ASBR

Beginning in privileged EXEC mode complete the following steps to configure an interface towards the receiving ASBR:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface fo1/0/10.1`
	`Device(config-subif)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-subif)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-subif)# ip address 141.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Sending AS: Configuring BGP

Beginning in privileged EXEC mode complete the following steps to configure a BGP session on the ASBR which is in the sending AS:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **bgp log-neighbor changes**
4. **neighbor** *ip-address* **remote-as** *as-number*
5. **neighbor** *ip-address* **update-source** *interface-type interface-number*
6. **address-family ipv4** [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
7. **neighbor** *ip-address* **activate**
8. **exit-address-family**
9. **address-family** *vpnv4*
10. **neighbor** *ip-address* **activate**
11. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
12. **exit-address-family**
13. **address-family** *vpnv6*
14. **neighbor** *ip-address* **activate**
15. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
16. **exit-address-family**
17. **address-family ipv4 vrf** *vrf-name*
18. **redistribute** *protocol*
19. **neighbor** *ip-address* **remote-as** *as-number*
20. **neighbor** *ip-address* **activate**
21. **exit-address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `Device(config-if)# router bgp 65001`	Configures a BGP routing process.
Step 3	**bgp log-neighbor changes** **Example:**	Enables logging of BGP neighbor resets.

	Command or Action	Purpose
	`Device(config-router)# bgp log-neighbor-changes`	
Step 4	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 1.1.1.1 remote-as 65001`	Configures an entry to the BGP neighbor table.
Step 5	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 1.1.1.1 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.

Step 6	**address-family ipv4** [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
	Example:
	`Device(config-router)# address-family ipv4`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 7	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 1.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 8	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits BGP address-family submode.
Step 9	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 10	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 1.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 11	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:**	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 1.1.1.1 send-community both`	

Step 12	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 13	**address-family** *vpnv6*
	Example:
	`Device(config-router)# address-family vpnv6`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

Step 14	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 1.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 15	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 1.1.1.1 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 16	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 17	**address-family ipv4 vrf** *vrf-name* **Example:** `Device(config-router)# address-family ipv4 vrf cu1`	Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.
Step 18	**redistribute** *protocol* **Example:** `Device(config-router-af)# redistribute connected`	Redistributes routes from one routing domain into another routing domain.
Step 19	**neighbor** *ip-address* **remote-as** *as-number* **Example:**	Configures an entry to the BGP neighbor table.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 141.1.1.2 remote-as 65002`	
Step 20	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 141.1.1.2 activate`	Enables the exchange of information with a BGP neighbor.
Step 21	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits BGP address-family submode.

Sending AS: Configuring a ASBR-P Interface and a IGP

Beginning in privileged EXEC mode complete the following steps to configure a ASBR-P interface and a IGP in the sending AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **no switchport**
4. **ip address** *ip-address mask*
5. **ip ospf** *process-id* **area** *area-id*
6. **mpls ip**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface** {*interface-id*	*subinterface-id*	*vlan-id*} **Example:** `Device(config)# interface Port-channel92`	Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.
Step 3	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.

	Command or Action	Purpose
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 92.1.1.1 255.255.255.248`	Sets a primary or secondary IP address for an interface.
Step 5	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 6	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 7	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Receiving AS: Configuring ASBR

Complete the following tasks to configure the ASBR which is in the AS receiving data from another AS.

Receiving AS: Configuring VRF for ASBR

Beginning in user EXEC mode complete the following steps to configure a VRF for a ASBR which is in the receiving AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*
5. **address-family ipv4**
6. **route-target import** *route-target-ext-community*
7. **route-target export** *route-target-ext-community*
8. **exit-address-family**
9. **address-family ipv6**
10. **route-target export** *route-target-ext-community*
11. **route-target import** *route-target-ext-community*
12. **exit-address-family**
13. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:3`	Creates routing and forwarding tables for a VRF instance.

Step 5	**address-family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		The address-family ipv4 command places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv4 address prefixes.

Step 6	**route-target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:2`	Creates a list of export route target communities for the specified VRF.
Step 7	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:1`	Creates a list of import route target communities for the specified VRF.
Step 8	**exit-address-family** **Example:** `Device(config-vrf-af)# exit-address-family`	Leaves the address family configuration mode and returns to router configuration mode.

	Command or Action	Purpose

Step 9	**address-family ipv6**
	Example:
	`Device(config-vrf)# address-family ipv6`
	`Device(config-vrf-af)#`
		Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.

Step 10	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:101`	Creates a list of export route target communities for the specified VRF.
Step 11	**route-target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:102`	Creates a list of import route target communities for the specified VRF.

Step 12	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to router configuration mode.

Step 13	**exit** **Example:** `Device(config-vrf)# exit`	Exits the router configuration mode and returns to global configuration mode.

Receiving AS: Configuring Interface Towards the Sending ASBR

Beginning in privileged EXEC mode complete the following steps to configure an interface towards the sending ASBR:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]
6. **exit**

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface fo1/0/10.1`
	`Device(config-subif)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-subif)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-subif)# ip address 141.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Step 6	**exit**
	Example:
	`Device(config-subif)# exit`
	`Device(config)#`
		Exits to global configuration mode.

Receiving AS: Configuring BGP

Beginning in privileged EXEC mode complete the following steps to configure a BGP session on the ASBR which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **neighbor** *ip-address* **remote-as** *as-number*
4. **address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
5. **neighbor** *ip-address* **activate**

6. **exit**
7. **address-family** *ipv6*
8. **neighbor** *ip-address* **activate**
9. **exit address-family**
10. **address-family** *vpnv4*
11. **neighbor** *ip-address* **activate**
12. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
13. **exit**
14. **address-family** *vpnv6*
15. **neighbor** *ip-address* **activate**
16. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
17. **exit**
18. **address-family** *ipv4*
19. **neighbor** *ip-address* **remote-as** *as-number*
20. **neighbor** *ip-address* **activate**
21. **exit address-family**
22. **end**

DETAILED STEPS

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

Step 2	**router bgp** *autonomous-system-number*
	Example:
	`Device(config)# router bgp 65002`
	`Device(config-router)#`
		Configures a BGP routing process.

Step 3	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 30.30.30.30 remote-as 65002`	Configures an entry to the BGP neighbor table.

Step 4	**address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
	Example:
	`Device(config-router)# address-family ipv4`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

	Command or Action	Purpose
Step 5	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.

Step 6	**exit**
	Example:
	`Device(config-router-af)# exit`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 7	**address-family** *ipv6*
	Example:
	`Device(config-router)# address-family ipv6`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 8	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.

Step 9	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 10	**address-family** *vpnv4*
	Example:
	`Device(config-router)# address-family vpnv4`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

Step 11	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.
Step 12	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 30.30.30.30 send-community both`	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose

Step 13	**exit**
	Example:
	`Device(config-router-af)# exit`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 14	**address-family** *vpnv6*
	Example:
	`Device(config-router)# address-family vpnv6`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 15	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.
Step 16	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 30.30.30.30 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 17	**exit**
	Example:
	`Device(config-router-af)# exit`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 18	**address-family** *ipv4*
	Example:
	`Device(config-router)# address-family ipv4 vrf cu1`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 19	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 141.1.1.1 remote-as 65001`	Configures an entry to the BGP neighbor table.
Step 20	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 141.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose

Step 21	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 22	**end** **Example:** `Device(config-router)# end`	Exits router BGP mode and returns to privileged EXEC mode.

Receiving AS: Configuring a ASBR-P Interface and a IGP

Beginning in privileged EXEC mode complete the following steps to configure a ASBR-P interface and a IGP which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **no switchport**
4. **ip address** *ip-address mask*
5. **ip ospf** *process-id* **area** *area-id*
6. **mpls ip**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*} **Example:** `Device(config)# interface FortyGigabitEthernet1/0/13`	Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.
Step 3	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.

	Command or Action	Purpose
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.
Step 5	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.
Step 6	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 7	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Receiving AS: Configuring P

Complete the following tasks to configure the P which is in the AS receiving data from another AS.

Receiving AS: Configuring ASBR-P Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a ASBR-P interface and IGP which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **no switchport**
4. **ip address** *ip-address mask*
5. **ip ospf** *process-id* **area** *area-id*
6. **mpls ip**
7. **exit**
8. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
9. **no switchport**
10. **ip address** *ip-address mask*
11. **ip ospf** *process-id* **area** *area-id*
12. **mpls ip**
13. **exit**
14. **exit**

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface HundredGigE1/0/13`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.1.1.2 255.255.255.0`	Sets a primary or secondary IP address for an interface.
Step 5	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.
Step 6	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 7	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.

Step 8	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface HundredGigE1/0/4`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 9	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status and erases all Layer 2 configurations.
Step 10	**ip address** *ip-address mask* **Example:**	Sets a primary or secondary IP address for an interface.

	Command or Action	Purpose
	`Device(config-if)# ip address 20.1.1.1 255.255.255.0`	
Step 11	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.
Step 12	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.

Step 13	**exit**
	Example:
	`Device(config-if)# exit`
	`Device(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Step 14	**exit** **Example:** `Device(config)# exit`	Exits router configuration mode, and returns to privileged EXEC mode.

Receiving AS: Configuring PE

Complete the following tasks to configure the PE which is in the AS receiving data from another AS.

Configuring VRF for PE2

Beginning in privileged EXEC mode complete the following steps to configure a VRF for a PE:

SUMMARY STEPS

1. **configure terminal**
2. **vrf definition** *vrf-name*
3. **rd** *route-distinguisher*
4. **address−family ipv4**
5. **route−target export** *route-target-ext-community*
6. **route−target import** *route-target-ext-community*
7. **exit−address−family**
8. **address−familyipv6**
9. **route−target export** *route-target-ext-community*
10. **route−target import** *route-target-ext-community*
11. **exit−address−family**
12. **exit**

DETAILED STEPS

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

Step 2	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 3	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:4`	Creates routing and forwarding tables for a VRF instance.

Step 4	**address−family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		The address-family ipv4 command places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv4 address prefixes.

Step 5	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:2`	Creates a list of export route target communities for the specified VRF.
Step 6	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:1`	Creates a list of import route target communities for the specified VRF.

Step 7	**exit−address−family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Leaves the address family configuration mode and returns to router configuration mode.

Step 8	**address−familyipv6**
	Example:
	`Device(config-vrf)# address-family ipv6`
	`Device(config-vrf-af)#`
		Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.

	Command or Action	Purpose
Step 9	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:102`	Creates a list of export route target communities for the specified VRF.
Step 10	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:101`	Creates a list of import route target communities for the specified VRF.

Step 11	**exit−address−family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to router configuration mode.

Step 12	**exit**
	Example:
	`Device(config-vrf)# exit`
	`Device(config)#`
		Exits the router configuration mode and returns to global configuration mode.

Receiving AS: Configuring PE-CE Interface

Beginning in privileged EXEC mode complete the following steps to configure a PE-CE interface which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]
6. **exit**

DETAILED STEPS

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

	Command or Action	Purpose

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface FortyGigabitEthernet1/0/5.1`
	`Device(config-subif)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-subif)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-subif)# ip address 151.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Step 6	**exit**
	Example:
	`Device(config-subif)# exit`
	`Device(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Receiving AS: Configuring BGP

Beginning in privileged EXEC mode complete the following steps to configure a BGP session on a PE which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **bgp log-neighbor changes**
4. **neighbor** *ip-address* **remote-as** *as-number*
5. **neighbor** *ip-address* **update-source** *interface-type interface-number*
6. **address-family ipv4**
7. **neighbor** *ip-address* **activate**
8. **exit-address-family**
9. **address-family** *vpnv4*
10. **neighbor** *ip-address* **activate**
11. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]

12. **exit-address-family**
13. **address-family ipv6**
14. **neighbor** *ip-address* **activate**
15. **exit-address-family**
16. **address-family** *vpnv6*
17. **neighbor** *ip-address* **activate**
18. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
19. **exit address-family**
20. **address-family ipv4 vrf** *vrf-name*]
21. **redistribute** *protocol*
22. **neighbor** *ip-address* **remote-as** *as-number*
23. **neighbor** *ip-address* **activate**
24. **exit address-family**
25. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `Device(config-if)# router bgp 65002`	Configures a BGP routing process.
Step 3	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor-changes`	Enables logging of BGP neighbor resets.
Step 4	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 10.10.10.10 remote-as 65002`	Configures an entry to the BGP neighbor table.
Step 5	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 10.10.10.10 update-source Loopback30`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.

	Command or Action	Purpose

Step 6	**address-family ipv4**
	Example:
	`Device(config-router)# address-family ipv4`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 7	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.

Step 8	**exit-address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 9	**address-family** *vpnv4*
	Example:
	`Device(config-router)# address-family vpnv4`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 10	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.
Step 11	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 10.10.10.10 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 12	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 13	**address-family ipv6** **Example:** `Device(config-router)# address-family ipv6`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

	Command or Action	Purpose
Step 14	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.

Step 15	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 16	**address-family** *vpnv6* **Example:** `Device(config-router)# address-family vpnv6`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 17	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.
Step 18	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 10.10.10.10 send-community both`	Enables the exchange of information with a BGP neighbor.
Step 19	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.

Step 20	**address-family ipv4 vrf** *vrf-name*]
	Example:
	`Device(config-router)# address-family ipv4 vrf cu1`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 21	**redistribute** *protocol* **Example:** `Device(config-router-af)# redistribute connected`	Redistributes routes from one routing domain into another routing domain.

	Command or Action	Purpose
Step 22	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 151.1.1.2 remote-as 65003`	Configures an entry to the BGP neighbor table.
Step 23	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 151.1.1.2 activate`	Enables the exchange of information with a BGP neighbor.

Step 24	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 25	**exit** **Example:** `Device(config-router)# exit`	Exits router configuration mode.

Receiving AS: Configuring a PE-P Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a PE-P interface and IGP which is in the receiving AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
4. **no switchport**
5. **ip address** *ip-address mask*
6. **ip ospf** *process-id* **area** *area-id*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface FortyGigabitEthernet1/0/4`
	`(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.

Step 5	**ip address** *ip-address mask*
	Example:
	`Device(config-if)# ip address 20.1.1.2`
	`255.255.255.0`
		Sets a primary or secondary IP address for an interface.

Step 6	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.

Step 7	**end**
	Example:
	`Device(config-if)# end`
	`Device(config)#`
		Exits interface configuration mode and returns to privileged EXEC mode.

Configuring MPLS VPN InterAS Option B

Configuring InterAS Option B using the Next-Hop-Self Method

To configure interAS Option B on ASBRs using the next-hop-self method, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **router-id** *ip-address*
5. **nsr**
6. **nsf**
7. **redistribute bgp** *autonomous-system-number*
8. **passive-interface** *interface-type interface-number*

9. **network** *ip-address wildcard-mask* **aread** *area-id*
10. **exit**
11. **router bgp** *autonomous-system-number*
12. **bgp router-id** *ip-address*
13. **bgp log-neighbor changes**
14. **no bgp default ipv4-unicast**
15. **no bgp default route-target filter**
16. **neighbor** *ip-address* **remote-as** *as-number*
17. **neighbor** *ip-address* **update-source** *interface-type interface-number*
18. **neighbor** *ip-address* **remote-as** *as-number*
19. **address-family** *ipv4*
20. **neighbor** *ip-address* **activate**
21. **neighbor** *ip-address* **send-label**
22. **exit address-family**
23. **address-family** *vpnv4*
24. **neighbor** *ip-address* **activate**
25. **neighbor** *ip-address* **send-community extended**
26. **neighbor** *ip-address* **next-hop-self**
27. **neighbor** *ip-address* **activate**
28. **neighbor** *ip-address* **send-community extended**
29. **exit address-family**
30. **bgp router-id** *ip-address*
31. **bgp log-neighbor changes**
32. **neighbor** *ip-address* **remote-as** *as-number*
33. **neighbor** *ip-address* **update-source** *interface-type interface-number*
34. **address-family** *vpnv4*
35. **neighbor** *ip-address* **activate**
36. **neighbor** *ip-address* **send-community extended**
37. **exit address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router ospf** *process-id* **Example:**	Configures an OSPF routing process and assign a process number.

	Command or Action	Purpose
	`Device(config)# router ospf 1`	
Step 4	**router-id** *ip-address* **Example:** `Device(config)# router-id 4.1.1.1`	Specifies a fixed router ID.
Step 5	**nsr** **Example:** `Device(config-router)# nsr`	Configures OSPF non-stop routing (NSR).
Step 6	**nsf** **Example:** `Device(config-router)# nsf`	Confgures OSPF non-stop forwarding (NSF).
Step 7	**redistribute bgp** *autonomous-system-number* **Example:** `Device(config-router)# redistribute bgp 200`	Redistributes routes from a BGP autonomous system into and OSPF routing process.

Step 8	**passive-interface** *interface-type interface-number*
	Example:
	`Device(config-router)# passive-interface GigabitEthernet 1/0/10`
	`Device(config-router)# passive-interface Tunnel0`
		Disables Open Shortest Path First (OSPF) routing updates on an interface.

Step 9	**network** *ip-address wildcard-mask* **aread** *area-id* **Example:** `Device(config-router)# network 4.1.1.0 0.0.0.0.255 area 0`	Defines an interface on which OSPF runs and defines the area ID for that interface.
Step 10	**exit** **Example:** `Device(config-router)# exit`	Exits router configuration mode.
Step 11	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 200`	Configures a BGP routing process.
Step 12	**bgp router-id** *ip-address* **Example:**	Configures a fixed router ID for the BGP routing process.

	Command or Action	Purpose
	`Device(config-router)# bgp router-id 4.1.1.1`	
Step 13	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor changes`	Enables logging of BGP neighbor resets.
Step 14	**no bgp default ipv4-unicast** **Example:** `Device(config-router)# no bgp default ipv4-unicast`	Disables advertisement of routing information for address family IPv4.
Step 15	**no bgp default route-target filter** **Example:** `Device(config-router)# no bgp default route-target filter`	Disables automatic BGP route-target community filtering.
Step 16	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 remote-as 200`	Configures an entry to the BGP neighbor table.
Step 17	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.
Step 18	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 remote-as 300`	Configures an entry to the BGP neighbor table.
Step 19	**address-family** *ipv4* **Example:** `Device(config-router)# address-family ipv4`	Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.
Step 20	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.32.1.2 activate`	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
Step 21	**neighbor** *ip-address* **send-label** **Example:** `Device(config-router-af)# neighbor 10.32.1.2 send-label`	Sends MPLS labels with BGP routes to a neighboring BGP router.
Step 22	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.
Step 23	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 24	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 4.1.1.3 activate`	Enables the exchange of information with a BGP neighbor.
Step 25	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 4.1.1.3 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 26	**neighbor** *ip-address* **next-hop-self** **Example:** `Device(config-router-af)# neighbor 4.1.1.3 next-hop-self`	Configure a router as the next hop for a BGP-speaking neighbor. This is the command that implements the next-hop-self method.
Step 27	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.30.1.2 activate`	Enables the exchange of information with a BGP neighbor.
Step 28	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 10.30.1.2 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 29	**exit address-family** **Example:**	Exits BGP address-family submode.

	Command or Action	Purpose
	`Device(config-router-af)# exit address-family`	
Step 30	**bgp router-id** *ip-address* **Example:** `Device(config-router)# bgp router-id 4.1.1.3`	Configures a fixed router ID for the BGP routing process.
Step 31	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor changes`	Enables logging of BGP neighbor resets.
Step 32	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 4.1.1.1 remote-as 200`	Configures an entry to the BGP neighbor table.
Step 33	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 4.1.1.1 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.
Step 34	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 35	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 4.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 36	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 4.1.1.1 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 37	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.

Configuring InterAS Option B using Redistribute Connected Method

To configure interAS Option B on ASBRs using the redistribute connected method, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **router-id** *ip-address*
5. **nsr**
6. **nsf**
7. **redistribute connected**
8. **passive-interface** *interface-type interface-number*
9. **network** *ip-address wildcard-mask* **aread** *area-id*
10. **exit**
11. **router bgp** *autonomous-system-number*
12. **bgp router-id** *ip-address*
13. **bgp log-neighbor changes**
14. **no bgp default ipv4-unicast**
15. **no bgp default route-target filter**
16. **neighbor** *ip-address* **remote-as** *as-number*
17. **neighbor** *ip-address* **update-source** *interface-type interface-number*
18. **neighbor** *ip-address* **remote-as** *as-number*
19. **address-family** *vpnv4*
20. **neighbor** *ip-address* **activate**
21. **neighbor** *ip-address* **send-community extended**
22. **neighbor** *ip-address* **activate**
23. **neighbor** *ip-address* **send-community extended**
24. **exit address-family**
25. **mpls ldp router-id** *interface-id* [**force**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**router ospf** *process-id* **Example:** `Device(config)# router ospf 1`	Configures an OSPF routing process and assign a process number.
Step 4	**router-id** *ip-address* **Example:** `Device(config)# router-id 5.1.1.1`	Specifies a fixed router ID.
Step 5	**nsr** **Example:** `Device(config-router)# nsr`	Configures OSPF non-stop routing (NSR).
Step 6	**nsf** **Example:** `Device(config-router)# nsf`	Confgures OSPF non-stop forwarding (NSF).
Step 7	**redistribute connected** **Example:** `Device(config-router)# redistribute connected`	Redistributes the next hop address of the remote ASBR into the local IGP. This is the command that implements redistribute connected method.

Step 8	**passive-interface** *interface-type interface-number*
	Example:
	`Device(config-router)# passive-interface GigabitEthernet 1/0/10`
	`Device(config-router)# passive-interface Tunnel0`
		Disables Open Shortest Path First (OSPF) routing updates on an interface.

Step 9	**network** *ip-address wildcard-mask* **aread** *area-id* **Example:** `Device(config-router)# network 5.1.1.0 0.0.0.0.255 area 0`	Defines an interface on which OSPF runs and defines the area ID for that interface.
Step 10	**exit** **Example:** `Device(config-router)# exit`	Exits router configuration mode.
Step 11	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 300`	Configures a BGP routing process.

	Command or Action	Purpose
Step 12	**bgp router-id** *ip-address* **Example:** `Device(config-router)# bgp router-id 5.1.1.1`	Configures a fixed router ID for the BGP routing process.
Step 13	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor changes`	Enables logging of BGP neighbor resets.
Step 14	**no bgp default ipv4-unicast** **Example:** `Device(config-router)# no bgp default ipv4-unicast`	Disables advertisement of routing information for address family IPv4.
Step 15	**no bgp default route-target filter** **Example:** `Device(config-router)# no bgp default route-target filter`	Disables automatic BGP route-target community filtering.
Step 16	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 5.1.1.3 remote-as 300`	Configures an entry to the BGP neighbor table.
Step 17	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.
Step 18	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 10.30.1.2 remote-as 200`	Configures an entry to the BGP neighbor table.
Step 19	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 20	**neighbor** *ip-address* **activate** **Example:**	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# **neighbor 5.1.1.3 activate**`	
Step 21	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 5.1.1.3 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 22	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.30.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 23	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 10.30.1.2 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 24	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.
Step 25	**mpls ldp router-id** *interface-id* [**force**] **Example:** `Device(config-router)# mpls ldp router-id Loopback0 force`	Specifies the preferred interface for determining the LDP router ID.

Verifying MPLS VPN InterAS Options Configuration

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

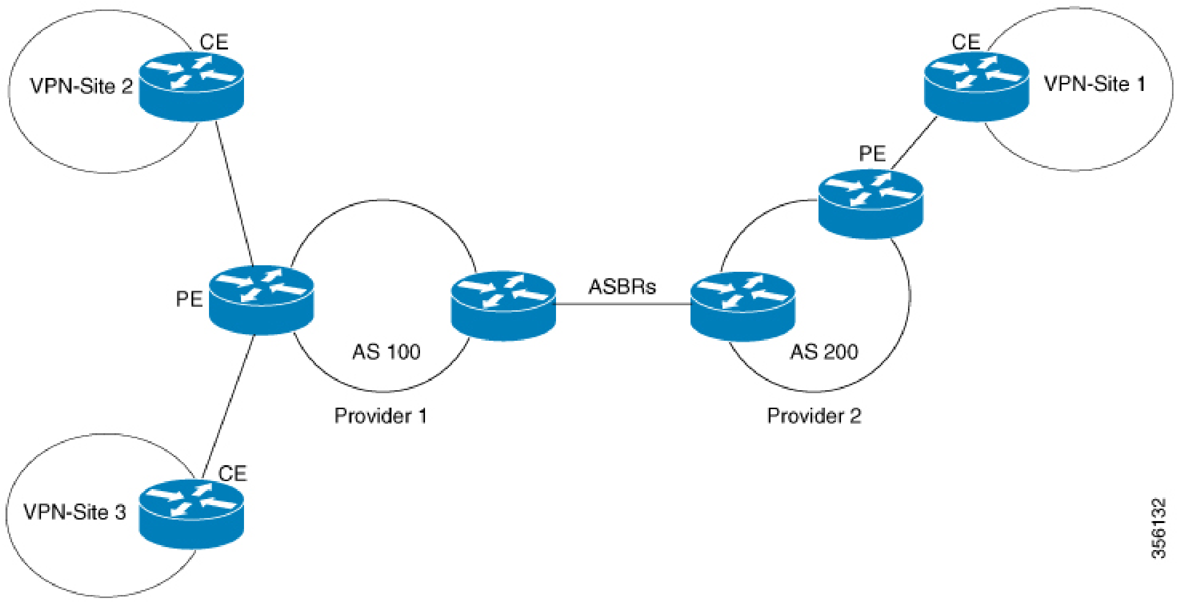
Command	Purpose
ping *ip-address* **source** *interface-type*	Checks the accessibility of devices. Use this command to check the connection between CE1 and CE2 using the loopback interface.
show bgp vpnv4 unicast labels	Displays incoming and outgoing BGP labels.
show mpls forwarding-table	Display the contents of the MPLS Label Forwarding Information Base.
show ip bgp	Displays entries in the BGP routing table.

Command	Purpose
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** } **route vrf** *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** *interface-type interface-id*	Verifies the route distinguisher (RD) and interface that are configured for the VRF.
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 MPLS VPN InterAS Options

Next-Hop-Self Method

Figure 9: Topology for InterAS Option B using Next-Hop-Self Method



Configuration for PE1-P1-ASBR1

PE1	P1	ASBR1
	interface Loopback0 ip address 4.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/4 no switchport ip address 10.10.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/23 no switchport ip address 10.20.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	interface Loopback0 ip address 4.1.1.1 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/10 no switchport ip address 10.30.1.1 255.255.255.0 mpls bgp forwarding interface GigabitEthernet1/0/23 no switchport ip address 10.20.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp router ospf 1 router-id 4.1.1.1 nsr nsf redistribute bgp 200 passive-interface GigabitEthernet1/0/10 passive-interface Tunnel0 network 4.1.1.0 0.0.0.255 area 0 router bgp 200 bgp router-id 4.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 4.1.1.3 remote-as 200 neighbor 4.1.1.3 update-source Loopback0 neighbor 10.30.1.2 remote-as 300 ! address-family ipv4 neighbor 10.30.1.2 activate neighbor 10.30.1.2 send-label exit-address-family ! address-family vpnv4 neighbor 4.1.1.3 activate neighbor 4.1.1.3 send-community extended neighbor 4.1.1.3 next-hop-self neighbor 10.30.1.2 activate neighbor 10.30.1.2 send-community extended exit-address-family

PE1	P1	ASBR1
vrf definition Mgmt-vrf ! address-family ipv4 exit-address-family ! address-family ipv6 exit-address-family ! vrf definition vrf1 rd 200:1 route-target export 200:1 route-target import 200:1 route-target import 300:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 4.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 192.1.1.1 255.255.255.255 ip ospf 200 area 0 ! interface GigabitEthernet2/0/4 no switchport ip address 10.10.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/9 description to-IXIA-1:p8 no switchport vrf forwarding vrf1 ip address 192.2.1.1 255.255.255.0 ip ospf 200 area 0 router ospf 200 vrf vrf1 router-id 192.1.1.1 nsr nsf redistribute connected redistribute bgp 200 network 192.1.1.1 0.0.0.0 area 0 network 192.2.1.0 0.0.0.255 area 0 router ospf 1 router-id 4.1.1.3 nsr nsf redistribute connected router bgp 200 bgp router-id 4.1.1.3 bgp log-neighbor-changes neighbor 4.1.1.1 remote-as 200 neighbor 4.1.1.1 update-source Loopback0		

PE1	P1	ASBR1
! address-family vpnv4 neighbor 4.1.1.1 activate neighbor 4.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf vrf1 redistribute connected redistribute ospf 200 maximum-paths ibgp 2 exit-address-family		

Configuration for ASBR2 – P2 – PE2

Table 6:

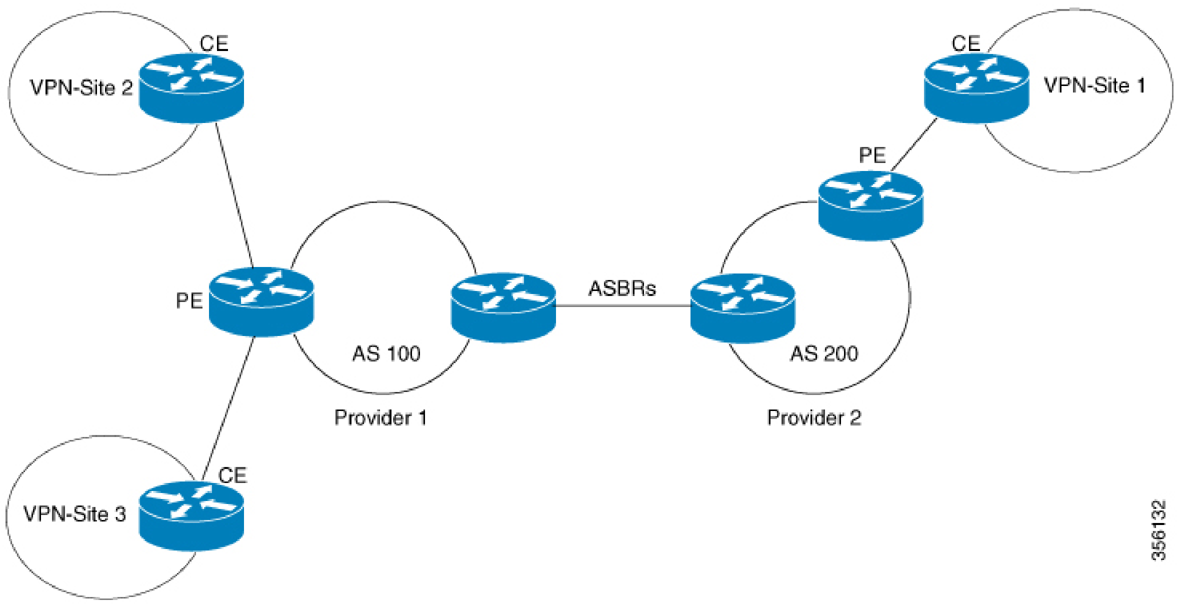
PE2	P2	ASBR2
	interface Loopback0 ip address 5.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/3 no switchport ip address 10.40.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	interface Loopback0 ip address 5.1.1.1 255.255.255.255 ip ospf 1 area 0 ! interface GigabitEthernet1/0/37 no switchport ip address 10.30.1.2 255.255.255.0 mpls bgp forwarding interface GigabitEthernet1/0/47 no switchport ip address 10.40.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp router ospf 1 router-id 5.1.1.1 nsr nsf passive-interface GigabitEthernet1/0/37 passive-interface Tunnel0 network 5.1.1.0 0.0.0.255 area 0 ! router bgp 300 bgp router-id 5.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 5.1.1.3 remote-as 300 neighbor 5.1.1.3 update-source Loopback0 neighbor 10.30.1.1 remote-as 200 ! address-family ipv4 neighbor 10.30.1.1 activate neighbor 10.30.1.1 send-label exit-address-family ! address-family vpnv4 neighbor 5.1.1.3 activate neighbor 5.1.1.3 send-community extended neighbor 5.1.1.3 next-hop-self neighbor 10.30.1.1 activate neighbor 10.30.1.1 send-community extended exit-address-family

PE2	P2	ASBR2
vrf definition vrf1 rd 300:1 route-target export 300:1 route-target import 300:1 route-target import 200:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 5.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 193.1.1.1 255.255.255.255 ip ospf 300 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/2 no switchport vrf forwarding vrf1 ip address 193.2.1.1 255.255.255.0 ip ospf 300 area 0 router ospf 300 vrf vrf1 router-id 193.1.1.1 nsr nsf redistribute connected redistribute bgp 300 network 193.1.1.1 0.0.0.0 area 0 network 193.2.1.0 0.0.0.255 area 0 ! router ospf 1 router-id 5.1.1.3 nsr nsf redistribute connected router bgp 300 bgp router-id 5.1.1.3 bgp log-neighbor-changes neighbor 5.1.1.1 remote-as 300 neighbor 5.1.1.1 update-source Loopback0 ! address-family ipv4 neighbor 5.1.1.1 activate neighbor 5.1.1.1 send-label exit-address-family ! address-family vpnv4 neighbor 5.1.1.1 activate		

PE2	P2	ASBR2
neighbor 5.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf vrf1 redistribute connected redistribute ospf 300 maximum-paths ibgp 2 exit-address-family		

IGP Redistribute Connected Subnets Method

Figure 10: Topology for InterAS Option B using Redistribute Connected Subnets Method



Configuration for PE1-P1-ASBR1

PE1	P1	ASBR1
	interface Loopback0 ip address 4.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/4 no switchport ip address 10.10.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/23 no switchport ip address 10.20.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	router ospf 1 router-id 4.1.1.1 nsr nsf redistribute connected passive-interface GigabitEthernet1/0/10 passive-interface Tunnel0 network 4.1.1.0 0.0.0.255 area 0 router bgp 200 bgp router-id 4.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 4.1.1.3 remote-as 200 neighbor 4.1.1.3 update-source Loopback0 neighbor 10.30.1.2 remote-as 300 ! address-family vpnv4 neighbor 4.1.1.3 activate neighbor 4.1.1.3 send-community extended neighbor 10.30.1.2 activate neighbor 10.30.1.2 send-community extended exit-address-family mpls ldp router-id Loopback0 force

PE1	P1	ASBR1
vrf definition Mgmt-vrf ! address-family ipv4 exit-address-family ! address-family ipv6 exit-address-family ! vrf definition vrf1 rd 200:1 route-target export 200:1 route-target import 200:1 route-target import 300:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 4.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 192.1.1.1 255.255.255.255 ip ospf 200 area 0 ! interface GigabitEthernet2/0/4 no switchport ip address 10.10.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/9 description to-IXIA-1:p8 no switchport vrf forwarding vrf1 ip address 192.2.1.1 255.255.255.0 ip ospf 200 area 0 router ospf 200 vrf vrf1 router-id 192.1.1.1 nsr nsf redistribute connected redistribute bgp 200 network 192.1.1.1 0.0.0.0 area 0 network 192.2.1.0 0.0.0.255 area 0 router ospf 1 router-id 4.1.1.3 nsr nsf redistribute connected router bgp 200 bgp router-id 4.1.1.3 bgp log-neighbor-changes neighbor 4.1.1.1 remote-as 200 neighbor 4.1.1.1 update-source Loopback0		

PE1	P1	ASBR1
! address-family vpnv4 neighbor 4.1.1.1 activate neighbor 4.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf vrf1 redistribute connected redistribute ospf 200 maximum-paths ibgp 2 exit-address-family		

Configuration for ASBR2 – P2 – PE2

PE2	P2	ASBR2
	interface Loopback0 ip address 5.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/3 no switchport ip address 10.40.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	router ospf 1 router-id 5.1.1.1 nsr nsf redistribute connected passive-interface GigabitEthernet1/0/10 passive-interface Tunnel0 network 5.1.1.0 0.0.0.255 area 0 router bgp 300 bgp router-id 5.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 5.1.1.3 remote-as 300 neighbor 5.1.1.3 update-source Loopback0 neighbor 10.30.1.1 remote-as 200 ! address-family vpnv4 neighbor 5.1.1.3 activate neighbor 5.1.1.3 send-community extended neighbor 10.30.1.1 activate neighbor 10.30.1.1 send-community extended exit-address-family mpls ldp router-id Loopback0 force

PE2	P2	ASBR2
vrf definition vrf1 rd 300:1 route-target export 300:1 route-target import 300:1 route-target import 200:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 5.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 193.1.1.1 255.255.255.255 ip ospf 300 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/2 no switchport vrf forwarding vrf1 ip address 193.2.1.1 255.255.255.0 ip ospf 300 area 0 router ospf 300 vrf vrf1 router-id 193.1.1.1 nsr nsf redistribute connected redistribute bgp 300 network 193.1.1.1 0.0.0.0 area 0 network 193.2.1.0 0.0.0.255 area 0 ! router ospf 1 router-id 5.1.1.3 nsr nsf redistribute connected router bgp 300 bgp router-id 5.1.1.3 bgp log-neighbor-changes neighbor 5.1.1.1 remote-as 300 neighbor 5.1.1.1 update-source Loopback0 ! address-family ipv4 neighbor 5.1.1.1 activate neighbor 5.1.1.1 send-label exit-address-family ! address-family vpnv4 neighbor 5.1.1.1 activate		

PE2	P2	ASBR2

`neighbor 5.1.1.1`
`send-community extended`
`exit-address-family`
`!`
`address-family ipv4 vrf vrf1`
`redistribute connected`
`redistribute ospf 300`
`maximum-paths ibgp 2`
`exit-address-family`		

Additional References for MPLS VPN InterAS Options

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	See the MPLS Commands section of the*Command Reference (Catalyst 9400 Series Switches)*

Feature History for MPLS VPN InterAS Options

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

.

Release	Feature	Feature Information
Cisco IOS XE Gibraltar 16.11.1	MPLS VPN InterAS Option B	InterAS Options use iBGP and eBGP peering to allow VPNs in different AS to communicate with each other. In an interAS option B network, ASBR ports are connected by one or more interfaces that are enabled to receive MPLS traffic.
Cisco IOS XE Amsterdam 17.1.1	MPLS VPN InterAS Option A	MPLS VPN InterAS Option A is the simplest to configure of the available InterAS Options. This option provides back to back virtual routing and forwarding (VRF) connectivity. Here, MPLS VPN providers exchange routes across VRF interfaces.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 9

Configuring MPLS over GRE

Prerequisites for MPLS over GRE

Ensure that the following routing protocols are configured and working properly.

- Label Distribution Protocol (LDP)—for MPLS label distribution.
- Routing protocol (ISIS or OSFP) between the core devices P1-P-P2
- MPLS between PE1-P1 and PE2-P2
- Since the ingress traffic enters the IP core from MPLS network and egress traffic leaves the IP core to enter the MPLS network, it is recommended to use QoS group value for defining QoS policies as we traverse the protocol boundary.

Restrictions for MPLS over GRE

- GRE Tunneling :
  - L2VPN over mGRE and L3VPN over mGRE is not supported.
  - The tunnel source can only be a loopback or a Layer 3 interface. These interfaces could either be physical interfaces or etherchannels.
  - Tunnel interface supports Static Routes, Enhanced Interior Gateway Routing Protocol (EIGRP) and Open Shortest Path First (OSPF) routing protocols.
  - GRE Options - Sequencing, Checksum and Source Route are not supported.

- IPv6 generic routing encapsulation (GRE) is not supported.
- Carrier Supporting Carrier (CSC) is not supported.
- Tunnel source cannot be a subinterface.

Information About MPLS over GRE

The MPLS over GRE feature provides a mechanism for tunneling Multiprotocol Label Switching (MPLS) packets over a non-MPLS network. This feature allows you to create a generic routing encapsulation (GRE) tunnel across a non-MPLS network. The MPLS packets are encapsulated within the GRE tunnel packets, and the encapsulated packets traverse the non-MPLS network through the GRE tunnel. When GRE tunnel packets are received at the other side of the non-MPLS network, the GRE tunnel packet header is removed and the inner MPLS packet is forwarded to its final destination. The core network between the end-points of the GRE tunnel uses ISIS or OSPF routing protocol whereas the GRE tunnel uses OSPF or EIGRP.

PE-to-PE Tunneling

The provider-edge-to-provider-edge (PE-to-PE) tunneling configuration provides a scalable way to connect multiple customer networks across a non-MPLS network. With this configuration, traffic that is destined to multiple customer networks is multiplexed through a single generic routing encapsulation (GRE) tunnel.

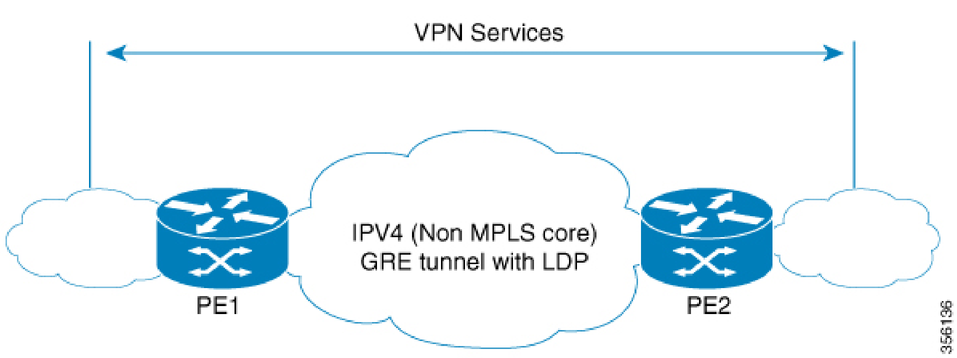
Note A similar nonscalable alternative is to connect each customer network through separate GRE tunnels (for example, connecting one customer network to each GRE tunnel).

The PE device on one side of the non-MPLS network uses the routing protocols (that operate within the non-MPLS network) to learn about the PE device on the other side of the non-MPLS network. The learned routes that are established between the PE devices are then stored in the main or default routing table.

The opposing PE device uses OSPF or EIGRP to learn about the routes that are associated with the customer networks that are behind the PE devices. These learned routes are not known to the non-MPLS network.

The following figure shows an end-to-end IP core from one PE device to another through the GRE tunnel that spans the non-MPLS network.

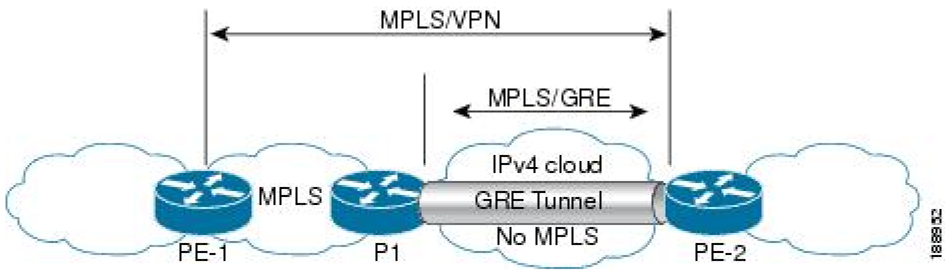
Figure 11: PE-to-PE Tunneling



P-to-PE Tunneling

The provider-to-provider-edge (P-to-PE) tunneling configuration provides a way to connect a PE device (P1) to a Multiprotocol Label Switching (MPLS) segment (PE-2) across a non-MPLS network. In this configuration, MPLS traffic that is destined to the other side of the non-MPLS network is sent through a single generic routing encapsulation (GRE) tunnel.

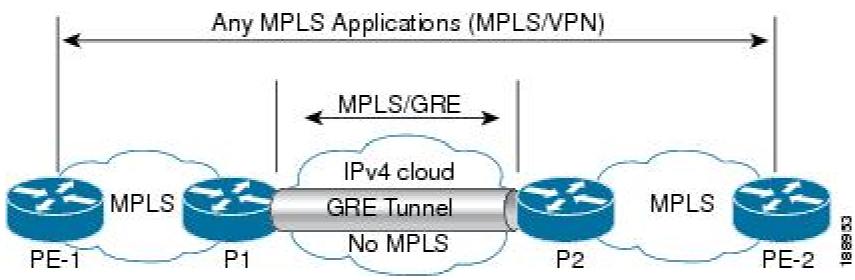
Figure 12: P-to-PE Tunneling



P-to-P Tunneling

As shown in the figure below, the provider-to-provider (P-to-P) configuration provides a method of connecting two Multiprotocol Label Switching (MPLS) segments (P1 to P2) across a non-MPLS network. In this configuration, MPLS traffic that is destined to the other side of the non-MPLS network is sent through a single generic routing encapsulation (GRE) tunnel.

Figure 13: P-to-P Tunneling



How to Configure MPLS over GRE

The following section provides the various configuration steps for MPLS over GRE:

Configuring the MPLS over GRE Tunnel Interface

To configure the MPLS over GRE feature, you must create a generic routing encapsulation (GRE) tunnel to span the non-MPLS networks. You must perform the following procedure on the devices located at both ends of the GRE tunnel.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface tunnel** *tunnel-number*
4. **ip address** *ip-address mask*
5. **tunnel source** *source-address*
6. **tunnel destination** *destination-address*
7. **mpls ip**
8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *tunnel-number* **Example:** `Device(config)# interface tunnel 1`	Creates a tunnel interface and enters interface configuration mode.
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.0.0.1 255.255.255.0`	Assigns an IP address to the tunnel interface.
Step 5	**tunnel source** *source-address* **Example:** `Device(config-if)# tunnel source 10.1.1.1`	Specifies the tunnel’s source IP address.
Step 6	**tunnel destination** *destination-address* **Example:** `Device(config-if)# tunnel destination 10.1.1.2`	Specifies the tunnel’s destination IP address.
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) on the tunnel’s physical interface.

	Command or Action	Purpose
Step 8	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

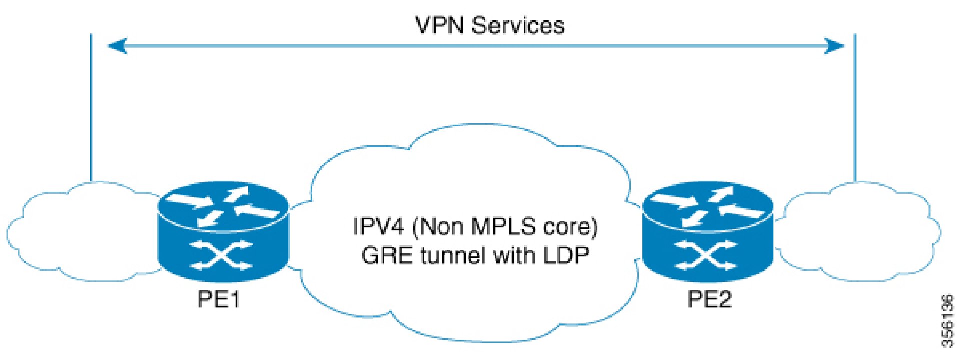
Configuration Examples for MPLS over GRE

The following section provides configuration examples for MPLS over GRE:

Example: PE-to-PE Tunneling

The following shows basic MPLS configuration on two Provider Edge (PE) devices, PE-to-PE tunneling, which use GRE tunnel to send traffic over non-MPLS network.

Figure 14: Topology for PE-to-PE Tunneling



PE1 Configuration

```
!
mpls ip
!
interface loopback 10
ip address 11.2.2.2 255.255.255.255
ip router isis
!
interface GigabitEthernet 1/1/1
ip address 1.1.1.1 255.255.255.0
ip router isis
!
interface Tunnel 1
ip address 10.0.0.1 255.255.255.0
ip ospf 1 are 0
tunnel source 11.2.2.2
tunnel destination 11.1.1.1
mpls ip
!
interface Vlan701
ip address 65.1.1.1 255.255.255.0
```

```
ip ospf 1 area 0
!
```

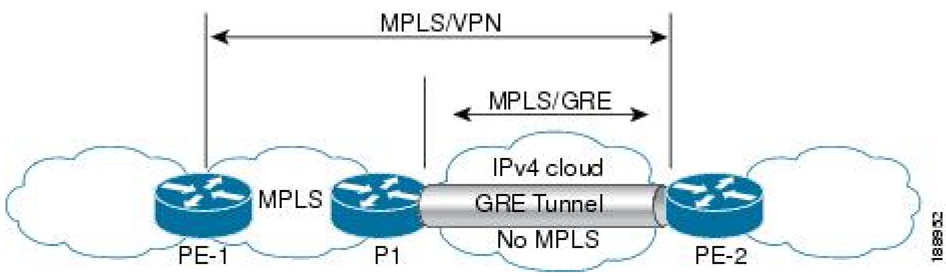
PE2 Configuration

```
!
mpls ip
!
interface loopback 10
ip address 11.1.1.1 255.255.255.255
ip router isis
!
interface GigabitEthernet 1/1/1
ip address 2.1.1.1 255.255.255.0
ip router isis
!
interface Tunnel 1
ip address 10.0.0.2 255.255.255.0
ip ospf 1 are 0
tunnel source 11.1.1.1
tunnel destination 11.2.2.2
mpls ip
!
interface Vlan701
ip address 75.1.1.1 255.255.255.0
ip ospf 1 area 0
!
```

Example: P-to-PE Tunneling

The following shows basic MPLS configuration on two Provider (P) devices, P-to-PE tunneling, which use GRE tunnel to send traffic over non-MPLS network.

Figure 15: Topology for P-to-PE Tunneling



PE1 Configuration

```
!
mpls ip
!
interface GigabitEthernet 1/1/1
ip address 3.1.1.2 255.255.255.0
ip ospf 1 are 0
mpls ip
!
interface Vlan701
ip address 75.1.1.1 255.255.255.0
ip ospf 1 area 0
!
```

P1 Configuration

```
!
mpls ip
!
interface loopback 10
ip address 11.2.2.2 255.255.255.255
ip router isis
!
interface GigabitEthernet 1/1/1
ip address 1.1.1.1 255.255.255.0
ip router isis
!
interface GigabitEthernet 1/1/2
ip address 3.1.1.1 255.255.255.0
ip ospf 1 are 0
mpls ip
!
interface Tunnel 1
ip address 10.0.0.1 255.255.255.0
ip ospf 1 are 0
tunnel source 11.2.2.2
tunnel destination 11.1.1.1
mpls ip
!
```

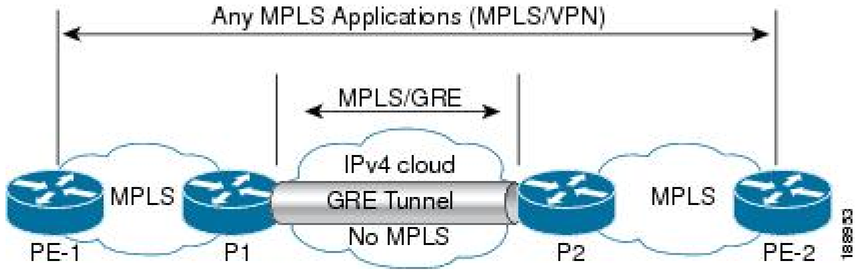
PE2 Configuration

```
!
mpls ip
!
interface loopback 10
ip address 11.1.1.1 255.255.255.255
ip router isis
!
interface GigabitEthernet 1/1/1
ip address 2.2.1.1 255.255.255.0
ip router isis
!
interface Tunnel 1
ip address 10.0.0.2 255.255.255.0
ip ospf 1 are 0
tunnel source 11.1.1.1
tunnel destination 11.2.2.2
mpls ip
!
interface Vlan701
ip address 75.1.1.1 255.255.255.0
ip ospf 1 area 0
!
```

Example: P-to-P Tunneling

The following example shows basic MPLS configuration on two Provider (P) devices, P-to-P tunneling, which use GRE tunnel to send traffic over non-MPLS network.

Figure 16: Topology for P-to-P Tunneling



P1 Configuration

```
!
interface Loopback10
 ip address 10.1.1.1 255.255.255.255
 ip router isis
!
interface Tunnel10
 ip address 10.10.10.1 255.255.255.252
 ip ospf 1 area 0
 mpls ip
 tunnel source 10.1.1.1
 tunnel destination 10.2.1.1
```

P2 Configuration

```
!
interface Tunnel10
 ip address 10.10.10.2 255.255.255.252
 ip ospf 1 area 0
 mpls ip
 tunnel source 10.2.1.1
 tunnel destination 10.1.1.1
!
interface Loopback10
 ip address 10.2.1.1 255.255.255.255
 ip router isis
```

Additional References for MPLS over GRE

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	See the MPLS Commands section of the *Command Reference (Catalyst 9400 Series Switches)*

Feature History for MPLS over GRE

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Gibraltar 16.11.1	MPLS over GRE	MPLS over GRE feature provides a mechanism for tunneling Multiprotocol Label Switching (MPLS) packets over non-MPLS networks by creating a generic routing encapsulation (GRE) tunnel. The MPLS packets are encapsulated within the GRE tunnel packets, and the encapsulated packets traverse the non-MPLS network through the GRE tunnel. When GRE tunnel packets are received at the other side of the non-MPLS network, the GRE tunnel packet header is removed and the inner MPLS packet is forwarded to its final destination.

Use the Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/

http://www.cisco.com/go/cfn.

CHAPTER 10

Configuring MPLS Layer 2 VPN over GRE

Information About MPLS Layer 2 VPN over GRE

The MPLS Layer 2 VPN over GRE feature provides a mechanism for tunneling Multiprotocol Label Switching (MPLS) packets over non-MPLS networks. This feature allows you to create a generic routing encapsulation (GRE) tunnel across a non-MPLS network. The MPLS packets are encapsulated within the GRE tunnel packets, and the encapsulated packets traverse the non-MPLS network through the GRE tunnel. When GRE tunnel packets are received at the other side of the non-MPLS network, the GRE tunnel packet header is removed and the inner MPLS packet is forwarded to its final destination.

To configure MPLS Layer 2 VPN over GRE, you must have configured either Virtual Private LAN Service (VPLS) or EoMPLS (Ethernet over MPLS).

Types of Tunneling Configurations

The following sections provide information about the different types of tunneling configurations that are supported.

PE-to-PE Tunneling

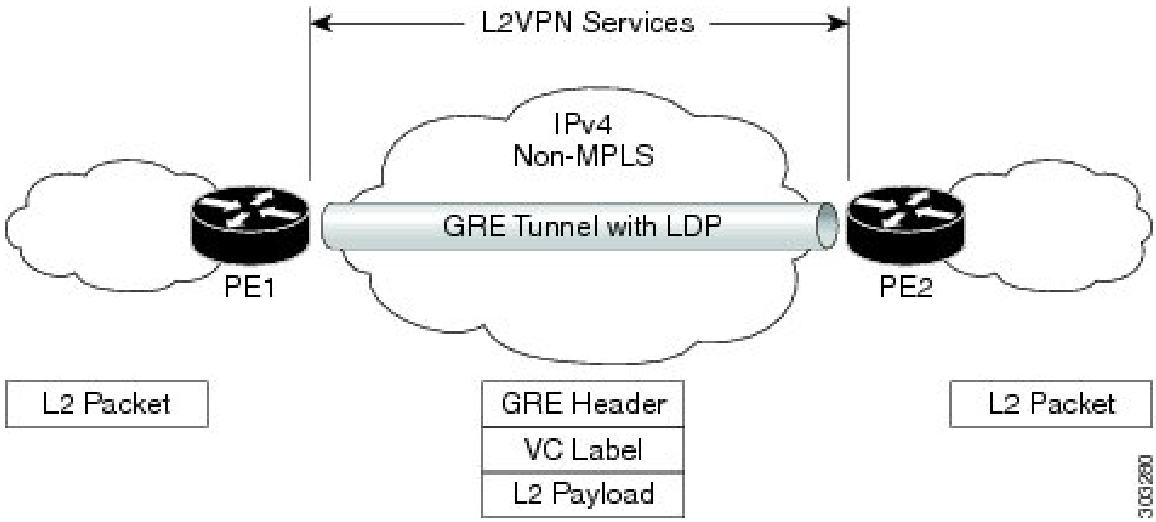
The provider edge-to-provider edge (PE-to-PE) tunneling configuration provides a scalable way to connect multiple customer networks across a non-MPLS network. With this configuration, traffic that is destined to multiple customer networks is multiplexed through a single GRE tunnel.

The PE device on one side of the non-MPLS network uses the routing protocols (that operate within the non-MPLS network) to learn about the PE device on the other side of the non-MPLS network. The learned routes that are established between the PE devices are then stored in the main or default routing table.

The opposing PE device uses Border Gateway Protocol (BGP) to learn about the routes that are associated with the customer networks that are behind the PE devices. These learned routes are not known to the non-MPLS network.

Figure 17: PE-to-PE Tunneling, on page 158 shows an end-to-end IP core from one PE device to another through the GRE tunnel that spans the non-MPLS network.

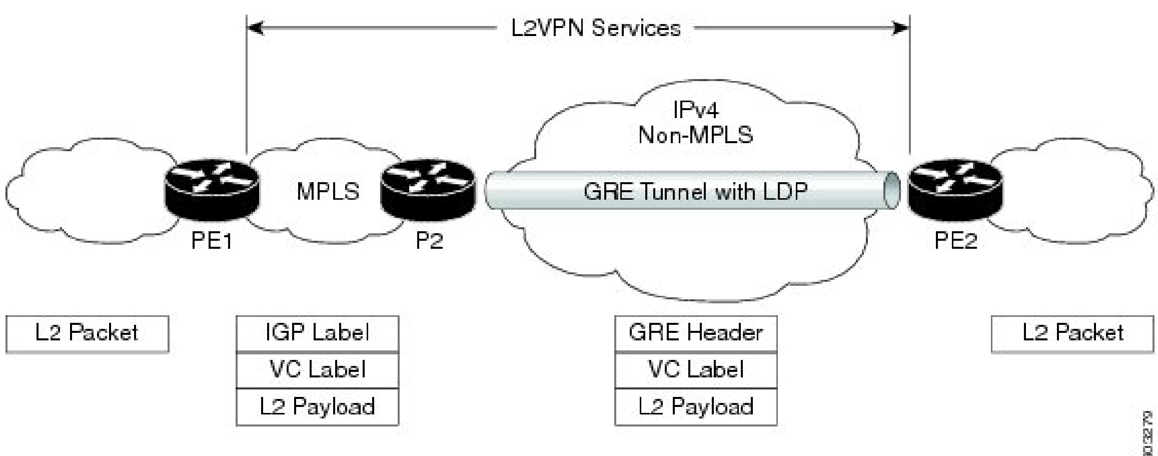
Figure 17: PE-to-PE Tunneling



P-to-PE Tunneling

Figure 18: P-to-PE Tunneling, on page 158 shows a method of connecting two MPLS segments (P2 to PE2) across a non-MPLS network. In this configuration, MPLS traffic that is destined to the other side of the non-MPLS network is sent through a single GRE tunnel.

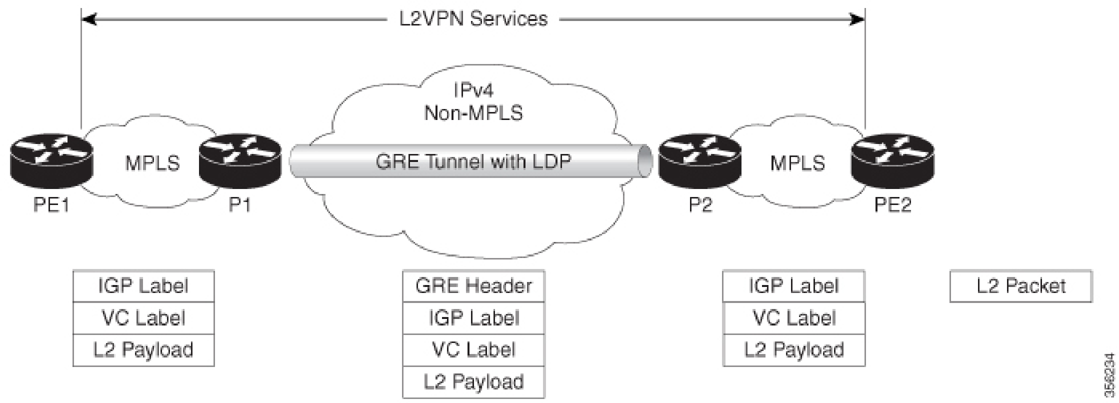
Figure 18: P-to-PE Tunneling



P-to-P Tunneling

Figure 19: P-to-P Tunneling, on page 159 shows a method of connecting two MPLS segments (P1 to P2) across a non-MPLS network. In this configuration, MPLS traffic that is destined to the other side of the non-MPLS network is sent through a single GRE tunnel.

Figure 19: P-to-P Tunneling



How to Configure MPLS Layer 3 VPN over GRE

To configure the MPLS over GRE feature, you must create a GRE tunnel to span the non-MPLS networks. Perform the following procedure on the devices that are located at both ends of the GRE tunnel.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *tunnel-number* **Example:** `Device(config)# interface tunnel 1`	Creates a tunnel interface and enters interface configuration mode.
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.0.0.1 255.255.255.0`	Assigns an IP address to the tunnel interface.
Step 5	**tunnel source** *source-address* **Example:** `Device(config-if)# tunnel source 10.1.1.1`	Configures the tunnel's source IP address.

	Command or Action	Purpose
Step 6	**tunnel destination** *destination-address* **Example:** `Device(config-if)# tunnel destination 10.1.1.2`	Configures the tunnel's destination IP address.
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS on the tunnel's physical interface.
Step 8	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuration Examples for MPLS Layer 2 VPN over GRE

The following section provides an example for configuring MPLS Layer 2 VPN over GRE.

Example: Configuring a GRE Tunnel That Spans a non-MPLS Network

The following examples show how to configure a generic GRE tunnel configuration that spans a non-MPLS network.

The following example shows the tunnel configuration on the PE1 device:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel 1
Device(config-if)# ip address 10.1.1.1 255.255.255.0
Device(config-if)# tunnel source 10.0.0.1
Device(config-if)# tunnel destination 10.0.0.2
Device(config-if)# ip ospf 1 area 0
Device(config-if)# mpls ip
```

The following example shows the tunnel configuration on the PE2 device:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel 1
Device(config-if)# ip address 10.1.1.2 255.255.255.0
Device(config-if)# tunnel source 10.0.0.2
Device(config-if)# tunnel destination 10.0.0.1
Device(config-if)# ip ospf 1 area 0
Device(config-if)# mpls ip
```

Additional References for Configuring MPLS Layer 2 VPN over GRE

Related Documents

Related Topic	Document Title
Configuring VPLS	For more information, see Information About VPLS.
Configuring Ethernet-over-MPLS (EoMPLS) and Pseudowire Redundancy (PWR)	For more information, see How to Configure Ethernet-over-MPLS, on page 49

Feature History for Configuring MPLS Layer 2 VPN over GRE

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Gibraltar 16.12.1	MPLS Layer 2 VPN over GRE	The MPLS Layer 2 VPN over GRE feature provides a mechanism for tunneling MPLS packets over non-MPLS networks.

Use the Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/

http://www.cisco.com/go/cfn.

CHAPTER 11

Configuring MPLS Layer 3 VPN over GRE

Prerequisites for MPLS Layer 3 VPN over GRE

- Ensure that your Multiprotocol Label Switching (MPLS) virtual private network (VPN) is configured.
- Ensure that the following routing protocols are configured:
  - Label Distribution Protocol (LDP): For MPLS label distribution.
  - Multiprotocol Border Gateway Protocol (MP-BGP): For VPN route and label distribution.
- We recommend that you use the Quality of Service (QoS) group value for defining QoS policies to traverse the protocol boundary. QoS group values are required because the ingress traffic enters the IP core from the MPLS network and the egress traffic leaves the IP core to enter the MPLS network.
- Before configuring a generic routing encapsulation (GRE) tunnel, configure a loopback interface (that is not attached to a virtual routing and forwarding [VRF]) interface with an IP address. This dummy loopback interface with an IPv4 address enables the internally created tunnel interface for IPv4 forwarding. You do not have to configure a loopback interface if the system has at least one interface that is not attached to the VRF and is configured with an IPv4 address.

Restrictions for MPLS Layer 3 VPN over GRE

The MPLS Layer 3 VPN over GRE feature does not support the following:

- QoS service policies that are configured on the tunnel interface

> **Note** Although QoS service policies configured on the tunnel interface are not supported, QoS service policies configured on a physical interface or a sub-interface are supported.

- GRE options such as sequencing, checksum, and source route
- IPv6 GRE configurations
- Advanced features such as Carrier Supporting Carrier (CSC)

Information About MPLS Layer 3 VPN over GRE

The MPLS Layer 3 VPN over GRE feature provides a mechanism for tunneling MPLS packets over non-MPLS networks. This feature allows you to create a GRE tunnel across a non-MPLS network. The MPLS packets are encapsulated within the GRE tunnel packets, and the encapsulated packets traverse the non-MPLS network through the GRE tunnel. When GRE tunnel packets are received at the other side of the non-MPLS network, the GRE tunnel packet header is removed and the inner MPLS packet is forwarded to its final destination.

Types of Tunneling Configurations

The following sections provide information about the different types of tunneling configurations that are supported.

PE-to-PE Tunneling

The provider edge-to-provider edge (PE-to-PE) tunneling configuration provides a scalable way to connect multiple customer networks across a non-MPLS network. With this configuration, traffic that is destined to multiple customer networks is multiplexed through a single GRE tunnel.

As shown in the Figure 20: PE-to-PE Tunneling, on page 165, the PE devices assign VRF numbers to the customer edge (CE) devices on each side of the non-MPLS network.

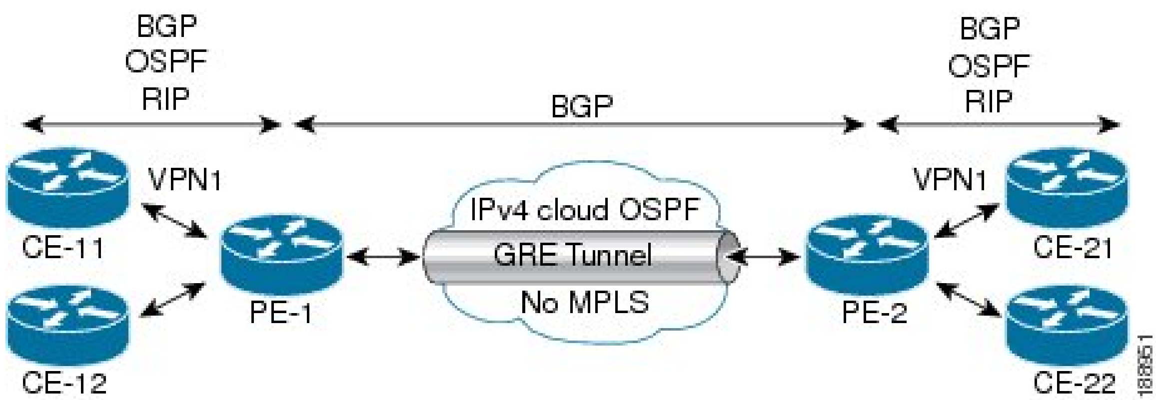
The PE devices use routing protocols such as Border Gateway Protocol (BGP), Open Shortest Path First (OSPF), or Routing Information Protocol (RIP) to learn about the IP networks behind the CE devices. The routes to the IP networks behind the CE devices are stored in the associated CE device's VRF routing table.

The PE device on one side of the non-MPLS network uses routing protocols (that operate within the non-MPLS network) to learn about the PE device on the other side of the non-MPLS network. The learned routes that are established between the PE devices are then stored in the main or default routing table.

The opposing PE device uses BGP to learn about the routes that are associated with the customer networks that are behind the PE devices. These learned routes are not known to the non-MPLS network.

Figure 20: PE-to-PE Tunneling, on page 165 shows BGP defining a static route to the BGP neighbor (the opposing PE device) through the GRE tunnel that spans the non-MPLS network. Because the routes that are learned by the BGP neighbor include the GRE tunnel next hop, all the customer network traffic is sent using the GRE tunnel.

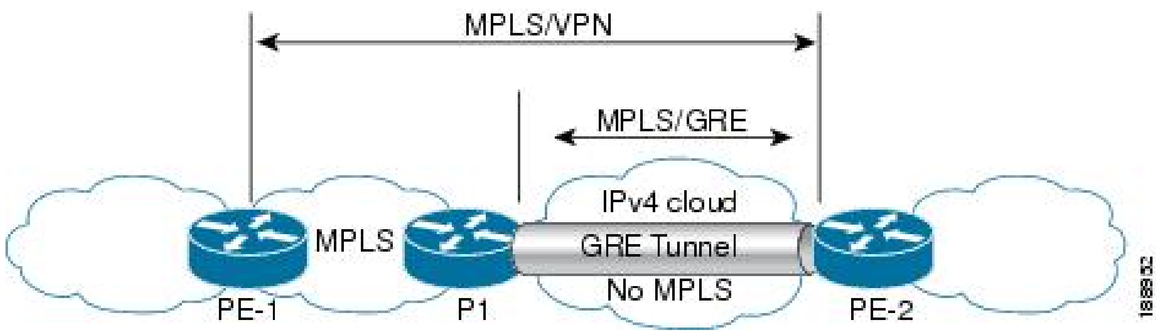
Figure 20: PE-to-PE Tunneling



P-to-PE Tunneling

Figure 21: P-to-PE Tunneling, on page 165 shows a method of connecting two MPLS segments (P2 to PE2) across a non-MPLS network. In this configuration, MPLS traffic that is destined to the other side of the non-MPLS network is sent through a single GRE tunnel.

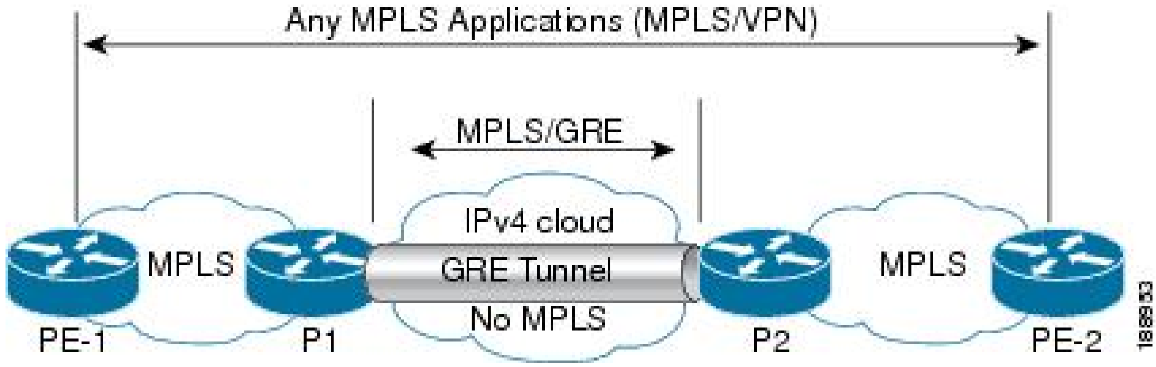
Figure 21: P-to-PE Tunneling



P-to-P Tunneling

Figure 22: P-to-P Tunneling, on page 166 shows a method of connecting two MPLS segments (P1 to P2) across a non-MPLS network. In this configuration, MPLS traffic that is destined to the other side of the non-MPLS network is sent through a single GRE tunnel.

Figure 22: P-to-P Tunneling



How to Configure MPLS Layer 3 VPN over GRE

To configure the MPLS over GRE feature, you must create a GRE tunnel to span the non-MPLS networks. Perform the following procedure on the devices that are located at both ends of the GRE tunnel.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *tunnel-number* **Example:** `Device(config)# interface tunnel 1`	Creates a tunnel interface and enters interface configuration mode.
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.0.0.1 255.255.255.0`	Assigns an IP address to the tunnel interface.
Step 5	**tunnel source** *source-address* **Example:** `Device(config-if)# tunnel source 10.1.1.1`	Configures the tunnel's source IP address.
Step 6	**tunnel destination** *destination-address* **Example:** `Device(config-if)# tunnel destination 10.1.1.2`	Configures the tunnel's destination IP address.

	Command or Action	Purpose
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS on the tunnel's physical interface.
Step 8	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuration Examples for MPLS Layer 3 VPN over GRE

The following sections provide various configuration examples for MPLS Layer 3 VPN over GRE.

Example: Configuring MPLS Layer 3 VPN over GRE (PE-to-PE Tunneling)

The following examples show how to configure Layer 3 VPN and the GRE tunnel from PE1 to PE2 (see Figure 20: PE-to-PE Tunneling, on page 165).

The following example shows how to configure a loopback interface on PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface Loopback10
Device(config-if)# ip address 209.165.200.225 255.255.255.255
Device(config-if)# end
```

The following example shows how to configure a loopback interface on PE2:

```
Device> enable
Device# configure terminal
Device(config)# interface Loopback3
Device(config-if)# ip address 209.165.202.129 255.255.255.255
Device(config-if)# end
```

The following example shows how to advertise a loopback in IGP on PE1:

```
Device> enable
Device# configure terminal
Device(config)# router ospf 10
Device(config-router)# router-id 198.51.100.10
Device(config-router)# end
```

The following example shows how to configure a GRE tunnel, configure a different IGP instance on the tunnel, and enable MPLS on the tunnel on PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel13
Device(config-if)# ip address 203.0.113.200 255.255.255.248
Device(config-if)# ip ospf 11 area 0
Device(config-if)# mpls ip
Device(config-if)# tunnel source 209.165.200.225
Device(config-if)# tunnel destination 209.165.202.129
Device(config-if)# end
```

The following example shows how to configure a GRE tunnel, configure a different IGP instance on the tunnel, and enable MPLS on the tunnel on PE2:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel31
Device(config-if)# ip address 203.0.113.201 255.255.255.248
Device(config-if)# ip ospf 11 area 0
Device(config-if)# mpls ip
Device(config-if)# tunnel source 209.165.202.129
Device(config-if)# tunnel destination 209.165.200.225
Device(config-if)# end
```

The following example shows how to advertise PE1 loopback IP for BGP in IGP instance configured on the tunnel:

```
Device> enable
Device# configure terminal
Device(config)# router ospf 11
Device(config-router)# router-id 198.51.100.11
Device(config-router)# network 192.0.1.1 0.0.0.0 area 0
Device(config-router)# end
```

The following example shows how to advertise PE2 loopback IP for BGP in IGP instance configured on the tunnel:

```
Device> enable
Device# configure terminal
Device(config)# router ospf 11
Device(config-router)# router-id 203.0.113.201
Device(config-router)# network 192.0.1.1 0.0.0.0 area 0
Device(config-router)# end
```

The following example shows how to configure VRF on PE1 where CE1 is connected:

```
Device> enable
Device# configure terminal
Device(config)# vrf definition vrf-1
Device (config-vrf)# rd 1:1
Device (config-vrf)# address-family ipv4
Device (config-vrf-af)# route-target import 1:2
Device (config-vrf-af)# route-target export 1:1
Device(config-vrf)# end
```

The following example shows how to configure VRF on PE2 where CE2 is connected:

```
Device> enable
Device# configure terminal
Device (config)# vrf definition vrf-1
Device (config-vrf)# rd 2:2
Device (config-vrf)# address-family ipv4
Device (config-vrf-af)# route-target import 1:1
Device (config-vrf-af)# route-target export 1:2
Device(config-vrf)# end
```

The following example shows how to configure PE1-CE1 interface:

```
Device> enable
Device# configure terminal
Device (config)# int po14.1
Device (config-subif)# encapsulation dot1Q 10
Device (config-subif)# vrf forwarding vrf-1
Device (config-subif)# ip address 14.2.1.1 255.255.255.0
Device(config-subif)# end
```

The following example shows how to configure PE2-CE2 interface:

```
Device> enable
Device# configure terminal
Device (config)# int po24.1
Device (config-subif)# encapsulation dot1Q 10
Device (config-subif)# vrf forwarding vrf-1
Device (config-subif)# ip address 24.2.1.1 255.255.255.0
Device(config-subif)# end
```

The following example shows how to configure PE1-CE1 External Border Gateway Protocol (EBGP):

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# address-family ipv4 vrf vrf-1
Device (config-router-af)# neighbor 14.2.1.2 remote-as 65041
Device (config-router-af)# neighbor 14.2.1.2 activate
Device (config-router-af)# exit-address-family
Device(config-router)# end
```

The following example shows how to configure PE2-CE2 EBGP:

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# address-family ipv4 vrf vrf-1
Device (config-router-af)# neighbor 24.2.1.2 remote-as 65041
Device (config-router-af)# neighbor 24.2.1.2 activate
Device (config-router-af)# exit-address-family
Device (config-router)# end
```

The following example shows how to configure PE1-PE2 MP-BGP on PE1:

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# neighbor 192.0.2.1 remote-as 65040
Device (config-router)# neighbor 192.0.2.1 update-source Loopback0
Device (config-router)# address-family ipv4
Device (config-router-af)# neighbor 192.0.2.1 activate
Device (config-router-af)# exit
Device (config-router)# address-family vpnv4
Device (config-router-af)#  neighbor 192.0.2.1 activate
Device (config-router-af)#  neighbor 192.0.2.1 send-community both
Device (config-router-af)# exit
Device (config-router)# end
```

Example: Configuring MPLS Layer 3 VPN over GRE (P-to-PE Tunneling)

The following examples show how to configure Layer 3 VPN on the PE devices (PE1 and PE2) and MPLS segment (P1), and the GRE tunnel from PE1 to P1 to PE2 (see Figure 21: P-to-PE Tunneling, on page 165).

The following example shows how to configure loopback interface for GRE tunnel for PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface Loopback4
```

```
Device(config-if)# ip address 209.165.200.230 255.255.255.255
Device(config-if)# end
```

The following example shows how to configure loopback interface for GRE tunnel for P1:

```
Device> enable
Device# configure terminal
Device(config)# interface Loopback100
Device(config-if)# ip address 209.165.200.235 255.255.255.255
Device(config-if)# end
```

The following example shows how to configure interface from PE1-P1 and configure IGP:

```
Device> enable
Device# configure terminal
Device(config)# interface Port-channel11
Device(config-if)# no switchport
Device(config-if)# ip address 209.165.201.1 255.255.255.248
Device(config-if)# ip ospf 10 area 0
Device(config-if)# end
```

The following example shows how to configure interface from P1-PE1 and configure IGP:

```
Device> enable
Device# configure terminal
Device(config)# interface Port-channel1
Device(config-if)# no switchport
Device(config-if)# ip address 209.165.201.2 255.255.255.248
Device(config-if)# ip broadcast-address 209.165.201.31
Device(config-if)# ip ospf 10 area 0
Device(config-if)# end
```

The following example shows how to advertise loopback in IGP on PE1:

```
Device> enable
Device# configure terminal
Device(config)# router ospf 10
Device(config-router)# router-id 198.51.100.10
Device(config-router)# network 209.165.200.230 0.0.0.0 area 0
Device(config-router)# end
```

The following example shows how to advertise loopback in IGP on P1:

```
Device> enable
Device# configure terminal
Device(config)# router ospf 10
Device(config-router)# router-id 198.51.100.20
Device(config-router)# network 209.165.200.235 0.0.0.0 area 0
Device(config-router)# end
```

The following example shows how to configure GRE tunnel, configure an IGP instance on the tunnel, and enable MPLS on the tunnel on PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel111
Device(config-if)# ip address 209.165.202.140 255.255.255.248
Device(config-if)# ip ospf 11 area 0
Device(config-if)# mpls ip
Device(config-if)# tunnel source 209.165.200.230
Device(config-if)# tunnel destination 209.165.200.235
Device(config-if)# end
```

The following example shows how to configure GRE tunnel, configure an IGP instance on the tunnel, and enable MPLS on the tunnel on P1:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel111
Device(config-if)# ip address 209.165.202.141 255.255.255.248
Device(config-if)# ip ospf 11 area 0
Device(config-if)# mpls ip
Device(config-if)# tunnel source 209.165.200.235
Device(config-if)# tunnel destination 209.165.200.230
Device(config-if)# end
```

The following example shows how to advertise PE loopback IP for BGP in tunnel's IGP instance on PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface Tunnel111
Device(config)# router ospf 11
Device(config-router)# router-id 198.51.100.11
Device(config-router)# network 192.0.1.1 0.0.0.0 area 0
Device(config-router)# end
```

The following example shows how to configure interface from PE2-P1, and configure IGP and MPLS:

```
Device> enable
Device# configure terminal
Device(config)# interface Port-channel12
Device(config-if)# no switchport
Device(config-if)# ip address 209.165.201.1 255.255.255.248
Device(config-if)# ip ospf 11 area 0
Device(config-if)# mpls ip
Device(config-if)# end
```

The following example shows how to configure interface from P1-PE2, and configure IGP:

```
Device> enable
Device# configure terminal
Device(config)# interface Port-channel12
Device(config-if)# no switchport
Device(config-if)# ip address 209.165.201.2 255.255.255.248
Device(config-if)# ip ospf 11 area 0
Device(config-if)# mpls ip
Device(config-if)# end
```

The following example shows how to create VRF on PE1 where CE1 is connected:

```
Device> enable
Device# configure terminal
Device(config)# vrf definition vrf-1
Device (config-vrf)# rd 1:1
Device (config-vrf)# address-family ipv4
Device (config-vrf-af)# route-target import 1:2
Device (config-vrf-af)# route-target export 1:1
Device (config-vrf-af)# exit
Device (config-vrf)# end
```

The following example shows how to create VRF on PE2 where CE2 is connected:

```
Device> enable
Device# configure terminal
Device (config)# vrf definition vrf-1
Device (config-vrf)# rd 2:2
Device (config-vrf)# address-family ipv4
Device (config-vrf-af)# route-target import 1:1
Device (config-vrf-af)# route-target export 1:2
```

```
Device (config-vrf-af)# exit
Device (config-vrf)# end
```

The following example shows how to configure PE1-CE1 interface:

```
Device> enable
Device# configure terminal
Device (config)# int po14.1
Device (config-subif)# encapsulation dot1Q 10
Device (config-subif)# vrf forwarding vrf-1
Device (config-subif)# ip address 14.2.1.1 255.255.255.0
Device (config-subif)# exit
Device (config)# end
```

The following example shows how to configure PE2-CE2 interface:

```
Device> enable
Device# configure terminal
Device (config)# int po24.1
Device (config-subif)# encapsulation dot1Q 10
Device (config-subif)# vrf forwarding vrf-1
Device (config-subif)# ip address 24.2.1.1 255.255.255.0
Device (config-subif)# exit
Device (config)# end
```

The following example shows how to configure PE1-CE1 EBGP:

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# address-family ipv4 vrf vrf-1
Device (config-router-af)# neighbor 14.2.1.2 remote-as 65041
Device (config-router-af)# neighbor 14.2.1.2 activate
Device (config-router-af)# exit-address-family
Device (config-router)# end
```

The following example shows how to configure PE2-CE2 EBGP:

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# address-family ipv4 vrf vrf-1
Device (config-router-af)# neighbor 24.2.1.2 remote-as 65041
Device (config-router-af)# neighbor 24.2.1.2 activate
Device (config-router-af)# exit-address-family
Device (config-router)# end
```

The following example shows how to configure PE1-PE2 MP-BGP on PE1:

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# neighbor 192.0.2.1 remote-as 65040
Device (config-router)# neighbor 192.0.2.1 update-source Loopback0
Device (config-router)# address-family ipv4
Device (config-router-af)# neighbor 192.0.2.1 activate
Device (config-router-af)# exit
Device (config-router)# address-family vpnv4
Device (config-router-af)# neighbor 192.0.2.1 activate
Device (config-router-af)# neighbor 192.0.2.1 send-community both
Device (config-router-af)# exit
Device (config-router)# end
```

The following example shows how to configure PE2-PE1 MP-BGP on PE2:

```
Device> enable
Device# configure terminal
Device (config)# router bgp 65040
Device (config-router)# neighbor 192.0.1.1 remote-as 65040
Device (config-router)# neighbor 192.0.1.1 update-source Loopback0
Device (config-router)# address-family ipv4
Device (config-router-af)# neighbor 192.0.1.1 activate
Device (config-router-af)# exit
Device (config-router)# address-family vpnv4
Device (config-router-af)# neighbor 192.0.1.1 activate
Device (config-router-af)# neighbor 192.0.1.1 send-community both
Device (config-router-af)# exit
Device (config-router)# end
```

Feature History for Configuring MPLS Layer 3 VPN over GRE

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Gibraltar 16.12.1	MPLS Layer 3 VPN over GRE	The MPLS Layer 3 VPN over GRE feature provides a mechanism for tunneling MPLS packets over a non-MPLS network.

Use the Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/

http://www.cisco.com/go/cfn.

CHAPTER 12

MPLS QoS: Classifying and Marking EXP

Classifying and Marking MPLS EXP

The QoS EXP Matching feature allows you to classify and mark network traffic by modifying the Multiprotocol Label Switching (MPLS) experimental bits (EXP) field. This module contains conceptual information and the configuration tasks for classifying and marking network traffic using the MPLS EXP field.

Prerequisites for Classifying and Marking MPLS EXP

- The switch must be configured as an MPLS provider edge (PE) or provider (P) router, which can include the configuration of a valid label protocol and underlying IP routing protocols.

Restrictions for Classifying and Marking MPLS EXP

- MPLS classification and marking can only occur in an operational MPLS Network.
- If a packet is classified by IP type of service (ToS) or class of service (CoS) at ingress, it cannot be reclassified by MPLS EXP at egress (imposition case). However, if a packet is classified by MPLS at ingress it can be reclassified by IP ToS, CoS, or Quality of Service (QoS) group at egress (disposition case).
- To apply QoS on traffic across protocol boundaries, use QoS-group. You can classify and assign ingress traffic to the QoS-group. Thereafter, you can the QoS-group at egress to classify and apply QoS.
- If a packet is encapsulated in MPLS, the MPLS payload cannot be checked for other protocols such as IP for classification or marking. Only MPLS EXP marking affects packets encapsulated by MPLS.

Information About Classifying and Marking MPLS EXP

This section provides information about classifying and marking MPLS EXP:

Classifying and Marking MPLS EXP Overview

The QoS EXP Matching feature allows you to organize network traffic by setting values for the MPLS EXP field in MPLS packets. 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. Setting the MPLS EXP value allows you to:

- Classify traffic

  The classification process 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. For more information, see the "Classifying Network Traffic" module.

- Police and mark traffic

  Policing causes traffic that exceeds the configured rate to be discarded or marked to a different drop level. Marking traffic 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. For more information, see the "Marking Network Traffic" module.

MPLS Experimental Field

The MPLS experimental bits (EXP) field is a 3-bit field in the MPLS header that you can use to define the QoS treatment (per-hop behavior) that a node should give to a packet. In an IP network, the DiffServ Code Point (DSCP) (a 6-bit field) defines a class and drop precedence. The EXP bits can be used to carry some of the information encoded in the IP DSCP and can also be used to encode the dropping precedence.

By default, Cisco IOS Software copies the three most significant bits of the DSCP or the IP precedence of the IP packet to the EXP field in the MPLS header. This action happens when the MPLS header is initially imposed on the IP packet. However, you can also set the EXP field by defining a mapping between the DSCP or IP precedence and the EXP bits. This mapping is configured using the **set mpls experimental** or **police** commands. For more information, see the "How to Classify and Mark MPLS EXP" section.

Note A policy map configured with **set ip dscp** is not supported on the provider edge device because the policy action for MPLS label imposition node should be based on **set mpls experimental imposition** value. However, a policy map with action **set ip dscp** is supported when both the ingress and egress interfaces are Layer 3 ports.

You can perform MPLS EXP marking operations using table-maps. It is recommended to assign QoS-group to a different class of traffic in ingress policy and translate QoS-group to DSCP and EXP markings in egress policy using table-map.

Benefits of MPLS EXP Classification and Marking

If a service provider does not want to modify the value of the IP precedence field in packets transported through the network, they can use the MPLS EXP field value to classify and mark IP packets.

By choosing different values for the MPLS EXP field, you can mark critical packets so that those packets have priority if network congestion occurs.

How to Classify and Mark MPLS EXP

This section provides information about how to classify and mark MPLS EXP:

Classifying MPLS Encapsulated Packets

You can use the **match mpls experimental topmost** command to define traffic classes based on the packet EXP values, inside the MPLS domain. You can use these classes to define services policies to mark the EXP traffic using the **police** command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **class-map** [**match-all** | **match-any**] *class-map-name*
4. **match mpls experimental topmost** *mpls-exp-value*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**class-map** [**match-all** | **match-any**] *class-map-name* **Example:** `Device(config)# class-map exp3`	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode. • Enter the class map name.
Step 4	**match mpls experimental topmost** *mpls-exp-value* **Example:** `Device(config-cmap)# match mpls experimental topmost 3`	Specifies the match criteria. **Note** The **match mpls experimental topmost** command classifies traffic on the basis of the EXP value in the topmost label header.
Step 5	**end** **Example:** `Device(config-cmap)# end`	(Optional) Returns to privileged EXEC mode.

Marking MPLS EXP on the Outermost Label

Perform this task to set the value of the MPLS EXP field on imposed label entries.

Before you begin

In typical configurations, marking MPLS packets at imposition is used with ingress classification on IP ToS or CoS fields.

> **Note** For IP imposition marking, the IP precedence value is copied to the MPLS EXP value by default.

> **Note** The egress policy on provider edge works with MPLS EXP class match, only if there is a remarking policy at ingress. The provider edge at ingress is an IP interface and only DSCP value is trusted by default. If you do not configure remarking policy at ingress the label for queueing is generated based on DSCP value and not MPLS EXP value. However, a transit provider router works without configuring remarking policy at ingress as the router works on MPLS interfaces.

> **Note** The **set mpls experimental imposition** command works only on packets that have new or additional MPLS labels added to them.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** *class-map-name*
5. **set mpls experimental imposition** *mpls-exp-value*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**policy-map** *policy-map-name* **Example:** `Device(config)# policy-map mark-up-exp-2`	Specifies the name of the policy map to be created and enters policy-map configuration mode. • Enter the policy map name.
Step 4	**class** *class-map-name* **Example:** `Device(config-pmap)# class prec012`	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode. • Enter the class map name.
Step 5	**set mpls experimental imposition** *mpls-exp-value* **Example:** `Device(config-pmap-c)# set mpls experimental imposition 2`	Sets the value of the MPLS EXP field on top label.
Step 6	**end** **Example:** `Device(config-pmap-c)# end`	(Optional) Returns to privileged EXEC mode.

Marking MPLS EXP on Label Switched Packets

Perform this task to set the MPLS EXP field on label switched packets.

Before you begin

> **Note** The **set mpls experimental topmost** command marks EXP for the outermost label of MPLS traffic. Due to this marking at ingress policy, the egress policy must include classification based on the MPLS EXP values.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** *class-map-name*
5. **set mpls experimental topmost** *mpls-exp-value*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Device> enable`	
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**policy-map** *policy-map-name* **Example:** `Device(config)# policy-map mark-up-exp-2`	Specifies the name of the policy map to be created and enters policy-map configuration mode. • Enter the policy map name.
Step 4	**class** *class-map-name* **Example:** `Device(config-pmap)# class-map exp012`	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode. • Enter the class map name.
Step 5	**set mpls experimental topmost** *mpls-exp-value* **Example:** `Device(config-pmap-c)# set mpls experimental topmost 2`	Sets the MPLS EXP field value in the topmost label on the output interface.
Step 6	**end** **Example:** `Device(config-pmap-c)# end`	(Optional) Returns to privileged EXEC mode.

Configuring Conditional Marking

To conditionally set the value of the MPLS EXP field on all imposed label, perform the following task:

Before you begin

Note The **set-mpls-exp-topmost-transmit** action affects MPLS encapsulated packets only. The **set-mpls-exp-imposition-transmit** action affects any new labels that are added to the packet.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** *class-map-name*
5. **police cir** *bps* **bc pir** *bps* **be**
6. **conform-action transmit**

7. **exceed-action set-mpls-exp-topmost-transmit dscp table** *dscp-table-value*
8. **violate-action drop**
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**policy-map** *policy-map-name* **Example:** `Device(config)# policy-map ip2tag`	Specifies the name of the policy map to be created and enters policy-map configuration mode. • Enter the policy map name.
Step 4	**class** *class-map-name* **Example:** `Device(config-pmap)# class iptcp`	Creates a class map to be used for matching traffic to a specified class, and enters policy-map class configuration mode. • Enter the class map name.
Step 5	**police cir** *bps* **bc pir** *bps* **be** **Example:** `Device(config-pmap-c)# police cir 1000000 pir 2000000`	Defines a policer for classified traffic and enters policy-map class police configuration mode.
Step 6	**conform-action transmit** **Example:** `Device(config-pmap-c-police)# conform-action transmit 3`	Defines the action to take on packets that conform to the values specified by the policer. • In this example, if the packet conforms to the committed information rate (cir) or is within the conform burst (bc) size, the MPLS EXP field is set to 3.
Step 7	**exceed-action set-mpls-exp-topmost-transmit dscp table** *dscp-table-value* **Example:** `Device(config-pmap-c-police)# exceed-action set-mpls-exp-topmost-transmit dscp table dscp2exp`	Defines the action to take on packets that exceed the values specified by the policer.

	Command or Action	Purpose
Step 8	**violate-action drop** **Example:** `Device(config-pmap-c-police)# violate-action drop`	Defines the action to take on packets whose rate exceeds the peak information rate (pir) and is outside the bc and be ranges. • You must specify the exceed action before you specify the violate action. • In this example, if the packet rate exceeds the pir rate and is outside the bc and be ranges, the packet is dropped.
Step 9	**end** **Example:** `Device(config-pmap-c-police)# end`	(Optional) Returns to privileged EXEC mode.

Configuration Examples for Classifying and Marking MPLS EXP

This section provides configuration examples for classifying and marking MPLS EXP:

Example: Classifying MPLS Encapsulated Packets

Defining an MPLS EXP Class Map

The following example defines a class map named exp3 that matches packets that contains MPLS experimental value 3:

```
Device(config)# class-map exp3
Device(config-cmap)# match mpls experimental topmost 3
Device(config-cmap)# exit
```

Defining a Policy Map and Applying the Policy Map to an Ingress Interface

The following example uses the class map created in the example above to define a policy map. This example also applies the policy map to a physical interface for ingress traffic.

```
Device(config)# policy-map change-exp-3-to-2
Device(config-pmap)# class exp3
Device(config-pmap-c)# set mpls experimental topmost 2
Device(config-pmap)# exit
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# service-policy input change-exp-3-to-2
Device(config-if)# exit
```

Defining a Policy Map and Applying the Policy Map to an Egress Interface

The following example uses the class map created in the example above to define a policy map. This example also applies the policy map to a physical interface for egress traffic.

```
Device(config)# policy-map WAN-out
Device(config-pmap)# class exp3
Device(config-pmap-c)# shape average 10000000
Device(config-pmap-c)# exit
Device(config-pmap)# exit
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# service-policy output WAN-out
Device(config-if)# exit
```

Example: Marking MPLS EXP on Outermost Label

Defining an MPLS EXP Imposition Policy Map

The following example defines a policy map that sets the MPLS EXP imposition value to 2 based on the IP precedence value of the forwarded packet:

```
Device# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device(config)# class-map prec012
Device(config-cmap)# match ip prec 0 1 2
Device(config-cmap)# exit
Device(config)# policy-map mark-up-exp-2
Device(config-pmap)# class prec012
Device(config-pmap-c)# set mpls experimental imposition 2
Device(config-pmap-c)# exit
Device(config-pmap)# exit
```

Applying the MPLS EXP Imposition Policy Map to a Main Interface

The following example applies a policy map to Gigabit Ethernet interface 0/0/0:

```
Device# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# service-policy input mark-up-exp-2
Device(config-if)# exit
```

Example: Marking MPLS EXP on Label Switched Packets

Defining an MPLS EXP Label Switched Packets Policy Map

The following example defines a policy map that sets the MPLS EXP topmost value to 2 according to the MPLS EXP value of the forwarded packet:

```
Device# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device(config)# class-map exp012
Device(config-cmap)# match mpls experimental topmost 0 1 2
Device(config-cmap)# exit
Device(config-cmap)# policy-map mark-up-exp-2
Device(config-pmap)# class exp012
Device(config-pmap-c)# set mpls experimental topmost 2
Device(config-pmap-c)# exit
Device(config-pmap)# exit
```

Applying the MPLS EXP Label Switched Packets Policy Map to a Main Interface

The following example shows how to apply the policy map to a main interface:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# service-policy input mark-up-exp-2
Device(config-if)# exit
```

Example: Configuring Conditional Marking

The example in this section creates a policer for the **iptcp** class, which is part of the **ip2tag** policy map, and attaches the policy map to the Gigabit Ethernet interface.

```
Device(config)# policy-map ip2tag
Device(config-pmap)# class iptcp
Device(config-pmap-c)# police cir 1000000 pir 2000000
Device(config-pmap-c-police)# conform-action transmit
Device(config-pmap-c-police)# exceed-action set-mpls-exp-imposition-transmit 2
Device(config-pmap-c-police)# violate-action drop
Device(config-pmap-c-police)# exit
Device(config-pmap-c)# exit
Device(config-pmap)# exit
Device(config)# interface GigabitEthernet 0/0/1
Device(config-if)# service-policy input ip2tag
```

Additional References

Related Documents

Related Topic	Document Title
QoS commands	*Cisco IOS Quality of Service Solutions Command Reference*

Feature History for QoS MPLS EXP

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	QoS MPLS EXP	The QoS EXP Matching feature allows you to classify, mark and queue network traffic by modifying the Multiprotocol Label Switching (MPLS) experimental bits (EXP) field.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 13

Configuring MPLS Static Labels

MPLS Static Labels

This document describes the Cisco MPLS Static Labels feature. The MPLS Static Labels feature provides the means to configure statically:

- The binding between a label and an IPv4 prefix
- The contents of an LFIB crossconnect entry

Prerequisites for MPLS Static Labels

The network must support the following Cisco IOS features before you enable MPLS static labels:

- Multiprotocol Label Switching (MPLS)
- Cisco Express Forwarding

Restrictions for MPLS Static Labels

- The trouble shooting process for MPLS static labels is complex.
- On a provider edge (PE) router for MPLS VPNs, there’s no mechanism for statically binding a label to a customer network prefix (VPN IPv4 prefix).
- MPLS static crossconnect is not supported.
- MPLS static labels aren’t supported for label-controlled Asynchronous Transfer Mode (lc-atm).
- MPLS static bindings aren’t supported for local prefixes.

Information About MPLS Static Labels

MPLS Static Labels Overview

Generally, label switching routers (LSRs) dynamically learn the labels they should use to label-switch packets. They do this by means of label distribution protocols that include:

- Label Distribution Protocol (LDP), the Internet Engineering Task Force (IETF) standard, used to bind labels to network addresses.
- Resource Reservation Protocol (RSVP) used to distribute labels for traffic engineering (TE)
- Border Gateway Protocol (BGP) used to distribute labels for Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs)

To use a learned label to label-switch packets, an LSR installs the label into its Label Forwarding Information Base (LFIB).

The MPLS Static Labels feature provides the means to configure statically:

- The binding between a label and an IPv4 prefix
- The contents of an LFIB crossconnect entry

Benefits of MPLS Static Labels

Static Bindings Between Labels and IPv4 Prefixes

You can configure static bindings between labels and IPv4 prefixes to support MPLS hop-by-hop forwarding through neighbor routers that don’t implement LDP label distribution.

How to Configure MPLS Static Labels

Configuring MPLS Static Prefix Label Bindings

To configure MPLS static prefix/label bindings, use the following commands beginning in global configuration mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label range** *min-label max-label* [**static** *min-static-label max-static-label*]
4. **mpls static binding ipv4** *prefix mask* [**input**| **output** *nexthop*] label

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
	`Device> enable`	
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mpls label range** *min-label max-label* [**static** *min-static-label max-static-label*] **Example:** `Device(config)# mpls label range 200 100000 static 16 199`	Specifies a range of labels for use with MPLS Static Labels feature. (Default is no labels reserved for static assignment.)
Step 4	**mpls static binding ipv4** *prefix mask* [**input**| **output** *nexthop*] label **Example:** `Device(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 55`	Specifies static binding of labels to IPv4 prefixes. Bindings specified are installed automatically in the MPLS forwarding table as routing demands.

Verifying MPLS Static Prefix Label Bindings

To verify the configuration for MPLS static prefix/label bindings, use this procedure:

SUMMARY STEPS

1. Enter **show mpls label range** command. The output shows that the new label ranges do not take effect until a reload occurs:
2. Enter the **show mpls static binding ipv4** command to show the configured static prefix/label bindings:
3. Use the **show mpls forwarding-table** command to determine which static prefix/label bindings are currently in use for MPLS forwarding.

DETAILED STEPS

Step 1 Enter **show mpls label range** command. The output shows that the new label ranges do not take effect until a reload occurs:

Example:

```
Device# show mpls label range

Downstream label pool: Min/Max label: 16/100000
   [Configured range for next reload: Min/Max label: 200/100000]
Range for static labels: Min/Max/Number: 16/199
```

The following output from the **show mpls label range** command, executed after a reload, indicates that the new label ranges are in effect:

Example:

```
Device# show mpls label range

Downstream label pool: Min/Max label: 200/100000
Range for static labels: Min/Max/Number: 16/199
```

Step 2 Enter the **show mpls static binding ipv4** command to show the configured static prefix/label bindings:

Example:

```
Device# show mpls static binding ipv4
10.17.17.17/32: Incoming label: 251 (in LIB)
  Outgoing labels:
     10.0.0.1                   18
10.18.18.18/32: Incoming label: 201 (in LIB)
  Outgoing labels:
10.0.0.1 implicit-null
```

Step 3 Use the **show mpls forwarding-table** command to determine which static prefix/label bindings are currently in use for MPLS forwarding.

Example:

```
Device# show mpls forwarding-table
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
201    Pop tag     10.18.18.18/32    0          PO1/1/0    point2point
       2/35        10.18.18.18/32    0          AT4/1/0.1  point2point
251    18          10.17.17.17/32    0          PO1/1/0    point2point
```

Monitoring and Maintaining MPLS Static Labels

To monitor and maintain MPLS static labels, use one or more of the following commands:

SUMMARY STEPS

1. **enable**
2. **show mpls forwarding-table**
3. **show mpls label range**
4. **show mpls static binding ipv4**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Devie> enable`	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
Step 2	**show mpls forwarding-table** **Example:** `Device# show mpls forwarding-table`	Displays the contents of the MPLS LFIB.
Step 3	**show mpls label range** **Example:** `Device# show mpls label range`	Displays information about the static label range.
Step 4	**show mpls static binding ipv4** **Example:** `Device# show mpls static binding ipv4`	Displays information about the configured static prefix/label bindings.

Configuration Examples for MPLS Static Labels

Example Configuring MPLS Static Prefixes Labels

In the following output, the **mpls label range** command reconfigures the range used for dynamically assigned labels 16–100000 to 200–100000. It configures a static label range of 16–199.

```
Device# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# mpls label range 200 100000 static 16 199
% Label range changes take effect at the next reload.
Router(config)# end
```

In the following output, the **show mpls label range** command indicates that the new label ranges don't take effect until a reload occurs:

```
Device# show mpls label range

Downstream label pool: Min/Max label: 16/100000
   [Configured range for next reload: Min/Max label: 200/100000]
Range for static labels: Min/Max/Number: 16/199
```

In the following output, the **show mpls label range** command, executed after a reload, indicates that the new label ranges are in effect:

```
Device# show mpls label range

Downstream label pool: Min/Max label: 200/100000
Range for static labels: Min/Max/Number: 16/199
```

In the following output, the **mpls static binding ipv4** commands configure static prefix/label bindings. They also configure input (local) and output (remote) labels for various prefixes:

```
Device# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 55
```

```
Device(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 output 10.0.0.66 2607
Device(config)# mpls static binding ipv4 10.6.0.0 255.255.0.0 input 17
Device(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 output 10.13.0.8 explicit-null
Device(config)# end
```

In the following output, the **show mpls static binding ipv4** command displays the configured static prefix/label bindings:

```
Device# show mpls static binding ipv4

10.0.0.0/8: Incoming label: none;
  Outgoing labels:
10.13.0.8           explicit-null
10.0.0.0/8: Incoming label: 55 (in LIB)
  Outgoing labels:
     10.0.0.66              2607
10.66.0.0/16: Incoming label: 17 (in LIB)
  Outgoing labels:  None
```

Additional References

Related Documents

Related Topic	Document Title
MPLS commands	*Multiprotocol Label Switching Command Reference*

Standards

Standard	Title
No new or modified standards are supported by this feature. Support for existing standards has not been modified by this feature.	--

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	--

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature History for MPLS Static Labels

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	MPLS Static Labels	The MPLS Static Labels feature provides the means to configure the binding between a label and an IPv4 prefix statically. The following commands were introduced or modified: **debug mpls static binding**, **mpls label range**, **mpls static binding ipv4**, **show mpls label range**, **show mpls static binding ipv4**

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 14

Configuring Virtual Private LAN Service (VPLS) and VPLS BGP-Based Autodiscovery

Restrictions for VPLS

- Layer 2 protocol tunneling configuration is not supported
- Virtual Circuit Connectivity Verification (VCCV) ping with explicit null is not supported.
- The switch is supported if configured only as a spoke in hierarchical Virtual Private LAN Services (VPLS) and not as a hub.
- Layer 2 VPN interworking functions are not supported.
- **ip unnumbered** command is not supported in Multiprotocol Label Switching (MPLS) configuration.
- Virtual Circuit (VC) statistics are not displayed for flood traffic in the output of **show mpls l2 vc vcid detail** command.
- Dot1q tunnel configuration is not supported in the attachment circuit.

Information About VPLS, VPLS BGP-Based Autodiscovery and Flow-Aware Transport

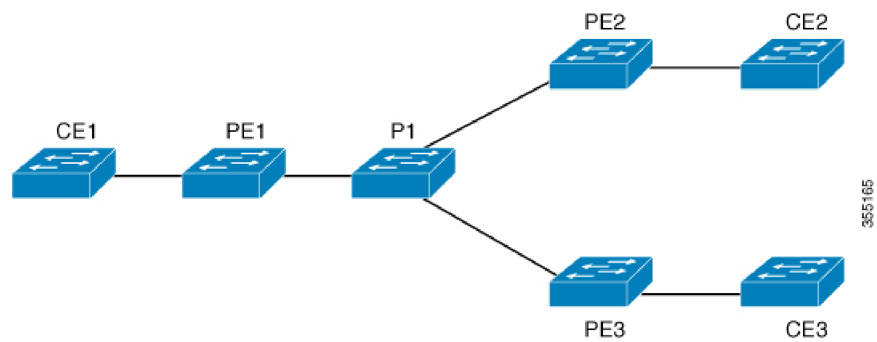
The following sections provide information about VPLS, VPLS BGP-based autodiscovery and flow-aware transport.

VPLS Overview

VPLS enables enterprises to link together their Ethernet-based LANs from multiple sites through the infrastructure provided by their service provider. From the enterprise perspective, the service provider's public network looks like one large Ethernet LAN. For the service provider, VPLS provides an opportunity to deploy another revenue-generating service on top of their existing network without major capital expenditures. Operators can extend the operational life of equipment in their network.

VPLS uses the provider core to join multiple attachment circuits together to simulate a virtual bridge between multiple attachment circuits. From a customer point of view, there is no topology for VPLS. All of the customer edge (CE) devices appear to connect to a logical bridge emulated by the provider core.

Figure 23: VPLS Topology



About Full-Mesh Configuration

The full-mesh configuration requires a full mesh of tunnel label switched paths (LSPs) between all the provider edge (PE) devices that participate in the VPLS. With full-mesh configuration, signaling overhead and packet replication requirements for each provisioned VC on a PE device are high.

For a full-mesh configuration, a virtual forwarding instance (VFI) is required on each participating PE device. The VFI includes the VPN ID of a VPLS domain, the addresses of other PE devices in the domain, and the type of tunnel signaling and encapsulation mechanism for each peer PE device.

A VPLS instance constitutes a set of VFIs formed by the interconnection of the emulated VCs. The VPLS instance forms the logic bridge over the packet switched network. The VPLS instance is assigned a unique VPN ID.

The PE devices use the VFI to establish a full-mesh LSP of emulated VCs to all the other PE devices in the VPLS instance. PE devices obtain the membership of a VPLS instance through the static configuration using the Cisco IOS CLI.

The full-mesh configuration allows the PE device to maintain a single broadcast domain. So when the PE device receives a broadcast, multicast, or unknown unicast packet on an attachment circuit, it sends the packet out on all other attachment circuits and emulated circuits, to all the other CE devices participating in that VPLS instance. The CE devices see the VPLS instance as an emulated LAN.

To avoid the problem of a packet looping in the provider core, the PE devices enforce a 'split-horizon' principle for the emulated VCs. The split-horizon principle ensures that a packet received on an emulated VC is not forwarded on any other emulated VC.

After the VFI has been defined, it needs to be bound to an attachment circuit to the CE device.

The packet forwarding decision is made by looking up the Layer 2 VFI of a particular VPLS domain.

A VPLS instance on a particular PE device receives Ethernet frames that enter on specific physical or logical ports and populates a MAC address table similarly to how an Ethernet switch works. The PE device uses the MAC address to switch those frames into the appropriate LSP, for delivery to the other PE device at a remote site.

If a MAC address is not populated in the MAC address table, the PE device replicates the Ethernet frame and floods it to all logical ports associated with that VPLS instance, except on the ingress port where the Ethernet frame had entered. The PE device updates the MAC address table as it receives packets on specific ports and removes addresses not used after specific periods.

About VPLS BGP-Based Autodiscovery

VPLS autodiscovery enables each PE device to discover other PE devices that are part of the same VPLS domain. VPLS autodiscovery also tracks PE devices when they are added to or removed from a VPLS domain. With VPLS autodiscovery enabled, it is no longer needed to manually configure a VPLS domain and maintain the configuration when a PE device is added or deleted. VPLS autodiscovery uses the Border Gateway Protocol (BGP) to discover VPLS members and set up and tear down pseudowires (PWs) in a VPLS domain.

BGP uses the Layer 2 VPN Routing Information Base (RIB) to store endpoint provisioning information, which is updated each time any Layer 2 VFI is configured. The prefix and path information is stored in the Layer 2 VPN database, which allows BGP to make decisions about the best path. When BGP distributes the endpoint provisioning information in an update message to all its BGP neighbors, this endpoint information is used to configure a pseudowire mesh to support Layer 2 VPN-based services.

The BGP autodiscovery mechanism facilitates the configuration of Layer 2 VPN services, which are an integral part of the VPLS feature. VPLS enables flexibility in deploying services by connecting geographically dispersed sites as a large LAN over high-speed Ethernet in a robust and scalable IP MPLS network.

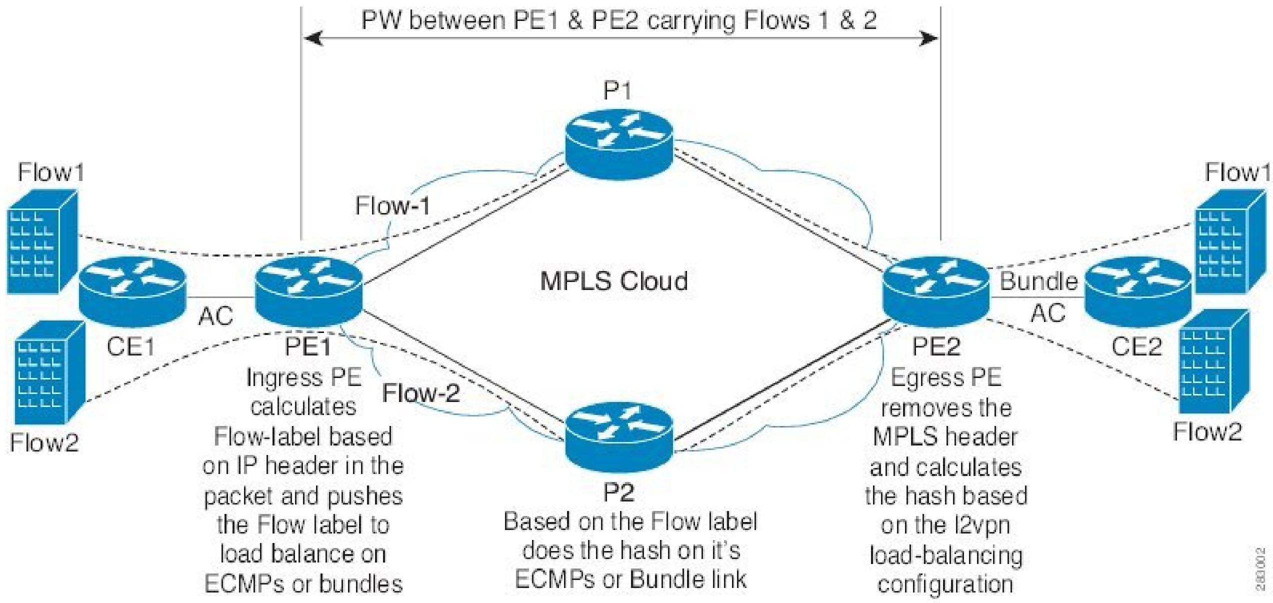
About Flow-Aware Transport Pseudowire

Devices typically load-balance traffic based on the lower most label in the label stack which is the same label for all flows on a given pseudowire. This can lead to asymmetric loadbalancing. The flow, in this context, refers to a sequence of packets that have the same source and destination pair. The packets are transported from a source provider edge (PE) device to a destination PE device.

Flow-aware transport PWs provide the capability to identify individual flows within a PW and provide devices the ability to use these flows to load-balance traffic. Flow-aware transport PWs are used to load-balance traffic in the core when equal cost multipaths (ECMP) are used. A flow label is created based on individual packet flows entering a PW; and is inserted as the lower most label in the packet. Devices can use the flow label for load-balancing which provides a better traffic distribution across ECMP paths or link-bundled paths in the core.

Figure 24: Flow-aware transport PW with two flows distributing over ECMPs and Bundle-Links shows a flow-aware transport PW with two flows distributing over ECMPs and bundle links.

Figure 24: Flow-aware transport PW with two flows distributing over ECMPs and Bundle-Links



An extra label is added to the stack, called the flow label, which contains the flow information of a virtual circuit (VC). A flow label is a unique identifier that distinguishes a flow within the PW, and is derived from source and destination MAC addresses, and source and destination IP addresses. The flow label contains the end of label stack (EOS) bit set and inserted after the VC label and before the control word (if any). The ingress PE calculates and forwards the flow label. The flow-aware transport PW configuration enables the flow label. The egress PE discards the flow label such that no decisions are made.

All core devices perform load balancing based on the flow-label in the flow-aware transport PW. Therefore, it is possible to distribute flows over ECMPs and link bundles.

Flow-aware transport PW works based on port-channel load-balance algorithm only.

Interoperability Between Cisco Catalyst 6000 Series Switches and Cisco Catalyst 9000 Series Switches

The following section describes how to enable sending and receiving flow labels between Cisco Catalyst 6000 Series Switches and Cisco Catalyst 9000 Series Switches.

On a Cisco Catalyst 6000 Series Switch configured with flow-aware transport PW (using Advanced VPLS) flow label negotiations are not supported. If the Cisco Catalyst 6000 Series Switch is in interoperability with a remote PE device such as a Cisco Catalyst 9000 Series Switch, then the Cisco Catalyst 9000 Series Switch cannot receive and send the flow label for data traffic. Configuring the **load-balance flow-label both static** command on the Cisco Catalyst 9000 Series Switch allows the Cisco Catalyst 9000 Series Switch to receive and send the flow labels even though the Cisco Catalyst 6000 Series Switch does not support flow label negotiations.

The following is a configuration example to enable sending and receiving flow labels:

```
Device> enable
Device# configure terminal
Device(config)# template type pseudowire mpls
Device(config-template)# encapsulation mpls
Device(config-template# load-balance flow ip dst-ip
```

```
Device(config-template)# load-balance flow-label both static
Device(config-template# end
```

How to Configure VPLS, VPLS BGP-Based Autodiscovery and Flow-Aware Transport

The following sections provide configuration information about VPLS, VPLS BGP-based autodiscovery and flow-aware transport.

Configuring Layer 2 PE Device Interfaces to CE Devices

You must configure Layer 2 PE device interfaces to CE devices. The following sections provide various configuration tasks that need to be completed before configuring VPLS.

Configuring 802.1Q Trunks on a PE Device for Tagged Traffic from a CE Device

To configure 802.1Q trunks on a PE device, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/24`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 4	**no ip address** *ip_address mask* [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing and enters interface configuration mode.
Step 5	**switchport** **Example:** `Device(config-if)# switchport`	Modifies the switching characteristics of the Layer 2 switched interface.

	Command or Action	Purpose
Step 6	**switchport trunk encapsulation dot1q** **Example:** `Device(config-if)# switchport trunk encapsulation dot1q`	Sets the switch port encapsulation format to 802.1Q.
Step 7	**switchport trunk allow vlan** *vlan_ID* **Example:** `Device(config-if)# switchport trunk allow vlan 2129`	Sets the list of allowed VLANs.
Step 8	**switchport mode trunk** **Example:** `Device(config-if)# switchport mode trunk`	Sets the interface to a trunking VLAN Layer 2 interface.
Step 9	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuring 802.1Q Access Ports on a PE Device for Untagged Traffic from a CE Device

To configure 802.1Q access ports on a PE device, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/24`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 4	**no ip address** *ip_address mask* [**secondary**] **Example:**	Disables IP processing.

	Command or Action	Purpose
	Device(config-if)# **no ip address**	
Step 5	**switchport** **Example:** Device(config-if)# **switchport**	Modifies the switching characteristics of the Layer 2 switched interface.
Step 6	**switchport mode access** **Example:** Device(config-if)# **switchport mode access**	Sets the interface type to nontrunking and nontagged single VLAN Layer 2 interface.
Step 7	**switchport access vlan** *vlan_ID* **Example:** Device(config-if)# **switchport access vlan 2129**	Sets the VLAN when the interface is in access mode.
Step 8	**end** **Example:** Device(config-if)# **end**	Returns to privileged EXEC mode.

Configuring Layer 2 VLAN Instances on a PE Device

Configuring the Layer 2 VLAN interface on the PE device, enables the Layer 2 VLAN instance on the PE device to the VLAN database, to set up the mapping between the VPLS and VLANs.

To configure Layer 2 VLAN instance on a PE device, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** Device> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Device# **configure terminal**	Enters global configuration mode.
Step 3	**vlan** *vlan-id* **Example:** Device(config)# **vlan 2129**	Configures a specific VLAN.

	Command or Action	Purpose
Step 4	**interface vlan** *vlan-id* **Example:** `Device(config-vlan)# interface vlan 2129`	Configures an interface on the VLAN.
Step 5	**end** **Example:** `Device(config-vlan)# end`	Returns to privileged EXEC mode.

Configuring VPLS

VPLS can be configured using either the Xconnect mode or protocol-CLI method.The following sections provide information about how to configure VPLS.

Configuring VPLS in Xconnect Mode

The following sections provide information on configuring VPLS in Xconnect mode.

Configuring MPLS on a PE Device

To configure MPLS on a PE device, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mpls ip** **Example:** `Device(config)# mpls ip`	Configures MPLS hop-by-hop forwarding.
Step 4	**mpls label protocol ldp** **Example:** `Device(config)# mpls label protocol ldp`	Specifies the default Label Distribution Protocol (LDP) for a platform.

	Command or Action	Purpose
Step 5	**mpls ldp logging neighbor-changes** **Example:** `Device(config)# mpls ldp logging neighbor-changes`	(Optional) Determines logging neighbor changes.
Step 6	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Configuring VFI on a PE Device

The VFI specifies the VPN ID of a VPLS domain, the addresses of other PE devices in this domain, and the type of tunnel signaling and encapsulation mechanism for each peer device.

To configure VFI and associated VCs on the PE device, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2 vfi** *vfi-name* **manual** **Example:** `Device(config)# l2 vfi 2129 manual`	Enables the Layer 2 VFI manual configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 2129`	Configures a VPN ID for a VPLS domain. The emulated VCs bound to this Layer 2 virtual routing and forwarding (VRF) use this VPN ID for signaling. **Note** *vpn-id* is the same as *vlan-id*.
Step 5	**neighbor** *router-id* {**encapsulation mpls**} **Example:** `Device(config-vfi)# neighbor remote-router-id encapsulation mpls`	Specifies the remote peering router ID and the tunnel encapsulation type or the pseudowire (PW) property to be used to set up the emulated VC.

	Command or Action	Purpose
Step 6	**end** **Example:** `Device(config-vfi)# end`	Returns to privileged EXEC mode.

Associating the Attachment Circuit with the VFI on the PE Device

After defining the VFI, you must associate it to one or more attachment circuits.

To associate the attachment circuit with the VFI, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface vlan** *vlan-id* **Example:** `Device(config)# interface vlan 2129`	Creates or accesses a dynamic switched virtual interface (SVI). **Note** *vlan-id* is the same as *vpn-id*.
Step 4	**no ip address** **Example:** `Device(config-if)# no ip address`	Disables IP processing. (You can configure a Layer 3 interface for the VLAN if you need to configure an IP address.)
Step 5	**xconnect vfi** *vfi-name* **Example:** `Device(config-if)# xconnect vfi 2129`	Specifies the Layer 2 VFI that you are binding to the VLAN port.
Step 6	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuring VPLS in Protocol-CLI Mode

The following sections provide information on configuring VPLS in protocol-CLI mode.

Configuring VPLS in Protocol-CLI Mode

To configure VPLS in protocol-CLI mode, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes an Layer 2 VPN VFI context and enters Layer 2 VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 10`	Configures a VPN ID for the VPLS domain.
Step 5	**member** *ip-address* **encapsulation mpls** **Example:** `Device(config-vfi)# member 2.2.2.2 encapsulation mpls`	Specifies the devices that form a point-to-point Layer 2 VPN VFI connection.
Step 6	**exit** **Example:** `Device(config-vfi)# exit`	Exits to privileged EXEC mode.
Step 7	Select one of the following: • **vlan configuration** *vlan-id* • **interface vlan** *vlan-id* **Example:** `Device(config)# vlan configuration 100`	Applies configuration to be applied on the VLAN or interface and enters VLAN or interface configuration mode.

	Command or Action	Purpose
	OR Device(config)# **interface vlan 100**	
Step 8	**member vfi** *vfi-name* **Example:** Device(config-vlan-config)# **member vfi vpls1**	Binds a VFI instance to a VLAN or an interface.
Step 9	**end** **Example:** Device(config-vlan-config)# **end**	Returns to privileged EXEC mode.

Configuring VPLS Flow-Aware Transport with Pseudowire Interface (in Protocol-CLI Mode)

To configure VPLS flow-aware transport with pseudowire interface, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** Device> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Device# **configure terminal**	Enters global configuration mode.
Step 3	**interface pseudowire** *number* **Example:** Device(config)# **interface pseudowire 1001**	Establishes a PW with the specified name, and enters pseudowire interface configuration mode.
Step 4	**encapsulation mpls** **Example:** Device(config-if)# **encapsulation mpls**	Specifies the tunneling encapsulation as MPLS.
Step 5	**neighbor** *peer-address vcid-value* **Example:** Device(config-if)# **neighbor 10.1.1.200 200**	Specifies the peer IP address and VC ID value of a Layer 2 VPN PW.
Step 6	**load-balance flow** **Example:**	Enables the load balancing with PW feature so that load balancing is done on a per-flow basis.

	Command or Action	Purpose
	`Device(config-if)# load-balance flow`	
Step 7	**load-balance flow-label** **Example:** `Device(config-if)# load-balance flow-label both`	Enables the flow-aware transport of MPLS PW feature and specifies how flow labels are to be used.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits to privileged EXEC mode.
Step 9	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes an Layer 2 VPN VFI context and enters Layer 2 VFI configuration mode.
Step 10	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 10`	Configures a VPN ID for the VPLS domain.
Step 11	**member pseudowire** *number* **Example:** `Device(config-vfi)# member pseudowire 1001`	Adds the pseudowire interface as a member of the VFI.
Step 12	**exit** **Example:** `Device(config-vfi)# exit`	Exits to privileged EXEC mode.

Step 13	Select one of the following:
	• **vlan configuration** *vlan-id*
	• **interface vlan** *vlan-id*
	Example:
	`Device(config)# vlan configuration 100`
	`OR`
	`Device(config)# interface vlan 100`
		Applies configuration to be applied on the VLAN or interface and enters VLAN or interface configuration mode.

Step 14	**member vfi** *vfi-name* **Example:** `Device(config-vlan-config)# member vfi vpls1`	Binds a VFI instance to a VLAN or an interface.

	Command or Action	Purpose
Step 15	**end** **Example:** `Device(config-vlan-config)# end`	Returns to privileged EXEC mode.

Configuring VPLS Flow-Aware Transport Using a Template (in Protocol-CLI Mode)

Configuring VPLS flow-aware transport using a template allows multiple PWs to share the same configuration.

To configure VPLS flow-aware transport using a template, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**template type pseudowire** [*template-name*] **Example:** `Device(config)# template type pseudowire mpls`	Specifies the name of a Layer 2 PW and enters pseudowire template configuration mode.
Step 4	**encapsulation mpls** **Example:** `Device(config-template)# encapsulation mpls`	Specifies the tunneling encapsulation as MPLS.
Step 5	**load-balance flow** **Example:** `Device(config-template)# load-balance flow`	Enables the load balancing with PW feature so that load balancing is done on a per-flow basis.
Step 6	**load-balance flow-label** **Example:** `Device(config-template)# load-balance flow-label both`	Enables the flow-aware transport of MPLS PW feature and specifies how flow labels are to be used.
Step 7	**exit** **Example:**	Exits to privileged EXEC mode.

	Command or Action	Purpose
	`Device(config-template)# exit`	
Step 8	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes an Layer 2 VPN VFI context and enters Layer 2 VFI configuration mode.
Step 9	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 10`	Configures a VPN ID for the VPLS domain.
Step 10	**member** *ip-address* **template** *template-name* **Example:** `Device(config-vfi)# member 102.102.102.102 template mpls`	Specifies the devices that form a point-to-point Layer 2 VPN VFI connection. • **ip-address**: IP address of the VFI neighbor. • **template** *template-name*: Specifies the template name mpls as the template method.
Step 11	**exit** **Example:** `Device(config-vfi)# exit`	Exits to privileged EXEC mode.

Step 12	Select one of the following:
	• **vlan configuration** *vlan-id*
	• **interface vlan** *vlan-id*
	Example:
	`Device(config)# vlan configuration 100`
	`OR`
	`Device(config)# interface vlan 100`
		Applies configuration to be applied on the VLAN or interface and enters VLAN or interface configuration mode.

Step 13	**member vfi** *vfi-name* **Example:** `Device(config-vlan-config)# member vfi vpls1`	Binds a VFI instance to a VLAN or an interface.
Step 14	**end** **Example:** `Device(config-vlan-config)# end`	Exits to privileged EXEC mode.

Configuring VPLS Flow-Aware Transport Using Pseudowire and a Template (in Protocol-CLI Mode)

To configure VPLS flow-aware transport using both PW and a template, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**template type pseudowire** [*template-name*] **Example:** `Device(config)# template type pseudowire mpls`	Specifies the name of a Layer 2 PW and enters pseudowire template configuration mode.
Step 4	**encapsulation mpls** **Example:** `Device(config-template)# encapsulation mpls`	Specifies the tunneling encapsulation as MPLS.
Step 5	**load-balance flow** **Example:** `Device(config-template)# load-balance flow`	Enables the load balancing with PW feature so that load balancing is done on a per-flow basis.
Step 6	**load-balance flow-label** **Example:** `Device(config-template)# load-balance flow-label both`	Enables the flow-aware transport of MPLS PW feature and specifies how flow labels are to be used.
Step 7	**exit** **Example:** `Device(config-template)# exit`	Exits to privileged EXEC mode.
Step 8	**interface pseudowire** *number* **Example:** `Device(config)# interface pseudowire 1001`	Establishes a PW with the specified name, and enters pseudowire interface configuration mode.
Step 9	**source template type pseudowire** [*template-name*] **Example:** `Device(config-if)# source template type pseudowire mpls`	Configures the source template of type pseudowire named mpls.

	Command or Action	Purpose
Step 10	**neighbor** *peer-address vcid-value* **Example:** `Device(config-if)# neighbor 10.1.1.200 200`	Specifies the peer IP address and VC ID value of a Layer 2 VPN PW.
Step 11	**exit** **Example:** `Device(config-if)# exit`	Exits to privileged EXEC mode.
Step 12	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes an Layer 2 VPN VFI context and enters Layer 2 VFI configuration mode.
Step 13	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 10`	Configures a VPN ID for the VPLS domain.
Step 14	**member pseudowire** *number* **Example:** `Device(config-vfi)# member pseudowire 1001`	Adds the pseudowire interface as a member of the VFI.
Step 15	**exit** **Example:** `Device(config-vfi)# exit`	Exits to privileged EXEC mode.

Step 16	Select one of the following:
	• **vlan configuration** *vlan-id*
	• **interface vlan** *vlan-id*
	Example:
	`Device(config)# vlan configuration 100`
	`OR`
	`Device(config)# interface vlan 100`
		Applies configuration to be applied on the VLAN or interface and enters VLAN or interface configuration mode.

Step 17	**member vfi** *vfi-name* **Example:** `Device(config-vlan-config)# member vfi vpls1`	Binds a VFI instance to a VLAN or an interface.
Step 18	**end** **Example:**	Exits to privileged EXEC mode.

	Command or Action	Purpose
	`Device(config-vlan-config)# end`	

Configuring VPLS BGP-based Autodiscovery

The following sections provide information about how to configure VPLS BGP-based Autodiscovery.

Enabling VPLS BGP-based Autodiscovery

To enabling VPLS BGP-based autodiscovery, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2 vfi** *vfi-name* **autodiscovery** **Example:** `Device(config)# l2 vfi 2128 autodiscovery`	Enables VPLS autodiscovery on a PE device and enters L2 VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 2128`	Configures a VPN ID for the VPLS domain.
Step 5	**end** **Example:** `Device(config-vfi)# end`	Returns to privileged EXEC mode.

Configuring BGP to Enable VPLS Autodiscovery

To configure BGP to enable VPLS autodiscovery, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 1000`	Enters router configuration mode for the specified routing process.
Step 4	**no bgp default ipv4-unicast** **Example:** `Device(config-router)# no bgp default ipv4-unicast`	Disables the IPv4 unicast address family for the BGP routing process. **Note** Routing information for the IPv4 unicast address family is advertised by default for each BGP routing session configured using the **neighbor remote-as router** command unless you configure the **no bgp default ipv4-unicast** command before configuring the **neighbor remote-as** command. Existing neighbor configurations are not affected.
Step 5	**bgp log-neighbor-changes** **Example:** `Device(config-router)# bgp log-neighbor-changes`	Enables logging of BGP neighbor resets.
Step 6	**neighbor remote-as** { *ip-address* | *peer-group-name* } **remote-as** *autonomous-system-number* **Example:** `Device(config-router)# neighbor 44.254.44.44 remote-as 1000`	Adds the IP address or peer group name of the neighbor in the specified autonomous system to the IPv4 multiprotocol BGP neighbor table of the local device. • If the *autonomous-system-number* argument matches the autonomous system number specified in the **router bgp** command, the neighbor is an internal neighbor. • If the *autonomous-system-number* argument does not match the autonomous system number specified in the **router bgp** command, the neighbor is an external neighbor.

	Command or Action	Purpose
Step 7	**neighbor** { *ip-address* | *peer-group-name* } **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 44.254.44.44 update-source Loopback300`	(Optional) Configures a device to select a specific source or interface to receive routing table updates.
Step 8	Repeat Steps 6 and 7 to configure other BGP neighbors.	Exits interface configuration mode.
Step 9	**address-family l2vpn** [**vpls**] **Example:** `Device(config-router)# address-family l2vpn vpls`	Specifies the Layer 2 VPN address family and enters address family configuration mode. The optional **vpls** keyword specifies that the VPLS endpoint provisioning information is to be distributed to BGP peers.
Step 10	**neighbor** { *ip-address* | *peer-group-name* } **activate** **Example:** `Device(config-router-af)# neighbor 44.254.44.44 activate`	Enables the exchange of information with a BGP neighbor.
Step 11	**neighbor** { *ip-address* | *peer-group-name* } **send-community** { **both** | **standard** | **extended** } **Example:** `Device(config-router-af)# neighbor 44.254.44.44 send-community both`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 12	Repeat Steps 10 and 11 to activate other BGP neighbors under an L2VPN address family.	
Step 13	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits address family configuration mode and returns to router configuration mode.
Step 14	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode and returns to privileged EXEC mode.

Configuring VPLS BGP-based Autodiscovery in Protocol-CLI Mode

The following sections provide information on configuring VPLS BGP-based autodiscovery in protocol-CLI mode.

Configuring VPLS BGP based Autodiscovery in Protocol-CLI mode

To configure VPLS BGP based autodiscovery in protocol-CLI mode, perform this procedure

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes an Layer 2 VPN VFI context and enters Layer 2 VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 10`	Configures a VPN ID for the VPLS domain.
Step 5	**autodiscovery bgp signaling ldp** **Example:** `Device(config-vfi)# autodiscovery bgp signaling ldp`	Enables BGP signaling and LDP signaling.
Step 6	**exit** **Example:** `Device(config-vfi-autodiscovery)# exit`	Exits to privileged EXEC mode.
Step 7	**exit** **Example:** `Device(config-vfi)# exit`	Exits to privileged EXEC mode.

	Command or Action	Purpose

Step 8	Select one of the following:
	• **vlan configuration** *vlan-id*
	• **interface vlan** *vlan-id*
	Example:
	`Device(config)# vlan configuration 100`
	`OR`
	`Device(config)# interface vlan 100`
		Applies configuration to be applied on the VLAN or interface and enters VLAN or interface configuration mode.

Step 9	**member vfi** *vfi-name* **Example:** `Device(config-vlan-config)# member vfi vpls1`	Binds a VFI instance to a VLAN or an interface.
Step 10	**end** **Example:** `Device(config-vlan-config)# end`	Exits to privileged EXEC mode.

Configuring VPLS BGP based Autodiscovery Flow-Aware Transport using Template (in Protocol-CLI Mode)

To configure VPLS BGP based autodiscovery flow-aware transport using template, perform this procedure

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**template type pseudowire** [*template-name*] **Example:** `Device(config)# template type pseudowire mpls`	Specifies the name of a Layer 2 PW and enters pseudowire template configuration mode.
Step 4	**encapsulation mpls** **Example:** `Device(config-template)# encapsulation mpls`	Specifies the tunneling encapsulation as MPLS.

	Command or Action	Purpose
Step 5	**load-balance flow** **Example:** `Device(config-template)# load-balance flow`	Enables the Any Transport over MPLS (AToM) load balancing with PW feature so that load balancing is done on a per-flow basis.
Step 6	**load-balance flow-label** **Example:** `Device(config-template)# load-balance flow-label both`	Enables the flow-aware transport of MPLS PW feature and specifies how flow labels are to be used.
Step 7	**exit** **Example:** `Device(config-template)# exit`	Exits to privileged EXEC mode.
Step 8	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes an Layer 2 VPN VFI context and enters Layer 2 VFI configuration mode.
Step 9	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 10`	Configures a VPN ID for the VPLS domain.
Step 10	**autodiscovery bgp signaling ldp template** *name* **Example:** `Device(config-vfi)# autodiscovery bgp signaling ldp template mpls`	Enables BGP signaling and LDP signaling.
Step 11	**exit** **Example:** `Device(config-vfi)# exit`	Exits to privileged EXEC mode.

Step 12	Select one of the following:
	• **vlan configuration** *vlan-id*
	• **interface vlan** *vlan-id*
	Example:
	`Device(config)# vlan configuration 100`
	`OR`
	`Device(config)# interface vlan 100`
		Applies configuration to be applied on the VLAN or interface and enters VLAN or interface configuration mode.

	Command or Action	Purpose
Step 13	**member vfi** *vfi-name* **Example:** `Device(config-vlan-config)# member vfi vpls1`	Binds a VFI instance to a VLAN or an interface.
Step 14	**end** **Example:** `Device(config-vlan-config)# end`	Exits to privileged EXEC mode.

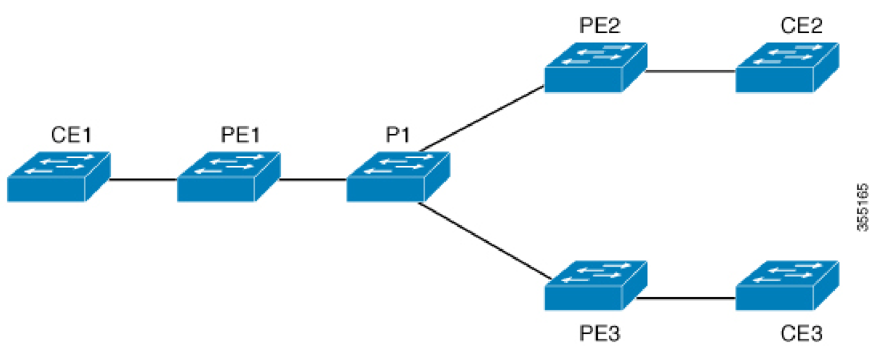
Configuration Examples for VPLS and VPLS BGP-Based Autodiscovery

This section provides the configuration examples for VPLS and VPLS BGP-Based Autodiscovery.

Example: Configuring VPLS in Xconnect Mode

The following example shows how to configure VPLS on a PE1 and PE2 devices:

Figure 25: VPLS Topology



PE1 Configuration
Device> **enable** Device# **configure terminal** Device(config)# **pseudowire-class vpls2129** Device(config-if)# **encapsulation mpls** Device(config-if)# **exit** Device(config)# **l2 vfi 2129 manual** Device(config-vfi)# **vpn id 2129** Device(config-vfi)# **neighbor 44.254.44.44 pw-class vpls2129** Device(config-vfi)# **neighbor 188.98.89.98 pw-class vpls2129** Device(config-vfi)# **exit** Device(config)# **interface TenGigabitEthernet1/0/24** Device(config-if)# **switchport trunk allowed vlan 2129** Device(config-if)# **switchport mode trunk** Device(config-if)# **exit** Device(config)# **interface vlan 2129** Device(config-vlan-config)# **no ip address** Device(config-vlan-config)# **xconnect vfi 2129**

Examples: Verifying VPLS Configured in Xconnect Mode

The following example is a sample output of the **show mpls 12transport vc detail** command. This command provides information about the virtual circuits.

```
Device# show mpls 12transport vc detail
 Local interface: VFI 2129 vfi up
  Interworking type is Ethernet
  Destination address: 44.254.44.44, VC ID: 2129, VC status: up
    Output interface: Gi1/0/9, imposed label stack {18 17}
    Preferred path: not configured
    Default path: active
    Next hop: 177.77.177.2
  Create time: 19:09:33, last status change time: 09:24:14
    Last label FSM state change time: 09:24:14
  Signaling protocol: LDP, peer 44.254.44.44:0 up
    Targeted Hello: 1.1.1.72(LDP Id) -> 44.254.44.44, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: not configured and not enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
MPLS VC labels: local 512, remote 17
    Group ID: local n/a, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: Off
```

```
  SSO Descriptor: 44.254.44.44/2129, local label: 512
  Dataplane:
    SSM segment/switch IDs: 20498/20492 (used), PWID: 2
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

The following example is a sample output of the **show l2vpn atom vc** command. The command shows that AToM over MPLS is configured on a VC.

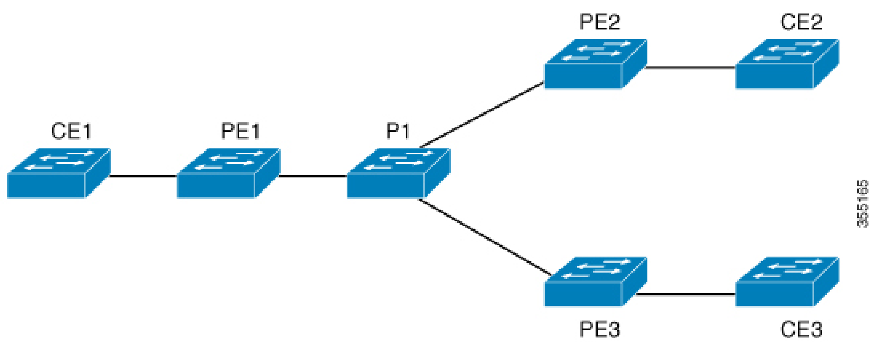
```
Device# show l2vpn atom vc detail

pseudowire100005 is up, VC status is up PW type: Ethernet
  Create time: 19:25:56, last status change time: 09:40:37
    Last label FSM state change time: 09:40:37
  Destination address: 44.254.44.44 VC ID: 2129
    Output interface: Gi1/0/9, imposed label stack {18 17}
    Preferred path: not configured
    Default path: active
    Next hop: 177.77.177.2
  Member of vfi service 2129
    Bridge-Domain id: 2129
    Service id: 0x32000003
  Signaling protocol: LDP, peer 44.254.44.44:0 up
    Targeted Hello: 1.1.1.72(LDP Id) -> 44.254.44.44, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: not configured and not enabled
     PWid FEC (128), VC ID: 2129
    Status TLV support (local/remote)         : enabled/supported
      LDP route watch                         : enabled
      Label/status state machine              : established, LruRru
      Local dataplane status received         : No fault
      BFD dataplane status received           : Not sent
      BFD peer monitor status received        : No fault
      Status received from access circuit     : No fault
      Status sent to access circuit           : No fault
      Status received from pseudowire i/f     : No fault
Status sent to network peer             : No fault
      Status received from network peer       : No fault
      Adjacency status of remote peer         : No fault
  Sequencing: receive disabled, send disabled
  Bindings
    Parameter    Local                          Remote
    ------------ ------------------------------ ------------------------------
    Label        512                            17
    Group ID     n/a                            0
    Interface
    MTU          1500                           1500
    Control word off                            off
    PW type      Ethernet                       Ethernet
    VCCV CV type 0x02                           0x02
                   LSPV [2]                       LSPV [2]
    VCCV CC type 0x06                           0x06
                   RA [2], TTL [3]               RA [2], TTL [3]
    Status TLV   enabled                        supported
  SSO Descriptor: 44.254.44.44/2129, local label: 512
  Dataplane:
    SSM segment/switch IDs: 20498/20492 (used), PWID: 2
  Rx Counters
    0 input transit packets, 0 bytes
```

```
  0 drops, 0 seq err
Tx Counters
  0 output transit packets, 0 bytes
  0 drops
```

Example: Configuring VPLS Flow-Aware Transport Using a Template (in Protocol-CLI Mode)

The following example shows how to configure VPLS on a PE1 and PE2 devices:

Figure 26: VPLS Topology



PE1 Configuration

```
Device> enable
Device# configure terminal
Device(config)# template type pseudowire mpls
Device(config-template)# encapsulation mpls
Device(config-template)# load-balance flow ip dst-ip
Device(config-template)# load-balance flow-label both
Device(config-template)# exit
Device(config)# interface Loopback0
Device(config-if)# ip address 1.1.1.30 255.255.255.255
Device(config-if)# ip ospf 1 area 0
Device(config-if)# exit
Device(config)# interface TwentyFiveGigE1/0/9
Device(config-if)# no switchport
Device(config-if)# ip address 80.0.0.30 255.255.255.0
Device(config-if)# ip ospf 1 area 0
Device(config-if)# mpls ip
Device(config-if)# exit
Device(config)# l2vpn vfi context foo
Device(config-vfi)# vpn id 2129
Device(config-vfi)# member 1.1.1.20 template mpls
Device(config-vfi)# exit
Device(config)# interface TwentyFiveGigE1/0/2
Device(config-if)# switchport mode access
Device(config-if)# switchport access vlan 100
Device(config-if)# exit
Device(config)# interface vlan 100
Device(config-vlan-config)# member vfi foo
Device(config-vlan-config)# end
```

Example: Configuring VPLS BGP-Auto Discovery

The following example shows how to configure VPLS on a PE device:

```
Device> enable
Device# configure terminal
Device(config)# router bgp 1000
Device(config-router)# bgp log-neighbor-changes
Device(config-router)# bgp graceful-restart
Device(config-router)# neighbor 44.254.44.44 remote-as 1000
Device(config-router)# neighbor 44.254.44.44 update-source Loopback300
Device(config-router)# address-family l2vpn vpls
Device(config-router-af)# neighbor 44.254.44.44 activate
Device(config-router-af)# neighbor 44.254.44.44 send-community both
Device(config-router-af)# exit-address-family
Device(config-router-af)# end
Device(config)# l2 vfi 2128 autodiscovery
Device(config-vfi)# vpn id 2128
Device(config-vfi)# exit
Device(config)# interface vlan 2128
Device(config-vlan-config)# no ip address
Device(config-vlan-config)# xconnect vfi 2128
!
```

Example: Verifying VPLS BGP-Auto Discovery

The following example is a sample output of the **show platform software fed sw 1 matm macTable vlan 2000** command.

```
Device# show platform software fed sw 1 matm macTable vlan 2000

VLAN  MAC             Type      Seq#   macHandle          siHandle           diHandle
      *a_time *e_time   ports
2000  2852.6134.05c8  0X8002    0      0xffbba312c8       0xffbb9ef938       0x5154
      0       0         Vlan2000
2000  0000.0078.9012  0X1       32627  0xffbb665ec8       0xffbb60b198       0xffbb653f98
      300     278448    Port-channel11
2000  2852.6134.0000  0X1       32651  0xffba15e1a8       0xff454c2328       0xffbb653f98
      300     63        Port-channel11
2000  0000.0012.3456  0X2000001 32655  0xffba15c508       0xff44f9ec98       0x0
      300     1         2000:33.33.33.33
Total Mac number of addresses:: 4
*a_time=aging_time(secs)  *e_time=total_elapsed_time(secs)
Type:
MAT_DYNAMIC_ADDR     0x1       MAT_STATIC_ADDR       0x2
MAT_CPU_ADDR         0x4       MAT_DISCARD_ADDR      0x8
MAT_ALL_VLANS        0x10      MAT_NO_FORWARD        0x20
MAT_IPMULT_ADDR      0x40      MAT_RESYNC            0x80
MAT_DO_NOT_AGE       0x100     MAT_SECURE_ADDR       0x200
MAT_NO_PORT          0x400     MAT_DROP_ADDR         0x800
MAT_DUP_ADDR         0x1000    MAT_NULL_DESTINATION  0x2000
MAT_DOT1X_ADDR       0x4000    MAT_ROUTER_ADDR       0x8000
MAT_WIRELESS_ADDR    0x10000   MAT_SECURE_CFG_ADDR   0x20000
MAT_OPQ_DATA_PRESENT 0x40000   MAT_WIRED_TUNNEL_ADDR 0x80000
MAT_DLR_ADDR         0x100000  MAT_MRP_ADDR          0x200000
```

```
MAT_MSRP_ADDR        0x400000  MAT_LISP_LOCAL_ADDR   0x800000
MAT_LISP_REMOTE_ADDR 0x1000000 MAT_VPLS_ADDR         0x2000000
```

The following example is a sample output of the **show bgp l2vpn vpls all** command.

```
Device# show bgp l2vpn vpls all

BGP table version is 6, local router ID is 222.5.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
  r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
  x best-external, a additional-path, c RIB-compressed,
  t secondary path,
 Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 1000:2128
*>   1000:2128:1.1.1.72/96
                0.0.0.0                            32768 ?
*>i  1000:2128:44.254.44.44/96
                44.254.44.44             0    100      0 ?
```

Feature History for VPLS and VPLS BGP-Based Autodiscovery

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.6.1	Configuring VPLS	VPLS enables enterprises to link together their Ethernet-based LANs from multiple sites via the infrastructure provided by their service provider.
Cisco IOS XE Gibraltar 16.12.1	Configuring VPLS BGP-based Autodiscovery	VPLS Autodiscovery enables each PE device to discover other PE devices that are part of the same VPLS domain.
Cisco IOS XE Amsterdam 17.1.1	VPLS Layer 2 Snooping : IGMP (IPv4)	IGMP snooping is supported on a VPLS configured network.

Use the Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/

http://www.cisco.com/go/cfn.

CHAPTER 15

Configuring Hierarchical VPLS with MPLS Access

Configuring Virtual Private LAN Service (VPLS) requires a full mesh of tunnel label switched paths (LSPs) between all the provider edge (PE) devices that participate in the VPLS. With full-mesh configuration, signaling overhead and packet replication requirements for each provisioned virtual circuit (VC) on a PE device are high. Configuring Hierarchical VPLS with Multiprotocol Label Switching (MPLS) Access reduces signaling overhead and packet replication between devices.

Prerequisites for Configuring Hierarchical VPLS with MPLS Access

Configure the PE to customer edge (CE) interface with a list of allowed VLANs.

Restrictions for Configuring Hierarchical VPLS with MPLS Access

- This feature is not supported if VPLS Autodiscovery is configured on pseudowires (PWs) that are attached to user provider edge (U-PE) devices. (When you create the VPLS, you can manually create the virtual forwarding interface (VFI)).
- This feature is not supported if Q-in-Q access is configured between a U-PE device and a N-PE device.
- Internet Group Management Protocol (IGMP) snooping is not supported.
- Cisco Discovery Protocol (CDP) is not supported.

- Multiprotocol Label Switching (MPLS) over generic routing encapsulation (GRE) and VPLS over GRE are not supported.

Information About Configuring Hierarchical VPLS with MPLS Access

The following section provides information about configuring hierarchical VPLS with MPLS access.

About Hierarchical VPLS with MPLS Access

A standard VPLS configuration comprises CE devices and PE devices. Using the Hierarchical VPLS with MPLS Access feature, each PE device is replaced with a U-PE and an N-PE device. U-PE devices communicate with the CE devices and N-PE devices on the access side, and N-PE devices communicate with other N-PE devices on the provider core.

Figure 27: Hierarchical VPLS with MPLS Access Configuration shows a hierarchical VPLS with MPLS access configuration. Each CE device is connected to a U-PE device through an attachment circuit. A U-PE device is connected to an N-PE device through a single pseudowire (PW) for each VPLS instance.

The following configuration types are supported between a U-PE device and an N-PE device:

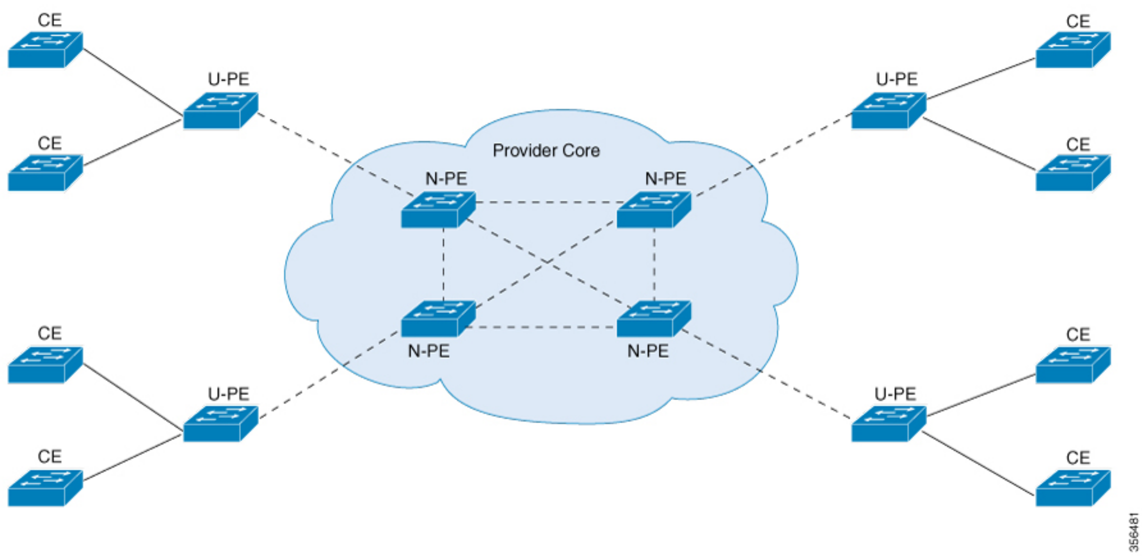
- Ethernet Q-in-Q

Note Ethernet Q-in-Q configurations are not supported in Cisco IOS XE Amsterdam 17.2.x.

- EoMPLS

N-PE devices are connected to each other through a mesh of PWs. Packets from a U-PE device to an N-PE device can be forwarded to other U- PE devices that are connected to the same N-PE device and to other N-PE devices, if any, because split horizon is disabled. Packets in the provider core are not forwarded back to the provider core because split horizon is enabled.

Figure 27: Hierarchical VPLS with MPLS Access Configuration



Features that Support Hierarchical VPLS with MPLS Access Configuration

The following is a list of features that support the Hierarchical VPLS with MPLS Access Configuration:

- VPLS integrated routing and bridging (IRB)
- VPLS MAC address withdrawal
- PW redundancy
- VPLS flow-aware transport PW

How to Configure Hierarchical VPLS with MPLS Access

The following sections provide information on how to configure the Hierarchical VPLS with MPLS Access feature.

Configuring VPLS (Protocol-CLI Method) on an N-PE Device

To configure VPLS (Protocol-CLI method) on an N-PE device, perform this procedure,

Note Repeat this procedure on each N-PE device.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn vfi context** *name* **Example:** `Device(config)# l2vpn vfi context vpn100`	Establishes a Layer 2 VPN VFI between two or more separate networks, and enters L2VFI configuration mode.
Step 4	**vpn id** *vpn id* **Example:** `Device(config-vfi)# vpn id 100`	Sets a VPN ID on the VPLS instance. • Use the same VPN ID for the N-PE devices that belong to the same VPN. • Make sure that the VPN ID is unique for each VPN in the service provider network. The range is from 1 to 4294967295.
Step 5	**member** *ip-address* **encapsulation mpls** **Example:** `Device(config-vfi)# member 4.4.4.4 encapsulation mpls`	Specifies the device that forms a point-to-point L2VPN VFI connection. • *ip-address*: IP address of the VFI neighbor (the N-PE device). • **encapsulation mpls**: Specifies **mpls** as the data encapsulation method.
Step 6	**exit** **Example:** `Device(config-vlan-config)# exit`	Returns to global configuration mode.
Step 7	**vlan configuration** *vlan-id* **Example:** `Device(config)# vlan configuration 100`	Applies the configuration on the VLAN, and enters VLAN configuration mode.
Step 8	**member vfi** *vfi-name* **Example:** `Device(config-vlan-config)# member vfi vpn100`	Binds a VFI instance to a VLAN or an interface.
Step 9	**member** *ip-address* **encapsulation mpls** **Example:**	Specifies the device that forms a point-to-point L2VPN VFI connection.

	Command or Action	Purpose
	Device(config-vlan-config)# **member 19.19.19.19 encapsulation mpls**	• *ip-address*: IP address of the VFI neighbor (the U-PE device). • **encapsulation mpls**: Specifies **mpls** as the data encapsulation method.
Step 10	**end** **Example:** Device(config-vlan-config)# **end**	Exits privileged EXEC mode.

Configuring EoMPLS VLAN (Xconnect Method) on an U-PE Device

To configure EoMPLS VLAN (Xconnect method) on an U-PE device, perform this procedure,

Note Perform this task on each U-PE device

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** Device> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Device# **configure terminal**	Enters global configuration mode.
Step 3	**interface** *interface-id.subinterface* **Example:** Device(config)# **interface TenGigabitEthernet1/6/21.100**	Defines the subinterface to be configured, and enters subinterface configuration mode.
Step 4	**encapsulation dot1q** *vlan-id* **Example:** Device(config-subif)# **encapsulation dot1q 100**	Enables IEEE 802.1Q encapsulation of traffic on the subinterface.
Step 5	**xconnect** *peer-ip-addr vc-id* **encapsulation mpls** **Example:** Device(config-if)# **xconnect 3.3.3.3 150 encapsulation mpls**	Binds the attachment circuit to a PW VC. The syntax for this command is the same as for all the other Layer 2 transports.

	Command or Action	Purpose
Step 6	**exit** **Example:** `Device(config-if)# exit`	Returns to global configuration mode.

Configuration Examples for Hierarchical VPLS with MPLS Access

The following example shows how to configure loopback interface for N-PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface loopback 0
Device(config-if)# ip address 3.3.3.3 255.255.255.255
Device(config-if)# ip ospf 1 area 0
Device(config-if)# end
```

The following example shows how to enable MPLS on N-PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface For 1/0/20
Device(config-if)# ip address 17.0.0.2 255.255.255.0
Device(config-if)# mpls ip
Device(config-if)# ip ospf 1 area 0
Device(config-if)# end
```

The following example shows how to enable VFI on N-PE1:

```
Device> enable
Device# configure terminal
Device(config)# l2vpn vfi context vpn100
Device(config-vfi)# vpn id 100
Device(config-vfi)# member 4.4.4.4 encapsulation mpls
```

The following example shows how to specify a point-to-point Layer 2 VPN (L2VPN) VFI connection on N-PE1:

```
Device> enable
Device# configure terminal
Device(config)# vlan configuration 100
Device(config-vlan-config)# member vfi vpn100
Device(config-vlan-config)# mmember 19.19.19.19 encapsulation mpls
```

The following example shows how to configure loopback interface for N-PE2:

```
Device> enable
Device# configure terminal
Device(config)# interface loopback 0
Device(config-if)# ip address 4.4.4.4 255.255.255.255
Device(config-if)# ip ospf 1 area 0
Device(config-if)# end
```

The following example shows how to enable MPLS on N-PE2:

```
Device> enable
Device# configure terminal
```

```
Device(config)# interface For 1/0/5
Device(config-if)# ip address 13.0.0.2 255.255.255.0
Device(config-if)# mpls ip
Device(config-if)# ip ospf 1 area 0
Device(config-if)# end
```

The following example shows how to enable VFI on the N-PE2:

```
Device> enable
Device# configure terminal
Device(config)# l2vpn vfi context vpn100
Device(config-vfi)# vpn id 100
Device(config-vfi)# member 3.3.3.3 encapsulation mpls
```

The following example shows how to specify a point-to-point L2VPN VFI connection on N-PE2:

```
Device> enable
Device# configure terminal
Device(config)# vlan configuration 100
Device(config-vlan-config)# member vfi vpn100
```

The following example shows how to configure loopback interface for U-PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface loopback 0
Device(config-if)# ip address 19.19.19.19 255.255.255.255
Device(config-if)# ip ospf 1 area 0
Device(config-if)# end
```

The following example shows how to enable MPLS on U-PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface Forty2/1
Device(config-if)# ip address 17.0.0.1 255.255.255.0
Device(config-if)# mpls ip
Device(config-if)# ip ospf 1 area 0
Device(config-if)# end
```

The following example shows how to enable EoMPLS on U-PE1:

```
Device> enable
Device# configure terminal
Device(config)# interface TenGig6/21.100
Device(config-if)# encapsulation dot1q 100
Device(config-if)# xconnect 3.3.3.3 100 encapsulation mpls
```

Additional References for Configuring Hierarchical VPLS with MPLS Access

Related Documents

Related Topic	Document Title
Configuring EoMPLS in VLAN mode (Protocol-CLI method)	Configuring Ethernet-over-MPLS (EoMPLS)

Related Topic	Document Title
Configuring VPLS and VPLS flow-aware transport	Configuring Virtual Private LAN Service (VPLS) and VPLS BGP-Based Autodiscovery

Feature History for Configuring Hierarchical VPLS with MPLS Access

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Amsterdam 17.2.1	Hierarchical VPLS with MPLS Access	Configuring VPLS requires a full mesh of tunnel LSPs between all the PE devices that participate in the VPLS. With full-mesh configuration, signaling overhead and packet replication requirements for each provisioned VC on a PE device are high. Configuring Hierarchical VPLS with MPLS Access reduces signaling overhead and packet replication between devices.s

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http://www.cisco.com/go/cfn.

CHAPTER 16

Configuring VPLS: Routed Pseudowire IRB for IPv4 Unicast

The VPLS: Routed Pseudowire IRB for IPv4 Unicast feature allows a switch interface to route traffic instead of using a router.

Restrictions for Configuring VPLS: Routed Pseudowire IRB for IPv4 Unicast

- This feature is not supported on the C9500-12Q, C9500-16X, C9500-24Q, C9500-40X models of the Cisco Catalyst 9500 Series Switches.
- This feature is not supported on a domain configured with multicast routing protocols.
- This feature is not supported for the IPv6 address family.
- VPLS over GRE is not supported with integrated routing and bridging (IRB).

Information About VPLS: Routed Pseudowire IRB for IPv4 Unicast

The following sections provide information about VPLS: Routed Pseudowire IRB for IPv4 Unicast.

About VPLS: Routed Pseudowire IRB for IPv4 Unicast

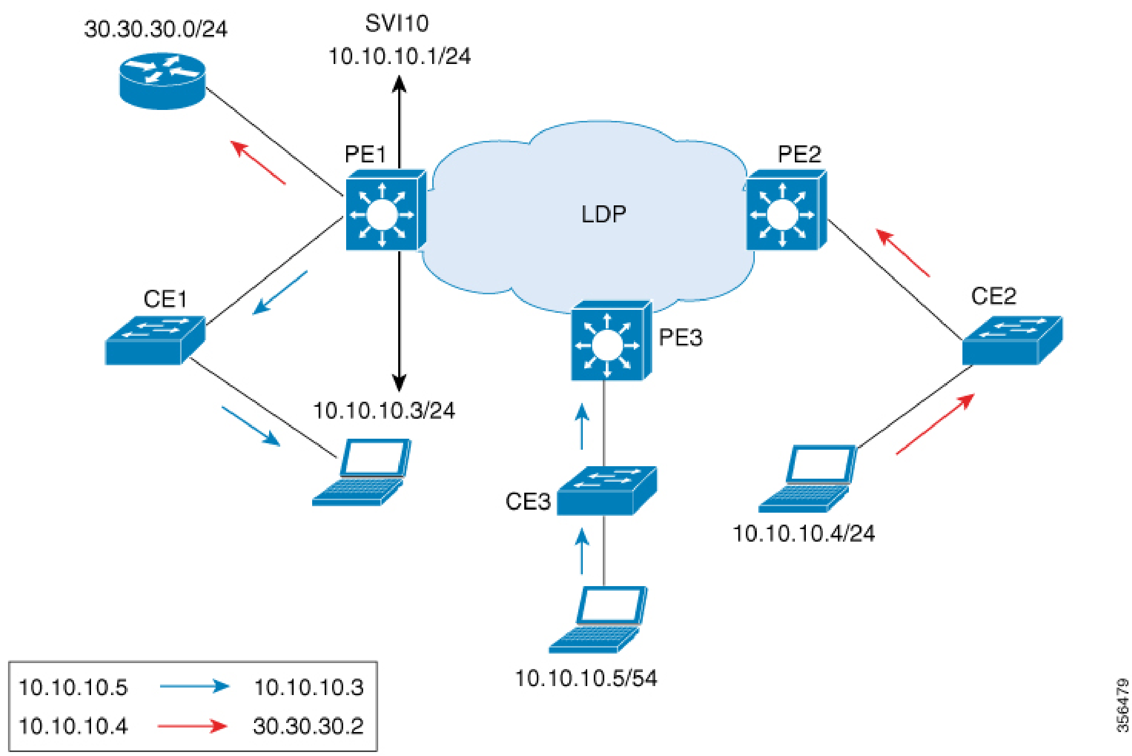
The VPLS: Routed Pseudowire IRB for IPv4 Unicast feature allows a Virtual Private LAN Services (VPLS) multipoint provider edge (PE) device interface to route the Layer 3 traffic along with switch the Layer 2 frames for pseudowire (PW) connections between PE devices. Note that the ability to route frames between interfaces does not affect the termination of a PW into the Layer 3 network (VPN or global) on the same device, or to tunnel Layer 3 frames over a Layer 2 tunnel (VPLS).

Centralized Integrated Routing and Bridging

In centralized Integrated Routing and Bridging (IRB), only one interface on a PE device is configured with IRB in the domain. All the host devices that are connected to PE devices are configured with this IRB interface IP address as the gateway.

The following figure shows a domain configured with centralized IRB. The figure shows that IRB is configured on the PE device (PE1) interface. All the hosts that are connected to the customer edge (CE) devices (CE1, CE2, and CE3), are configured with the IRB interface IP address (10.10.10.1) as the gateway. In this scenario, only those packets that are destined for the Layer 3 router (30.30.30.0/24) undergo Layer 3 packet rewrite because these interfaces or routers are reachable from the PE1 device. All the hosts communicate only in Layer 2 because they are part of the same bridge domain (10.10.10.x).

Figure 28: Centralized IRB

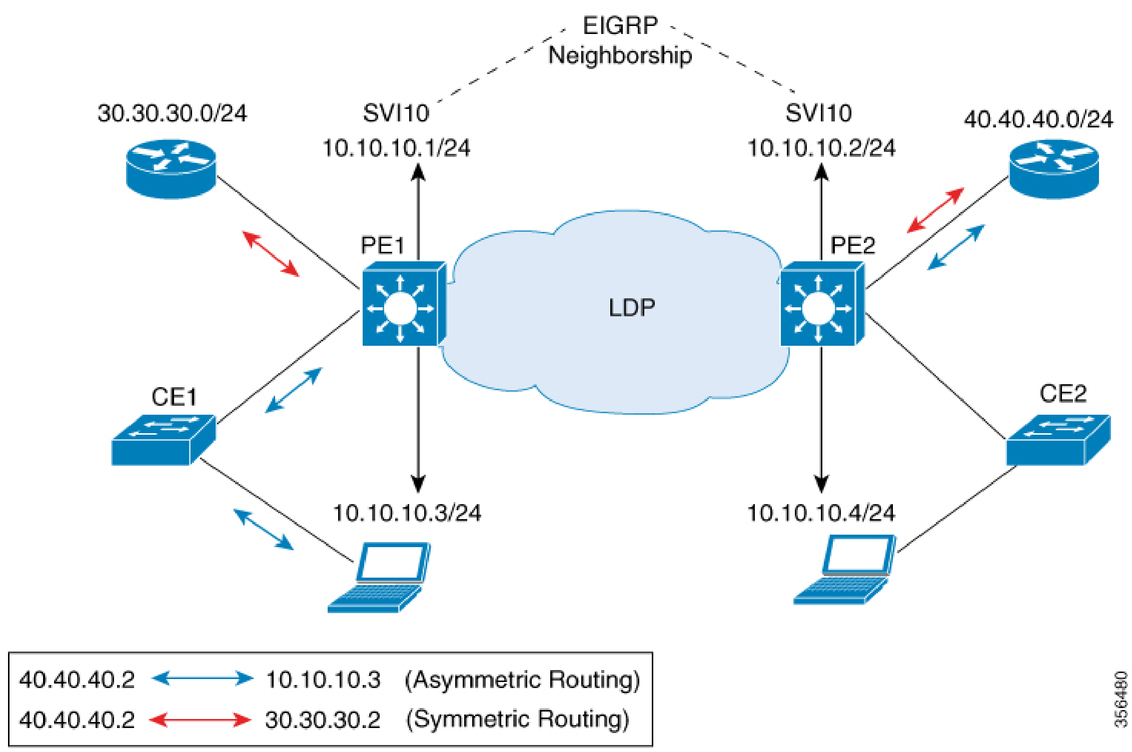


Distributed Integrated Routing and Bridging

In distributed IRB, all the interfaces across all the PE devices are configured with IRB in the domain. The routing protocols enabled on the PE devices allow routes to be learnt between PE devices.

The following figure shows a domain that is configured with distributed IRB. Enhanced Interior Gateway Routing Protocol (EIGRP) is configured on the interfaces of the PE devices (PE1 and PE2), which allows routers (30.30.30.0/24 and 40.40.40.0/24) to exchange routes. Hosts connected to the CE devices are configured with the local IRB interface IP address as the gateway. For example, host 10.10.10.3 is configured with IRB interface IP address 10.10.10.1 as the gateway, and host 10.10.10.4 is configured with IRB interface IP address 10.10.10.2 as the gateway. In this scenario, if the incoming traffic is through a switch virtual interface (SVI), the outgoing traffic can also be reached by SVI through the MPLS network because the relationship is formed across IRB interfaces under the same bridge domain (10.10.10.x).

Figure 29: Distributed IRB



In the above diagram, where traffic is incoming on PE1 destined for a router interface reachable through PE2, routing takes place on egress of the PE (that is, PE2) based on the gateway configuration. In such a scenario, the packet reaching PE2 always has the source MAC as host MAC, and not the gateway MAC (which ages out after aging time). If the gateway MAC ages out, flooding occurs in the reverse direction traffic. Therefore, we recommend that in case of asymmetric routing, you configure an ARP timeout on the IRB interface that is lower than the MAC aging time so that flooding does not occur across PEs in the VPLS domain.

In this scenario (where traffic is incoming from CE1), both ingress and egress interfaces point to the SVI in the forwarding pipeline of PE1. Although this is expected, it generates ICMP redirect messages. Therefore, we recommend that you configure **no ip redirects** command on the SVI in interface configuration mode so that ICMP redirect messages are not generated in case of distributed IRB.

Features Supported with VPLS: Routed Pseudowire IRB for IPv4 Unicast

The following are the features that are supported on an interface that is configured with the VPLS: Routed Pseudowire IRB for IPv4 Unicast feature:

- IPv4 unicast routing protocols
- Virtual routing and forwarding (VRF)

- DHCP relay
- Address Resolution Protocol (ARP) timeout
- Blocking of Internet Control Message Protocol (ICMP) redirect messages

Configuring VPLS: Routed Pseudowire IRB for IPv4 Unicast

To configure VPLS: Routed Pseudowire IRB for IPv4 Unicast, perform this procedure.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface vlan** *vlan-id* **Example:** `Device(config)# interface vlan 100`	Configures a VLAN interface and enters interface configuration mode
Step 4	**xconnect vfi** *vfi-name* **Example:** `Device(config-if)# xconnect vfi VFI100`	Specifies the Layer 2 VFI that you are binding to the VLAN port.
Step 5	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.10.10.1 255.255.255.0`	Assigns the IP address to the interface.

Example: Configuring Distributed IRB

The following example shows how to configure distributed IRB:

```
Device> enable
Device# configure terminal
Device(config)# template type pseudowire VPLS
Device(config-template)# encapsulation mpls
Device(config-template)# l2vpn vfi context VPLS
Device(config-template)# vpn id 10
Device(config-template)# member pseudowire1
Device(config-if)# end
```

```
Device(config)# interface pseudowire1
Device(config-if)# source template type pseudowire VPLS
Device(config-if)# encapsulation mpls
Device(config-if)# signaling protocol ldp
Device(config-if)# neighbor 10.10.10.10 10
Device(config-if)# end

Device(config)# interface Vlan10
Device(config-if)# ip address 10.10.10.1 255.255.255.0
Device(config-if)# no ip redirects
Device(config-if)# member vfi VPLS
Device(config-if)# end
```

Feature History for Configuring VPLS: Routed Pseudowire IRB for IPv4 Unicast

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Amsterdam 17.2.1	VPLS: Routed Pseudowire IRB for IPv4 Unicast	The VPLS: Routed Pseudowire IRB for IPv4 Unicast feature allows a switch interface to route traffic instead of using a router.

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http://www.cisco.com/go/cfn.

CHAPTER 17

Configuring MPLS VPN Route Target Rewrite

Prerequisites for MPLS VPN Route Target Rewrite

- You should know how to configure Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs).
- You need to identify the RT replacement policy and target device for the autonomous system (AS).

Restrictions for MPLS VPN Route Target Rewrite

Route Target Rewrite can only be implemented in a single AS topology.

ip unnumbered command is not supported in MPLS configuration.

Information About MPLS VPN Route Target Rewrite

This section provides information about MPLS VPN Route Target Rewrite:

Route Target Replacement Policy

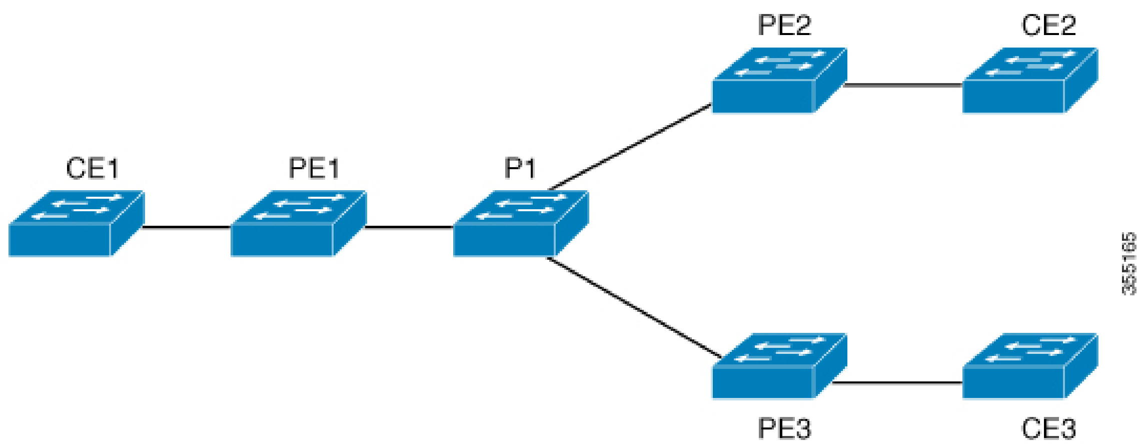
Routing policies for a peer include all configurations that may impact inbound or outbound routing table updates. The MPLS VPN Route Target Rewrite feature can influence routing table updates by allowing the replacement of route targets on inbound and outbound Border Gateway Protocol (BGP) updates. Route targets are carried as extended community attributes in BGP Virtual Private Network IP Version 4 (VPNv4) updates. Route target extended community attributes are used to identify a set of sites and VPN routing and forwarding (VRF) instances that can receive routes with a configured route target.

You can configure the MPLS VPN Route Target Rewrite feature on provider edge (PE) devices.

The figure below shows an example of route target replacement on PE devices in an Multiprotocol Label Switching (MPLS) VPN single autonomous system topology. This example includes the following configurations:

- PE1 is configured to import and export RT 65000:1 for VRF Customer A and to rewrite all inbound VPNv4 prefixes with RT 65000:1 to RT 65000:2.
- PE2 is configured to import and export RT 65000:2 for VRF Customer B and to rewrite all inbound VPNv4 prefixes with RT 65000:2 to RT 65000:1.

Figure 30: Route Target Replacement on Provide Edge(PE) devices in a single MPLS VPN Autonomous System Topology



Route Maps and Route Target Replacement

The MPLS VPN Route Target Rewrite feature extends the Border Gateway Protocol (BGP) inbound/outbound route map functionality to enable route target replacement. The **set extcomm-list delete** command entered in route-map configuration mode allows the deletion of a route target extended community attribute based on an extended community list.

How to Configure MPLS VPN Route Target Rewrite

This section provides the configuration steps for MPLS VPN Route Target Rewrite:

Configuring a Route Target Replacement Policy

Perform this task to configure a route target (RT) replacement policy for your internetwork.

If you configure a provider edge (PE) device to rewrite RT *x* to RT *y* and the PE has a virtual routing and forwarding (VRF) instance that imports RT *x* , you need to configure the VRF to import RT *y* in addition to RT *x* .

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip extcommunity-list** {*standard-list-number* | *expanded-list-number*} {**permit** | **deny**} [*regular-expression*] [**rt** | **soo** *extended-community-value*]
4. **route-map** *map-name* [**permit** | **deny**] [*sequence-number*]
5. **match extcommunity** {*standard-list-number* | *expanded-list-number*}
6. **set extcomm-list** *extended-community-list-number* **delete**
7. **set extcommunity** {**rt** *extended-community-value* [**additive**] | **soo** *extended-community-value*}
8. **end**
9. **show route-map** *map-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip extcommunity-list** {*standard-list-number* | *expanded-list-number*} {**permit** | **deny**} [*regular-expression*] [**rt** | **soo** *extended-community-value*] **Example:** `Device(config)# ip extcommunity-list 1 permit rt 65000:2`	Creates an extended community access list and controls access to it. • The *standard-list-number* argument is an integer from 1 to 99 that identifies one or more permit or deny groups of extended communities. • The *expanded-list-number* argument is an integer from 100 to 500 that identifies one or more permit or deny groups of extended communities. Regular expressions can be configured with expanded lists but not standard lists. • The **permit** keyword permits access for a matching condition. • The **deny** keyword denies access for a matching condition. • The *regular-expression* argument specifies an input string pattern to match against. When you use an expanded extended community list to match route targets, include the pattern RT: in the regular expression.

	Command or Action	Purpose

		• The **rt** keyword specifies the route target extended community attribute. The **rt** keyword can be configured only with standard extended community lists and not expanded community lists.
		• The **soo** keyword specifies the site of origin (SOO) extended community attribute. The **soo** keyword can be configured only with standard extended community lists and not expanded community lists.
		• The *extended-community-value* argument specifies the route target or site of origin. The value can be one of the following combinations:
		  • autonomous-system-number:network-number
		  • ip-address:network-number
		
		The colon is used to separate the autonomous system number and network number or IP address and network number.

Step 4	**route-map** *map-name* [**permit** | **deny**] [*sequence-number*] **Example:** `Device(config)# route-map rtrewrite permit 10`	Defines the conditions for redistributing routes from one routing protocol into another or enables policy routing and enables route-map configuration mode. • The *map-name* argument defines a meaningful name for the route map. The **redistribute** router configuration command uses this name to reference this route map. Multiple route maps can share the same map name. • If the match criteria are met for this route map, and the **permit** keyword is specified, the route is redistributed as controlled by the set actions. In the case of policy routing, the packet is policy routed. If the match criteria are not met, and the **permit** keyword is specified, the next route map with the same map tag is tested. If a route passes none of the match criteria for the set of route maps sharing the same name, it is not redistributed by that set. The **permit** keyword is the default. • If the match criteria are met for the route map and the **deny** keyword is specified, the route is not redistributed. In the case of policy routing, the packet is not policy routed, and no further route maps sharing the same map tag name will be examined. If the packet is not policy routed, the normal forwarding algorithm is used.

	Command or Action	Purpose
		• The *sequence-number* argument is a number that indicates the position a new route map will have in the list of route maps already configured with the same name. If given with the **no** form of this command, the position of the route map should be deleted.

Step 5	**match extcommunity** {*standard-list-number* | *expanded-list-number*}
	Example:
	`Device(config-route-map)# match extcommunity 1`
	Example:
	`Device(config-route-map)# match extcommunity 101`
		Matches the Border Gateway Protocol (BGP) extended community list attributes.
		• The *standard-list-number* argument is a number from 1 to 99 that identifies one or more permit or deny groups of extended community attributes.
		• The *expanded-list-number* argument is a number from 100 to 500 that identifies one or more permit or deny groups of extended community attributes.

Step 6	**set extcomm-list** *extended-community-list-number* **delete** **Example:** `Device(config-route-map)# set extcomm-list 1 delete`	Removes a route target from an extended community attribute of an inbound or outbound BGP Virtual Private Network Version 4 (VPNv4) update. • The *extended-community-list-number* argument specifies the extended community list number.

Step 7	**set extcommunity** {**rt** *extended-community-value* [**additive**] | **soo** *extended-community-value*}
	Example:
	`Device(config-route-map)# set extcommunity rt 65000:1 additive`
		Sets BGP extended community attributes.
		• The **rt** keyword specifies the route target extended community attribute.
		• The **soo** keyword specifies the site of origin extended community attribute.
		• The *extended-community-value* argument specifies the value to be set. The value can be one of the following combinations:
		  • autonomous-system-number : network-number
		  • ip-address : network-number
		The colon is used to separate the autonomous system number and network number or IP address and network number.
		• The **additive** keyword adds a route target to the existing route target list without replacing any existing route targets.

Step 8	**end** **Example:** `Device(config-route-map)# end`	(Optional) Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 9	**show route-map** *map-name* **Example:** `Device# show route-map extmap`	(Optional) Verifies that the match and set entries are correct. • The *map-name* argument is the name of a specific route map.

Applying the Route Target Replacement Policy

Perform the following tasks to apply the route target replacement policy to your network:

Associating Route Maps with Specific BGP Neighbors

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp** *as-number*
4. **neighbor** {*ip-address* | *peer-group-name*} **remote-as** *as-number*
5. **address-family vpnv4** [**unicast**]
6. **neighbor** {*ip-address* | *peer-group-name*} **activate**
7. **neighbor** {*ip-address* | *peer-group-name*} **send-community** [**both** | **extended** | **standard**]
8. **neighbor** {*ip-address* | *peer-group-name*} **route-map** *map-name* {**in** | **out**}
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *as-number* **Example:** `Device(config)# router bgp 100`	Configures a Border Gateway Protocol (BGP) routing process and places the device in router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the device to other BGP devices and tags the routing information passed along.

	Command or Action	Purpose
		The range is 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.
Step 4	**neighbor** {*ip-address* | *peer-group-name*} **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 172.10.0.2 remote-as 200`	Adds an entry to the BGP or multiprotocol BGP neighbor table. • The *ip-address* argument specifies the IP address of the neighbor. • The *peer-group-name* argument specifies the name of a BGP peer group. • The *as-number* argument specifies the autonomous system to which the neighbor belongs.
Step 5	**address-family vpnv4** [**unicast**] **Example:** `Device(config-router)# address-family vpnv4`	Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard Virtual Private Network Version 4 (VPNv4) address prefixes. • The optional **unicast** keyword specifies VPNv4 unicast address prefixes.
Step 6	**neighbor** {*ip-address* | *peer-group-name*} **activate** **Example:** `Device(config-router-af)# neighbor 172.16.0.2 activate`	Enables the exchange of information with a neighboring BGP device. • The *ip-address* argument specifies the IP address of the neighbor. • The *peer-group-name* argument specifies the name of a BGP peer group.
Step 7	**neighbor** {*ip-address* | *peer-group-name*} **send-community** [**both** | **extended** | **standard**] **Example:** `Device(config-router-af)# neighbor 172.16.0.2 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor. • The *ip-address* argument specifies the IP address of the BGP-speaking neighbor. • The *peer-group-name* argument specifies the name of a BGP peer group. • The **both** keyword sends standard and extended community attributes. • The **extended** keyword sends an extended community attribute. • The **standard** keyword sends a standard community attribute.
Step 8	**neighbor** {*ip-address* | *peer-group-name*} **route-map** *map-name* {**in** | **out**} **Example:**	Apply a route map to incoming or outgoing routes • The *ip-address* argument specifies the IP address of the neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 172.16.0.2 route-map extmap in`	• The *peer-group-name* argument specifies the name of a BGP or multiprotocol peer group. • The *map-name* argument specifies the name of a route map. • The **in** keyword applies route map to incoming routes. • The **out** keyword applies route map to outgoing routes.
Step 9	**end** **Example:** `Device(config-router-af)# end`	(Optional) Returns to privileged EXEC mode.

Verifying the Route Target Replacement Policy

SUMMARY STEPS

1. **enable**
2. **show ip bgp vpnv4 vrf** *vrf-name*
3. **exit**

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode. Enter your password if prompted.

Example:

```
Device> enable
Device#
```

Step 2 **show ip bgp vpnv4 vrf** *vrf-name*

Verifies that Virtual Private Network Version 4 (VPNv4) prefixes with a specified route target (RT) extended community attribute are replaced with the proper RT extended community attribute to verify that the provider edge (PE) devices receive the rewritten RT extended community attributes.

Verify route target replacement on PE1:

Example:

```
Device# show ip bgp vpnv4 vrf Customer_A 192.168.1.1/32 internal
BGP routing table entry for 65000:1:192.168.1.1/32, version 6901
Paths: (1 available, best #1, table Customer_A)
  Advertised to update-groups:
     5
  Refresh Epoch 1
  650002
    3.3.3.3 (metric 3) (via default) from 3.3.3.3 (55.5.4.1)
```

```
Origin IGP, metric 0, localpref 100, valid, internal, best
Extended Community: RT:65000:1
mpls labels in/out nolabel/3025
rx pathid: 0, tx pathid: 0x0
net: 0xFFB0A72E38, path: 0xFFB0E6A370, pathext: 0xFFB0E5D970
flags: net: 0x0, path: 0x7, pathext: 0x181
```

Step 3 **exit**

Returns to user EXEC mode:

Example:

```
Device# exit
Device>
```

Configuration Examples for MPLS VPN Route Target Rewrite

The following section provides configuration examples for MPLS VPN Route Target Rewrite:

Examples: Applying Route Target Replacement Policies

Examples: Associating Route Maps with Specific BGP Neighbor

This example shows the association of route map extmap with a Border Gateway Protocol (BGP) neighbor. The BGP inbound route map is configured to replace route targets (RTs) on incoming updates.

```
router bgp 1
address-family vpnv4
neighbor 2.2.2.2 route-map rtrewrite in
```

This example shows the association of the same route map with the outbound BGP neighbor. The route map is configured to replace RTs on outgoing updates.

```
router bgp 1
address-family vpnv4
neighbor 2.2.2.2 route-map rtrewrite out
```

Feature History for MPLS VPN Route Target Rewrite

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Fuji 16.9.1	MPLS VPN Route Target Rewrite	The MPLS VPN Route Target Rewrite feature can influence routing table updates by allowing the replacement of route targets on inbound and outbound Border Gateway Protocol (BGP) updates.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 18

Configuring MPLS VPN-Inter-AS-IPv4 BGP Label Distribution

Information About MPLS VPN InterAS Options

The MPLS VPN InterAS Options provide various ways of interconnecting VPNs between different MPLS VPN service providers. This allows sites of a customer to exist on several carrier networks (autonomous systems) and have seamless VPN connectivity between these sites.

ASes and ASBRs

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, 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.

An AS boundary router (ASBR) is a device in an AS that is connected by using more than one routing protocol, and exchanges routing information with other ASBRs by using an exterior routing protocol (for example, eBGP), or use static routes, or both.

Separate ASes from different service providers communicate by exchanging information in the form of VPN IP addresses and they use the following protocols to share routing information:

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

  iBGP distributes network layer information for IP prefixes within each VPN and each AS.

- 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.

MPLS VPN InterAS Options configuration is supported and can include an inter provider VPN, which is MPLS VPNs that include two or more ASes, connected by separate border edge routers. The ASes exchange routes using eBGP, and no iBGP or routing information is exchanged between the ASes.

MPLS VPN InterAS Options

The following options defined in RFC4364 provide MPLS VPN connectivity between different ASes:

- InterAS Option A – This option provides back-to-back virtual routing and forwarding (VRF) connectivity. Here, MPLS VPN providers exchange routes across VRF interfaces.
- InterAS Option B – This option provides VPNv4 route distribution between ASBRs.

InterAS Option A

In terms of configuration, interAS Option A is the simplest of all available options.

A typical AS consists of these devices – Provider Edge(PE), Customer Edge(CE) and an Autonomous System Boundary Router(ASBR). The target is to enable VRF connectivity between CE devices (also referred to as VPN sites) in a network. In order to facilitate interAS option A, you have to perform the following for each VPN site:

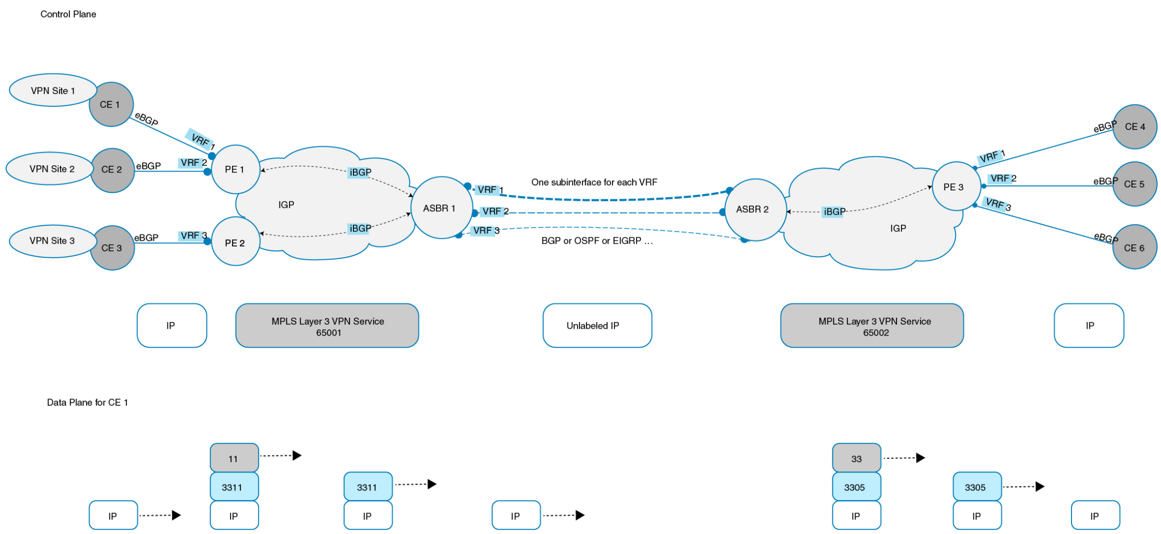
- Assign a VRF interface to each VPN site
- Define an interface or sub-interface for each VRF interface. (If multiple VPN sites are involved, they cannot all be associated with a single interface, and therefore, a sub-interface must be configured for each VRF). Optionally, a dedicated QoS policy may be applied to each subinterface.
- Create a BGP (or other routing protocol) session for each VRF.

With the above configuration in place, traffic flow with option A is as follows: Within the AS, data packets travel like regular Layer 3 VPN traffic. Traffic flow between ASBRs when traversing ASes is in the form of unlabeled IP packets on a VRF interface. Any routing protocol may be used to exchange routing information between the ASBRs in the different ASes.

While this option provides certain advantages (flexibility in terms of the routing protocol that can be used within an AS and between ASBRs, and security by means of a QoS policy on a subinterface), the scale for interAS option A is limited by the scale numbers for subinterfaces and VRFs. This option is therefore suited only to scenarios where the number of VPNs and the number of routes to transfer, is limited (and not likely to increase).

The figure below shows the data packet flow from CE 1, CE 2, CE 3 to CE 4, CE 5, CE 6 respectively. The explanation below takes the instance of the route advertisement and data packet flow from CE1 in AS-65001 to CE 4 in AS-65002.

Figure 31: MPLS VPN InterAS Option A Topology

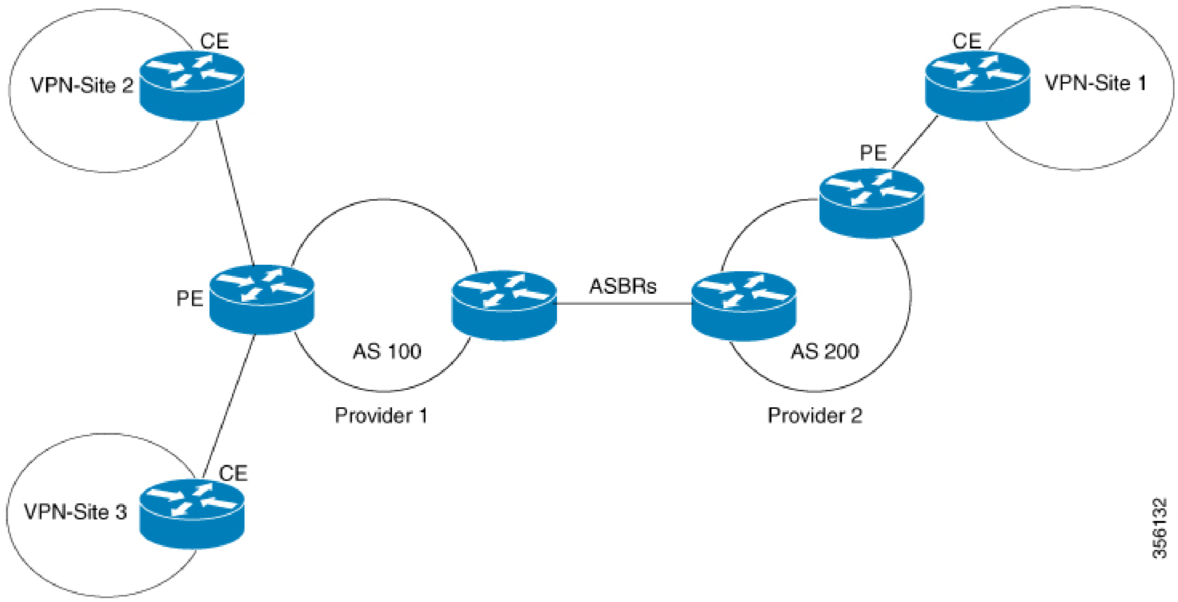


The IP traffic between CE 1 and PE 1 is sent over a VRF sub-interface by using eBGP. Once the packet reaches PE 1 it is sent to ASBR 1 as a two-label MPLS stack. The outermost label is the Interior Gateway protocol (IGP) label and the inner label is the VPN label. Layer 3 VPN traffic is sent from PE 1 to ASBR 1 in AS-65001 and from ASBR 2 to PE 3 in AS-65002 over a MPLS cloud. At ASBR 1, both the labels (IGP and VPN) are popped (removed). From ASBR 1 to ASBR 2 traffic flows as an unlabelled IP packet on a VRF interface. In this example, the routing protocol used between the two ASBRs is eBGP. The two label MPLS stack is pushed once the IP packet reaches ASBR 2. After the packet reaches PE 3, the VPN label is removed. The IGP label is also popped in case of explicit NULL IGP. The VPN packet is sent to CE4 through a VRF interface.

InterAS Option B

In an interAS option B network, ASBR ports are connected by one or more interfaces that are enabled to receive MPLS traffic. With this option, the ASBRs peer with each other using eBGP session. The ASBR also functions as a PE router and peers with every PE router in their AS. The ASBR does not hold any VRFs but holds all or a subset of VPNv4 routes from PE router that need to be passed to the other AS. VPNv4 routes are kept unique in ASBR using route-distinguisher and are filtered using route targets. The ASBRs exchange VPNv4 routes and VPN labels using eBGP.

Figure 32: Topology for InterAS Option B



Two methods are supported to distribute the next hop for VPNv4 routes between ASBRs. There is no requirement for LDP or any IGP to be enabled on the link connecting the two ASBRs. The MP-eBGP session between directly connected interfaces on the ASBRs enables the interfaces to forward labeled packets. To ensure this MPLS forwarding for directly connected BGP peers, you must configure mpls bgp forwarding command on the interface connecting to ASBR. This command is implemented in the IOS for directly connected interfaces. Upto 200 BGP neighbors can be configured.

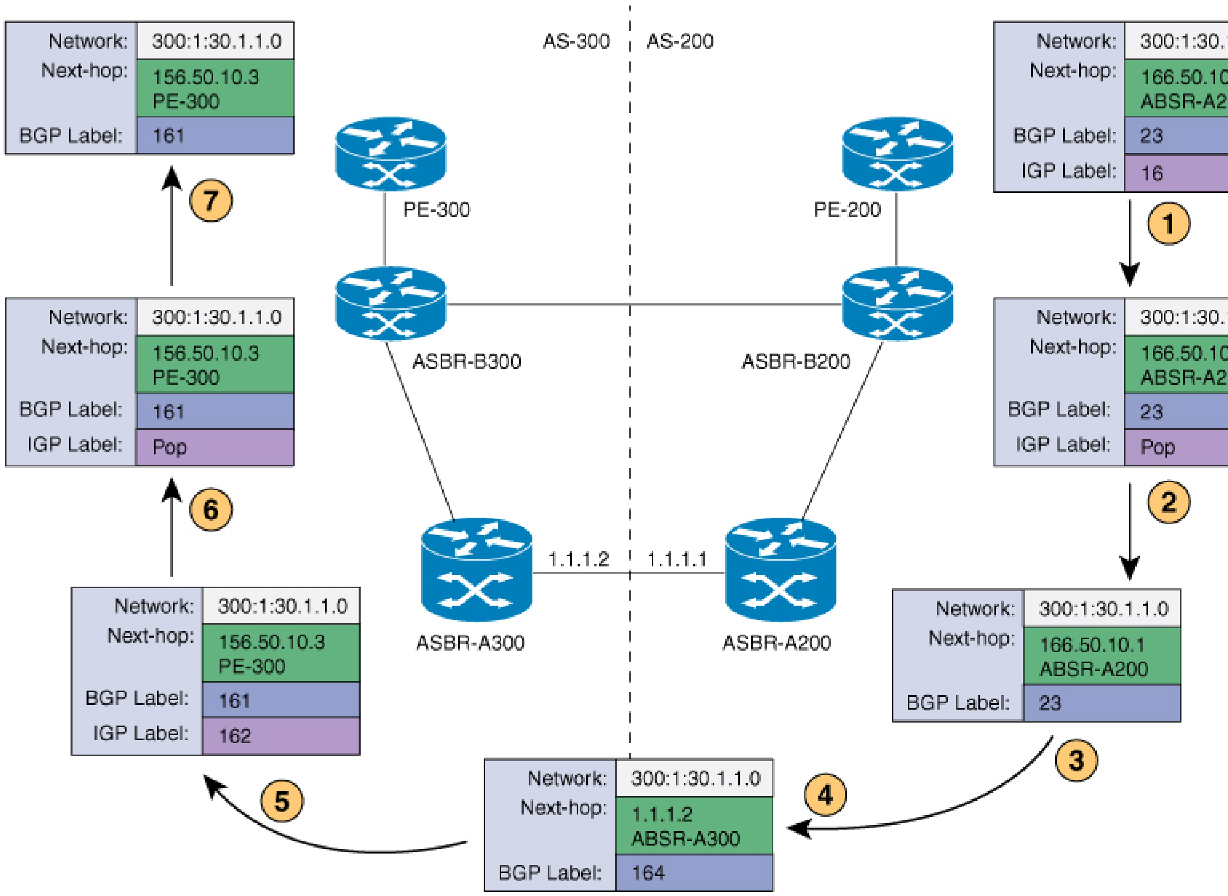
- **Next-hop-self Method:** Changing next-hop to that of the local ASBR for all VPNv4 routes learnt from the other ASBR.
- **Redistribute Connected Subnets Method:** Redistributing the next hop address of the remote ASBR into the local IGP using redistribute connected subnets command , i.e., the next hop is not changed when the VPNv4 routes are redistributed into the local AS.

Note In case of multiple equal paths - ECMP towards remote AS, you have to configure MPLS static label bindings towards remote Loopback on ASBR. Otherwise, you may experience packet loss.

The label switch path forwarding sections described below has AS200 configured with the Next-hop-self method and the AS300 is configured with Redistribute-subnet method.

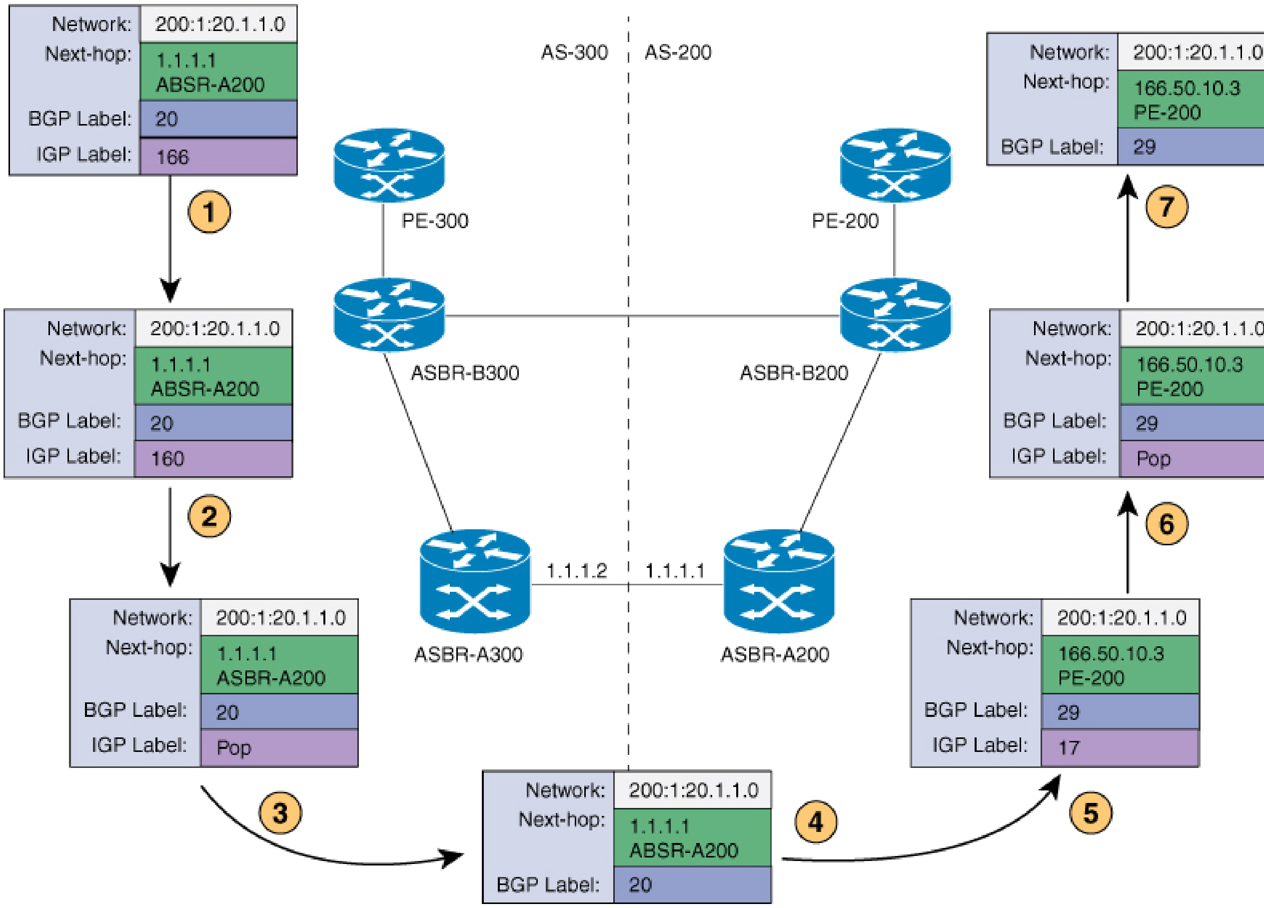
Next-Hop Self Method

The following figure shows the label forwarding path for next-hop-self method. The labels get pushed, swapped and popped on the stack as packet makes its way from PE-200 in AS 200 to PE-300 in AS 300. In step 5, ASBR-A300 receives labeled frame, replaces label 164 with label 161 pushes IGP label 162 onto the label stack.



Redistribute Connected Subnet Method

The following figure shows the label forwarding path for Redistribute connected subnets method. The labels get pushed, swapped and popped on the stack as packet travels from PE- 300 in AS 300 to PE-200 in AS 200. In step 5, ASBR-A200 receives frame with BGP label 20, swaps it with label 29 and pushes label 17.



How to Configure MPLS VPN InterAS Options

The following section provides information about how to configure MPLS VPN InterAS Options.

Configuring MPLS VPN InterAS Option A

Sending AS: Configuring PE

Complete the following tasks to configure the PE which is in the AS sending data to another AS.

Sending AS: Configuring a VRF for a PE

Beginning in user EXEC mode complete the following steps to configure a VRF for a PE which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*
5. **address-family ipv4**
6. **route−target export** *route-target-ext-community*
7. **route−target import** *route-target-ext-community*
8. **exit−address−family**
9. **address−family ipv6**
10. **route−target export** *route-target-ext-community*
11. **route−target import** *route-target-ext-community*
12. **exit-address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:1`	Creates routing and forwarding tables for a VRF instance.

Step 5	**address-family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.

Step 6	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:1`	Creates a list of export route target communities for the specified VRF.

	Command or Action	Purpose
Step 7	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:2`	Creates a list of import route target communities for the specified VRF.

Step 8	**exit−address−family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to VRF configuration mode.

Step 9	**address−family ipv6** **Example:** `Device(config-vrf)# address-family ipv6`	Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.
Step 10	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:101`	Creates a list of export route target communities for the specified VRF.
Step 11	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:102`	Creates a list of import route target communities for the specified VRF.

Step 12	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to VRF configuration mode.

Sending AS: Configuring a PE-CE Interface

Beginning in privileged EXEC mode complete the following steps to configure a PE-CE interface which is in the sending AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]
6. **exit**

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface Gi1/1/0/13.1`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-if)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-if)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-if)# ip address 140.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Step 6	**exit**
	Example:
	`Device(config-if)# exit`
	`Device(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Sending AS: Configuring BGP

Beginning in user EXEC mode complete the following steps to configure a BGP session for a PE which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp** *autonomous-system-number*
4. **neighbor** *ip-address* **remote-as** *as-number*
5. **address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]

6. **neighbor** *ip-address* **activate**
7. **exit address-family**
8. **address-family** *vpnv4*
9. **neighbor** *ip-address* **activate**
10. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send-community** [**both** | **standard** | **extended**]
11. **exit address-family**
12. **address-family** *vpnv6*
13. **neighbor** *ip-address* **activate**
14. **neighbor** *ip-address* **send-community extended**
15. **exit address-family**
16. **address-family ipv4 vrf** *vrf-name*
17. **redistribute** *protocol*
18. **neighbor** *ip-address* **remote-as** *as-number*
19. **neighbor** *ip-address* **activate**
20. **exit address-family**
21. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**router bgp** *autonomous-system-number*
	Example:
	`Device(config)# router bgp 65001`
	`Device(config-router)#`
		Configures a BGP routing process.

Step 4	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 2.2.2.2 remote-as 65001`	Configures an entry to the BGP neighbor table.
Step 5	**address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*] **Example:**	Enters address family configuration mode for configuring BGP routing sessions that use standard IPv4 address prefixes.

	Command or Action	Purpose
	`Device(config-router)# address-family ipv4` `Device(config-router-af)#`	
Step 6	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 2.2.2.2 activate`	Enables the exchange of information with a BGP neighbor.

Step 7	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 8	**address-family** *vpnv4*
	Example:
	`Device(config-router)# address-family vpnv4`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 9	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 2.2.2.2 activate`	Enables the exchange of information with a BGP neighbor.
Step 10	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send-community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 2.2.2.2 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 11	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 12	**address-family** *vpnv6*
	Example:
	`Device(config-router)# address-family vpnv6`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

Step 13	**neighbor** *ip-address* **activate** **Example:**	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 2.2.2.2 activate`	
Step 14	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 2.2.2.2 send-community extended`	Specifies that a community attribute should be sent to a BGP neighbor.

Step 15	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 16	**address-family ipv4 vrf** *vrf-name*
	Example:
	`Device(config-router)# address-family ipv4 vrf cu1`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IPv4 address prefixes.

Step 17	**redistribute** *protocol* **Example:** `Device(config-router-af)# redistribute connected`	Redistributes routes from one routing domain into another routing domain.
Step 18	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 140.1.1.2 remote-as 65002`	Configures an entry to the BGP neighbor table.
Step 19	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 140.1.1.2 activate`	Enables the exchange of information with a BGP neighbor.

Step 20	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 21	**exit** **Example:**	Exits router BGP mode.

	Command or Action	Purpose
	`Device(config-router)# exit`	

Sending AS: Configuring a PE-P Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a PE-P interface and IGP which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
4. **no switchport**
5. **ip address** *ip-address mask*
6. **ip ospf** *process-id* **area** *area-id*
7. **mpls ip**
8. **exit**
9. **router ospf** *process-id*
10. **router-id** *ip-address*
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface po91`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Sets the interface to the routed-interface status and erases all Layer 2 configurations.
Step 5	**ip address** *ip-address mask* **Example:**	Sets a primary or secondary IP address for an interface.

	Command or Action	Purpose
	`Device(config-if)# ip address 91.1.1.1 255.255.255.248`	
Step 6	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.
Step 9	**router ospf** *process-id* **Example:** `Device(config)# router ospf 2`	Configures an OSPF routing process and assigns a process number.
Step 10	**router-id** *ip-address* **Example:** `Device(config-router)# router-id 1.1.1.1`	Specifies a fixed router ID.
Step 11	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode and returns to privileged EXEC mode.

Sending AS: Configuring P

Complete the following tasks to configure the P which is in the AS sending data to another AS.

Sending AS: Configuring P-PE Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a P-PE interface and IGP which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
4. **no switchport**
5. **ip address** *ip-address mask*
6. **ip ospf** *process-id* **area** *area-id*
7. **mpls ip**

8. **exit**
9. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
10. **no switchport**
11. **ip address** *ip-address mask*
12. **ip ospf** *process-id* **area** *area-id*
13. **mpls ip**
14. **exit**
15. **router ospf** *process-id*
16. **router-id** *ip-address*
17. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface Port-channel91`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Sets the interface to the routed-interface status and erases all Layer 2 configuration.
Step 5	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 91.1.1.2 255.255.255.248`	Sets a primary or secondary IP address for an interface.
Step 6	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 7	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.

	Command or Action	Purpose

Step 8	**exit**
	Example:
	`Device(config-if)# exit`
	`Device(config)#`
		Exits interface configuration mode.

Step 9	**interface** {*interface-id* | *subinterface-id* | *vlan-id*} **Example:** `Device(config)# interface Port-channel92`	Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.
Step 10	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.
Step 11	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 92.1.1.2 255.255.255.248`	Sets a primary or secondary IP address for an interface.
Step 12	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 13	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 14	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.

Step 15	**router ospf** *process-id*
	Example:
	`Device(config)# router ospf 2`
	`Device(config-router)#`
		Configures an OSPF routing process and assign a process number.

Step 16	**router-id** *ip-address* **Example:** `Device(config-router)# router-id 5.5.5.5`	Specifies a fixed router ID.
Step 17	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode, and returns to privileged EXEC mode.

Sending AS: Configuring ASBR

Complete the following tasks to configure the ASBR which is in the AS sending data to another AS.

Sending AS: Configuring VRF for ASBR

Beginning in user EXEC mode complete the following steps to configure a VRF for a ASBR which is in the sending AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*
5. **address-family ipv4**
6. **route-target export** *route-target-ext-community*
7. **route-target import** *route-target-ext-community*
8. **exit-address-family**
9. **address-family ipv6**
10. **route-target export** *route-target-ext-community*
11. **route-target import***route-target-ext-community*
12. **exit-address-family**
13. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:2`	Creates routing and forwarding tables for a VRF instance.

	Command or Action	Purpose

Step 5	**address-family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		The address-family ipv4 command places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv4 address prefixes.

Step 6	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:2`	Creates a list of export route target communities for the specified VRF.
Step 7	**route-target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:1`	Creates a list of import route target communities for the specified VRF.

Step 8	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Leaves the address family configuration mode and returns to router configuration mode.

Step 9	**address-family ipv6** **Example:** `Device(config-vrf)# address-family ipv6`	Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.
Step 10	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 100:102`	Creates a list of export route target communities for the specified VRF.
Step 11	**route-target import***route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 100:101`	Creates a list of import route target communities for the specified VRF.

Step 12	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to router configuration mode.

Step 13	**exit** **Example:**	Exits the router configuration mode and returns to global configuration mode.

	Command or Action	Purpose
	Device(config-vrf)# **exit**	

Sending AS: Configuring Interface Towards the Receiving ASBR

Beginning in privileged EXEC mode complete the following steps to configure an interface towards the receiving ASBR:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface fo1/0/10.1`
	`Device(config-subif)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-subif)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-subif)# ip address 141.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Sending AS: Configuring BGP

Beginning in privileged EXEC mode complete the following steps to configure a BGP session on the ASBR which is in the sending AS:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **bgp log-neighbor changes**
4. **neighbor** *ip-address* **remote-as** *as-number*
5. **neighbor** *ip-address* **update-source** *interface-type interface-number*
6. **address-family ipv4** [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
7. **neighbor** *ip-address* **activate**
8. **exit-address-family**
9. **address-family** *vpnv4*
10. **neighbor** *ip-address* **activate**
11. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
12. **exit-address-family**
13. **address-family** *vpnv6*
14. **neighbor** *ip-address* **activate**
15. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
16. **exit-address-family**
17. **address-family ipv4 vrf** *vrf-name*
18. **redistribute** *protocol*
19. **neighbor** *ip-address* **remote-as** *as-number*
20. **neighbor** *ip-address* **activate**
21. **exit-address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `Device(config-if)# router bgp 65001`	Configures a BGP routing process.
Step 3	**bgp log-neighbor changes** **Example:**	Enables logging of BGP neighbor resets.

	Command or Action	Purpose
	`Device(config-router)# bgp log-neighbor-changes`	
Step 4	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 1.1.1.1 remote-as 65001`	Configures an entry to the BGP neighbor table.
Step 5	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 1.1.1.1 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.

Step 6	**address-family ipv4** [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
	Example:
	`Device(config-router)# address-family ipv4`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 7	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 1.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 8	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits BGP address-family submode.
Step 9	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 10	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 1.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 11	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:**	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 1.1.1.1 send-community both`	

Step 12	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 13	**address-family** *vpnv6*
	Example:
	`Device(config-router)# address-family vpnv6`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

Step 14	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 1.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 15	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 1.1.1.1 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 16	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 17	**address-family ipv4 vrf** *vrf-name* **Example:** `Device(config-router)# address-family ipv4 vrf cu1`	Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.
Step 18	**redistribute** *protocol* **Example:** `Device(config-router-af)# redistribute connected`	Redistributes routes from one routing domain into another routing domain.
Step 19	**neighbor** *ip-address* **remote-as** *as-number* **Example:**	Configures an entry to the BGP neighbor table.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 141.1.1.2 remote-as 65002`	
Step 20	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 141.1.1.2 activate`	Enables the exchange of information with a BGP neighbor.
Step 21	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits BGP address-family submode.

Sending AS: Configuring a ASBR-P Interface and a IGP

Beginning in privileged EXEC mode complete the following steps to configure a ASBR-P interface and a IGP in the sending AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **no switchport**
4. **ip address** *ip-address mask*
5. **ip ospf** *process-id* **area** *area-id*
6. **mpls ip**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*} **Example:** `Device(config)# interface Port-channel92`	Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.
Step 3	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.

	Command or Action	Purpose
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 92.1.1.1 255.255.255.248`	Sets a primary or secondary IP address for an interface.
Step 5	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 2 area 0`	Enables OSPF on an interface.
Step 6	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 7	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Receiving AS: Configuring ASBR

Complete the following tasks to configure the ASBR which is in the AS receiving data from another AS.

Receiving AS: Configuring VRF for ASBR

Beginning in user EXEC mode complete the following steps to configure a VRF for a ASBR which is in the receiving AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vrf definition** *vrf-name*
4. **rd** *route-distinguisher*
5. **address-family ipv4**
6. **route-target import** *route-target-ext-community*
7. **route-target export** *route-target-ext-community*
8. **exit-address-family**
9. **address-family ipv6**
10. **route-target export** *route-target-ext-community*
11. **route-target import** *route-target-ext-community*
12. **exit-address-family**
13. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:3`	Creates routing and forwarding tables for a VRF instance.

Step 5	**address-family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		The address-family ipv4 command places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv4 address prefixes.

Step 6	**route-target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:2`	Creates a list of export route target communities for the specified VRF.
Step 7	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:1`	Creates a list of import route target communities for the specified VRF.
Step 8	**exit-address-family** **Example:** `Device(config-vrf-af)# exit-address-family`	Leaves the address family configuration mode and returns to router configuration mode.

	Command or Action	Purpose

Step 9	**address-family ipv6**
	Example:
	`Device(config-vrf)# address-family ipv6`
	`Device(config-vrf-af)#`
		Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.

Step 10	**route-target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:101`	Creates a list of export route target communities for the specified VRF.
Step 11	**route-target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:102`	Creates a list of import route target communities for the specified VRF.

Step 12	**exit-address-family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to router configuration mode.

Step 13	**exit** **Example:** `Device(config-vrf)# exit`	Exits the router configuration mode and returns to global configuration mode.

Receiving AS: Configuring Interface Towards the Sending ASBR

Beginning in privileged EXEC mode complete the following steps to configure an interface towards the sending ASBR:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]
6. **exit**

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface fo1/0/10.1`
	`Device(config-subif)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-subif)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-subif)# ip address 141.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Step 6	**exit**
	Example:
	`Device(config-subif)# exit`
	`Device(config)#`
		Exits to global configuration mode.

Receiving AS: Configuring BGP

Beginning in privileged EXEC mode complete the following steps to configure a BGP session on the ASBR which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **neighbor** *ip-address* **remote-as** *as-number*
4. **address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
5. **neighbor** *ip-address* **activate**

6. **exit**
7. **address-family** *ipv6*
8. **neighbor** *ip-address* **activate**
9. **exit address-family**
10. **address-family** *vpnv4*
11. **neighbor** *ip-address* **activate**
12. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
13. **exit**
14. **address-family** *vpnv6*
15. **neighbor** *ip-address* **activate**
16. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
17. **exit**
18. **address-family** *ipv4*
19. **neighbor** *ip-address* **remote-as** *as-number*
20. **neighbor** *ip-address* **activate**
21. **exit address-family**
22. **end**

DETAILED STEPS

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

Step 2	**router bgp** *autonomous-system-number*
	Example:
	`Device(config)# router bgp 65002`
	`Device(config-router)#`
		Configures a BGP routing process.

Step 3	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 30.30.30.30 remote-as 65002`	Configures an entry to the BGP neighbor table.

Step 4	**address-family** *ipv4* [**mdt** | **multicast** | **tunnel** | **unicast** [**vrf** *vrf-name*] | [**vrf** *vrf-name*]
	Example:
	`Device(config-router)# address-family ipv4`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

	Command or Action	Purpose
Step 5	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.

Step 6	**exit**
	Example:
	`Device(config-router-af)# exit`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 7	**address-family** *ipv6*
	Example:
	`Device(config-router)# address-family ipv6`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 8	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.

Step 9	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 10	**address-family** *vpnv4*
	Example:
	`Device(config-router)# address-family vpnv4`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

Step 11	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.
Step 12	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 30.30.30.30 send-community both`	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose

Step 13	**exit**
	Example:
	`Device(config-router-af)# exit`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 14	**address-family** *vpnv6*
	Example:
	`Device(config-router)# address-family vpnv6`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 15	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 30.30.30.30 activate`	Enables the exchange of information with a BGP neighbor.
Step 16	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send–community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 30.30.30.30 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 17	**exit**
	Example:
	`Device(config-router-af)# exit`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 18	**address-family** *ipv4*
	Example:
	`Device(config-router)# address-family ipv4 vrf cu1`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 19	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 141.1.1.1 remote-as 65001`	Configures an entry to the BGP neighbor table.
Step 20	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 141.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose

Step 21	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 22	**end** **Example:** `Device(config-router)# end`	Exits router BGP mode and returns to privileged EXEC mode.

Receiving AS: Configuring a ASBR-P Interface and a IGP

Beginning in privileged EXEC mode complete the following steps to configure a ASBR-P interface and a IGP which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **no switchport**
4. **ip address** *ip-address mask*
5. **ip ospf** *process-id* **area** *area-id*
6. **mpls ip**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*} **Example:** `Device(config)# interface FortyGigabitEthernet1/0/13`	Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.
Step 3	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.

	Command or Action	Purpose
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.
Step 5	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.
Step 6	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 7	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Receiving AS: Configuring P

Complete the following tasks to configure the P which is in the AS receiving data from another AS.

Receiving AS: Configuring ASBR-P Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a ASBR-P interface and IGP which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **no switchport**
4. **ip address** *ip-address mask*
5. **ip ospf** *process-id* **area** *area-id*
6. **mpls ip**
7. **exit**
8. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
9. **no switchport**
10. **ip address** *ip-address mask*
11. **ip ospf** *process-id* **area** *area-id*
12. **mpls ip**
13. **exit**
14. **exit**

DETAILED STEPS

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

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface HundredGigE1/0/13`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.1.1.2 255.255.255.0`	Sets a primary or secondary IP address for an interface.
Step 5	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.
Step 6	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables Multiprotocol Label Switching (MPLS) forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.
Step 7	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.

Step 8	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface HundredGigE1/0/4`
	`Device(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 9	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status and erases all Layer 2 configurations.
Step 10	**ip address** *ip-address mask* **Example:**	Sets a primary or secondary IP address for an interface.

	Command or Action	Purpose
	`Device(config-if)# ip address 20.1.1.1 255.255.255.0`	
Step 11	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.
Step 12	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 and IPv6 packets along normally routed paths for a particular interface.

Step 13	**exit**
	Example:
	`Device(config-if)# exit`
	`Device(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Step 14	**exit** **Example:** `Device(config)# exit`	Exits router configuration mode, and returns to privileged EXEC mode.

Receiving AS: Configuring PE

Complete the following tasks to configure the PE which is in the AS receiving data from another AS.

Configuring VRF for PE2

Beginning in privileged EXEC mode complete the following steps to configure a VRF for a PE:

SUMMARY STEPS

1. **configure terminal**
2. **vrf definition** *vrf-name*
3. **rd** *route-distinguisher*
4. **address−family ipv4**
5. **route−target export** *route-target-ext-community*
6. **route−target import** *route-target-ext-community*
7. **exit−address−family**
8. **address−familyipv6**
9. **route−target export** *route-target-ext-community*
10. **route−target import** *route-target-ext-community*
11. **exit−address−family**
12. **exit**

DETAILED STEPS

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

Step 2	**vrf definition** *vrf-name*
	Example:
	`Device(config)# vrf definition cu1`
	`Device(config-vrf)#`
		Configures a VRF table and enters VRF configuration mode.

Step 3	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 1:4`	Creates routing and forwarding tables for a VRF instance.

Step 4	**address−family ipv4**
	Example:
	`Device(config-vrf)# address-family ipv4`
	`Device(config-vrf-af)#`
		The address-family ipv4 command places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv4 address prefixes.

Step 5	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:2`	Creates a list of export route target communities for the specified VRF.
Step 6	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:1`	Creates a list of import route target communities for the specified VRF.

Step 7	**exit−address−family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Leaves the address family configuration mode and returns to router configuration mode.

Step 8	**address−familyipv6**
	Example:
	`Device(config-vrf)# address-family ipv6`
	`Device(config-vrf-af)#`
		Places the device in address family configuration mode, from which you can configure routing sessions that use standard IPv6 address prefixes.

	Command or Action	Purpose
Step 9	**route−target export** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target export 200:102`	Creates a list of export route target communities for the specified VRF.
Step 10	**route−target import** *route-target-ext-community* **Example:** `Device(config-vrf-af)# route-target import 200:101`	Creates a list of import route target communities for the specified VRF.

Step 11	**exit−address−family**
	Example:
	`Device(config-vrf-af)# exit-address-family`
	`Device(config-vrf)#`
		Exits the address family configuration mode and returns to router configuration mode.

Step 12	**exit**
	Example:
	`Device(config-vrf)# exit`
	`Device(config)#`
		Exits the router configuration mode and returns to global configuration mode.

Receiving AS: Configuring PE-CE Interface

Beginning in privileged EXEC mode complete the following steps to configure a PE-CE interface which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
3. **encapsulation dot1q** *vlan-id*
4. **vrf forwarding** *vrf-name*
5. **ip address** *ip address mask* [**secondary**]
6. **exit**

DETAILED STEPS

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

	Command or Action	Purpose

Step 2	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface FortyGigabitEthernet1/0/5.1`
	`Device(config-subif)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 3	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-subif)# encapsulation dot1q 900`	Enables IEEE 802.1Q encapsulation of traffic on a specified interface.
Step 4	**vrf forwarding** *vrf-name* **Example:** `Device(config-subif)# vrf forwarding cu1`	Associates the VRF with the Layer 3 interface.
Step 5	**ip address** *ip address mask* [**secondary**] **Example:** `Device(config-subif)# ip address 151.1.1.1 255.255.255.0`	Sets a primary or secondary IP address for an interface.

Step 6	**exit**
	Example:
	`Device(config-subif)# exit`
	`Device(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Receiving AS: Configuring BGP

Beginning in privileged EXEC mode complete the following steps to configure a BGP session on a PE which is in the receiving AS:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **bgp log-neighbor changes**
4. **neighbor** *ip-address* **remote-as** *as-number*
5. **neighbor** *ip-address* **update-source** *interface-type interface-number*
6. **address-family ipv4**
7. **neighbor** *ip-address* **activate**
8. **exit-address-family**
9. **address-family** *vpnv4*
10. **neighbor** *ip-address* **activate**
11. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]

12. **exit-address-family**
13. **address-family ipv6**
14. **neighbor** *ip-address* **activate**
15. **exit-address-family**
16. **address-family** *vpnv6*
17. **neighbor** *ip-address* **activate**
18. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**]
19. **exit address-family**
20. **address-family ipv4 vrf** *vrf-name*]
21. **redistribute** *protocol*
22. **neighbor** *ip-address* **remote-as** *as-number*
23. **neighbor** *ip-address* **activate**
24. **exit address-family**
25. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `Device(config-if)# router bgp 65002`	Configures a BGP routing process.
Step 3	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor-changes`	Enables logging of BGP neighbor resets.
Step 4	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 10.10.10.10 remote-as 65002`	Configures an entry to the BGP neighbor table.
Step 5	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 10.10.10.10 update-source Loopback30`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.

	Command or Action	Purpose

Step 6	**address-family ipv4**
	Example:
	`Device(config-router)# address-family ipv4`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 7	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.

Step 8	**exit-address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 9	**address-family** *vpnv4*
	Example:
	`Device(config-router)# address-family vpnv4`
	`Device(config-router-af)#`
		Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 10	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.
Step 11	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 10.10.10.10 send-community both`	Enables the exchange of information with a BGP neighbor.

Step 12	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 13	**address-family ipv6** **Example:** `Device(config-router)# address-family ipv6`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv6 address prefixes.

	Command or Action	Purpose
Step 14	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.

Step 15	**exit-address-family**
	Example:
	`Device(config-router-af)# exit-address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 16	**address-family** *vpnv6* **Example:** `Device(config-router)# address-family vpnv6`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 17	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.10 activate`	Enables the exchange of information with a BGP neighbor.
Step 18	**neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **send−community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 10.10.10.10 send-community both`	Enables the exchange of information with a BGP neighbor.
Step 19	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.

Step 20	**address-family ipv4 vrf** *vrf-name*]
	Example:
	`Device(config-router)# address-family ipv4 vrf cu1`
	`Device(config-router-af)#`
		Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.

Step 21	**redistribute** *protocol* **Example:** `Device(config-router-af)# redistribute connected`	Redistributes routes from one routing domain into another routing domain.

	Command or Action	Purpose
Step 22	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 151.1.1.2 remote-as 65003`	Configures an entry to the BGP neighbor table.
Step 23	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 151.1.1.2 activate`	Enables the exchange of information with a BGP neighbor.

Step 24	**exit address-family**
	Example:
	`Device(config-router-af)# exit address-family`
	`Device(config-router)#`
		Exits BGP address-family submode.

Step 25	**exit** **Example:** `Device(config-router)# exit`	Exits router configuration mode.

Receiving AS: Configuring a PE-P Interface and IGP

Beginning in user EXEC mode complete the following steps to configure a PE-P interface and IGP which is in the receiving AS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {*interface-id* | *subinterface-id* | *vlan-id*}
4. **no switchport**
5. **ip address** *ip-address mask*
6. **ip ospf** *process-id* **area** *area-id*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**interface** {*interface-id* | *subinterface-id* | *vlan-id*}
	Example:
	`Device(config)# interface FortyGigabitEthernet1/0/4`
	`(config-if)#`
		Enters interface configuration mode and specifies the Ethernet interface, subinterface, or VLAN to be associated with the VRF.

Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Set the interface to the routed-interface status erases all Layer 2 configurations.
Step 5	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 20.1.1.2 255.255.255.0`	Sets a primary or secondary IP address for an interface.
Step 6	**ip ospf** *process-id* **area** *area-id* **Example:** `Device(config-if)# ip ospf 10 area 0`	Enables OSPF on an interface.

Step 7	**end**
	Example:
	`Device(config-if)# end`
	`Device(config)#`
		Exits interface configuration mode and returns to privileged EXEC mode.

Configuring MPLS VPN InterAS Option B

Configuring InterAS Option B using the Next-Hop-Self Method

To configure interAS Option B on ASBRs using the next-hop-self method, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **router-id** *ip-address*
5. **nsr**
6. **nsf**
7. **redistribute bgp** *autonomous-system-number*
8. **passive-interface** *interface-type interface-number*

9. **network** *ip-address wildcard-mask* **aread** *area-id*
10. **exit**
11. **router bgp** *autonomous-system-number*
12. **bgp router-id** *ip-address*
13. **bgp log-neighbor changes**
14. **no bgp default ipv4-unicast**
15. **no bgp default route-target filter**
16. **neighbor** *ip-address* **remote-as** *as-number*
17. **neighbor** *ip-address* **update-source** *interface-type interface-number*
18. **neighbor** *ip-address* **remote-as** *as-number*
19. **address-family** *ipv4*
20. **neighbor** *ip-address* **activate**
21. **neighbor** *ip-address* **send-label**
22. **exit address-family**
23. **address-family** *vpnv4*
24. **neighbor** *ip-address* **activate**
25. **neighbor** *ip-address* **send-community extended**
26. **neighbor** *ip-address* **next-hop-self**
27. **neighbor** *ip-address* **activate**
28. **neighbor** *ip-address* **send-community extended**
29. **exit address-family**
30. **bgp router-id** *ip-address*
31. **bgp log-neighbor changes**
32. **neighbor** *ip-address* **remote-as** *as-number*
33. **neighbor** *ip-address* **update-source** *interface-type interface-number*
34. **address-family** *vpnv4*
35. **neighbor** *ip-address* **activate**
36. **neighbor** *ip-address* **send-community extended**
37. **exit address-family**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router ospf** *process-id* **Example:**	Configures an OSPF routing process and assign a process number.

	Command or Action	Purpose
	`Device(config)# router ospf 1`	
Step 4	**router-id** *ip-address* **Example:** `Device(config)# router-id 4.1.1.1`	Specifies a fixed router ID.
Step 5	**nsr** **Example:** `Device(config-router)# nsr`	Configures OSPF non-stop routing (NSR).
Step 6	**nsf** **Example:** `Device(config-router)# nsf`	Confgures OSPF non-stop forwarding (NSF).
Step 7	**redistribute bgp** *autonomous-system-number* **Example:** `Device(config-router)# redistribute bgp 200`	Redistributes routes from a BGP autonomous system into and OSPF routing process.

Step 8	**passive-interface** *interface-type interface-number*
	Example:
	`Device(config-router)# passive-interface GigabitEthernet 1/0/10`
	`Device(config-router)# passive-interface Tunnel0`
		Disables Open Shortest Path First (OSPF) routing updates on an interface.

Step 9	**network** *ip-address wildcard-mask* **aread** *area-id* **Example:** `Device(config-router)# network 4.1.1.0 0.0.0.0.255 area 0`	Defines an interface on which OSPF runs and defines the area ID for that interface.
Step 10	**exit** **Example:** `Device(config-router)# exit`	Exits router configuration mode.
Step 11	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 200`	Configures a BGP routing process.
Step 12	**bgp router-id** *ip-address* **Example:**	Configures a fixed router ID for the BGP routing process.

	Command or Action	Purpose
	`Device(config-router)# bgp router-id 4.1.1.1`	
Step 13	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor changes`	Enables logging of BGP neighbor resets.
Step 14	**no bgp default ipv4-unicast** **Example:** `Device(config-router)# no bgp default ipv4-unicast`	Disables advertisement of routing information for address family IPv4.
Step 15	**no bgp default route-target filter** **Example:** `Device(config-router)# no bgp default route-target filter`	Disables automatic BGP route-target community filtering.
Step 16	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 remote-as 200`	Configures an entry to the BGP neighbor table.
Step 17	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.
Step 18	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 remote-as 300`	Configures an entry to the BGP neighbor table.
Step 19	**address-family** *ipv4* **Example:** `Device(config-router)# address-family ipv4`	Enters address family configuration mode for configuring BGP routing sessions that use standard IP Version 4 address prefixes.
Step 20	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.32.1.2 activate`	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
Step 21	**neighbor** *ip-address* **send-label** **Example:** `Device(config-router-af)# neighbor 10.32.1.2 send-label`	Sends MPLS labels with BGP routes to a neighboring BGP router.
Step 22	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.
Step 23	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 24	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 4.1.1.3 activate`	Enables the exchange of information with a BGP neighbor.
Step 25	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 4.1.1.3 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 26	**neighbor** *ip-address* **next-hop-self** **Example:** `Device(config-router-af)# neighbor 4.1.1.3 next-hop-self`	Configure a router as the next hop for a BGP-speaking neighbor. This is the command that implements the next-hop-self method.
Step 27	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.30.1.2 activate`	Enables the exchange of information with a BGP neighbor.
Step 28	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 10.30.1.2 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 29	**exit address-family** **Example:**	Exits BGP address-family submode.

	Command or Action	Purpose
	`Device(config-router-af)# exit address-family`	
Step 30	**bgp router-id** *ip-address* **Example:** `Device(config-router)# bgp router-id 4.1.1.3`	Configures a fixed router ID for the BGP routing process.
Step 31	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor changes`	Enables logging of BGP neighbor resets.
Step 32	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 4.1.1.1 remote-as 200`	Configures an entry to the BGP neighbor table.
Step 33	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 4.1.1.1 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.
Step 34	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 35	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 4.1.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 36	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 4.1.1.1 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 37	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.

Configuring InterAS Option B using Redistribute Connected Method

To configure interAS Option B on ASBRs using the redistribute connected method, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **router-id** *ip-address*
5. **nsr**
6. **nsf**
7. **redistribute connected**
8. **passive-interface** *interface-type interface-number*
9. **network** *ip-address wildcard-mask* **aread** *area-id*
10. **exit**
11. **router bgp** *autonomous-system-number*
12. **bgp router-id** *ip-address*
13. **bgp log-neighbor changes**
14. **no bgp default ipv4-unicast**
15. **no bgp default route-target filter**
16. **neighbor** *ip-address* **remote-as** *as-number*
17. **neighbor** *ip-address* **update-source** *interface-type interface-number*
18. **neighbor** *ip-address* **remote-as** *as-number*
19. **address-family** *vpnv4*
20. **neighbor** *ip-address* **activate**
21. **neighbor** *ip-address* **send-community extended**
22. **neighbor** *ip-address* **activate**
23. **neighbor** *ip-address* **send-community extended**
24. **exit address-family**
25. **mpls ldp router-id** *interface-id* [**force**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**router ospf** *process-id* **Example:** `Device(config)# router ospf 1`	Configures an OSPF routing process and assign a process number.
Step 4	**router-id** *ip-address* **Example:** `Device(config)# router-id 5.1.1.1`	Specifies a fixed router ID.
Step 5	**nsr** **Example:** `Device(config-router)# nsr`	Configures OSPF non-stop routing (NSR).
Step 6	**nsf** **Example:** `Device(config-router)# nsf`	Confgures OSPF non-stop forwarding (NSF).
Step 7	**redistribute connected** **Example:** `Device(config-router)# redistribute connected`	Redistributes the next hop address of the remote ASBR into the local IGP. This is the command that implements redistribute connected method.

Step 8	**passive-interface** *interface-type interface-number*
	Example:
	`Device(config-router)# passive-interface GigabitEthernet 1/0/10`
	`Device(config-router)# passive-interface Tunnel0`
		Disables Open Shortest Path First (OSPF) routing updates on an interface.

Step 9	**network** *ip-address wildcard-mask* **aread** *area-id* **Example:** `Device(config-router)# network 5.1.1.0 0.0.0.0.255 area 0`	Defines an interface on which OSPF runs and defines the area ID for that interface.
Step 10	**exit** **Example:** `Device(config-router)# exit`	Exits router configuration mode.
Step 11	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 300`	Configures a BGP routing process.

	Command or Action	Purpose
Step 12	**bgp router-id** *ip-address* **Example:** `Device(config-router)# bgp router-id 5.1.1.1`	Configures a fixed router ID for the BGP routing process.
Step 13	**bgp log-neighbor changes** **Example:** `Device(config-router)# bgp log-neighbor changes`	Enables logging of BGP neighbor resets.
Step 14	**no bgp default ipv4-unicast** **Example:** `Device(config-router)# no bgp default ipv4-unicast`	Disables advertisement of routing information for address family IPv4.
Step 15	**no bgp default route-target filter** **Example:** `Device(config-router)# no bgp default route-target filter`	Disables automatic BGP route-target community filtering.
Step 16	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 5.1.1.3 remote-as 300`	Configures an entry to the BGP neighbor table.
Step 17	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 4.1.1.3 update-source Loopback0`	Allows Cisco IOS software to use a specific operational interface for TCP connections by the BGP sessions.
Step 18	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 10.30.1.2 remote-as 200`	Configures an entry to the BGP neighbor table.
Step 19	**address-family** *vpnv4* **Example:** `Device(config-router)# address-family vpnv4`	Configures the device in address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.
Step 20	**neighbor** *ip-address* **activate** **Example:**	Enables the exchange of information with a BGP neighbor.

	Command or Action	Purpose
	`Device(config-router-af)# neighbor 5.1.1.3 activate`	
Step 21	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 5.1.1.3 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 22	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.30.1.1 activate`	Enables the exchange of information with a BGP neighbor.
Step 23	**neighbor** *ip-address* **send-community extended** **Example:** `Device(config-router-af)# neighbor 10.30.1.2 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 24	**exit address-family** **Example:** `Device(config-router-af)# exit address-family`	Exits BGP address-family submode.
Step 25	**mpls ldp router-id** *interface-id* [**force**] **Example:** `Device(config-router)# mpls ldp router-id Loopback0 force`	Specifies the preferred interface for determining the LDP router ID.

Verifying MPLS VPN InterAS Options Configuration

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

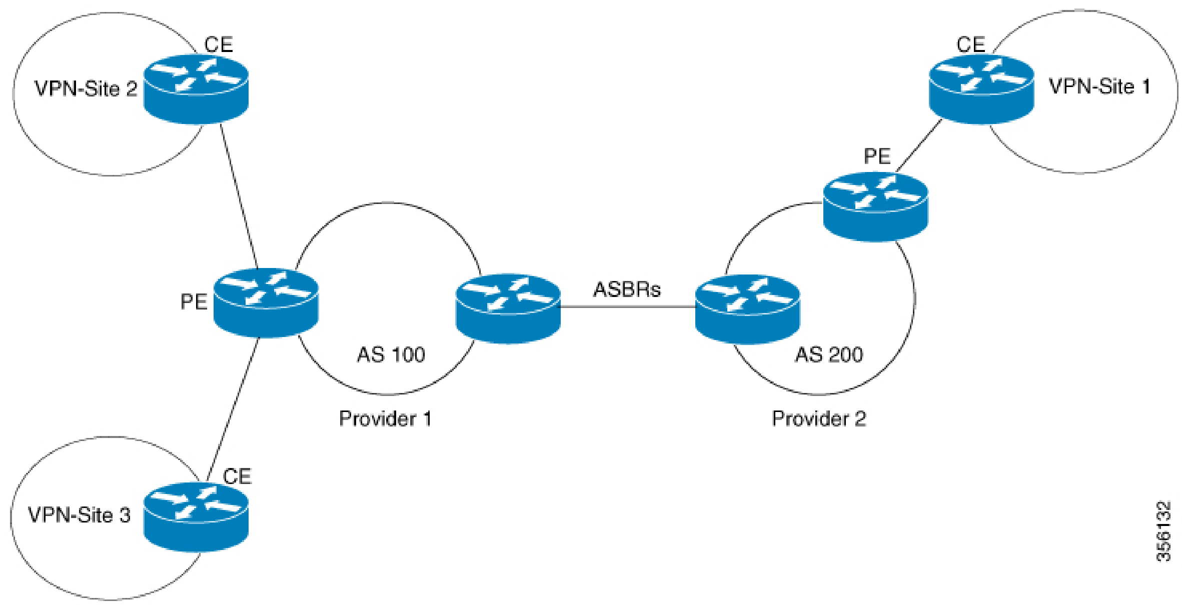
Command	Purpose
ping *ip-address* **source** *interface-type*	Checks the accessibility of devices. Use this command to check the connection between CE1 and CE2 using the loopback interface.
show bgp vpnv4 unicast labels	Displays incoming and outgoing BGP labels.
show mpls forwarding-table	Display the contents of the MPLS Label Forwarding Information Base.
show ip bgp	Displays entries in the BGP routing table.

Command	Purpose
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** } **route vrf** *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** *interface-type interface-id*	Verifies the route distinguisher (RD) and interface that are configured for the VRF.
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 MPLS VPN InterAS Options

Next-Hop-Self Method

Figure 33: Topology for InterAS Option B using Next-Hop-Self Method



Configuration for PE1-P1-ASBR1

PE1	P1	ASBR1
	interface Loopback0 ip address 4.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/4 no switchport ip address 10.10.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/23 no switchport ip address 10.20.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	interface Loopback0 ip address 4.1.1.1 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/10 no switchport ip address 10.30.1.1 255.255.255.0 mpls bgp forwarding interface GigabitEthernet1/0/23 no switchport ip address 10.20.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp router ospf 1 router-id 4.1.1.1 nsr nsf redistribute bgp 200 passive-interface GigabitEthernet1/0/10 passive-interface Tunnel0 network 4.1.1.0 0.0.0.255 area 0 router bgp 200 bgp router-id 4.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 4.1.1.3 remote-as 200 neighbor 4.1.1.3 update-source Loopback0 neighbor 10.30.1.2 remote-as 300 ! address-family ipv4 neighbor 10.30.1.2 activate neighbor 10.30.1.2 send-label exit-address-family ! address-family vpnv4 neighbor 4.1.1.3 activate neighbor 4.1.1.3 send-community extended neighbor 4.1.1.3 next-hop-self neighbor 10.30.1.2 activate neighbor 10.30.1.2 send-community extended exit-address-family

PE1	P1	ASBR1
vrf definition Mgmt-vrf ! address-family ipv4 exit-address-family ! address-family ipv6 exit-address-family ! vrf definition vrf1 rd 200:1 route-target export 200:1 route-target import 200:1 route-target import 300:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 4.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 192.1.1.1 255.255.255.255 ip ospf 200 area 0 ! interface GigabitEthernet2/0/4 no switchport ip address 10.10.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/9 description to-IXIA-1:p8 no switchport vrf forwarding vrf1 ip address 192.2.1.1 255.255.255.0 ip ospf 200 area 0 router ospf 200 vrf vrf1 router-id 192.1.1.1 nsr nsf redistribute connected redistribute bgp 200 network 192.1.1.1 0.0.0.0 area 0 network 192.2.1.0 0.0.0.255 area 0 router ospf 1 router-id 4.1.1.3 nsr nsf redistribute connected router bgp 200 bgp router-id 4.1.1.3 bgp log-neighbor-changes neighbor 4.1.1.1 remote-as 200 neighbor 4.1.1.1 update-source Loopback0		

PE1	P1	ASBR1

`!`
`address-family vpnv4`
`neighbor 4.1.1.1 activate`
`neighbor 4.1.1.1`
`send-community extended`
`exit-address-family`
`!`
`address-family ipv4 vrf vrf1`
`redistribute connected`
`redistribute ospf 200`
`maximum-paths ibgp 2`
`exit-address-family`		

Configuration for ASBR2 – P2 – PE2

Table 7:

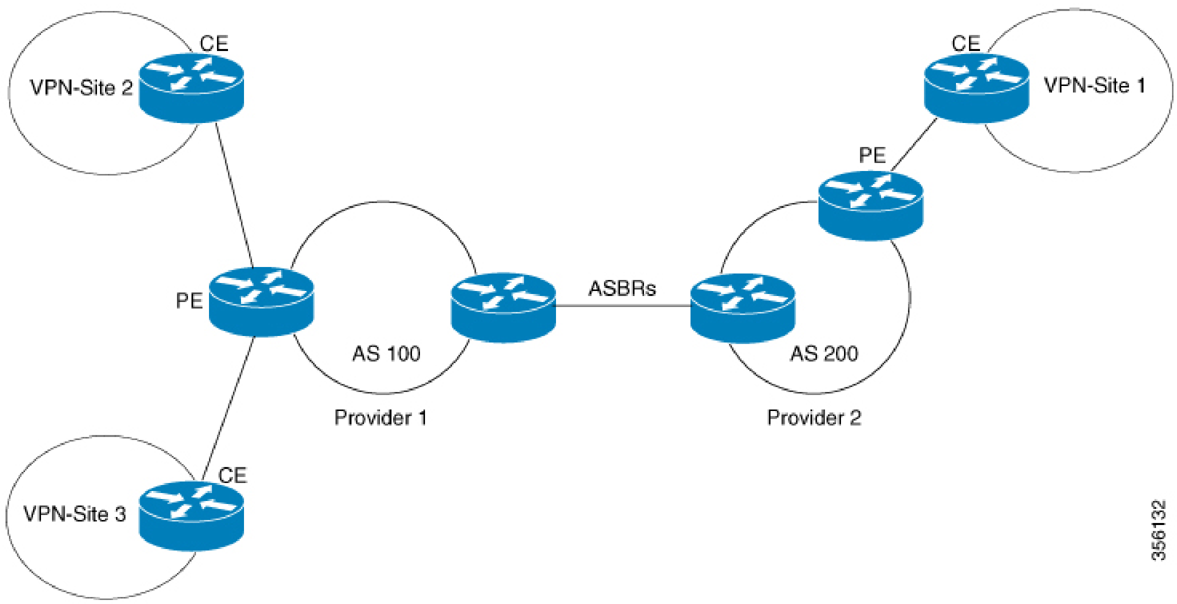
PE2	P2	ASBR2
	interface Loopback0 ip address 5.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/3 no switchport ip address 10.40.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	interface Loopback0 ip address 5.1.1.1 255.255.255.255 ip ospf 1 area 0 ! interface GigabitEthernet1/0/37 no switchport ip address 10.30.1.2 255.255.255.0 mpls bgp forwarding interface GigabitEthernet1/0/47 no switchport ip address 10.40.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp router ospf 1 router-id 5.1.1.1 nsr nsf passive-interface GigabitEthernet1/0/37 passive-interface Tunnel0 network 5.1.1.0 0.0.0.255 area 0 ! router bgp 300 bgp router-id 5.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 5.1.1.3 remote-as 300 neighbor 5.1.1.3 update-source Loopback0 neighbor 10.30.1.1 remote-as 200 ! address-family ipv4 neighbor 10.30.1.1 activate neighbor 10.30.1.1 send-label exit-address-family ! address-family vpnv4 neighbor 5.1.1.3 activate neighbor 5.1.1.3 send-community extended neighbor 5.1.1.3 next-hop-self neighbor 10.30.1.1 activate neighbor 10.30.1.1 send-community extended exit-address-family

PE2	P2	ASBR2
vrf definition vrf1 rd 300:1 route-target export 300:1 route-target import 300:1 route-target import 200:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 5.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 193.1.1.1 255.255.255.255 ip ospf 300 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/2 no switchport vrf forwarding vrf1 ip address 193.2.1.1 255.255.255.0 ip ospf 300 area 0 router ospf 300 vrf vrf1 router-id 193.1.1.1 nsr nsf redistribute connected redistribute bgp 300 network 193.1.1.1 0.0.0.0 area 0 network 193.2.1.0 0.0.0.255 area 0 ! router ospf 1 router-id 5.1.1.3 nsr nsf redistribute connected router bgp 300 bgp router-id 5.1.1.3 bgp log-neighbor-changes neighbor 5.1.1.1 remote-as 300 neighbor 5.1.1.1 update-source Loopback0 ! address-family ipv4 neighbor 5.1.1.1 activate neighbor 5.1.1.1 send-label exit-address-family ! address-family vpnv4 neighbor 5.1.1.1 activate		

PE2	P2	ASBR2
neighbor 5.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf vrf1 redistribute connected redistribute ospf 300 maximum-paths ibgp 2 exit-address-family		

IGP Redistribute Connected Subnets Method

Figure 34: Topology for InterAS Option B using Redistribute Connected Subnets Method



Configuration for PE1-P1-ASBR1

PE1	P1	ASBR1
	interface Loopback0 ip address 4.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/4 no switchport ip address 10.10.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/23 no switchport ip address 10.20.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	router ospf 1 router-id 4.1.1.1 nsr nsf redistribute connected passive-interface GigabitEthernet1/0/10 passive-interface Tunnel0 network 4.1.1.0 0.0.0.255 area 0 router bgp 200 bgp router-id 4.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 4.1.1.3 remote-as 200 neighbor 4.1.1.3 update-source Loopback0 neighbor 10.30.1.2 remote-as 300 ! address-family vpnv4 neighbor 4.1.1.3 activate neighbor 4.1.1.3 send-community extended neighbor 10.30.1.2 activate neighbor 10.30.1.2 send-community extended exit-address-family mpls ldp router-id Loopback0 force

PE1	P1	ASBR1
vrf definition Mgmt-vrf ! address-family ipv4 exit-address-family ! address-family ipv6 exit-address-family ! vrf definition vrf1 rd 200:1 route-target export 200:1 route-target import 200:1 route-target import 300:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 4.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 192.1.1.1 255.255.255.255 ip ospf 200 area 0 ! interface GigabitEthernet2/0/4 no switchport ip address 10.10.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/9 description to-IXIA-1:p8 no switchport vrf forwarding vrf1 ip address 192.2.1.1 255.255.255.0 ip ospf 200 area 0 router ospf 200 vrf vrf1 router-id 192.1.1.1 nsr nsf redistribute connected redistribute bgp 200 network 192.1.1.1 0.0.0.0 area 0 network 192.2.1.0 0.0.0.255 area 0 router ospf 1 router-id 4.1.1.3 nsr nsf redistribute connected router bgp 200 bgp router-id 4.1.1.3 bgp log-neighbor-changes neighbor 4.1.1.1 remote-as 200 neighbor 4.1.1.1 update-source Loopback0		

PE1	P1	ASBR1
! address-family vpnv4 neighbor 4.1.1.1 activate neighbor 4.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf vrf1 redistribute connected redistribute ospf 200 maximum-paths ibgp 2 exit-address-family		

Configuration for ASBR2 – P2 – PE2

PE2	P2	ASBR2
	interface Loopback0 ip address 5.1.1.2 255.255.255.255 ip ospf 1 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.1 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp interface GigabitEthernet2/0/3 no switchport ip address 10.40.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp	router ospf 1 router-id 5.1.1.1 nsr nsf redistribute connected passive-interface GigabitEthernet1/0/10 passive-interface Tunnel0 network 5.1.1.0 0.0.0.255 area 0 router bgp 300 bgp router-id 5.1.1.1 bgp log-neighbor-changes no bgp default ipv4-unicast no bgp default route-target filter neighbor 5.1.1.3 remote-as 300 neighbor 5.1.1.3 update-source Loopback0 neighbor 10.30.1.1 remote-as 200 ! address-family vpnv4 neighbor 5.1.1.3 activate neighbor 5.1.1.3 send-community extended neighbor 10.30.1.1 activate neighbor 10.30.1.1 send-community extended exit-address-family mpls ldp router-id Loopback0 force

PE2	P2	ASBR2
vrf definition vrf1 rd 300:1 route-target export 300:1 route-target import 300:1 route-target import 200:1 ! address-family ipv4 exit-address-family interface Loopback0 ip address 5.1.1.3 255.255.255.255 ip ospf 1 area 0 ! interface Loopback1 vrf forwarding vrf1 ip address 193.1.1.1 255.255.255.255 ip ospf 300 area 0 interface GigabitEthernet1/0/1 no switchport ip address 10.50.1.2 255.255.255.0 ip ospf 1 area 0 mpls ip mpls label protocol ldp ! interface GigabitEthernet1/0/2 no switchport vrf forwarding vrf1 ip address 193.2.1.1 255.255.255.0 ip ospf 300 area 0 router ospf 300 vrf vrf1 router-id 193.1.1.1 nsr nsf redistribute connected redistribute bgp 300 network 193.1.1.1 0.0.0.0 area 0 network 193.2.1.0 0.0.0.255 area 0 ! router ospf 1 router-id 5.1.1.3 nsr nsf redistribute connected router bgp 300 bgp router-id 5.1.1.3 bgp log-neighbor-changes neighbor 5.1.1.1 remote-as 300 neighbor 5.1.1.1 update-source Loopback0 ! address-family ipv4 neighbor 5.1.1.1 activate neighbor 5.1.1.1 send-label exit-address-family ! address-family vpnv4 neighbor 5.1.1.1 activate		

PE2	P2	ASBR2
neighbor 5.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf vrf1 redistribute connected redistribute ospf 300 maximum-paths ibgp 2 exit-address-family		

Additional References for MPLS VPN InterAS Options

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	See the MPLS Commands section of the*Command Reference (Catalyst 9400 Series Switches)*

Feature History for MPLS VPN InterAS Options

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

.

Release	Feature	Feature Information
Cisco IOS XE Gibraltar 16.11.1	MPLS VPN InterAS Option B	InterAS Options use iBGP and eBGP peering to allow VPNs in different AS to communicate with each other. In an interAS option B network, ASBR ports are connected by one or more interfaces that are enabled to receive MPLS traffic.
Cisco IOS XE Amsterdam 17.1.1	MPLS VPN InterAS Option A	MPLS VPN InterAS Option A is the simplest to configure of the available InterAS Options. This option provides back to back virtual routing and forwarding (VRF) connectivity. Here, MPLS VPN providers exchange routes across VRF interfaces.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.

CHAPTER 19

Configuring Seamless MPLS

Information about Seamless MPLS

The following sections provide information about Seamless MPLS.

Overview of Seamless MPLS

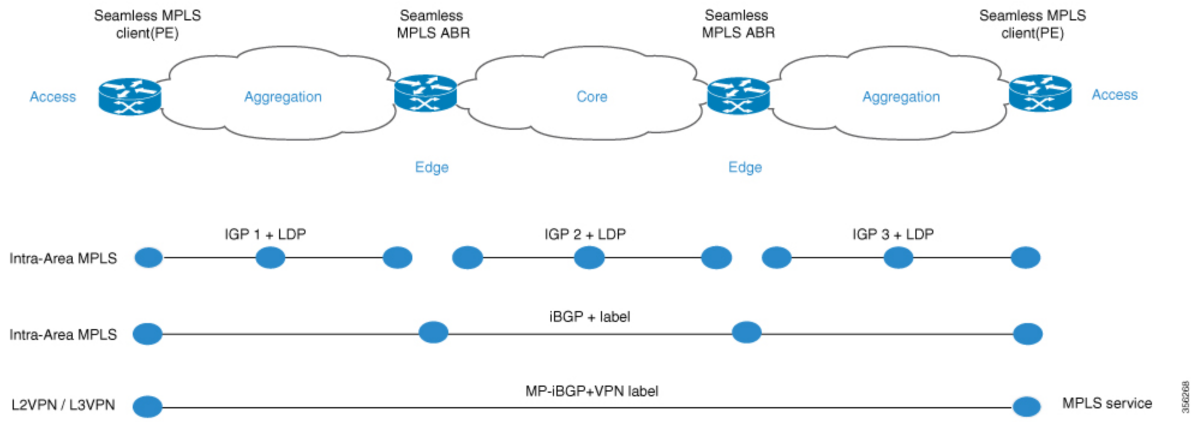
Seamless MPLS provides a highly flexible and scalable architecture to integrate multiple networks into a single MPLS domain. It is based on existing and well known protocols.

A large MPLS network can have several types of platforms and services in different parts of the network. Such a network would usually be divided into areas such as a core area and aggregation areas, and each of these areas have different Interior Gateway Protocols (IGPs). The IGP prefixes from one area cannot be distributed to another area. If the IGP prefixes cannot be distributed, then end-to-end Label-Switched-Paths (LSP) cannot be established. This affects the scalability of the network.

Seamless MPLS introduces greater scalability by establishing end-to-end LSPs. Seamless MPLS uses the Border Gateway Protocol (BGP) instead of IGP to forward the loopback prefixes of the Provider Edge (PE) routers. BGP distributes the prefixes end-to-end. This eliminates the need to install IGP prefixes of one domain in another domain.

Seamless MPLS introduces separation of the service and transport planes and provides end to end service independent transport. It removes the need for service specific configurations in network transport nodes.

Architecture for Seamless MPLS



The figure shows a network with three different areas: one core and two aggregation areas on the side. Each area runs its own IGP, with no redistribution between them on the Area Border Router (ABR). Use of BGP is needed in order to provide an end-to-end MPLS LSP. BGP advertises the loopbacks of the PE routers with a label across the whole domain, and provides an end-to-end LSP. BGP is deployed between the PEs and ABRs.

Seamless MPLs uses BGP to provide an end-to-end MPLS LSP. BGP is deployed between the PEs and the ABRs. BGP sends the IPv4 prefix and label. BGP advertises the loopbacks of the PE routers with a label across the whole domain and provides an end-to-end LSP.

When using IGP in the network, the next-hop address of the prefixes is the loopback prefix of the PE routers. This prefix is not known to the IGP being used in other parts of the network. The next hop address cannot be used to recurse to an IGP prefix. To avoid this the prefixes are carried in BGP. The ABRs are configured as Route Reflectors (RR). And the RRs are configured to set the next hop to self even for the reflected iBGP prefixes.

There are two possible scenarios.

- The ABR does not set the next hop to self for the prefixes advertised (reflected by BGP) by the ABR into the aggregation part of the network. The ABR needs to redistribute the loopback prefixes of the ABRs from the core IGP into the aggregation IGP. Only the ABR loopback prefixes (from the core) need to be advertised into the aggregation part, not the loopback prefixes from the PE routers from the remote aggregation parts.
- The ABR sets the next hop to self for the prefixes advertised (reflected by BGP) by the ABR into the aggregation part. Because of this, the ABR does not need to redistribute the loopback prefixes of the ABRs from the core IGP into the aggregation IGP.

In both scenarios, the ABR sets the next hop to self for the prefixes advertised (reflected by BGP) by the ABR from the aggregation part of the network into the core part.

How to configure Seamless MPLs

The following sections provide information on how to configure Seamless MPLS.

Configuring Seamless MPLS on the PE Router

The following steps can be used to configure Seamless MPLS on the PE Router

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface loopback** *slot/port*
4. **ip address** *ip-address subnet-mask*
5. **interface ethernet** *slot/port*
6. **no ip address**
7. **xconnect** *peer-ip-address vcid* **encapsulation mpls**
8. **router ospf** *process-id*
9. **network** *ip-address wild-mask* **area** *area-id*
10. **network** *ip-address wild-mask* **area** *area-id*
11. **router bgp** *autonomous-system-number*
12. **bgp log neighbor changes**
13. **address-family ipv4**
14. **network** *network-number* **mask** *network-mask*
15. **no bgp default ipv4 unicast**
16. **no bgp default route-target filter**
17. **neighbor** *ip-address* **remote-as** *autonomous-system-number*
18. **neighbor** *ip-address* **update-source** *interface-type interface-number*
19. **neighbor** *ip-address* **send-label**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface loopback** *slot/port* **Example:** `Device(config-if)# interface Loopback0`	Configures a Loopback interface and enters interface configuration mode.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Device(config-if)ip address 10.100.1.4 255.255.255.255`	Enters the IP address for the interface.

	Command or Action	Purpose
Step 5	**interface ethernet** *slot/port* **Example:** `Device(config-if)# interface Ethernet1/0`	Configures an Ethernet interface and enters interface configuration mode.
Step 6	**no ip address** **Example:** `Device(config-if)# no ip address`	Removes an IP address definition.
Step 7	**xconnect** *peer-ip-address vcid* **encapsulation mpls** **Example:** `Device(config-if)# xconnect 10.100.1.5 100 encapsulation mpls`	Specifies MPLS as the tunneling method to encapsulate.
Step 8	**router ospf** *process-id* **Example:** `Device(config)# router ospf 2`	Configures the OSPF routing process.
Step 9	**network** *ip-address wild-mask* **area** *area-id* **Example:** `Device(config-router)# network 10.2.0.0 0.0.255.255 area 0`	Defines the interfaces on which OSPF runs and defines the area ID for those interfaces.
Step 10	**network** *ip-address wild-mask* **area** *area-id* **Example:** `Device(config-router)# network 10.100.1.4 0.0.0.0 area 0`	Defines the interfaces on which OSPF runs and defines the area ID for those interfaces.
Step 11	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 1`	Configures the BGP routing process.
Step 12	**bgp log neighbor changes** **Example:** `Device(config-router)# bgp log neighbor changes`	Enables logging of BGP neighbor resets.
Step 13	**address-family ipv4** **Example:** `Device(config-router)# address-family ipv4`	Enters address family configuration mode.
Step 14	**network** *network-number* **mask** *network-mask* **Example:** `Device(config-router-af)# network 10.100.1.4 mask 255.255.255.255`	Specifies the networks to be advertised by BGP and multiprotocol BGP routing processes.

	Command or Action	Purpose
Step 15	**no bgp default ipv4 unicast** **Example:** `Device(config-router-af)# no bgp default ipv4 unicast`	Disables default IPv4 unicast address family for peering session establishment
Step 16	**no bgp default route-target filter** **Example:** `Device(config-router-af)# no bgp default route-target filter`	Disables automatic BGP route-target community filtering.
Step 17	**neighbor** *ip-address* **remote-as** *autonomous-system-number* **Example:** `Device(config-router-af)# neighbor 10.100.1.1 remote-as 1`	Adds an entry to the BGP or multiprotocol BGP neighbor table.
Step 18	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router-af)# neighbor 10.100.1.1 update-source Loopback0`	Allows BGP sessions to use any operational interface for TCP connections.
Step 19	**neighbor** *ip-address* **send-label** **Example:** `Device(config-router-af)# neighbor 10.100.1.1 send-label`	Enables a BGP router to send MPLS labels with BGP routes to a neighboring BGP router.

Configuring Seamless MPLS on the Route Reflector

The following steps can be used to configure Seamless MPLS on the Route Reflector.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface loopback** *slot/port*
4. **ip address** *ip-address subnet-mask*
5. **router ospf** *process-id*
6. **network** *ip-address wild-mask* **area** *area-id*
7. **network** *ip-address wild-mask* **area** *area-id*
8. **exit**
9. **router ospf** *process-id*
10. **redistribute ospf** *instance-tag* **route-map** *map-name*
11. **network** *ip-address wild-mask* **area** *area-id*
12. **exit**

13. **router bgp** *autonomous-system-number*
14. **bgp log neighbor changes**
15. **address-family ipv4**
16. **neighbor** *ip-address* **remote-as** *autonomous-system-number*
17. **neighbor** *ip-address* **update-source** *interface-type interface-number*
18. **neighbor** *ip-address* **next-hop-self all**
19. **neighbor** *ip-address* **send-label**
20. **neighbor** *ip-address* **remote-as** *autonomous-system-number*
21. **neighbor** *ip-address* **update-source** *interface-type interface-number*
22. **neighbor** *ip-address* **route-reflector-client**
23. **neighbor** *ip-address* **next-hop-self all**
24. **neighbor** *ip-address* **send-label**
25. **exit**
26. **ip prefix-list** *name* **seq** *number* **permit** *prefix*
27. **route-map** *name* **permit** *sequence-number*
28. **match ip address prefix-list** *prefix-list-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface loopback** *slot/port* **Example:** `Device(config-if)# interface Loopback0`	Configures a Loopback interface and enters interface configuration mode.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Device(config-if)# ip address 10.100.1.1 255.255.255.255`	Enters the IP address for the interface.
Step 5	**router ospf** *process-id* **Example:** `Device(config)# router ospf 1`	Configures the OSPF routing process.
Step 6	**network** *ip-address wild-mask* **area** *area-id* **Example:**	Defines the interfaces on which OSPF runs and defines the area ID for those interfaces.

	Command or Action	Purpose
	`Device(config-router)# network 10.1.0.0 0.0.255.255 area 0`	
Step 7	**network** *ip-address wild-mask* **area** *area-id* **Example:** `Device(config-router)# 10.100.1.1 0.0.0.0 area 0`	Defines the interfaces on which OSPF runs and defines the area ID for those interfaces.
Step 8	**exit** **Example:** `Device(config-router)#exit`	Exits the configuration mode.
Step 9	**router ospf** *process-id* **Example:** `Device(config)# router ospf 2`	Configures the OSPF routing process.
Step 10	**redistribute ospf** *instance-tag* **route-map** *map-name* **Example:** `Device(config-router)# redistribute ospf 1 subnets match internal route-map ospf1-into-ospf2`	Injects routes from one routing domain into OSPF.
Step 11	**network** *ip-address wild-mask* **area** *area-id* **Example:** `Device(config-router)# network 10.2.0.0 0.0.255.255 area 0`	Defines the interfaces on which OSPF runs and defines the area ID for those interfaces.
Step 12	**exit** **Example:** `Device(config-router)#exit`	Exits the configuration mode.
Step 13	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 1`	Configures the BGP routing process.
Step 14	**bgp log neighbor changes** **Example:** `Device(config-router)# bgp log neighbor changes`	Enables logging of BGP neighbor resets.
Step 15	**address-family ipv4** **Example:** `Device(config-router)# address family ipv4`	Enters address family configuration mode.
Step 16	**neighbor** *ip-address* **remote-as** *autonomous-system-number* **Example:** `Device(config-route-af)# neighbor 10.100.1.2 remote-as 1`	Adds an entry to the BGP or multiprotocol BGP neighbor table.

	Command or Action	Purpose
Step 17	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router-af)# neighbor 10.100.1.2 update-source Loopback0`	Allows BGP sessions to use any operational interface for TCP connections.
Step 18	**neighbor** *ip-address* **next-hop-self all** **Example:** `Device(config-router-af)# neighbor 10.100.1.2 next-hop-self all`	Configures a router as the next hop for a BGP-speaking neighbor or peer group.
Step 19	**neighbor** *ip-address* **send-label** **Example:** `Device(config-router-af)# neighbor 10.100.1.2 send-label`	Enables a BGP router to send MPLS labels with BGP routes to a neighboring BGP router.
Step 20	**neighbor** *ip-address* **remote-as** *autonomous-system-number* **Example:** `Device(config-router-af)# neighbor 10.100.1.4 remote-as 1`	Adds an entry to the BGP or multiprotocol BGP neighbor table.
Step 21	**neighbor** *ip-address* **update-source** *interface-type interface-number* **Example:** `Device(config-router-af)# neighbor 10.100.1.4 update-source Loopback0`	Allows BGP sessions to use any operational interface for TCP connections.
Step 22	**neighbor** *ip-address* **route-reflector-client** **Example:** `Device(config_router-af)# neighbor 10.100.1.4 route-reflector-client`	Configures the router as a BGP route reflector and configure the specified neighbor as its client.
Step 23	**neighbor** *ip-address* **next-hop-self all** **Example:** `Device(config-router-af)# neighbor 10.100.1.4 next-hop-self all`	Configures a router as the next hop for a BGP-speaking neighbor or peer group.
Step 24	**neighbor** *ip-address* **send-label** **Example:** `Device(config-router-af)# neighbor 10.100.1.4 send-label`	Enables a BGP router to send MPLS labels with BGP routes to a neighboring BGP router.
Step 25	**exit** **Example:** `Device(config-router)#exit`	Exits the configuration mode.

	Command or Action	Purpose
Step 26	**ip prefix-list** *name* **seq** *number* **permit** *prefix* **Example:** `Device(config)# ip prefix-list prefix-list-ospf1-into-ospf2 seq 5 permit 10.100.1.1/32`	Creates a prefix list to match IP packets or routes against.
Step 27	**route-map** *name* **permit** *sequence-number* **Example:** `Device(config)# route-map ospf1-into-ospf2 permit 10`	Creates the route map entry. Enters route-map configuration mode.
Step 28	**match ip address prefix-list** *prefix-list-name* **Example:** `Device(config-route-map)# match ip address prefix-list prefix-list-ospf1-into-ospf2`	Distributes routes that have a destination IP network number address that is permitted by a prefix list.

Configuration Examples for Seamless MPLS

The following sections provide examples for configuring Seamless MPLS.

Example: Configuring Seamless MPLS on PE Router 1

The following example shows how to configure Seamless MPLS on PE router 1.

```
Device(config-if)#interface Loopback0
 Device(config-if)#ip address 10.100.1.4 255.255.255.255
!
Device(config-if)# interface Ethernet1/0
Device(config-if)# no ip address
Device(config-if)# xconnect 10.100.1.5 100 encapsulation mpls
!
Device(config)# router ospf 2
Device(config-router)# network 10.2.0.0 0.0.255.255 area 0
Device(config-router)# network 10.100.1.4 0.0.0.0 area 0
!
Device(config)#router bgp 1
Device(config-router)# bgp log-neighbor-changes
Device(config-router)# address family ipv4
Device(config-router-af)# network 10.100.1.4 mask 255.255.255.255
Device(config-router-af)# no bgp default ipv4 unicast
Device(config-router-af)# no bgp default route-target filter
Device(config-router-af)# neighbor 10.100.1.1 remote-as 1
Device(config-router-af)# neighbor 10.100.1.1 update-source Loopback0
Device(config-router-af)# neighbor 10.100.1.1 send-label
```

Example: Configuring Seamless MPLS on Route Reflector 1

The following examples shows how to configure Seamless MPLS on route reflector 1.

```
Device(cofig-if)# interface Loopback0
Device(cofig-if)# ip address 10.100.1.1 255.255.255.255
```

```
Device(config)# router ospf 1
Device(config-router)# network 10.1.0.0 0.0.255.255 area 0
Device(config-router)# network 10.100.1.1 0.0.0.0 area 0
!
Device(config)# router ospf 2
Device(config-router)# redistribute ospf 1 subnets match internal route-map ospf1-into-ospf2
Device(config-router)# network 10.2.0.0 0.0.255.255 area 0
!
Device(config)# router bgp 1
Device(config-router)# bgp log-neighbor-changes
Device(config-router)# address family ipv4
Device(config-router-af)# neighbor 10.100.1.2 remote-as 1
Device(config-router-af)# neighbor 10.100.1.2 update-source Loopback0
Device(config-router-af)# neighbor 10.100.1.2 next-hop-self all
Device(config-router-af)# neighbor 10.100.1.2 send-label
Device(config-router-af)# neighbor 10.100.1.4 remote-as 1
Device(config-router-af)# neighbor 10.100.1.4 update-source Loopback0
Device(config-router-af)# neighbor 10.100.1.4 route-reflector-client
Device(config-router-af)# neighbor 10.100.1.4 next-hop-self all
Device(config-router-af)# neighbor 10.100.1.4 send-label

Device(config)# ip prefix-list prefix-list-ospf1-into-ospf2 seq 5 permit 10.100.1.1/32

Device(config)# route-map ospf1-into-ospf2 permit 10
Device(conifg-route-mao)# match ip address prefix-list prefix-list-ospf1-into-ospf2
```

Example: Configuring Seamless MPLS on PE Router 2

The following example shows how to configure Seamless MPLS on PE router 2.

```
Device(config-if)#interface Loopback0
 Device(config-if)#ip address 10.100.1.5 255.255.255.255
!
Device(config-if)# interface Ethernet1/0
Device(config-if)# no ip address
Device(config-if)# xconnect 10.100.1.4 100 encapsulation mpls
!
Device(config)# router ospf 3
Device(config-router)# network 10.3.0.0 0.0.255.255 area 0
Device(config-router)# network 10.100.1.5 0.0.0.0 area 0
!
Device(config)#router bgp 1
Device(config-router)# bgp log-neighbor-changes
Device(config-router)# address family ipv4
Device(config-router-af)# network 10.100.1.5 mask 255.255.255.255
Device(config-router-af)# no bgp default ipv4 unicast
Device(config-router-af)# no bgp default route-target filter
Device(config-router-af)# neighbor 10.100.1.2 remote-as 1
Device(config-router-af)# neighbor 10.100.1.2 update-source Loopback0
Device(config-router-af)# neighbor 10.100.1.2 send-label
```

Example: Configuring Seamless MPLS on Route Reflector 2

The following examples shows how to configure Seamless MPLS on route reflector 2.

```
Device(cofig-if)# interface Loopback0
Device(cofig-if)# ip address 10.100.1.2 255.255.255.255
Device(config)# router ospf 1
Device(config-router)# network 10.1.0.0 0.0.255.255 area 0
Device(config-router)# network 10.100.1.2 0.0.0.0 area 0
!
```

```
Device(config)# router ospf 3
Device(config-router)# redistribute ospf 1 subnets match internal route-map ospf1-into-ospf3
Device(config-router)# network 10.3.0.0 0.0.255.255 area 0
!
Device(config)# router bgp 1
Device(config-router)# bgp log-neighbor-changes
Device(config-router)# address family ipv4
Device(config-router-af)# neighbor 10.100.1.1 remote-as 1
Device(config-router-af)# neighbor 10.100.1.1 update-source Loopback0
Device(config-router-af)# neighbor 10.100.1.1 next-hop-self all
Device(config-router-af)# neighbor 10.100.1.1  send-label
Device(config-router-af)# neighbor 10.100.1.5 remote-as 1
Device(config-router-af)# neighbor 10.100.1.5 update-source Loopback0
Device(config-router-af)# neighbor 10.100.1.5 route-reflector-client
Device(config-router-af)# neighbor 10.100.1.5 next-hop-self all
Device(config-router-af)# neighbor 10.100.1.5 send-label

Device(config)# ip prefix-list prefix-list-ospf1-into-ospf3 seq 5 permit 10.100.1.1/32

Device(config)# route-map ospf1-into-ospf3 permit 10
Device(conifg-route-mao)# match ip address prefix-list prefix-list-ospf1-into-ospf3
```

Feature History for Seamless MPLS

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Gibraltar 16.12.1	Seamless MPLS	Seamless MPLS provides a highly flexible and scalable architecture to integrate multiple networks into a single MPLS domain. It is based on existing and well known protocols.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.