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CHAPTER 1

MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

The Multiprotocol Label Switching (MPLS) VPN Inter-AS with Autonomous System Boundary Routers (ASBRs) Exchanging VPN-IPv4 Addresses feature allows a MPLS VPN to span service providers and autonomous systems. This module explains how to enable ASBRs to use Exterior Border Gateway Protocol (EBGP) to exchange IPv4 Network Layer Reachability Information (NLRI) in the form of VPN-IPv4 addresses.

• Finding Feature Information, page 1
• Prerequisites for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, page 2
• Restrictions for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, page 2
• Information About MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, page 2
• How to Configure MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, page 11
• Configuration Examples for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, page 16
• Additional References, page 29
• Feature Information for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, page 30

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
Prerequisites for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

- Before you configure Exterior Border Gateway Protocol (EBGP) routing between autonomous systems or subautonomous systems in an Multiprotocol Label Switching (MPLS) VPN, ensure that you have properly configured all MPLS VPN routing instances and sessions. The configuration tasks outlined in this section build from those configuration tasks. Perform the following tasks as described in the Configuring MPLS Layer 3 VPNs module:
  - Define VPN routing instances
  - Configure BGP routing sessions in the MPLS core
  - Configure provider-edge-provider-edge (PE-to-PE) routing sessions in the MPLS core
  - Configure BGP provider-edge-customer-edge (PE-to-CE) routing sessions
  - Configure a VPN-IPv4 EBGP session between directly connected Autonomous System Boundary Routers (ASBRs)

Restrictions for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

Multihop VPN-IPv4 Exterior Border Gateway Protocol (EBGP) is not supported.

Information About MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

MPLS VPN Inter-AS Introduction

An autonomous system is a single network or group of networks that is controlled by a common system administration group and that uses a single, clearly defined routing protocol.

As VPNs grow, their requirements expand. In some cases, VPNs need to reside on different autonomous systems in different geographic areas. Also, some VPNs need to extend across multiple service providers (overlapping VPNs). Regardless of the complexity and location of the VPNs, the connection between autonomous systems must be seamless to the customer.

Benefits of MPLS VPN Inter-AS

An MultiprotocolLabel Switching (MPLS) VPN Inter-AS provides the following benefits:
• Allows a VPN to cross more than one service provider backbone: Service providers running separate autonomous systems can jointly offer MPLS VPN services to the same customer. A VPN can begin at one customer site and traverse different VPN service provider backbones before arriving at another site of the same customer. Previously, MPLS VPN could traverse only a single Border Gateway Protocol (BGP) autonomous system service provider backbone. This feature allows multiple autonomous systems to form a continuous (and seamless) network between customer sites of a service provider.

• Allows a VPN to exist in different areas: A service provider can create a VPN in different geographic areas. Having all VPN traffic flow through one point (between the areas) allows for better rate control of network traffic between the areas.

• Allows confederations to optimize Internal Border Gateway Protocol (IBGP) meshing: IBGP meshing in an autonomous system is more organized and manageable. An autonomous system can be divided into multiple, separate subautonomous systems and then classify them into a single confederation (even though the entire VPN backbone appears as a single autonomous system). This capability allows a service provider to offer MPLS VPNs across the confederation because it supports the exchange of labeled VPN-IPv4 Network Layer Reachability Information (NLRI) between the subautonomous systems that form the confederation.

Use of Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

Separate autonomous systems from different service providers can communicate by exchanging IPv4 Network Layer Reachability Information (NLRI) in the form of VPN-IPv4 addresses. The Autonomous System Border Routers (ASBRs) use Exterior Border Gateway Protocol (EBGP) to exchange network reachability information. Then an Interior Gateway Protocol (IGP) distributes the network layer information for VPN-IPv4 prefixes throughout each VPN and each autonomous system. Routing information uses the following protocols:

• Within an autonomous system, routing information is shared using an IGP.

• Between autonomous systems, routing information is shared using an EBGP. An EBGP allows a service provider to set up an interdomain routing system that guarantees the loop-free exchange of routing information between separate autonomous systems.

The primary function of an EBGP is to exchange network reachability information between autonomous systems, including information about the list of autonomous system routes. The autonomous systems use EBGP border edge devices to distribute the routes, which include label switching information. Each border edge device rewrites the next hop and labels. See the Information Exchange in an MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses, on page 4 section for more information.

Interautonomous system configurations supported in an MPLS VPN are as follows:

• **Interprovider VPN**— MPLS VPNs that include two or more autonomous systems, connected by separate border edge devices. The autonomous systems exchange routes using EBGP. No IGP or routing information is exchanged between the autonomous systems.

• **BGP confederations**— MPLS VPNs that divide a single autonomous system into multiple subautonomous systems, and classify them as a single, designated confederation. The network recognizes the confederation as a single autonomous system. The peers in the different autonomous systems communicate over EBGP sessions; however, they can exchange route information as if they were IBGP peers.
Information Exchange in an MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

This section contains the following topics:

Transmission of Information in an MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

The figure below illustrates an Multiprotocol Label Switching (MPLS) VPN consisting of two separate autonomous systems. Each autonomous system operates under different administrative control and runs a different Interior Gateway Protocol (IGP). Service providers exchange routing information through Exterior Border Gateway Protocol (EBGP) border edge devices (ASBR1, ASBR2).

Figure 1: EBGP Connection Between Two MPLS VPN Inter-AS Systems with ASBRs Exchanging VPN-IPv4 Addresses

This configuration uses the following process to transmit information:
SUMMARY STEPS

1. The provider edge device (PE-1) assigns a label for a route before distributing that route. The PE device uses the multiprotocol extensions of Border Gateway Protocol (BGP) to transmit label mapping information. The PE device distributes the route as a VPN-IPv4 address. The address label and the VPN identifier are encoded as part of the IPv4 Network Layer Reachability Information (NLRI).

2. The two route reflectors (RR-1 and RR-2) reflect VPN-IPv4 internal routes within the autonomous system. The border edge devices (ASBR1 and ASBR2) of the autonomous systems advertise the VPN-IPv4 external routes.

3. The EBGP border edge device (ASBR1) redistributes the route to the next autonomous system (ASBR2). ASBR1 specifies its own address as the value of the EBGP next-hop attribute and assigns a new label. The address ensures the following:

4. The EBGP border edge device (ASBR2) redistributes the route in one of the following ways, depending on its configuration:

DETAILED STEPS

Step 1
The provider edge device (PE-1) assigns a label for a route before distributing that route. The PE device uses the multiprotocol extensions of Border Gateway Protocol (BGP) to transmit label mapping information. The PE device distributes the route as a VPN-IPv4 address. The address label and the VPN identifier are encoded as part of the IPv4 Network Layer Reachability Information (NLRI).

Step 2
The two route reflectors (RR-1 and RR-2) reflect VPN-IPv4 internal routes within the autonomous system. The border edge devices (ASBR1 and ASBR2) of the autonomous systems advertise the VPN-IPv4 external routes.

Step 3
The EBGP border edge device (ASBR1) redistributes the route to the next autonomous system (ASBR2). ASBR1 specifies its own address as the value of the EBGP next-hop attribute and assigns a new label. The address ensures the following:

- The next-hop device is always reachable in the service provider (P) backbone network.
- The label assigned by the distributing device is properly interpreted. (The label associated with a route must be assigned by the corresponding next-hop device.)

Step 4
The EBGP border edge device (ASBR2) redistributes the route in one of the following ways, depending on its configuration:

- If the IBGP neighbors are configured with the `neighbor next-hop-self` command, ASBR2 changes the next-hop address of updates received from the EBGP peer, then forwards it.

- If the IBGP neighbors are not configured with the `neighbor next-hop-self` command, the next-hop address does not change. ASBR2 must propagate a host route for the EBGP peer through the IGP. To propagate the EBGP VPN-IPv4 neighbor host route, use the `redistribute connected subnets` command. The EBGP VPN-IPv4 neighbor host route is automatically installed in the routing table when the neighbor comes up. This is essential to establish the label switched path between PE devices in different autonomous systems.
Exchange of VPN Routing Information in an MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

Autonomous systems exchange VPN routing information (routes and labels) to establish connections. To control connections between autonomous systems, the provider edge (PE) devices and Exterior Border Gateway Protocol (EBGP) border edge devices maintain a Label Forwarding Information Base (LFIB). The LFIB manages the labels and routes that the PE devices and EBGP border edge devices receive during the exchange of VPN information.

The figure below illustrates the exchange of VPN route and label information between autonomous systems. The autonomous systems use the following conditions to exchange VPN routing information:

- Routing information includes:
  - The destination network (N)
  - The next-hop field associated with the distributing device
  - A local MPLS label (L)

- An RD1: route distinguisher is part of a destination network address. It makes the VPN-IPv4 route globally unique in the VPN service provider environment.

- The Autonomous System Border Routers (ASBRs) are configured to change the next-hop (next hop-self) when sending VPN-IPv4 Network Layer Reachability Information (NLRI) to the Internal Border Gateway Protocol (IBGP) neighbors. Therefore, the ASBRs must allocate a new label when they forward the NLRI to the IBGP neighbors.

![Figure 2: Exchanging Routes and Labels Between MPLS VPN Inter-AS Systems with ASBRs Exchanging VPN-IPv4 Addresses](image-url)
The figure below illustrates the exchange of VPN route and label information between autonomous systems. The only difference is that ASBR2 is configured with the `redistribute connected` command, which propagates the host routes to all PEs. The `redistribute connected` command is necessary because ASBR2 is not configured to change the next-hop address.

**Figure 3: Exchanging Routes and Labels with the redistribute connected Command in an MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses**

---

**Packet Forwarding Between MPLS VPN Inter-AS Systems with ASBRs Exchanging VPN-IPv4 Addresses**

The figure below illustrates how packets are forwarded between autonomous systems in an interprovider network using the following packet forwarding method.

Packets are forwarded to their destination by means of Multiprotocol Label Switching (MPLS). Packets use the routing information stored in the Label Forwarding Information Base (LFIB) of each provider edge (PE) device and Exterior Border Gateway Protocol (EBGP) border edge device.

The service provider VPN backbone uses dynamic label switching to forward labels.

Each autonomous system uses standard multilevel labeling to forward packets between the edges of the autonomous system devices (for example, from CE-5 to PE-3). Between autonomous systems, only a single level of labeling is used, corresponding to the advertised route.

A data packet carries two levels of labels when traversing the VPN backbone:
The first label (IGP route label) directs the packet to the correct PE device or EBGP border edge device. (For example, the Interior Gateway Protocol (IGP) label of ASBR2 points to the ASBR2 border edge device.)

The second label (VPN route label) directs the packet to the appropriate PE device or EBGP border edge device.

**Figure 4: Forwarding Packets Between MPLS VPN Inter-AS Systems with ASBRs Exchanging VPN-IPv4 Addresses**
The figure below shows the same packet forwarding method as described in the figure above, except the EBGP device (ASBR1) forwards the packet without reassigning it a new label.

**Figure 5: Forwarding Packets Without a New Label Assignment Between MPLS VPN Inter-AS Systems with ASBRs Exchanging VPN-IPv4 Addresses**

---

**Use of a Confederation for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses**

A confederation is a collection of multiple subautonomous systems that are grouped together. A confederation reduces the total number of peer devices in an autonomous system. A confederation divides an autonomous system into subautonomous systems and assigns a confederation identifier to the autonomous systems. A VPN can span service providers running in separate autonomous systems or in multiple subautonomous systems that form a confederation.

In a confederation, each subautonomous system is fully meshed with other subautonomous systems. The subautonomous systems communicate using an Interior Gateway Protocol (IGP), such as Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS). Each subautonomous system also has an Exterior Border Gateway Protocol (EBGP) connection to the other subautonomous systems. The confederation EBGP (CEBGP) border edge devices forward next-hop-self addresses between the specified subautonomous systems. The next-hop-self address forces the Border Gateway Protocol (BGP) to use a specified address as the next hop rather than letting the protocol choose the next hop.

You can configure a confederation with separate subautonomous systems in either of two ways:

- You can configure a device to forward next-hop-self addresses between only the CEBGP border edge devices (both directions). The subautonomous systems (IBGP peers) at the subautonomous system border do not forward the next-hop-self address. Each subautonomous system runs as a single IGP domain. However, the CEBGP border edge device addresses are known in the IGP domains.

- You can configure a device to forward next-hop-self addresses between the CEBGP border edge devices (both directions) and within the IBGP peers at the subautonomous system border. Each subautonomous
system runs as a single IGP domain but also forwards next-hop-self addresses between the PE devices in the domain. The CEBGP border edge device addresses are known in the IGP domains.

The figure below illustrates a typical MPLS VPN confederation configuration. In this confederation configuration:

- The two CEBGP border edge devices exchange VPN-IPv4 addresses with labels between the two subautonomous systems.
- The distributing device changes the next-hop addresses and labels and uses a next-hop-self address.
- IGP-1 and IGP-2 know the addresses of CEBGP-1 and CEBGP-2.

Figure 6: EBGП Connection Between Two Subautonomous Systems in a Confederation

In this confederation configuration:

- CEBGP border edge devices function as neighboring peers between the subautonomous systems. The subautonomous systems use EBGП to exchange route information.
- Each CEBGP border edge device (CEBGП-1, CEBGP-2) assigns a label for the route before distributing the route to the next subautonomous system. The CEBGP border edge device distributes the route as a VPN-IPv4 address by using the multiprotocol extensions of BGP. The label and the VPN identifier are encoded as part of the IPv4 Network Layer Reachability Information (NLRI).
- Each provider edge (PE) and CEBGP border edge device assigns its own label to each VPN-IPv4 address prefix before redistributing the routes. The CEBGP border edge devices exchange VPN-IPv4 addresses with the labels. The next-hop-self address is included in the label (as the value of the EBGП next-hop attribute). Within the subautonomous systems, the CEBGP border edge device address is distributed throughout the IBGP neighbors, and the two CEBGP border edge devices are known to both confederations.
How to Configure MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

Configuring the ASBRs to Exchange VPN-IPv4 Addresses

To configure an Exterior Border Gateway Protocol (EBGP) Autonomous System Border Router (ASBR) to exchange VPN-IPv4 routes with another autonomous system, perform this task.

Note: Issue the `redistribute connected subnets` command in the Interior Gateway Protocol (IGP) configuration portion of the device to propagate host routes for VPN-IPv4 EBGP neighbors to other devices and provider edge devices. Alternatively, you can specify the next-hop-self address when you configure Internal Border Gateway Protocol (IBGP) neighbors.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `no bgp default route-target filter`
5. `address-family vpnv4 [unicast]`
6. `neighbor peer-group-name remote-as as-number`
7. `neighbor peer-group-name activate`
8. `exit-address-family`
9. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>Command or Action</td>
</tr>
<tr>
<td>------</td>
<td>-------------------</td>
</tr>
</tbody>
</table>
| 3    | `router bgp as-number` | Creates an EBGP routing process and assigns it an autonomous system number.  
  - The autonomous system number is passed along and identifies the device to EBGP devices in another autonomous system. |
| 4    | `no bgp default route-target filter` | Disables BGP route-target filtering and places the device in configuration mode.  
  - All received BGP VPN-IPv4 routes are accepted by the device. |
| 5    | `address-family vpnv4 [unicast]` | Configures a routing session to carry VPNv4 addresses across the VPN backbone and places the device in address family configuration mode.  
  - Each address has been made globally unique by the addition of an 8-byte route distinguisher (RD).  
  - The unicast keyword specifies a unicast prefix. |
| 6    | `neighbor peer-group-name remote-as as-number` | Enters the address family configuration mode and specifies a neighboring EBGP peer group.  
  - This EBGP peer group is identified to the specified autonomous system. |
| 7    | `neighbor peer-group-name activate` | Activates the advertisement of the VPNv4 address family to a neighboring EBGP device. |
| 8    | `exit-address-family` | Exits from the address family submode of the router configuration mode. |
| 9    | `end` | Exits to privileged EXEC mode. |
Configuring EBGP Routing to Exchange VPN Routes Between Subautonomous Systems in a Confederation

Perform this task to configure EBGP routing to exchange VPN routes between subautonomous systems in a confederation.

**Note**
To ensure that the host routes for VPN-IPv4 EBGP neighbors are propagated (by means of the IGP) to the other devices and provider edge devices, specify the `redistribute connected` command in the IGP configuration portion of the CEBGP device. If you are using OSPF, make sure that the OSPF process is not enabled on the CEBGP interface where the “redistribute connected” subnet exists.

**Note**
In this confederation, subautonomous system IGP domains must know the addresses of CEBGP-1 and CEBGP-2. If you do not specify a next-hop-self address as part of the router configuration, ensure that the addresses of all PE devices in the subautonomous system are distributed throughout the network, not just the addresses of CEBGP-1 and CEBGP-2.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. router bgp sub-autonomous-system
4. bgp confederation identifier as-number
5. bgp confederation peers sub-autonomous-system
6. no bgp default route-target filter
7. address-family vpnv4 [unicast]
8. neighbor peer-group-name remote-as as-number
9. neighbor peer-group-name next-hop-self
10. neighbor peer-group-name activate
11. exit-address-family
12. end

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device# configure terminal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp sub-autonomous-system</td>
<td>Creates an EBGP routing process and assigns it an autonomous system number and enters the device in configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config)# router bgp 2</td>
<td>- The subautonomous system number is passed along to identify the device to EBGP devices in other subautonomous systems.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> bgp confederation identifier as-number</td>
<td>Defines an EBGP confederation by specifying a confederation identifier associated with each subautonomous system.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# bgp confederation identifier 100</td>
<td>- The subautonomous systems appear as a single autonomous system.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> bgp confederation peers sub-autonomous-system</td>
<td>Specifies the subautonomous systems that belong to the confederation (identifies neighbors of other subautonomous systems within the confederation as special EBGP peers).</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# bgp confederation peers 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> no bgp default route-target filter</td>
<td>Disables BGP route-target community filtering. All received BGP VPN-IPv4 routes are accepted by the device.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# no bgp default route-target filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> address-family vpnv4 [unicast]</td>
<td>Configures a routing session to carry VPNv4 addresses across the VPN backbone. Each address is made globally unique by the addition of an 8-byte RD. Enters address family configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# address-family vpnv4</td>
<td>- The <strong>unicast</strong> keyword specifies a unicast prefix.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 8</strong> neighbor peer-group-name remote-as as-number</td>
<td>Enters the address family configuration mode and specifies a neighboring EBGP peer group.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 1 remote-as 1</td>
<td>- This EBGP peer group is identified to the specified subautonomous system.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong> neighbor peer-group-name next-hop-self</td>
<td>Advertises the device as the next hop for the specified neighbor.</td>
<td></td>
</tr>
</tbody>
</table>
### Summary Steps

1. `enable`
2. `show ip bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name} [summary] [labels]`
3. `show mpls forwarding-table [network {mask | length} | labels label [-label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]] [vrf vrf-name] [detail]`
4. `disable`

### Detailed Steps

<table>
<thead>
<tr>
<th>Command or Action</th>
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</tr>
</thead>
<tbody>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
</tbody>
</table>
### Step 2

**show ip bgp vpnv4**

- **Example:**
  
  ```
  Device# show ip bgp vpnv4 all labels
  ```

  Displays VPN address information from the BGP table.

  - Use the **all** and **labels** keywords to display information about all VPNv4 labels.

### Step 3

**show mpls forwarding-table**

- **Example:**
  
  ```
  Device# show mpls forwarding-table
  ```

  Displays the contents of the MPLS LFIB (such as VPNv4 prefix/length and BGP next-hop destination for the route).

### Step 4

**disable**

- **Example:**
  
  ```
  Device# disable
  ```

  Returns to user EXEC mode.

---

### Configuration Examples for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

**Example: Configuring MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses**

The network topology in the figure below shows two autonomous systems, which are configured as follows:

- Autonomous system 1 (AS1) includes provider edge 1 (PE1), P1, and Exterior Border Gateway Protocol 1(EBGP1). The Interior Gateway Protocol (IGP) is Open Shortest Path First(OSPF).
- Autonomous system 2 (AS2) includes PE2, P2, and EBGP2. The IGP is Intermediate System to Intermediate System (IS-IS).
- Customer edge 1 (CE1) and CE2 belong to the same VPN, which is called VPN1.
- The P devices are route reflectors.
- EBGP1 is configured with the **redistribute connected subnets** command.
EBGP2 is configured with the `neighbor next-hop-self` command.

**Figure 7: Configuring Two Autonomous Systems**

```
interface Loopback1
  ip address 10.1.0.4 255.0.0.0
!
interface GigabitEthernet0/0/0
  no ip address
  encapsulation frame-relay
  frame-relay intf-type dce
!
interface GigabitEthernet0/5/3 point-to-point
  ip address 10.1.0.2 255.0.0.0
  frame-relay interface-dlci 22
!
router ospf 1
  network 192.168.3.0 255.255.0.0 area 0
```

**Example: Configuration for Autonomous System 1 CE1**

The following example shows how to configure CE1 in VPN1 in a topology with two autonomous systems:

```
interface Loopback1
  ip address 10.1.0.4 255.0.0.0
!
interface GigabitEthernet0/0/0
  no ip address
  encapsulation frame-relay
  frame-relay intf-type dce
!
interface GigabitEthernet0/5/3 point-to-point
  ip address 10.1.0.2 255.0.0.0
  frame-relay interface-dlci 22
!
router ospf 1
  network 192.168.3.0 255.255.0.0 area 0
```

**Example: Configuration for Autonomous System 1 PE1**

The following example shows how to configure PE1 in AS1 in a topology with two autonomous systems:

```
ip cef
!
ip vrf V1
  rd 1:105
  route-target export 1:100
  route-target import 1:100
!
interface GigabitEthernet0/0/0
  no ip address
  encapsulation frame-relay
  no fair-queue
clockrate 2000000
!
interface GigabitEthernet0/0/0.3 point-to-point
  ip vrf forwarding V1
  ip address 192.168.2.4 255.255.0.0
  frame-relay interface-dlci 22
!
interface GigabitEthernet0/5/3
  ip address 192.168.3.5 255.255.0.0
  tag-switching ip
```
Example: Configuration for Autonomous System 1 P1

The following example shows how to configure P1 in AS1 in a topology with two autonomous systems:

```plaintext
router ospf 1
  log-adjacency-changes
  network 192.168.41.0 255.255.0.0 area 0
!
router ospf 10 vrf V1
  log-adjacency-changes
  redistribute bgp 1 metric 100 subnets
  network 192.168.41.0 255.255.0.0 area 0
!
router bgp 1
  no synchronization
  neighbor 1 peer-group
  neighbor 1 remote-as 1
  neighbor 1 update-source Loopback0
  neighbor 192.168.11.10 peer-group R
  no auto-summary
!
  address-family ipv4 vrf V1
    redistribute ospf 10
    no auto-summary
    no synchronization
    exit-address-family
!
  address-family vpnv4
    neighbor R activate
    neighbor R send-community extended
    neighbor 192.168.11.10 peer-group R
    no auto-summary
    exit-address-family
```

Example: Configuring MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

Example: Configuring MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses
Example: Configuration for Autonomous System 1 EBGP1

The following example shows how to configure EBGP1 in AS1 in a topology with two autonomous systems:

```conf
ip cef
!
interface Loopback0
  ip address 10.2.2.1 255.0.0.0
!
interface Loopback0
  ip address 10.2.2.1 255.0.0.0
!
interface GigabitEthernet0/5/3
  ip address 10.1.0.5 255.0.0.0
tag-switching ip
!
interface GigabitEthernet0/0/0
!
interface GigabitEthernet0/0/0.1 point-to-point
!
router ospf 1
  log-adjacency-changes
  redistribute connected subnets
  network 10.1.0.5 255.0.0.0 area 0
!
router bgp 1
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  neighbor R peer-group
  neighbor R remote-as 1
  neighbor R update-source Loopback0
  neighbor 10.1.0.2 remote-as 2
  neighbor 10.1.0.2 peer-group R
  no auto-summary
!
address-family vpnv4
  neighbor R activate
  neighbor R send-community extended
  neighbor 10.1.0.2 activate
  neighbor 10.1.0.2 send-community extended
  neighbor 10.1.0.2 peer-group R
  no auto-summary
  exit-address-family
```

Example: Configuration for Autonomous System 2 EBGP2

The following example shows how to configure EBGP2 in AS2 in a topology with two autonomous systems:

```conf
ip cef
!
ip vrf V1
  rd 2:103
  route-target export 1:100
  route-target import 1:100
!
interface Loopback0
  ip address 10.1.1.2 255.0.0.0
  ip router isis
!
interface Loopback1
  ip vrf forwarding V1
```
Example: Configuration for Autonomous System 2 P2

The following example shows how to configure P2 in AS2 in a topology with two autonomous systems:

```plaintext
ip cef
ip vrf V1
rd 2:108
route-target export 1:100
route-target import 1:100
interface Loopback0
ip address 10.1.0.2 255.0.0.0
ip router isis
interface Loopback1
ip vrf forwarding V1
ip address 10.1.0.2 255.0.0.0
```
Example: Configuration for Autonomous System 2 PE2

The following example shows how to configure PE2 in AS2 in a topology with two autonomous systems:

```
! interface GigabitEthernet0/0/0
  ip address 10.2.1.4 255.0.0.0
  ip router isis
  tag-switching ip
!
interface GigabitEthernet0/0/3
  no ip address
  encapsulation frame-relay
  frame-relay intf-type dce
!
interface GigabitEthernet0/0/3.1 point-to-point
  ip unnumbered Loopback0
  ip router isis
  tag-switching ip
  frame-relay interface-dlci 23
!
router isis
  net aa.0002.0000.0000.0008.00
!
router bgp 2
  no synchronization
  bgp log-neighbor-changes
  neighbor R peer-group
  neighbor R remote-as 2
  neighbor R update-source Loopback0
  neighbor R route-reflector-client
  neighbor 10.1.2.1 peer-group R
  neighbor 10.0.1.2 peer-group R
!
address-family ipv4 vrf V1
  redistribute connected
  no auto-summary
  no synchronization
  exit-address-family
!
address-family vpnv4
  neighbor R activate
  neighbor R route-reflector-client
  neighbor R send-community extended
  neighbor 10.1.2.1 peer-group R
  neighbor 10.0.1.2 peer-group R
  exit-address-family

Example: Configuring MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

Example: Configuring MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses
Example: Configuration for Autonomous System 2 CE2

The following example shows how to configure CE2 in VPN1 in a topology with two autonomous systems:

```plaintext
interface Loopback0
 ip address 192.168.2.2 255.255.0.0
!
interface GigabitEthernet0/0/0
 no ip address
 encapsulation frame-relay
 no fair-queue
 clockrate 2000000
!
interface GigabitEthernet0/0/0.1 point-to-point
 ip unnumbered Loopback0
 frame-relay interface-dlci 24
!
router ospf 1

equipment test

Example: Configuring MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses in a Confederation

The network topology in the figure below shows a single internet service provider, which is partitioning the backbone with confederations. The autonomous system number of the provider is 100. The two autonomous systems run their own IGPs and are configured as follows:
• Autonomous system 1 (AS1) includes provider edge 1 (PE1), P1, Autonomous System Border Router 1 (ASBR1). The Interior Gateway Protocol (IGP) is Open Shortest Path First (OSPF).

• Autonomous system 2 (AS2) includes PE2, P2, ASBR2. The IGP is Intermediate System to Intermediate System (IS-IS).

• Customer edge 1 (CE1) and CE2 belong to the same VPN, which is called VPN1.

• The P devices are route reflectors.

• ASBR1 is configured with the **redistribute connected subnets** command.

• ASBR2 is configured with the **neighbor next-hop-self** command.

**Figure 8: Configuring Two Autonomous Systems in a Confederation**

**Example: Configuration for Autonomous System 1 CE1**

The following example shows how to configure CE1 in VPN1 in a confederation topology:

```
interface Loopback1
 ip address 192.168.3.4 255.255.255.255
!
interface GigabitEthernet0/4/7
 no ip address
 encapsulation frame-relay
 frame-relay intf-type dce
!
interface GigabitEthernet0/4/7.1 point-to-point
 ip address 192.168.1.3 255.255.0.0
 frame-relay interface-dlci 22
!
router ospf 1
 network 192.168.0.1 255.255.255.0 area 0
```

**Example: Configuration for Autonomous System 1 PE1**

The following example shows how to configure PE1 in AS1 in a confederation topology:

```
! ip cef
!
ip vrf V1
 rd 1:105
 route-target export 1:100
```
route-target import 1:100
interface GigabitEthernet0/0/0
no ip address
encapsulation frame-relay
no fair-queue
clockrate 2000000
interface GigabitEthernet0/0/0.3 point-to-point
ip vrf forwarding V1
ip address 10.0.2.4 255.0.0.0
frame-relay interface-dlci 22
interface GigabitEthernet0/4/7
ip address 10.1.2.6 255.0.0.0
tag-switching lp
router ospf 1
log-adjacency-changes
network 10.1.8.4 255.0.0.0 area 0
router ospf 10 vrf V1
log-adjacency-changes
redistribute bgp 1 metric 100 subnets
network 10.1.8.4 255.0.0.0 area 0
router bgp 1
no synchronization
bgp confederation identifier 100
bgp confederation identifier 100
neighbor 1 peer-group
neighbor 1 remote-as 1
neighbor 1 update-source Loopback0
neighbor 10.2.1.2 peer-group R
no auto-summary
address-family ipv4 vrf V1
redistribute ospf 10
no auto-summary
no synchronization
exit-address-family
address-family vpnv4
neighbor R activate
neighbor R send-community extended
neighbor 10.2.1.2 peer-group R
no auto-summary
exit-address-family

Example: Configuration for Autonomous System 1 P1

The following example shows how to configure P1 in AS1 in a confederation topology:

ip cef
interface Loopback0
ip address 10.0.0.2 255.0.0.0
interface GigabitEthernet0/0/0
ip address 10.2.1.1 255.0.0.0
tag-switching ip
interface GigabitEthernet0/4/7
ip address 10.2.2.1 255.0.0.0
duplex auto
speed auto
tag-switching ip
router ospf 1
log-adjacency-changes
network 10.1.2.2 255.0.0.0 area 0
!
router bgp 1
  no synchronization
  bgp log-neighbor-changes
  bgp confederation identifier 100
  neighbor R peer-group
  neighbor R remote-as 1
  neighbor R update-source Loopback0
  neighbor R route-reflector-client
  neighbor 10.0.0.4 peer-group R
  neighbor 10.0.0.5 peer-group R
!
address-family vpnv4
  neighbor R activate
  neighbor R route-reflector-client
  neighbor R send-community extended
  neighbor 10.1.0.4 peer-group R
  neighbor 10.1.0.5 peer-group R
  exit-address-family

Example: Configuration for Autonomous System 1 ASBR1

The following example shows how to configure ASBR1 in AS1 in a confederation topology:

ip cef
!
interface Loopback0
  ip address 10.0.0.4 255.0.0.0
!
interface GigabitEthernet0/0/0
  ip address 10.2.1.40 255.255.255.0
tag-switching ip
!
interface GigabitEthernet0/5/3
  no ip address
  no atm scrambling cell-payload
  no atm ilmi-keepalive
!
interface GigabitEthernet0/5/3.1 point-to-point
  ip address 10.0.0.1 255.0.0.0
  pvc 1/100
!
router ospf 1
  log-adjacency-changes
  redistribute connected subnets
  network 10.0.0.3 255.0.0.0 area 0
!
router bgp 1
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  bgp confederation identifier 100
  bgp confederation peers 1
  neighbor R peer-group
  neighbor R remote-as 1
  neighbor R update-source Loopback0
  neighbor 10.0.0.2 remote-as 2
  neighbor 10.0.0.1 next-hop-self
  neighbor 10.0.0.2 peer-group R
  no auto-summary
!
address-family vpnv4
  neighbor R activate
  neighbor R send-community extended
  neighbor 10.0.0.2 activate
  neighbor 10.0.0.2 next-hop-self
  neighbor 10.0.0.2 send-community extended
  neighbor 10.0.0.2 peer-group R
Example: Configuration for Autonomous System 2 ASBR2

The following example shows how to configure ASBR2 in AS2 in a confederation topology:

```
no auto-summary
exit-address-family

Example: Configuration for Autonomous System 2 ASBR2
```

```
ip cef
ip vrf V1
rd 2:103
route-target export 1:100
route-target import 1:100
! interface Loopback0
ip address 10.0.0.3 255.0.0.0
ip router isis
! interface Loopback1
ip vrf forwarding V1
ip address 10.0.0.3 255.0.0.0
! interface GigabitEthernet0/4/7
no ip address
encapsulation frame-relay
load-interval 30
no fair-queue
clockrate 2000000
! interface GigabitEthernet0/4/7.2 point-to-point
ip unnumbered Loopback0
ip router isis
tag-switching ip
frame-relay interface-dlci 23
! interface GigabitEthernet0/5/3
no ip address
atm clock INTERNAL
no atm scrambling cell-payload
no atm ilmi-keepalive
! interface GigabitEthernet0/5/3.1 point-to-point
ip address 10.0.0.2 255.0.0.0
pvc 1/100
! router isis
net aa.0002.0000.0000.0003.00
! router bgp 2
no synchronization
no bgp default route-target filter
bgp log-neighbor-changes
bgp confederation identifier 100
bgp confederation peers 1
neighbor 10.0.0.1 remote-as 1
neighbor 10.0.0.1 next-hop-self
neighbor 10.0.0.8 remote-as 2
neighbor 10.0.0.8 update-source Loopback0
neighbor 10.0.0.8 next-hop-self
!
address-family ipv4 vrf V1
redistribute connected
no auto-summary
no synchronization
exit-address-family
!
address-family vpnv4
neighbor 10.0.0.1 activate
neighbor 10.0.0.1 next-hop-self
neighbor 10.0.0.1 send-community extended
```
neighbor 10.0.0.8 activate
neighbor 10.0.0.8 next-hop-self
neighbor 10.0.0.8 send-community extended
exit-address-family

**Example: Configuration for Autonomous System 2 P2**

The following example shows how to configure P2 in AS2 in a confederation topology:

```plaintext
ip cef
ip vrf V1
rd 2:108
route-target export 1:100
route-target import 1:100

interface Loopback0
  ip address 10.0.0.8 255.0.0.0
  ip router isis

interface Loopback1
  ip vrf forwarding V1
  ip address 10.0.0.8 255.0.0.0

interface GigabitEthernet0/0/0
  ip address 10.9.1.2 255.0.0.0
  ip router isis
tag-switching ip

interface GigabitEthernet0/5/3
  no ip address
  encapsulation frame-relay
  frame-relay intf-type dce

interface GigabitEthernet0/5/3.1 point-to-point
  ip unnumbered Loopback0
  ip router isis
tag-switching ip
  frame-relay interface-dlci 23
router isis
  net aa.0002.0000.0000.0008.00

router bgp 2
  no synchronization
  bgp log-neighbors-changes
  bgp confederation identifier 100
  neighbor R peer-group
  neighbor R remote-as 2
  neighbor R update-source Loopback0
  neighbor R route-reflector-client
  neighbor 10.0.0.3 peer-group R
  neighbor 10.0.0.9 peer-group R

address-family ipv4 vrf V1
  redistribute connected
  no auto-summary
  no synchronization
  exit-address-family

address-family vpnv4
  neighbor R activate
  neighbor R route-reflector-client
  neighbor R send-community extended
  neighbor 10.0.0.3 peer-group R
  neighbor 10.0.0.9 peer-group R
  exit-address-family
```
Example: Configuration for Autonomous System 2 PE2

The following example shows how to configure PE2 in AS2 in a confederation topology:

```
  ip cef

  ip vrf V1
    rd 2:109
    route-target export 1:100
    route-target import 1:100

  interface Loopback0
    ip address 10.0.0.9 255.0.0.0
    ip router isis

  interface Loopback1
    ip vrf forwarding V1
    ip address 10.0.0.9 255.0.0.0

  interface GigabitEthernet0/0/4
    no ip address
    encapsulation frame-relay
    frame-relay intf-type dce
    no fair-queue
clockrate 2000000

  interface GigabitEthernet0/0/4.1 point-to-point
    description Bethel
    ip vrf forwarding V1
    ip unnumbered Loopback1
    frame-relay interface-dlci 24

  interface GigabitEthernet0/4/7
    ip address 10.9.1.1 255.0.0.0
    ip router isis
    tag-switching ip

  router ospf 10 vrf V1
    log-adjacency-changes
    redistribute bgp 2 subnets
    network 10.0.0.2 255.0.0.0 area 0

  router isis
    net aa.0002.0000.0000.0009.00

  router bgp 2
    no synchronization
    bgp log-neighbor-changes
    bgp confederation identifier 100
    neighbor 10.0.0.8 remote-as 2
    neighbor 10.0.0.8 update-source Loopback0

  address-family ipv4 vrf V1
    redistribute connected
    redistribute ospf 10
    no auto-summary
    no synchronization

  exit-address-family

  address-family vpnv4
    neighbor 10.0.0.8 activate
    neighbor 10.0.0.8 send-community extended

  exit-address-family
```
Example: Configuration for Autonomous System 2 CE2

The following example shows how to configure CE2 in VPN1 in a confederation topology:

interface Loopback0
  ip address 10.0.0.11 255.0.0.0
!
interface GigabitEthernet0/0/7
  no ip address
  encapsulation frame-relay
  no fair-queue
  clockrate 2000000
!
interface GigabitEthernet0/0/7.1 point-to-point
  ip unnumbered Loopback0
  frame-relay interface-dlci 24
!
router ospf 1
  network 10.0.1.2 255.0.0.0 area 0

Additional References

Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS</td>
<td>MPLS Product Literature</td>
</tr>
</tbody>
</table>

Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.</td>
</tr>
</tbody>
</table>

MIBs

<table>
<thead>
<tr>
<th>MIB</th>
<th>MIBs Link</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
</tr>
</tbody>
</table>
### RFCs

<table>
<thead>
<tr>
<th>RFC</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 1700</td>
<td>Assigned Numbers</td>
</tr>
<tr>
<td>RFC 1966</td>
<td>BGP Route Reflection: An Alternative to Full Mesh IBGP</td>
</tr>
<tr>
<td>RFC 2842</td>
<td>Capabilities Advertisement with BGP-4</td>
</tr>
<tr>
<td>RFC 2858</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 3107</td>
<td>Carrying Label Information in BGP-4</td>
</tr>
</tbody>
</table>

### Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></td>
</tr>
</tbody>
</table>

### Feature Information for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.
### Table 1: Feature Information for MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS VPN Interautonomous System Support</td>
<td>Cisco IOS XE Release 3.7S</td>
<td>The MPLS VPN Interautonomous System Support feature enables an MPLS VPN to span service providers and autonomous systems. This feature explains how to configuring the Inter-AS using the ASBRs to exchange VPN-IPv4 Addresses. In Cisco IOS XE Release 3.7S, support was added for the Cisco ASR 903 Router. This feature uses no new or modified commands.</td>
</tr>
</tbody>
</table>
MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

The MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels feature allows a Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) to span service providers and autonomous systems. This module explains how to configure an MPLS VPN Inter-AS network so that the Autonomous System Boundary Routers (ASBRs) exchange IPv4 routes with MPLS labels of the provider edge (PE) routers. Route reflectors (RRs) exchange VPN-IPv4 routes by using multihop, multiprotocol, external Border Gateway Protocol (eBGP).

- Finding Feature Information, page 33
- Prerequisites for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels, page 34
- Restrictions for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels, page 35
- Information About MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels, page 35
- How to Configure MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels, page 38
- Configuration Examples for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels, page 53
- Additional References, page 66
- Feature Information for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels, page 68

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.
Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

The network must be properly configured for MPLS VPN operation before you configure MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels.

The table below lists the Cisco 12000 series line card support in Cisco IOS S releases.

Table 2: Cisco 12000 Series Line Card Support in Cisco IOS S Releases

<table>
<thead>
<tr>
<th>Type</th>
<th>Line Cards</th>
<th>Cisco IOS Release Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td>4-Port OC-3 ATM</td>
<td>12.0(22)S</td>
</tr>
<tr>
<td></td>
<td>1-Port OC-12 ATM</td>
<td>12.0(23)S</td>
</tr>
<tr>
<td></td>
<td>4-Port OC-12 ATM</td>
<td>12.0(27)S</td>
</tr>
<tr>
<td></td>
<td>8-Port OC-3 ATM</td>
<td></td>
</tr>
<tr>
<td>Channelized interface</td>
<td>2-Port CHOC-3</td>
<td>12.0(22)S</td>
</tr>
<tr>
<td></td>
<td>6-Port Ch T3 (DS1)</td>
<td>12.0(23)S</td>
</tr>
<tr>
<td></td>
<td>1-Port CHOC-12 (DS3)</td>
<td>12.0(27)S</td>
</tr>
<tr>
<td></td>
<td>1-Port CHOC-12 (OC-3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-Port CHOC-12 ISE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-Port CHOC-48 ISE</td>
<td></td>
</tr>
<tr>
<td>Electrical interface</td>
<td>6-Port DS3</td>
<td>12.0(22)S</td>
</tr>
<tr>
<td></td>
<td>12-Port DS3</td>
<td>12.0(23)S</td>
</tr>
<tr>
<td></td>
<td>6-Port E3</td>
<td>12.0(27)S</td>
</tr>
<tr>
<td></td>
<td>12-Port E3</td>
<td></td>
</tr>
<tr>
<td>Ethernet</td>
<td>3-Port GbE</td>
<td>12.0(23)S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.0(27)S</td>
</tr>
</tbody>
</table>
### Restrictions for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

- For networks configured with eBGP multihop, you must configure a label switched path (LSP) between nonadjacent routers.
- The physical interfaces that connect the BGP speakers must support Cisco Express Forwarding or distributed Cisco Express Forwarding and MPLS.

### Information About MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

#### MPLS VPN Inter-AS Introduction

An autonomous system is a single network or group of networks that is controlled by a common system administration group and that uses a single, clearly defined routing protocol.

As VPNs grow, their requirements expand. In some cases, VPNs need to reside on different autonomous systems in different geographic areas. Also, some VPNs need to extend across multiple service providers (overlapping VPNs). Regardless of the complexity and location of the VPNs, the connection between autonomous systems must be seamless to the customer.
Benefits of MPLS VPN Inter-AS

An Multiprotocol Label Switching (MPLS) VPN Inter-AS provides the following benefits:

- Allows a VPN to cross more than one service provider backbone: Service providers running separate autonomous systems can jointly offer MPLS VPN services to the same customer. A VPN can begin at one customer site and traverse different VPN service provider backbones before arriving at another site of the same customer. Previously, MPLS VPN could traverse only a single Border Gateway Protocol (BGP) autonomous system service provider backbone. This feature allows multiple autonomous systems to form a continuous (and seamless) network between customer sites of a service provider.

- Allows a VPN to exist in different areas: A service provider can create a VPN in different geographic areas. Having all VPN traffic flow through one point (between the areas) allows for better rate control of network traffic between the areas.

- Allows confederations to optimize Internal Border Gateway Protocol (IBGP) meshing: IBGP meshing in an autonomous system is more organized and manageable. An autonomous system can be divided into multiple, separate subautonomous systems and then classify them into a single confederation (even though the entire VPN backbone appears as a single autonomous system). This capability allows a service provider to offer MPLS VPNs across the confederation because it supports the exchange of labeled VPN-IPv4 Network Layer Reachability Information (NLRI) between the subautonomous systems that form the confederation.

Information About Using MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

This feature can configure a MPLS VPN Inter-AS network so that the ASBRs exchange IPv4 routes with MPLS labels of the PE routers. RRs exchange VPN-IPv4 routes by using multihop, multiprotocol, External Border Gateway Protocol (eBGP). This method of configuring the Inter-AS system is often called MPLS VPN Inter-AS--IPv4 BGP Label Distribution.

Benefits of MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

An Inter-AS system can be configured so that the ASBRs exchange the IPv4 routes and MPLS labels has the following benefits:

- Saves the ASBRs from having to store all the VPN-IPv4 routes. Using the route reflectors to store the VPN-IPv4 routes and forward them to the PE routers results in improved scalability compared with configurations where the ASBR holds all of the VPN-IPv4 routes and forwards the routes based on VPN-IPv4 labels.

- Simplifies the configuration at the border of the network by having the route reflectors hold the VPN-IPv4 routes.

- Enables a non-VPN core network to act as a transit network for VPN traffic. You can transport IPv4 routes with MPLS labels over a non-MPLS VPN service provider.
Eliminates the need for any other label distribution protocol between adjacent LSRs. If two adjacent label switch routers (LSRs) are also BGP peers, BGP can handle the distribution of the MPLS labels. No other label distribution protocol is needed between the two LSRs.

How the Inter-AS Works When ASBRs Exchange IPv4 Routes with MPLS Labels

A VPN service provider network to exchange IPv4 routes with MPLS labels can be configured. The VPN service provider network can be configured as follows:

- Route reflectors exchange VPN-IPv4 routes by using multihop, multiprotocol eBGP. This configuration also preserves the next-hop information and the VPN labels across the autonomous systems.
- A local PE router (for example, PE1 in the figure below) needs to know the routes and label information for the remote PE router (PE2). This information can be exchanged between the PE routers and ASBRs in one of two ways:
  - Internal Gateway Protocol (IGP) and Label Distribution Protocol (LDP): The ASBR can redistribute the IPv4 routes and MPLS labels it learned from eBGP into IGP and LDP and vice versa.
  - Internal Border Gateway Protocol (iBGP) IPv4 label distribution: The ASBR and PE router can use direct iBGP sessions to exchange VPN-IPv4 and IPv4 routes and MPLS labels.

Alternatively, the route reflector can reflect the IPv4 routes and MPLS labels learned from the ASBR to the PE routers in the VPN. This is accomplished by the ASBR exchanging IPv4 routes and MPLS labels with the route reflector. The route reflector also reflects the VPN-IPv4 routes to the PE routers in the VPN. For example, in VPN1 of the figure below, RR1 reflects to PE1 the VPN-IPv4 routes it learned and IPv4 routes and MPLS labels learned from ASBR1. Using the route reflectors to store the VPN-IPv4 routes and forward them through the PE routers and ASBRs allows for a scalable configuration.

BGP Routing Information

BGP routing information includes the following items:

- A network number (prefix), which is the IP address of the destination.
• Autonomous system path, which is a list of the other autonomous systems through which a route passes on its way to the local router. The first autonomous system in the list is closest to the local router; the last autonomous system in the list is farthest from the local router and usually the autonomous system where the route began.

• Path attributes, which provide other information about the autonomous system path, for example, the next hop.

Types of BGP Messages and MPLS Labels

MPLS labels are included in the update messages that a router sends. Routers exchange the following types of BGP messages:

• Keepalive messages--Routers exchange keepalive messages to determine if a neighboring router is still available to exchange routing information. The router sends these messages at regular intervals. (Sixty seconds is the default for Cisco routers.) The keepalive message does not contain routing data; it contains only a message header.

• Notification messages--When a router detects an error, it sends a notification message.

• Open messages--After a router establishes a TCP connection with a neighboring router, the routers exchange open messages. This message contains the number of the autonomous system to which the router belongs and the IP address of the router that sent the message.

• Update messages--When a router has a new, changed, or broken route, it sends an update message to the neighboring router. This message contains the NLRI, which lists the IP addresses of the usable routes. The update message includes any routes that are no longer usable. The update message also includes path attributes and the lengths of both the usable and unusable paths. Labels for VPN-IPv4 routes are encoded in the update message as specified in RFC 2858. The labels for the IPv4 routes are encoded in the update message as specified in RFC 3107.

How BGP Sends MPLS Labels with Routes

When BGP (eBGP and iBGP) distributes a route, it can also distribute an MPLS label that is mapped to that route. The MPLS label mapping information for the route is carried in the BGP update message that contains the information about the route. If the next hop is not changed, the label is preserved.

When you issue the neighbor send-label command on both BGP routers, the routers advertise to each other that they can then send MPLS labels with the routes. If the routers successfully negotiate their ability to send MPLS labels, the routers add MPLS labels to all outgoing BGP updates.

How to Configure MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

To configure MPLS VPN Inter-AS with ASBRs exchanging IPv4 routes and MPLS labels, perform the tasks in the following sections:

The figure below shows the following sample configuration:

• The configuration consists of two VPNs.
• The ASBRs exchange the IPv4 routes with MPLS labels.
• The route reflectors exchange the VPN-IPv4 routes using multihop MPLS eBGP.
• The route reflectors reflect the IPv4 and VPN-IPv4 routes to the other routers in their autonomous system.

Configuring the ASBRs to Exchange IPv4 Routes and MPLS Labels

Perform this task to configure the ASBRs to exchange IPv4 routes and MPLS labels. This configuration procedure uses ASBR1 as an example.

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 ipv4 [multicast | unicast | mdt | vrf vrf-name]
6. neighbor {ip-address | peer-group-name} activate
7. neighbor ip-address send-label
8. exit-address-family
9. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><strong>Enter your password if prompted.</strong></td>
</tr>
</tbody>
</table>

Router> enable
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>router bgp as-number</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config)# router bgp 100</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>neighbor {ip-address</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router)# neighbor hh.0.0.1 remote-as 200</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>address-family ipv4 [multicast</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router)# address-family ipv4</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>neighbor {ip-address</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router-af)# neighbor hh.0.0.1 activate</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>neighbor ip-address send-label</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router-af)# neighbor hh.0.0.1 send-label</td>
</tr>
</tbody>
</table>
### Purpose

**Command or Action**
- exit-address-family

**Example:**
```
Router(config-router-af)# exit-address-family
```

**Step 8**

Exits address family configuration mode.

---

**Command or Action**
- end

**Example:**
```
Router(config-router-af)# end
```

**Step 9**

(Optional) Exits to privileged EXEC mode.

---

### Configuring the Route Reflectors to Exchange VPN-IPv4 Routes

Perform this task to enable the route reflectors to exchange VPN-IPv4 routes by using multihop, multiprotocol eBGP.

This procedure also specifies that the next hop information and the VPN label are to be preserved across the autonomous systems. This procedure uses RR1 as an example of the route reflector.

#### SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp as-number
4. neighbor {ip-address | peer-group-name} remote-as as-number
5. neighbor {ip-address | peer-group-name} ebgp-multihop [ttl]
6. address-family vpnv4 [unicast]
7. neighbor {ip-address | peer-group-name} activate
8. neighbor {ip-address | peer-group-name} next-hop unchanged
9. exit-address-family
10. end

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable</td>
</tr>
<tr>
<td></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

**Example:**
```
Router> enable
```
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>configure terminal</td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Configures a BGP routing process and places the router in router configuration mode.</td>
</tr>
<tr>
<td>router bgp as-number</td>
<td>- The <em>as-number</em> argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# router bgp 100</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Adds an entry to the BGP or multiprotocol BGP neighbor table.</td>
</tr>
<tr>
<td>neighbor {ip-address</td>
<td>remote-as as-number</td>
</tr>
<tr>
<td>peer-group-name}</td>
<td>Example: Router(config-router)# neighbor bb.bb.bb.bb remote-as 200</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>Accepts and attempts BGP connections to external peers residing on networks that are not directly connected.</td>
</tr>
<tr>
<td>neighbor {ip-address</td>
<td>peer-group-name}</td>
</tr>
<tr>
<td>ebgp-multihop [ttl]</td>
<td>Example: Router(config-router)# neighbor bb.bb.bb.bb ebgp-multihop 255</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>Enters address family configuration mode for configuring routing sessions, such as BGP sessions, that use standard VPNv4 address prefixes.</td>
</tr>
<tr>
<td>address-family vpnv4 [unicast]</td>
<td>- The optional <em>unicast</em> keyword specifies VPNv4 unicast address prefixes.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router)# address-family vpnv4</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>Enables the exchange of information with a neighboring router.</td>
</tr>
<tr>
<td>neighbor {ip-address</td>
<td>peer-group-name} activate</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router-af)# neighbor bb.bb.bb.bb activate</td>
<td>• The <code>peer-group-name</code> argument specifies the name of a BGP peer group.</td>
</tr>
</tbody>
</table>

**Step 8**

<table>
<thead>
<tr>
<th>neighbor {ip-address</th>
<th>peer-group-name}</th>
<th>next-hop unchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config-router-af)# neighbor ip-address next-hop unchanged</td>
<td>Enables an eBGP multihop peer to propagate the next hop unchanged.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The <code>ip-address</code> argument specifies the IP address of the next hop.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The <code>peer-group-name</code> argument specifies the name of a BGP peer group that is the next hop.</td>
</tr>
</tbody>
</table>

**Step 9**

<table>
<thead>
<tr>
<th>exit-address-family</th>
<th>Exits address family configuration mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router-af)# exit-address-family</td>
<td></td>
</tr>
</tbody>
</table>

**Step 10**

<table>
<thead>
<tr>
<th>end</th>
<th>(Optional) Exits to privileged EXEC mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router)# end</td>
<td></td>
</tr>
</tbody>
</table>

### Configuring the Route Reflector to Reflect Remote Routes in Its Autonomous System

Perform this task to enable the RR to reflect the IPv4 routes and labels learned by the ASBR to the PE routers in the autonomous system.

This is accomplished by making the ASBR and PE router route reflector clients of the RR. This procedure also explains how to enable the RR to reflect the VPN-IPv4 routes.
SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp as-number
4. address-family ipv4 [multicast | unicast | vrf vrf-name]
5. neighbor {ip-address | peer-group-name activate
6. neighbor ip-address route-reflector-client
7. neighbor ip-address send-label
8. exit-address-family
9. address-family vpnv4 [unicast]
10. neighbor {ip-address | peer-group-name} activate
11. neighbor ip-address route-reflector-client
12. exit-address-family
13. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures a BGP routing process and places the router in router configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# router bgp 100</td>
<td>• The <strong>as-number</strong> argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td><strong>Step 4</strong> address-family ipv4 [multicast</td>
<td>unicast</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router)# address-family ipv4</td>
<td>• The <strong>multicast</strong> keyword specifies IPv4 multicast address prefixes.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>unicast</strong> keyword specifies IPv4 unicast address prefixes.</td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>The vrf vrf-name keyword and argument specify the name of the VRF instance to associate with subsequent IPv4 address family configuration mode commands.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Enable the exchange of information with a neighboring router.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>neighbor</strong> **ip-address</td>
<td>peer-group-name** <strong>activate</strong></td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Router(config-router-af)# neighbor ee.ee.ee.ee activate</strong></td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>neighbor</strong> <strong>ip-address route-reflector-client</strong></td>
<td>Configures the router as a BGP route reflector and configures the specified neighbor as its client.</td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Router(config-router-af)# neighbor ee.ee.ee.ee route-reflector-client</strong></td>
<td>• The <em>ip-address</em> argument specifies the IP address of the BGP neighbor being configured as a client.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>neighbor</strong> <strong>ip-address send-label</strong></td>
<td>Enables a BGP router to send MPLS labels with BGP routes to a neighboring BGP router.</td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Router(config-router-af)# neighbor ee.ee.ee.ee send-label</strong></td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighboring router.</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>exit-address-family</strong></td>
<td>Exits address family configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Router(config-router-af)# exit-address-family</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td><strong>address-family vpnv4 [unicast]</strong></td>
<td>Enters address family configuration mode for configuring routing sessions, such as BGP sessions, that use standard VPNv4 address prefixes.</td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Router(config-router)# address-family vpnv4</strong></td>
<td>• The optional <em>unicast</em> keyword specifies VPNv4 unicast address prefixes.</td>
</tr>
<tr>
<td><strong>Step 10</strong></td>
<td><strong>neighbor</strong> **ip-address</td>
<td>peer-group-name** <strong>activate</strong></td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Router(config-router-af)# neighbor ee.ee.ee.ee activate</strong></td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
</tbody>
</table>
### Purpose

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 11</strong></td>
<td>Enables the RR to pass iBGP routes to the neighboring router.</td>
</tr>
<tr>
<td><strong>neighbor ip-address route-reflector-client</strong></td>
<td>Enables the RR to pass iBGP routes to the neighboring router.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router-af)# neighbor ee.ee.ee.ee route-reflector-client</td>
</tr>
</tbody>
</table>

| **Step 12**       | Exits address family configuration mode. |
| **exit-address-family** | Exits address family configuration mode. |
| **Example:**       | Router(config-router-af)# exit-address-family |

| **Step 13**       | (Optional) Exits to privileged EXEC mode. |
| **end**           | (Optional) Exits to privileged EXEC mode. |
| **Example:**       | Router(config-router-af)# end |

### Verifying the MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels Configuration

If you use ASBRs to distribute the IPv4 labels and route reflectors to distribute the VPN-IPv4 routes, use the following procedures to help verify the configuration:

The figure below shows the configuration that is referred to in the next several sections.
Verifying the Route Reflector Configuration

Perform this task to verify the route reflector configuration.

SUMMARY STEPS

1. enable
2. show ip bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name } [summary] [labels]
3. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>show ip bgp vpnv4 {all</td>
<td>rd route-distinguisher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use the all and summary keywords to verify that a multihop, multiprotocol eBGP session exists between the route reflectors and that the VPNv4 routes are being exchanged between the route reflectors.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# show ip bgp vpnv4 all summary</td>
<td>The last two lines of the command output show the following information:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prefixes are being learned from PE1 and then passed to RR2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prefixes are being learned from RR2 and then passed to PE1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use the all and labels keywords to verify that the route reflectors exchange VPNv4 label information.</td>
</tr>
<tr>
<td>3.</td>
<td>disable</td>
<td>(Optional) Exits to user EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# disable</td>
<td></td>
</tr>
</tbody>
</table>

Verifying that CE1 Can Communicate with CE2

Perform this task to verify that router CE1 has NLRI for router CE2.
SUMMARY STEPS

1. enable
2. show ip route [ip-address [mask] [longer-prefixes]] | [protocol [protocol-id]] | [list [access-list-number | access-list-name]]
3. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable</td>
</tr>
<tr>
<td>Example:</td>
<td>Router&gt; enable</td>
</tr>
<tr>
<td></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>show ip route [ip-address [mask] [longer-prefixes]]</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# show ip route nn.nn.nn.nn</td>
</tr>
<tr>
<td></td>
<td>Displays the current state of the routing table.</td>
</tr>
<tr>
<td></td>
<td>• Use the ip-address argument to verify that CE1 has a route to CE2.</td>
</tr>
<tr>
<td></td>
<td>• Use this command to verify the routes learned by CE1. Make sure that the route for CE2 is listed.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>disable</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# disable</td>
</tr>
<tr>
<td></td>
<td>(Optional) Exits to privileged EXEC mode.</td>
</tr>
</tbody>
</table>

Verifying that PE1 Can Communicate with CE2

Perform this task to verify that router PE1 has NLRI for router CE2.
SUMMARY STEPS

1. enable
2. show ip route vrf vrf-name [connected] [protocol [as-number] [tag] [output-modifiers]] [list number [output-modifiers]] [profile] [static [ []] [summaryoutput-modifiers]] [supernets-only [output-modifiers]] [traffic-engineering [output-modifiers]]
3. show ip bgp vpnv4 { all | rd route-distinguisher | vrf vrf-name} [ip-prefix | length [longer-prefixes] [output-modifiers][]] [network-address mask] [as-number] [connected] [protocol [output-modifiers]] [as-path [output-modifiers]] [community] [community-list] [dampened-paths] [filter-list] [flap-statistics] [inconsistent-as] [neighbors] [paths [line]] [peer-group] [quote-regexp] [regexp] [summary] [tags]
4. show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]
5. show mpls forwarding-table {[network [mask] | length] | labels label [-label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]] [detail]
6. show ip bgp [network] [network-mask] [longer-prefixes]
7. show ip bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name} [summary] [labels]
8. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

**Step 2**

```
show ip route vrf vrf-name [connected] [protocol [as-number] [tag] [output-modifiers]] [list number [output-modifiers]] [profile] [static [ []] [summaryoutput-modifiers]] [supernets-only [output-modifiers]] [traffic-engineering [output-modifiers]]
```

Example:
```
Router# show ip route vrf vpn1 nn.nn.nn.nn
```

**Step 3**

```
show ip bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name} [ip-prefix | length [longer-prefixes] [output-modifiers]] [network-address mask] [longer-prefixes [output-modifiers]] [as-number] [connected] [protocol [output-modifiers]] [as-path [output-modifiers]] [community] [community-list] [dampened-paths] [filter-list] [flap-statistics] [inconsistent-as] [neighbors] [paths [line]] [peer-group] [quote-regexp] [regexp] [summary] [tags]
```

Example:
```
Router# show ip bgp vpnv4 vrf vpn1 nn.nn.nn.nn
```

(Additional steps and explanations are provided in the document for detailed steps.)
### Command or Action

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# show ip bgp vpnv4 all nn.nn.nn.nn</code></td>
<td>(Optional) Displays entries in the BGP routing table.</td>
</tr>
</tbody>
</table>

**Step 4**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]</code></td>
<td>(Optional) Displays entries in the Forwarding Information Base (FIB) or displays a summary of the FIB.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Router# show ip cef vrf vpn1 nn.nn.nn.nn</code></td>
<td>- Use this command to verify that the Cisco Express Forwarding entries are correct.</td>
</tr>
</tbody>
</table>

**Step 5**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>`show mpls forwarding-table [network [mask] length] [labels label [-label] interface interface</td>
<td>next-hop address</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Router# show mpls forwarding-table</code></td>
<td>- Use this command to verify the IGP label for the BGP next hop router (autonomous system boundary).</td>
</tr>
</tbody>
</table>

**Step 6**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>show ip bgp [network] [network-mask] [longer-prefixes]</code></td>
<td>(Optional) Displays entries in the BGP routing table.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Router# show ip bgp ff.ff.ff.ff</code></td>
<td>- Use the <code>show ip bgp</code> command to verify the label for the remote egress PE router (PE2).</td>
</tr>
</tbody>
</table>

**Step 7**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>`show ip bgp vpnv4 {all</td>
<td>rd route-distinguisher</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Router# show ip bgp vpnv4 all labels</code></td>
<td>- Use the <code>all</code> and <code>summary</code> keywords to verify the VPN label of CE2, as advertised by PE2.</td>
</tr>
</tbody>
</table>

**Step 8**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>disable</code></td>
<td>(Optional) Exits to user EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Router# disable</code></td>
<td></td>
</tr>
</tbody>
</table>

### Verifying that PE2 Can Communicate with CE2

Perform this task to ensure that PE2 can access CE2.
### SUMMARY STEPS

1. enable
2. show ip route vrf vrf-name [connected] [protocol [as-number] [tag] [output-modifiers]] [list number [output-modifiers]] [profile] [static [output-modifiers]] [summary [output-modifiers]] [supernets-only [output-modifiers]] [traffic-engineering [output-modifiers]]
3. show mpls forwarding-table [vrf vrf-name] [network {mask | length} | labels label [-label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]] [detail]
4. show ip bgp vpnv4 { all | rd route-distinguisher | vrf vrf-name} [summary] [labels]
5. show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]
6. disable

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> show ip route vrf vrf-name [connected] [protocol [as-number] [tag] [output-modifiers]] [list number [output-modifiers]] [profile] [static [output-modifiers]] [summary [output-modifiers]] [supernets-only [output-modifiers]] [traffic-engineering [output-modifiers]]</td>
<td>(Optional) Displays the IP routing table associated with a VRF.</td>
</tr>
<tr>
<td>Example: Router# show ip route vrf vpn1 nn.nn.nn.nn</td>
<td>• Use this command to check the VPN routing and forwarding table for CE2. The output provides next-hop information.</td>
</tr>
<tr>
<td><strong>Step 3</strong> show mpls forwarding-table [vrf vrf-name] [network {mask</td>
<td>length}</td>
</tr>
<tr>
<td>Example: Router# show mpls forwarding-table vrf vpn1 nn.nn.nn.nn</td>
<td>• Use the vrf keyword to check the VPN routing and forwarding table for CE2. The output provides the label for CE2 and the outgoing interface.</td>
</tr>
<tr>
<td><strong>Step 4</strong> show ip bgp vpnv4 { all</td>
<td>rd route-distinguisher</td>
</tr>
<tr>
<td>Example: Router# show ip bgp vpnv4 all labels</td>
<td>• Use the all and labels keywords to check the VPN label for CE2 in the multiprotocol BGP table.</td>
</tr>
<tr>
<td><strong>Step 5</strong> show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]</td>
<td>(Optional) Displays entries in the FIB or displays a summary of the FIB.</td>
</tr>
</tbody>
</table>
Verifying the ASBR Configuration

Perform this task to verify that the ASBRs exchange IPv4 routes with MPLS labels or IPv4 routes without labels as prescribed by a route map.

SUMMARY STEPS

1. enable
2. show ip bgp [network] [network-mask] [longer-prefixes]
3. show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]
4. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> show ip bgp [network] [network-mask] [longer-prefixes]</td>
<td>(Optional) Displays entries in the BGP routing table.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# show ip bgp ff.ff.ff.ff</td>
<td>• Use this command to check that:</td>
</tr>
<tr>
<td></td>
<td>• ASBR1 receives an MPLS label for PE2 from ASBR2.</td>
</tr>
<tr>
<td></td>
<td>• ASBR1 receives IPv4 routes for RR2 without labels from ASBR2.</td>
</tr>
<tr>
<td></td>
<td>• ASBR2 distributes an MPLS label for PE2 to ASBR1.</td>
</tr>
</tbody>
</table>
### Purpose

Command or Action  | Purpose
--- | ---
| **Step 3** show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail] | (Optional) Displays entries in the FIB or displays a summary of the FIB.
|  | • Use this command from ASBR1 and ASBR2 to check that:
|  | • The Cisco Express Forwarding entry for PE2 is correct.
|  | • The Cisco Express Forwarding entry for RR2 is correct.
| Example: Router# show ip cef ff.ff.ff.ff | 
| Example: Router# show ip cef bb.bb.bb.bb | 
| **Step 4** disable | (Optional) Exits to user EXEC mode.
| Example: Router# disable | 

### Configuration Examples for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

**Configuring MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels over an MPLS VPN Service Provider Examples**

Configuration examples for Inter-AS using BGP to distribute routes and MPLS labels over an MPLS VPN service provider included in this section are as follows:

The figure below shows two MPLS VPN service providers. The service provider distributes the VPN-IPv4 routes between the route reflectors. The MPLS VPN service providers distribute the IPv4 routes with MPLS labels between the ASBRs.

The configuration example shows the following two techniques you can use to distribute the VPN-IPv4 routes and the IPv4 routes with MPLS labels of the remote RRs and PEs to the local RRs and PEs:

• Autonomous system 100 uses the RRs to distribute the VPN-IPv4 routes learned from the remote RRs. The RRs also distribute the remote PE address and label learned from ASBR1 using IPv4 labels.

• In Autonomous system 200, the IPv4 routes that ASBR2 learned are redistributed into IGP.
Route Reflector 1 Configuration Example (MPLS VPN Service Provider)

The configuration example for RR1 specifies the following:

- RR1 exchanges VPN-IPv4 routes with RR2 using multiprotocol, multihop eBGP.
- The VPN-IPv4 next-hop information and the VPN label are preserved across the autonomous systems.
- RR1 reflects to PE1:
  - The VPN-IPv4 routes learned from RR2
  - The IPv4 routes and MPLS labels learned from ASBR1

```text
ip subnet-zero
ip cef
!
interface Loopback0
  ip address aa.aa.aa.aa 255.255.255.255
interface Ethernet0/3
  ip address dd.0.0.2 255.0.0.0
router ospf 10
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  network aa.aa.aa.aa 0.0.0.0 area 100
  network dd.0.0.0 0.255.255.255 area 100
!
router bgp 100
  bgp cluster-id 1
  bgp log-neighbor-changes
timers bgp 10 30
neighbor ee.ee.ee.ee remote-as 100
neighbor ee.ee.ee.ee update-source Loopback0
neighbor ww ww ww ww remote-as 100
neighbor bb bb bb bb remote-as 200
neighbor bb bb bb bb ebgp-multihop 255
neighbor bb bb bb bb update-source Loopback0
no auto-summary
!
address-family ipv4
neighbor ee.ee.ee.ee activate
neighbor ee.ee.ee.ee route-reflector-client !IPv4+labels session to PE1
neighbor ee.ee.ee.ee send-label
```
neighbor ww.ww.ww.ww activate
neighbor ww.ww.ww.ww route-reflector-client !IPv4+labels session to ASBR1
neighbor ww.ww.ww.ww send-label
no neighbor bb.bb.bb.bb activate
no auto-summary
no synchronization
exit-address-family

address-family vpnv4
neighbor ee.ee.ee.ee activate
neighbor ee.ee.ee.ee route-reflector-client !VPNv4 session with PE1
neighbor ee.ee.ee.ee send-community extended
neighbor bb.bb.bb.bb next-hop-unchanged !MH-VPNv4 session with RR2
neighbor bb.bb.bb.bb send-community extended !with next hop unchanged
exit-address-family

ip default-gateway 3.3.0.1
no ip classless

snmp-server engineID local 00000009020000D0584B25C0
snmp-server community public RO
snmp-server community write RW
no snmp-server ifindex persist
snmp-server packetsize 2048

ASBR1 Configuration Example (MPLS VPN Service Provider)

ASBR1 exchanges IPv4 routes and MPLS labels with ASBR2.

In this example, ASBR1 uses route maps to filter routes:

- A route map called OUT specifies that ASBR1 should distribute the PE1 route (ee.ee) with labels and the RR1 route (aa.aa) without labels.
- A route map called IN specifies that ASBR1 should accept the PE2 route (ff.ff) with labels and the RR2 route (bb.bb) without labels.

ip subnet-zero
mpls label protocol ldp

interface Loopback0
ip address ww.ww.ww.ww 255.255.255.255

interface Ethernet0/2
ip address hh.0.0.2 255.0.0.0

interface Ethernet0/3
ip address dd.0.0.1 255.0.0.0
mpls label protocol ldp
mpls ip

router ospf 10
log-adjacency-changes
auto-cost reference-bandwidth 1000
redistribute connected subnets
passive-interface Ethernet0/2
network ww.ww.ww.ww 0.0.0.0 area 100
network dd.0.0.0 0.255.255.255 area 100

router bgp 100
bgp log-neighbor-changes
timers bgp 10 30
neighbor aa.aa.aa.aa remote-as 100
neighbor aa.aa.aa.aa update-source Loopback0
neighbor hh.0.0.1 remote-as 200
no auto-summary
!
address-family ipv4
redistribute ospf 10 ! so that PE1 & RR1 loopbacks
neighbor aa.aa.aa.aa activate ! get into the BGP table
neighbor aa.aa.aa.aa send-label
neighbor hh.0.0.1 activate
neighbor hh.0.0.1 advertisement-interval 5
neighbor hh.0.0.1 route-map IN in
neighbor hh.0.0.1 route-map OUT out
neighbor hh.0.0.1 send-label
neighbor hh.0.0.1 route-map OUT in
neighbor hh.0.0.1 route-map OUT out
neighbor hh.0.0.1 send-label
neighbor kk.0.0.1 activate
neighbor kk.0.0.1 advertisement-interval 5
neighbor kk.0.0.1 route-map IN in
neighbor kk.0.0.1 route-map OUT out
neighbor kk.0.0.1 send-label
neighbor kk.0.0.1 route-map OUT in
neighbor kk.0.0.1 route-map OUT out
no auto-summary
no synchronization
exit-address-family
!
ip default-gateway 3.3.0.1
ip classless
!
access-list 1 permit ee.ee.ee.ee log !Setting up the access lists
access-list 2 permit ff.ff.ff.ff log
access-list 3 permit aa.aa.aa.aa log
access-list 4 permit bb.bb.bb.bb log
route-map IN permit 10
match ip address 2
match mpls-label
!
route-map IN permit 11
match ip address 4
!
route-map OUT permit 12
match ip address 3
!
route-map OUT permit 13
match ip address 1
set mpls-label
!
end

Route Reflector 2 Configuration Example (MPLS VPN Service Provider)

RR2 exchanges VPN-IPv4 routes with RR1 through multihop, multiprotocol eBGP. This configuration also
specifies that the next-hop information and the VPN label are preserved across the autonomous systems:

ip subnet-zero
ip cef
!
interface Loopback0
  ip address bb.bb.bb.bb 255.255.255.255
!
interface Serial1/1
  ip address ii.0.0.2 255.0.0.0
!
router ospf 20
  log-adjacency-changes
  network bb.bb.bb.bb 0.0.0.0 area 200
  network ii.0.0.0 0.255.255.255 area 200
!
router bgp 200
  bgp cluster-id 1
  bgp log-neighbor-changes
  timers bgp 10 30
  neighbor aa.aa.aa.aa remote-as 100
neighbor aa.aa.aa.aa ebgp-multihop 255
neighbor aa.aa.aa.aa update-source Loopback0
neighbor ff.ff.ff.ff remote-as 200
neighbor ff.ff.ff.ff update-source Loopback0
no auto-summary

address-family vpnv4
neighbor aa.aa.aa.aa activate
neighbor aa.aa.aa.aa next-hop-unchanged
neighbor aa.aa.aa.aa send-community extended
neighbor ff.ff.ff.ff activate
neighbor ff.ff.ff.ff route-reflector-client
neighbor ff.ff.ff.ff send-community extended
exit-address-family

ip default-gateway 3.3.0.1
no ip classless

end

ASBR2 Configuration Example (MPLS VPN Service Provider)

ASBR2 exchanges IPv4 routes and MPLS labels with ASBR1. However, in contrast to ASBR1, ASBR2 does not use the RR to reflect IPv4 routes and MPLS labels to PE2. ASBR2 redistributes the IPv4 routes and MPLS labels learned from ASBR1 into IGP. PE2 can now reach these prefixes.

ip subnet-zero
ip cef

mpls label protocol ldp

interface Loopback0
  ip address xx.xx.xx.xx 255.255.255.255

interface Ethernet1/0
  ip address hh.0.0.1 255.0.0.0

interface Ethernet1/2
  ip address jj.0.0.1 255.0.0.0
mpls label protocol ldp
mpls ip

router ospf 20
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  redistribute bgp 200 subnets ! Redistributing the routes learned from
  passive-interface Ethernet1/0 ! ASBR1(eBGP+labels session) into IGP
  network xx.xx.xx.xx 0.0.0.0 area 200
  network jj..0.0 0.255.255.255 area 200

  router bgp 200
  bgp log-neighbor-changes
timers bgp 10 30
neighbor bb.bb.bb.bb remote-as 200
neighbor bb.bb.bb.bb update-source Loopback0
neighbor hh.0.0.2 remote-as 100
no auto-summary

address-family ipv4
  redistribute ospf 20 ! Redistributing IGP into BGP
  neighbor hh.0.0.2 activate ! so that PE2 & RR2 loopbacks
  neighbor hh.0.0.2 advertisement-interval 5 ! will get into the BGP-4 table.
  neighbor hh.0.0.2 route-map IN in
  neighbor hh.0.0.2 route-map OUT out
  neighbor hh.0.0.2 send-label
  neighbor kk.0.0.2 activate
  neighbor kk.0.0.2 advertisement-interval 5
  neighbor kk.0.0.2 route-map IN in
Configuring MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels over a Non-MPLS VPN Service Provider Examples

Configuration examples for Inter-AS using BGP to distribute routes and MPLS labels over a non MPLS VPN service provider included in this section are as follows:

The figure below shows two MPLS VPN service providers that are connected through a non MPLS VPN service provider. The autonomous system in the middle of the network is configured as a backbone autonomous system that uses LDP or Tag Distribution Protocol (TDP) to distribute MPLS labels. Traffic engineering tunnels can also be used instead of TDP or LDP to build the LSP across the non MPLS VPN service provider.
Route Reflector 1 Configuration Example (Non-MPLS VPN Service Provider)

The configuration example for RR1 specifies the following:

- RR1 exchanges VPN-IPv4 routes with RR2 using multiprotocol, multihop eBGP.
- The VPN-IPv4 next-hop information and the VPN label are preserved across the autonomous systems.
- RR1 reflects to PE1:
  - The VPN-IPv4 routes learned from RR2
  - The IPv4 routes and MPLS labels learned from ASBR1

```plaintext
ip subnet-zero
ip cef
!
interface Loopback0
 ip address aa.aa.aa.aa 255.255.255.255
!
interface Serial1/2
 ip address dd.0.0.2 255.0.0.0
clockrate 124061
!
router ospf 10
 log-adjacency-changes
 auto-cost reference-bandwidth 1000
 network aa.aa.aa.aa 0.0.0.0 area 100
 network dd.0.0.0 0.255.255.255 area 100
!
router bgp 100
 bgp cluster-id 1
 bgp log-neighbor-changes
timers bgp 10 30
neighbor ee.ee.ee.ee remote-as 100
neighbor ee.ee.ee.ee update-source Loopback0
neighbor ww.ww.ww.ww remote-as 100
neighbor ww.ww.ww.ww update-source Loopback0
neighbor bb.bb.bb.bb remote-as 200
```
neighbor bb.bb.bb.bb ebgp-multihop 255
eighbor bb.bb.bb.bb update-source Loopback0
no auto-summary
!
address-family ipv4
neighbor ee.ee.ee.ee activate
neighbor ee.ee.ee.ee route-reflector-client
neighbor ee.ee.ee.ee send-label
neighbor ww.ww.ww.ww activate
neighbor ww.ww.ww.ww route-reflector-client
neighbor ww.ww.ww.ww send-label
no neighbor bb.bb.bb.bb activate
no auto-summary
no synchronization
exit-address-family
!
address-family vpnv4
neighbor ee.ee.ee.ee activate
neighbor ee.ee.ee.ee route-reflector-client
neighbor ee.ee.ee.ee send-community extended
neighbor bb.bb.bb.bb activate
neighbor bb.bb.bb.bb next-hop-unchanged
neighbor bb.bb.bb.bb send-community extended
exit-address-family
!
ip default-gateway 3.3.0.1
no ip classless
!
snmp-server engineID local 00000009020000D0584B25C0
snmp-server community public RO
snmp-server community write RW
no snmp-server ifindex persist
snmp-server packetsize 2048
!
end

ASBR1 Configuration Example (Non-MPLS VPN Service Provider)

ASBR1 exchanges IPv4 routes and MPLS labels with ASBR2.

In this example, ASBR1 uses route maps to filter routes:

- A route map called OUT specifies that ASBR1 should distribute the PE1 route (ee.ee) with labels and the RR1 route (aa.aa) without labels.

- A route map called IN specifies that ASBR1 should accept the PE2 route (ff.ff) with labels and the RR2 route (bb.bb) without labels.

ip subnet-zero
ip cef distributed
mpls label protocol ldp
!
interface Loopback0
  ip address ww.ww.ww.ww 255.255.255.255
!
interface Serial3/0/0
  ip address kk.0.0.2 255.0.0.0
  ip route-cache distributed
!
interface Ethernet0/3
  ip address dd.0.0.1 255.0.0.0
  mpls label protocol ldp
  mpls ip
!
routing ospf 10
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
passive-interface Serial3/0/0
network ww.ww.ww.ww 0.0.0.0 area 100
network dd.0.0.0 0.255.255.255 area 100

routing bgp 100
bgp log-neighbor-changes
timers bgp 10 30
neighbor aa.aa.aa.aa remote-as 100
neighbor aa.aa.aa.aa update-source Loopback0
neighbor kk.0.0.1 remote-as 200
no auto-summary
!
address-family ipv4
redistribute ospf 10 ! Redistributing IGP into BGP
neighbor aa.aa.aa.aa activate ! so that PE1 & RR1 loopbacks
neighbor aa.aa.aa.aa send-label ! get into BGP table
neighbor kk.0.0.1 activate
neighbor kk.0.0.1 advertisement-interval 5
neighbor kk.0.0.1 send-label
neighbor kk.0.0.1 route-map IN in ! Accepting routes specified in route map IN
neighbor kk.0.0.1 route-map OUT out ! Distributing routes specified in route map OUT
no auto-summary
no synchronization
exit-address-family
!

ip default-gateway 3.3.0.1
ip classless
!
access-list 1 permit ee.ee.ee.ee log
access-list 2 permit ff.ff.ff.ff log
access-list 3 permit aa.aa.aa.aa log
access-list 4 permit bb.bb.bb.bb log
!
route-map IN permit 10
match ip address 2
match mpls-label
!
route-map IN permit 11
match ip address 4
!
route-map OUT permit 12
match ip address 3
!
route-map OUT permit 13
match ip address 1
set mpls-label
!
end

Route Reflector 2 Configuration Example (Non-MPLS VPN Service Provider)

RR2 exchanges VPN-IPv4 routes with RR1 using multihop, multiprotocol eBGP. This configuration also
specifies that the next-hop information and the VPN label are preserved across the autonomous systems:

ip subnet-zero
ip cef
!
interface Loopback0
    ip address bb.bb.bb.bb 255.255.255.255
!
interface Serial1/1
    ip address ii.0.0.2 255.0.0.0
!
router ospf 20
log-adjacency-changes
network bb.bb.bb.bb 0.0.0.0 area 200
network ii.0.0.0 0.255.255.255 area 200
!
router bgp 200
ASBR2 Configuration Example (Non-MPLS VPN Service Provider)

ASBR2 exchanges IPv4 routes and MPLS labels with ASBR1. However, in contrast to ASBR1, ASBR2 does not use the RR to reflect IPv4 routes and MPLS labels to PE2. ASBR2 redistributes the IPv4 routes and MPLS labels learned from ASBR1 into IGP. PE2 can now reach these prefixes.

ip subnet-zero
ip cef
!
mpls label protocol ldp
!
interface Loopback0
  ip address xx.xx.xx.xx 255.255.255.255
interface Ethernet0/1
  ip address qq.0.0.2 255.0.0.0
interface Ethernet1/2
  ip address jj.0.0.1 255.0.0.0
mpls label protocol ldp
mpls ip
!
router ospf 20
log-adjacency-changes
auto-cost reference-bandwidth 1000
redistribute connected subnets
redistribute bgp 200 subnets
passive-interface Ethernet0/1
!redistributing the routes learned from ASBR2 (eBGP+labels session) into IGP
network xx.xx.xx.xx 0.0.0.0 area 200
!so that PE2 will learn them
network jj.0.0.0 0.255.255.255 area 200
!
router bgp 200
bgp log-neighbor-changes
timers bgp 10 30
neighbor bb.bb.bb.bb remote-as 200
neighbor bb.bb.bb.bb update-source Loopback0
neighbor qq.0.0.1 remote-as 100
no auto-summary
!
address-family ipv4
! Redistributing IGP into BGP
redistribute ospf 20
so that PE2 & RR2 loopbacks
neighbor qq.0.0.1 activate
neighbor qq.0.0.1 advertise-interval 5
neighbor qq.0.0.1 route-map IN in
neighbor qq.0.0.1 route-map OUT out
neighbor qq.0.0.1 send-label
no auto-summary
no synchronization
exit-address-family
!
address-family vpnv4
neighbor bb.bb.bb.bb activate
neighbor bb.bb.bb.bb send-community extended
exit-address-family
!
ip default-gateway 3.3.0.1
ip classless
!
access-list 1 permit ff.ff.ff.ff log
access-list 2 permit ee.ee.ee.ee log
access-list 3 permit bb.bb.bb.bb log
access-list 4 permit aa.aa.aa.aa log
!
route-map IN permit 11
match ip address 2
match mpls-label
!
route-map IN permit 12
match ip address 4
!
route-map OUT permit 10
match ip address 1
set mpls-label
!
route-map OUT permit 13
match ip address 3
!
end

ASBR3 Configuration Example (Non-MPLS VPN Service Provider)

ASBR3 belongs to a non MPLS VPN service provider. ASBR3 exchanges IPv4 routes and MPLS labels with ASBR1. ASBR3 also passes the routes learned from ASBR1 to ASBR4 through RR3.

Note

Do not redistribute eBGP routes learned into iBGP if you are using iBGP to distribute the routes and labels. This is not a supported configuration.

ip subnet-zero
ip cef
!
interface Loopback0
  ip address yy.yy.yy.yy 255.255.255.255
interface Hssi4/0
  ip address mm.0.0.0.1 255.0.0.0
mpls ip
  hssi internal-clock
!
interface Serial5/0
  ip address kk.0.0.1 255.0.0.0
  load-interval 30
  clockrate 124061
!
routing ospf 30
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  network yy.yy.yy.yy 0.0.0.0 area 300
  network mm.0.0.0 0.255.255.255 area 300
!
router bgp 300
bgp log-neighbor-changes
timers bgp 10 30
neighbor cc.cc.cc.cc remote-as 300
neighbor cc.cc.cc.cc update-source Loopback0
neighbor kk.0.0.2 remote-as 100
no auto-summary
  !
neighbor cc.cc.cc.cc activate
neighbor cc.cc.cc.cc send-label
neighbor kk.0.0.2 activate
neighbor kk.0.0.2 advertisement-interval 5
neighbor kk.0.0.2 send-label
neighbor kk.0.0.2 route-map IN in
neighbor kk.0.0.2 route-map OUT out
no auto-summary
no synchronization
exit-address-family
!
ip classless
  !
access-list 1 permit ee.ee.ee.ee log
access-list 2 permit ff.ff.ff.ff log
access-list 3 permit aa.aa.aa.aa log
access-list 4 permit bb.bb.bb.bb log
  !
route-map IN permit 10
  match ip address 1
  match mpls-label
  !
route-map IN permit 11
  match ip address 3
  !
route-map OUT permit 12
  match ip address 2
  set mpls-label
  !
route-map OUT permit 13
  match ip address 4
  !
ip default-gateway 3.3.0.1
ip classless
!
end

Route Reflector 3 Configuration Example (Non-MPLS VPN Service Provider)

RR3 is a non MPLS VPN RR that reflects IPv4 routes with MPLS labels to ASBR3 and ASBR4.

ip subnet-zero
mpls label protocol ldp
mpls traffic-eng auto-bw timers
no mpls ip
!
interface Loopback0
  ip address cc.cc.cc.cc 255.255.255.255
!
interface POS0/2
  ip address pp.0.0.1 255.0.0.0
crc 16
clock source internal
!
router ospf 30
  log-adjacency-changes
  network cc.cc.cc.cc 0.0.0.0 area 300
  network pp.0.0.0 0.255.255.255 area 300
!
router bgp 300
  bgp log-neighbor-changes
neighbor zz.zz.zz.zz remote-as 300
neighbor zz.zz.zz.zz update-source Loopback0
neighbor yy.yy.yy.yy remote-as 300
neighbor yy.yy.yy.yy update-source Loopback0
no auto-summary
!
address-family ipv4
neighbor zz.zz.zz.zz activate
neighbor zz.zz.zz.zz route-reflector-client
neighbor zz.zz.zz.zz send-label ! iBGP+labels session with ASBR3
neighbor yy.yy.yy.yy activate
neighbor yy.yy.yy.yy route-reflector-client
neighbor yy.yy.yy.yy send-label ! iBGP+labels session with ASBR4
no auto-summary
no synchronization
exit-address-family
!
ip default-gateway 3.3.0.1
ip classless
!
end

ASBR4 Configuration Example (Non-MPLS VPN Service Provider)

ASBR4 belongs to a non MPLS VPN service provider. ASBR4 and ASBR3 exchange IPv4 routes and MPLS labels by means of RR3.

Note

Do not redistribute eBGP routes learned into iBGP if you are using iBGP to distribute the routes and labels. This is not a supported configuration.

ip subnet-zero
ip cef distributed
!
interface Loopback0
  ip address zz.zz.zz.zz 255.255.255.255
!
interface Ethernet0/2
  ip address qq.0.0.1 255.0.0.0
!
interface POS1/1/0
  ip address pp.0.0.2 255.0.0.0
  ip route-cache distributed
!
interface Hssi2/1/1
  ip address mm.0.0.2 255.0.0.0
  ip route-cache distributed
mpls label protocol ldp
mpls ip
hssi internal-clock
!
router ospf 30
log-adjacency-changes
auto-cost reference-bandwidth 1000
redistribute connected subnets
passive-interface Ethernet0/2
network zz.zz.zz.zz 0.0.0.0 area 300
network pp.0.0.0 0.255.255.255 area 300
network mm.0.0.0 0.255.255.255 area 300
!
router bgp 300
bgp log-neighbor-changes
timers bgp 10 30
neighbor cc.cc.cc.cc remote-as 300
neighbor cc.cc.cc.cc update-source Loopback0
neighbor qq.0.0.2 remote-as 200
no auto-summary
!
address-family ipv4
neighbor cc.cc.cc.cc activate
neighbor cc.cc.cc.cc send-label
neighbor qq.0.0.2 activate
neighbor qq.0.0.2 advertisement-interval 5
neighbor qq.0.0.2 send-label
neighbor qq.0.0.2 route-map IN in
neighbor qq.0.0.2 route-map OUT out
no auto-summary
no synchronization
exit-address-family
!
ip classless
!
access-list 1 permit ff.ff.ff.ff log
access-list 2 permit ee.ee.ee.ee log
access-list 3 permit bb.bb.bb.bb log
access-list 4 permit aa.aa.aa.aa log
!
route-map IN permit 10
  match ip address 1
  match mpls-label
!
route-map IN permit 11
  match ip address 3
!
route-map OUT permit 12
  match ip address 2
  set mpls-label
!
route-map OUT permit 13
  match ip address 4
!
ip default-gateway 3.3.0.1
ip classless
!
end

Additional References

Related Documents

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<tr>
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<tbody>
<tr>
<td>MPLS</td>
<td>MPLS Product Literature</td>
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Standards

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MIBs

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<th>MIBs Link</th>
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<td>No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.</td>
<td>To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
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RFCs

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<th>Title</th>
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<td>RFC 1700</td>
<td>Assigned Numbers</td>
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<tr>
<td>RFC 1966</td>
<td>BGP Route Reflection: An Alternative to Full Mesh IBGP</td>
</tr>
<tr>
<td>RFC 2842</td>
<td>Capabilities Advertisement with BGP-4</td>
</tr>
<tr>
<td>RFC 2858</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 3107</td>
<td>Carrying Label Information in BGP-4</td>
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Technical Assistance

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></td>
</tr>
</tbody>
</table>
Feature Information for MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Configuration Information</th>
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</table>
| MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels | 12.0(21)ST 12.0(22)S 12.0(23)S 12.2(13)T 12.0(24)S 12.2(14)S 12.0(27)S 12.0(29)S Cisco IOS XE Release 2.5 | This module explains how to configure an MPLS VPN Inter-AS network so that the ASBRs exchange IPv4 routes with MPLS labels of the provider edge (PE) routers. Route reflectors (RRs) exchange VPN-IPv4 routes by using multihop, multiprotocol, external Border Gateway Protocol (eBGP).

In Cisco IOS XE Release 2.5, this feature was implemented on the Cisco ASR 1000 Series Routers.

This feature uses no new or modified commands. |
MPLS VPN Multipath Support for Inter-AS VPNs

The MPLS VPN Multipath Support for Inter-AS VPNs feature supports Virtual Private Network (VPN)v4 multipath for Autonomous System Boundary Routers (ASBRs) in the interautonomous system (Inter-AS) Multiprotocol Label Switching (MPLS) VPN environment. It allows load balancing of VPN traffic when you use the VPNv4 peering model for Inter-AS VPNs.

- Finding Feature Information, page 69
- Restrictions for MPLS VPN Multipath Support for Inter-AS VPNs, page 69
- Information About MPLS VPN Multipath Support for Inter-AS VPNs, page 70
- How to Configure MPLS VPN Multipath Support for Inter-AS VPNs, page 71
- Configuration Examples for MPLS VPN Multipath Support for Inter-AS VPNs, page 78
- Additional References, page 85
- Feature Information for MPLS VPN Multipath Support for Inter-AS VPNs, page 87
- Glossary, page 88

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for MPLS VPN Multipath Support for Inter-AS VPNs

The following restrictions apply to configuring multipath load sharing for Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) interautonomous system (Inter-AS) Autonomous System Boundary Routers (ASBRs) exchanging VPN-IPv4 routes:
• Per-packet load balancing is not supported for this feature. Load balancing for this feature works on the IP source and destination hash or on the bottom label in the label stack, depending on the platform and depth of the MPLS label stack.

• If MPLS scalability is an issue for you, we recommend that you do not enable VPNv4 multipath on ASBRs.

Information About MPLS VPN Multipath Support for Inter-AS VPNs

Load Sharing with MPLS VPN Inter-AS ASBRs

Before the MPLS VPN Interautonomous System Support feature, if multiple paths existed across Autonomous System Boundary Routers (ASBRs), the Border Gateway Protocol (BGP) executed the best path algorithm and marked only one of the paths as the best path. This path was added to the routing table and became the only path that was used for forwarding traffic between ASBRs.

The MPLS VPN Multipath Support for Inter-AS VPNs feature extends the functionality of BGP so that it can pick one path as the best path and mark the other legitimate paths between ASBRs as multipath. This allows the load sharing of traffic among the different multipaths and the best path to reach the destination. No Routing Information Base (RIB) or Cisco Express Forwarding entries are associated with the Virtual Private Network (VPN)-IPv4 prefixes.

The MPLS VPN Multipath Support for Inter-AS VPNs feature applies to ASBRs that do not have a VPN routing and forwarding (VRF) instance configuration. BGP installs a number of learned VPN-IPv4 prefixes into the Multiprotocol Label Switching (MPLS) forwarding table (LFIB). VPN-IPv4 entries in the LFIB consist of the Route Distinguisher (RD) and the IPv4 prefix and are called VPNv4 entries.

The MPLS VPN Multipath Support for Inter-AS VPNs feature requires that you configure the `maximum-paths number-of-paths` command in address family configuration mode. This command is used to set the number of parallel (equal-cost) routes that BGP installs in the routing table to configure multipath load sharing. The number of paths that can be configured is determined by the version of Cisco software.

Note

The `maximum-paths` command cannot be configured with the `maximum-paths eibgp` command for the same BGP routing process.
The figure below shows an example of VPNv4 load balancing for ASBRs in an Inter-AS network. In this example, ASBR1 load balances the traffic from the CE device CE1 to CE2 using the two available links—ASBR2 and ASBR3.

**Figure 9: Example of VPNv4 Load Balancing for ASBRs in an Inter-AS Network**

When you configure an ASBR for VPNv4 load balancing, you must configure the `next-hop-self` command for the iBGP peers. Without this command, the next hop that is propagated to the iBGP peer is the ASBR2 address or the ASBR3 address, depending on which one BGP selects as the best path. Configuring the `next-hop-self` command provides direct VPNv4 forwarding entries in the MPLS forwarding table for the VPNv4 prefixes learned from the remote ASBRs. VPNv4 forwarding entries are not created if you do not configure the `next-hop-self` command.

> **Note**
> If the number of forwarding entries in the MPLS forwarding table on the system or on a line card is a concern for your network, we recommend that you do not enable VPNv4 multipath on ASBRs.

### How to Configure MPLS VPN Multipath Support for Inter-AS VPNs

#### Configuring eBGP Multipath Load Sharing for MPLS VPN Inter-AS ASBRs

Perform this task to configure the external Border Gateway Protocol (eBGP) multipath load sharing for MPLS VPN Inter-AS ASBRs exchanging Virtual Private Network (VPN)-IPv4 routes. This allows for more efficient use of the label switched paths (LSPs) in an interautonomous system network because you can set up the load sharing of traffic among the different multipaths and the best path to reach the destination.
The figure below shows an eBGP multipath configuration for three VPN-IPv4 ASBRs. The links from ASBR1 to ASBR2 and ASBR3 have an eBGP VPN-IPv4 session configured. In the figure below, eBGP multipath load sharing is configured on ASBR1.

**Figure 10: eBGP Multipath Configuration for Three VPN-IPv4 ASBRs**

The configurations in the figure above is used as an example for this task.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `no bgp default route-target filter`
5. `neighbor {ip-address | peer-group-name} remote-as as-number`
6. `neighbor {ip-address | peer-group-name} update-source interface-type interface-number`
7. `neighbor {ip-address | peer-group-name} next-hop-self`
8. `neighbor {ip-address | peer-group-name} remote-as as-number`
9. Repeat Step 8 for each BGP neighbor.
10. `address-family vpnv4 [unicast]`
11. `neighbor {ip-address | peer-group-name} activate`
12. `neighbor {ip-address | peer-group-name} next-hop-self`
13. `neighbor {ip-address | peer-group-name} send-community [both | standard | extended]`
14. `neighbor {ip-address | peer-group-name | ipv6-address} activate`
15. `neighbor {ip-address | peer-group-name} send-community [both | standard | extended]`
16. Repeat Steps 14 and 15 for each BGP neighbor.
17. `maximum-paths number-paths`
18. `exit-address-family`
19. `end`
## DETAILED STEPS

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Device&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Device# configure terminal</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>router bgp as-number</code></td>
<td>Configures an eBGP routing process and places the device in router configuration mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td>• The <code>as-number</code> argument indicates the number of an autonomous system that identifies the device to other BGP devices and tags the routing information passed along. The range is 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td></td>
<td>Device(config)# router bgp 1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>no bgp default route-target filter</code></td>
<td>Disables BGP route-target community filtering.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td>• All received VPN-IPv4 routes are accepted by the configured device. Accepting VPN-IPv4 routes is the desired behavior for a device configured as an ASBR.</td>
</tr>
<tr>
<td></td>
<td>Device(config-router)# no bgp default route-target filter</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>`neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number`</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td>• <code>ip-address</code>—IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>Device(config-router)# neighbor 10.1.0.4 remote-as 1</td>
<td>• <code>peer-group-name</code>—Name of a BGP peer group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <code>as-number</code>—The autonomous system to which the neighbor belongs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 6</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>`neighbor {ip-address</td>
<td>peer-group-name} update-source interface-type interface-number`</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td>• <code>ip-address</code>—IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>Device(config-router)# neighbor 10.1.0.4 update-source loopback 0</td>
<td>• <code>peer-group-name</code>—Name of a BGP peer group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <code>interface-typeinterface-number</code>—Type and number for the operational interface.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This example shows how to set up BGP TCP connections for the specified neighbor with the IP address of the loopback interface rather than the best local address.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> neighbor {ip-address</td>
<td>peer-group-name} next-hop-self</td>
<td>Configures the device as the next hop for a BGP neighbor or peer group.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# neighbor 10.1.0.4 next-hop-self</td>
<td>• ip-address—IP address of the BGP neighbor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• peer-group-name—Name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 8</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number</td>
<td>Adds an entry to the BGP or multiprotocol BGP neighbor table.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# neighbor 172.16.1.9 remote-as 2</td>
<td>• ip-address—IP address of the neighbor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• peer-group-name—Name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• as-number—Autonomous system to which the neighbor belongs.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong> Repeat Step 8 for each BGP neighbor.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Step 10</strong> address-family vpnv4 [unicast]</td>
<td>Enters address family configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# address-family vpnv4</td>
<td>• unicast—Specifies a unicast prefix.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>This command configures a routing session to carry VPN-IPv4 addresses across the VPN backbone. Each address is globally unique by the addition of an 8-byte RD.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 11</strong> neighbor {ip-address</td>
<td>peer-group-name} activate</td>
<td>Enables the exchange of information with a neighboring device.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.1.0.4 activate</td>
<td>• ip-address—IP address of the neighbor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• peer-group-name—Name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 12</strong> neighbor {ip-address</td>
<td>peer-group-name} next-hop-self</td>
<td>Configures the device as the next hop for a BGP neighbor or peer group.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.1.0.4 next-hop-self</td>
<td>• ip-address—IP address of the BGP neighbor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• peer-group-name—Name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 13</strong> neighbor {ip-address</td>
<td>peer-group-name} send-community [both</td>
<td>standard</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.1.0.4 send-community extended</td>
<td>• ip-address—IP address of the neighboring device.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• peer-group-name—Name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• both—Specifies that both standard and extended communities will be sent.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• standard—Specifies that only standard communities will be sent.</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td><strong>Step 14</strong> neighbor {ip-address</td>
<td>peer-group-name</td>
<td>ipv6-address} activate</td>
</tr>
<tr>
<td><strong>Step 15</strong> neighbor {ip-address</td>
<td>peer-group-name} send-community [both</td>
<td>standard</td>
</tr>
<tr>
<td><strong>Step 16</strong> Repeat Steps 14 and 15 for each BGP neighbor.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 17</strong> maximum-paths number-paths</td>
<td>Configures the maximum number of parallel routes that an IP routing protocol will install into the routing table.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 18</strong> exit-address-family</td>
<td>Exits from address family configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 19</strong> end</td>
<td>(Optional) Exits to privileged EXEC mode.</td>
<td></td>
</tr>
</tbody>
</table>

**Example:**

```
Device(config-router-af)# neighbor 172.16.1.9 activate

Device(config-router-af)# neighbor 172.16.1.9 send-community extended

Device(config-router-af)# maximum-paths 2

Device(config-router-af)# exit-address-family

Device(config-router)# end
```
Example

The following example shows the configuration for external Border Gateway Protocol (eBGP) multipath for VPNv4 sessions on the ASBR1 device:

```
configure terminal
router bgp 1
no bgp default route-target filter
neighbor 10.1.0.4 remote-as 1
neighbor 10.1.0.4 update-source Loopback 0
neighbor 10.1.0.4 next-hop-self
neighbor 172.16.1.9 remote-as 2
neighbor 172.16.2.8 remote-as 2
!
address-family vpnv4
neighbor 10.1.0.4 activate
neighbor 10.1.0.4 next-hop-self
neighbor 10.1.0.4 send-community extended
neighbor 172.16.1.9 activate
neighbor 172.16.1.9 send-community extended
neighbor 172.16.2.8 activate
neighbor 172.16.2.8 send-community extended
maximum-paths 2
exit-address-family
end
```

Verifying eBGP Multipath Load Sharing for MPLS VPN Inter-AS ASBRs

Perform the following task to verify that the external Border Gateway Protocol (eBGP) multipath load sharing for Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) interautonomous system (Inter-AS) Autonomous System Boundary Routers (ASBRs) is operating as you expect.

The configurations in the figure above are used as an example for the task that follows.

**SUMMARY STEPS**

1. enable
2. show ip bgp vpnv4 all [summary]
3. show ip bgp vpnv4 all
4. show ip bgp vpnv4 [network]
5. show mpls forwarding-table
6. exit

**DETAILED STEPS**

**Step 1** enable
Enables privileged EXEC mode. Enter your password if required.
Step 2

**show ip bgp vpnv4 all [summary]**

Verifies that all peers are up.

**Example:**

```
Device# show ip bgp vpnv4 all summary
```

<table>
<thead>
<tr>
<th>Neighbor</th>
<th>V</th>
<th>AS</th>
<th>MsgRcvd</th>
<th>MsgSent</th>
<th>TblVer</th>
<th>InQ</th>
<th>OutQ</th>
<th>Up/Down</th>
<th>State/PfxRcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.0.4</td>
<td>4</td>
<td>1</td>
<td>87</td>
<td>86</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>01:24:56</td>
<td>2</td>
</tr>
<tr>
<td>172.16.1.9</td>
<td>4</td>
<td>2</td>
<td>88</td>
<td>88</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>01:25:49</td>
<td>2</td>
</tr>
<tr>
<td>172.16.2.8</td>
<td>4</td>
<td>2</td>
<td>88</td>
<td>88</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>01:25:49</td>
<td>2</td>
</tr>
</tbody>
</table>

The output shows that all peers expected to be up are up and sending and receiving messages.

**Step 3**

**show ip bgp vpnv4 all**

Verifies that BGP has paths from both remote ASBRs.

**Example:**

```
Device# show ip bgp vpnv4 all
```

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
<th>Metric</th>
<th>LocPrf</th>
<th>Weight</th>
<th>Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

Route Distinguisher: 1:105

*192.168.0.1/32 10.1.0.3 11 100 0 ?

*192.168.0.2/32 172.16.2.8 0 2 ?

*192.168.1.0 10.1.0.3 0 100 0 ?

*192.168.2.0 172.16.1.9 0 2 ?

*192.161.1.9 0 2 ?

The bold entries in the output confirm that BGP has a path to ASBR2 (172.16.2.8) and to ASBR3 (172.16.1.9).

**Step 4**

**show ip bgp vpnv4 [network]**

Verifies that paths are marked as multipath.

**Example:**

```
Device# show ip bgp vpnv4 192.168.2.0
```

BGP routing table entry for 1:105:192.168.2.0/24, version 3

Paths: (2 available, best #1, no table)

- Advertised to update-groups:
  - 2

  172.16.2.8 from 172.16.2.8 (10.2.0.8)
  - Origin incomplete, localpref 100, valid, external, multipath
  - best
  - Extended Community: RT:1:100 OSPF DOMAIN ID:0x0005:0x00000000A0200
  - OSPF RT:0.0.0.0:2:0 OSPF ROUTER ID:192.168.2.2:512,
    mpls labels in/out 21/25

  2

  172.16.1.9 from 172.16.1.9 (10.2.0.9)
  - Origin incomplete, localpref 100, valid, external, multipath
  - Extended Community: RT:1:100 OSPF DOMAIN ID:0x0005:0x00000000A0200
OSPF RT:0.0.0.0:2:0 OSPF ROUTER ID:192.168.2.2:512,
mpls labels in/out 21/25

In the output, the “multipath” and “mpls labels in/out 21/25" are in bold text for example purposes only.

**Step 5**

**show mpls forwarding-table**

Verifies that MPLS forwarding is properly set up and counters are increasing when traffic is present.

### Example:

```
Device# show mpls forwarding-table
```

<table>
<thead>
<tr>
<th>Local Label</th>
<th>Outgoing Prefix</th>
<th>Bytes Label</th>
<th>Outgoing Switched</th>
<th>Outgoing Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Pop Label</td>
<td>172.16.1.9/32</td>
<td>0</td>
<td>Et1/0 172.16.1.9</td>
</tr>
<tr>
<td>17</td>
<td>Pop Label</td>
<td>172.16.2.8/32</td>
<td>0</td>
<td>Et2/0 172.16.2.8</td>
</tr>
<tr>
<td>18</td>
<td>Pop Label</td>
<td>10.1.1.0/24</td>
<td>0</td>
<td>Et0/0 10.1.2.4</td>
</tr>
<tr>
<td>19 16</td>
<td>Pop Label</td>
<td>10.1.0.4/32</td>
<td>0</td>
<td>Et0/0 10.1.2.4</td>
</tr>
<tr>
<td>20</td>
<td>Pop Label</td>
<td>10.1.0.3/32</td>
<td>0</td>
<td>Et0/0 10.1.2.4</td>
</tr>
<tr>
<td>21 25</td>
<td>1:105:192.168.2/24</td>
<td>0</td>
<td>Et1/0 172.16.1.1.9</td>
<td></td>
</tr>
<tr>
<td>22 24</td>
<td>1:105:192.168.0.2/32</td>
<td>0</td>
<td>Et1/0 172.16.1.1.9</td>
<td></td>
</tr>
<tr>
<td>23 19</td>
<td>1:105:192.168.0.1/32</td>
<td>0</td>
<td>Et2/0 172.16.2.8</td>
<td></td>
</tr>
<tr>
<td>24 20</td>
<td>1:105:192.168.1.0/24</td>
<td>0</td>
<td>Et0/0 10.1.2.4</td>
<td></td>
</tr>
</tbody>
</table>
```

**Step 6**

**exit**

Exits to user EXEC mode. For example:

```
Device# exit
Device>
```

---

**Configuration Examples for MPLS VPN Multipath Support for Inter-AS VPNs**

**Example: Configuring eBGP Multipath Load Sharing for MPLS VPN Inter-AS ASBRs**

This section includes examples that show how to configure the external Border Gateway Protocol (eBGP) multipath load sharing for Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) interautonomous system (Inter-AS) Autonomous System Boundary Routers (ASBRs) that exchange VPN-IPv4 routes.
The network topology in the figure below shows two autonomous systems, which are configured as follows:

- Autonomous system 1 contains PE1, P1, and ASBR1.
- Autonomous system 2 contains PE2, P2, ASBR2, and ASBR3.
- CE1 and CE2 belong to the same VPN, which is called VPN1.
- The P devices are route reflectors.
- ASBR1 and ASBR2 are configured with the `neighbor next-hop-self` command for the internal BGP (iBGP) neighbors.
- ASBR1 and ASBR2 are configured with the `maximum paths` commands to set up eBGP multipath load sharing.

**Figure 11: Configuring eBGP Multipath Load Sharing Between MPLS Inter-AS ASBRs Exchanging VPN-IPv4 Routes**

The following examples show how to configure eBGP multipath load sharing for MPLS VPN Inter-AS ASBRs that exchange VPN-IPv4 routes. This section includes sample configurations for PE1, ASBR1, ASBR2, and PE2 devices.

**Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 1 CE1**

The following example shows how to configure CE1 in VPN1:

```
! hostname CE1
! interface Loopback 1
  ip address 192.168.0.1 255.255.255.255
! interface Ethernet 1/0
  description Link to PE1
  ip address 192.168.1.1 255.255.255.0
! router ospf 1
  log-adjacency-changes
  network 192.168.0.0 0.0.255.255 area 0
! end
```
Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 1 PE1

The following example shows how to configure PE1 in autonomous system 1:

```plaintext
! hostname PE1
! ip cef
! ip vrf V1
  rd 1:105
  route-target export 1:100
  route-target import 1:100
! interface Loopback 0
  ip address 10.1.0.3 255.255.255.255
! interface Ethernet 0/0
  description Link to CE1
  ip vrf forwarding V1
  ip address 192.168.1.2 255.255.255.0
! interface Ethernet 1/0
  description Link to P1
  ip address 10.1.1.3 255.255.255.0
  mpls ip
! router ospf 10 vrf V1
  log-adjacency-changes
  redistribute bgp 1 metric 100 subnets
  network 192.168.0.0 0.0.255.255 area 0
! router ospf 1
  log-adjacency-changes
  network 10.0.0.0 0.255.255.255 area 0
! router bgp 1
  no synchronization
  bgp log-neighbor-changes
  neighbor 10.1.0.4 remote-as 1
  no neighbor 10.1.0.4 transport path-mtu-discovery
  neighbor 10.1.0.4 update-source Loopback 0
  no auto-summary
! address-family vpnv4
  neighbor 10.1.0.4 activate
  neighbor 10.1.0.4 send-community extended
  exit-address-family
! address-family ipv4 vrf V1
  redistribute ospf 10 vrf V1
  no auto-summary
  no synchronization
  exit-address-family
! end
```

Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 1 P1

The following example shows how to configure P1 in autonomous system 1:

```plaintext
! hostname P1
! ip cef
! interface Loopback 0
```
Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 1 ASBR1

The following example shows how to configure ASBR1 in autonomous system 1:

hostname ASBR1
!
ip cef
!
interface Loopback 0
  ip address 10.1.0.5 255.255.255.255
!
interface Ethernet 0/0
  description Core link to P1
  ip address 10.1.2.5 255.255.255.0
  mpls ip
!
interface Ethernet 1/0
  description Link to ASBR2
  ip address 172.16.2.5 255.255.255.0
  mpls bgp forwarding
!
interface Serial 3/0
  description Link to ASBR3
  ip address 172.16.1.5 255.255.255.0
  mpls bgp forwarding
  serial restart-delay 0
!
router ospf 1
  log-adjacency-changes
  network 10.0.0.0 0.255.255.255 area 0
!
router bgp 1
  no synchronization
  bgp log-neighbor-changes
  neighbor R peer-group
  neighbor R remote-as 1
  no neighbor R transport path-mtu-discovery
  neighbor R update-source Loopback 0
  neighbor R route-reflector-client
  neighbor 10.1.0.3 peer-group R
  neighbor 10.1.0.5 peer-group R
  no auto-summary
!
address-family vpnv4
  neighbor R send-community extended
  neighbor R route-reflector-client
  neighbor 10.1.0.3 activate
  neighbor 10.1.0.5 activate
!
exit-address-family
end
no synchronization
no bgp default route-target filter
bgp log-neighbor-changes
neighbor 10.1.0.4 remote-as 1
neighbor 172.16.1.9 remote-as 2
neighbor 172.16.2.8 remote-as 2
no auto-summary
!
address-family vpnv4
neighbor 10.1.0.4 activate
neighbor 10.1.0.4 send-community extended
neighbor 10.1.0.4 next-hop-self
neighbor 172.16.1.9 activate
neighbor 172.16.1.9 send-community extended
neighbor 172.16.2.8 activate
neighbor 172.16.2.8 send-community extended
maximum-paths 2
exit-address-family
!
end

The following example shows how to configure ASBR2 in autonomous system 2:

! hostname ASBR2
!
ip cef
!
interface Loopback 0
   ip address 10.2.0.8 255.255.255.255
!
interface Loopback 1
   no ip address
   shutdown
!
interface Ethernet 0/0
   description Link to ASBR1
   ip address 172.16.2.8 255.255.255.0
   mpls bgp forwarding
!
interface Serial 2/0
   description Link to P2
   ip address 10.2.2.8 255.255.255.0
   mpls ip
   no fair-queue
   serial restart-delay 0
!
router ospf 1
   log-adjacency-changes
   redistribute connected subnets
   network 10.0.0.0 0.255.255.255 area 0
!
router bgp 2
   no synchronization
   no bgp default route-target filter
   bgp log-neighbor-changes
   neighbor 10.2.0.7 remote-as 2
   neighbor 10.2.0.7 update-source Loopback 0
   neighbor 10.2.0.7 next-hop-self
   neighbor 172.16.2.5 remote-as 1
   no auto-summary
!
address-family vpnv4
neighbor 10.2.0.7 activate
neighbor 10.2.0.7 send-community extended
neighbor 10.2.0.7 next-hop-self
neighbor 172.16.2.5 activate
neighbor 172.16.2.5 send-community extended

Example: Configuring eBGP Multipath Load Sharing for MPLS VPN Inter-AS ASBRs
Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 2 ASBR3

The following example shows how to configure ASBR3 in autonomous system 2:

```plaintext
! hostname ASBR3
! ip cef
! interface Loopback 0
  ip address 10.2.0.9 255.255.255.255
! interface Ethernet 0/0
  description Link to ASBR1
  ip address 172.16.1.9 255.255.255.0
  mpls bgp forwarding
! interface Serial 3/0
  description Link to P2
  ip address 10.2.3.9 255.255.255.0
  mpls ip
  no fair-queue
  serial restart-delay 0
! router ospf 1
  log-adjacency-changes
  redistribute connected subnets
  network 10.0.0.0 0.255.255.255 area 0
!
router bgp 2
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  neighbor 10.2.0.7 remote-as 2
  neighbor 10.2.0.7 update-source Loopback 0
  neighbor 10.2.0.7 next-hop-self
  neighbor 172.16.1.5 remote-as 1
  no auto-summary
!
address-family vpnv4
  neighbor 10.2.0.7 activate
  neighbor 10.2.0.7 send-community extended
  neighbor 10.2.0.7 next-hop-self
  neighbor 172.16.1.5 activate
  neighbor 172.16.1.5 send-community extended
  exit-address-family
!
end
```

Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 2 P2

The following example shows how to configure P2 in autonomous system 2:

```plaintext
! hostname P2
! ip cef
! interface Loopback 0
  ip address 10.2.0.7 255.255.255.255
! interface Ethernet 1/0
  description Link to PE2
```
ip address 10.2.1.7 255.255.255.0
mpls ip

interface Serial 2/0
description Link to ASBR2
ip address 10.2.2.7 255.255.255.0
mpls ip
no fair-queue
serial restart-delay 0

interface Serial 3/0
description Link to ASBR3
ip address 10.2.3.7 255.255.255.0
mpls ip
serial restart-delay 0

router ospf 1
log-adjacency-changes
network 10.0.0.0 0.255.255.255 area 0

router bgp 2
no synchronization
bgp log-neighbor-changes
neighbor R peer-group
neighbor R remote-as 2
no neighbor R transport path-mtu-discovery
neighbor R update-source Loopback 0
neighbor R route-reflector-client
neighbor 10.2.0.6 peer-group R
neighbor 10.2.0.8 peer-group R
neighbor 10.2.0.9 peer-group R
no auto-summary

address-family vpnv4
neighbor R send-community extended
neighbor R route-reflector-client
neighbor 10.2.0.6 activate
neighbor 10.2.0.8 activate
neighbor 10.2.0.9 activate
exit-address-family

end

Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 2 PE2

The following example shows how to configure PE2 in autonomous system 2:

hostname PE2
ip cef
ip vrf V1
rd 1:105
route-target export 1:100
route-target import 1:100

interface Loopback 0
ip address 10.2.0.6 255.255.255.255

interface Ethernet 0/0
description Link to P2
ip address 10.2.1.6 255.255.255.0
mpls ip

interface Serial 2/0
description Link to CE2
ip vrf forwarding V1
ip address 192.168.2.2 255.255.255.0
no fair-queue
Example: Multipath Support for Inter-AS VPNs Configuration for Autonomous System 2 CE2

The following example shows how to configure CE2 in VPN1:

```
hostname CE2
!
interface Loopback 0
  ip address 192.168.0.2 255.255.255.255
!
interface Serial 2/0
  description Link to PE2
  ip address 192.168.2.1 255.255.255.0
  no fair-queue
  serial restart-delay 0
!
router ospf 1
  log-adjacency-changes
  network 192.168.0.0 0.0.255.255 area 0
end
```

Additional References

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco IOS commands</td>
<td>Cisco IOS Master Command List, All Releases</td>
</tr>
<tr>
<td>MPLS commands</td>
<td>Cisco IOS Multiprotocol Label Switching Command Reference</td>
</tr>
</tbody>
</table>
### Related Topic

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<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
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<tr>
<td>Configuration tasks for basic MPLS VPNs</td>
<td>&quot;Configuring MPLS VPNs&quot; module in the <em>MPLS: Layer 3 VPNs Configuration Guide</em></td>
</tr>
<tr>
<td>Configuration tasks for MPLS VPN Inter-AS system exchanging IPv4 routes and MPLS labels</td>
<td>&quot;MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels&quot; module in the <em>MPLS: Layer 3 VPNs Inter-AS and CSC Configuration Guide</em></td>
</tr>
<tr>
<td>Information about monitoring MPLS VPNs with MIBs</td>
<td>&quot;MPLS VPN SNMP MIB Notifications&quot; module in the <em>MPLS: Embedded Management and MIBs Configuration Guide</em></td>
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### RFCs

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<tr>
<td>RFC 1164</td>
<td><em>Application of the Border Gateway Protocol in the Internet</em></td>
</tr>
<tr>
<td>RFC 1700</td>
<td><em>Assigned Numbers</em></td>
</tr>
<tr>
<td>RFC 1771</td>
<td><em>A Border Gateway Protocol 4</em></td>
</tr>
<tr>
<td>RFC 1965</td>
<td><em>Autonomous System Confederation for BGP</em></td>
</tr>
<tr>
<td>RFC 1966</td>
<td><em>BGP Route Reflection: An Alternative to Full Mesh iBGP</em></td>
</tr>
<tr>
<td>RFC 2547</td>
<td><em>BGP/MPLS VPNs</em></td>
</tr>
<tr>
<td>RFC 2842</td>
<td><em>Capabilities Advertisement with BGP-4</em></td>
</tr>
<tr>
<td>RFC 2858</td>
<td><em>Multiprotocol Extensions for BGP-4</em></td>
</tr>
<tr>
<td>RFC 3107</td>
<td><em>Carrying Label Information in BGP-4</em></td>
</tr>
</tbody>
</table>
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
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<tbody>
<tr>
<td>The Cisco Support and Documentation website provides online resources to</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
<tr>
<td>download documentation, software, and tools. Use these resources to install</td>
<td></td>
</tr>
<tr>
<td>and configure the software and to troubleshoot and resolve technical issues</td>
<td></td>
</tr>
<tr>
<td>with Cisco products and technologies. Access to most tools on the Cisco</td>
<td></td>
</tr>
<tr>
<td>Support and Documentation website requires a Cisco.com user ID and password.</td>
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</table>

Feature Information for MPLS VPN Multipath Support for Inter-AS VPNs

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 4: Feature Information for MPLS VPN Multipath Support for Inter-AS VPNs

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
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<tbody>
<tr>
<td>MPLS VPN Multipath Support for Inter-AS VPNs</td>
<td>12.2(30)S, 12.2(33)SRA, 12.2(33)SXH, 12.4(20)T, Cisco IOS XE Release 3.8S, Cisco IOS XE Release 3.9S</td>
<td>The MPLS VPN Multipath Support for Inter-AS VPNs feature supports Virtual Private Network (VPN)v4 multipath for Autonomous System Boundary Routers (ASBRs) in the interautonomous system (Inter-AS) Multiprotocol Label Switching (MPLS) VPN environment. It allows load balancing of VPN traffic when you use the VPNv4 peering model for Inter-AS VPNs. In Cisco IOS XE Release 3.8S, support was added for the Cisco ISR 4400 Series Routers. In Cisco IOS XE Release 3.9S, support was added for the Cisco CSR 1000V. No commands were introduced or modified.</td>
</tr>
</tbody>
</table>
Glossary

**autonomous system**—A collection of networks under a common administration sharing a common routing strategy.

**BGP**—Border Gateway Protocol. An interdomain routing protocol that exchanges network reachability information with other BGP systems (which may be within the same autonomous system or between multiple autonomous systems).

**CE device**—customer edge device. A device that is part of a customer network and that interfaces to a provider edge (PE) device. CE devices do not recognize associated MPLS VPNs.

**eBGP**—exterior Border Gateway Protocol. A BGP between devices located within different autonomous systems. When two devices, located in different autonomous systems, are more than one hop away from one another, the eBGP session between the two devices is considered a multihop BGP.

**iBGP**—interior Border Gateway Protocol. A BGP between devices within the same autonomous system.

**LFIB**—Label Forwarding Information Base. Data structure used in MPLS to hold information about incoming and outgoing labels and associated Forwarding Equivalence Class (FEC) packets.

**MPLS**—Multiprotocol Label Switching. The name of the IETF working group responsible for label switching, and the name of the label switching approach it has standardized.

**PE device**—provider edge device. A device that is part of a service provider’s network. It is connected to a customer edge (CE) device and all MPLS VPN processing occurs in the PE device.

**RD**—route distinguisher. An 8-byte value that is concatenated with an IPv4 prefix to create a unique VPN-IPv4 prefix.

**VPN**—Virtual Private Network. A secure MPLS-based network that shares resources on one or more physical networks (typically implemented by one or more service providers). A VPN contains geographically dispersed sites that can communicate securely over a shared backbone network.

**VRF**—VPN routing and forwarding instance. Routing information that defines a Virtual Private Network (VPN) site that is attached to a provider edge (PE) device. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table.
MPLS VPN--Inter-AS Option AB

The MPLS VPN--Inter-AS Option AB feature combines the best functionality of an Inter-AS Option (10) A and Inter-AS Option (10) B network to allow a Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) service provider to interconnect different autonomous systems to provide VPN services. These networks are defined in RFC 4364 section 10 “Multi-AS Backbones,” subsections a and b, respectively.

When different autonomous systems are interconnected in an MPLS VPN--Inter-AS Option AB configuration, the entire network configuration is scaled and simplified, and maintains IP quality of service (QoS) functions between Autonomous System Boundary Router (ASBR) peers.

In an Inter-AS Option A network, ASBR peers are connected by multiple subinterfaces with at least one interface VPN that spans the two autonomous systems. These ASBRs associate each subinterface with a VPN routing and forwarding (VRF) instance and a Border Gateway Protocol (BGP) session to signal unlabeled IP prefixes. As a result, traffic between the back-to-back VRFs is IP. In this scenario, the VPNs are isolated from each other, and because the traffic is IP, QoS mechanisms that operate on IP traffic can be applied to achieve customer Service Level Agreements (SLAs). The downside of this configuration is that one BGP session is needed for each subinterface (and at least one subinterface for each VPN), which causes scalability concerns as this network grows.

In an Inter-AS Option B network, ASBR peers are connected by one or more subinterfaces that are enabled to receive MPLS traffic. A Multiprotocol Border Gateway Protocol (MP-BGP) session is used to distribute labeled VPN prefixes between the ASBR. As a result, the traffic that flows between them is labeled. The downside of this configuration is that, because the traffic is MPLS, QoS mechanisms that can be applied only to IP traffic cannot be applied and the VRFs cannot be isolated.

- Finding Feature Information, page 90
- Prerequisites for MPLS VPN--Inter-AS Option AB, page 90
- Restrictions for MPLS VPN--Inter-AS Option AB, page 90
- Information About MPLS VPN--Inter-AS Option AB, page 90
- How to Configure Inter-AS Option AB, page 98
- Configuration Examples for MPLS VPN--Inter-AS Option AB, page 107
- Additional References, page 128
- Feature Information for MPLS VPN--Inter-AS Option AB, page 130
- Glossary, page 131
Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for MPLS VPN--Inter-AS Option AB

Follow the appropriate configuration tasks outlined in the following documents:

• Configuring MPLS Layer 3 VPNs
• MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses
• MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels

Before configuring the MPLS VPN--Inter-AS Option AB feature, perform these tasks:

• Enable Cisco Express Forwarding, which is required for the MPLS VPN routing and forwarding operation.
• Identify the VPNs for the MPLS VPN--Inter-AS Option AB network and configure the VRFs to which these VPNs belong. These VRFs are used for Inter-AS Option AB connections on the ASBR interface.

Restrictions for MPLS VPN--Inter-AS Option AB

• The In Service Software Upgrade (ISSU) feature can be configured only on the active Route Processor (RP) if the standby RP supports this feature. The ISSU feature can be configured if both the active and standby RP support this feature.
• Carrier Supporting Carrier (CSC) MPLS load-balancing on ASBR Option AB VRF interfaces is not supported.
• VPNv6 is not supported.

Information About MPLS VPN--Inter-AS Option AB

MPLS VPN--Inter-AS Option AB Introduction

MPLS VPN service providers need to interconnect different autonomous systems to provide service for multiple VPN customers. The MPLS VPN--Inter-AS Option AB feature allows the different autonomous systems to interconnect by using a single MP-BGP session in the global routing table to carry control plane traffic. This MP-BGP session signals VPN prefixes between two ASBRs for each VRF instance. The data plane traffic is on a VRF interface. This traffic can either be IP or MPLS.
Benefits of MPLS VPN--Inter-AS Option AB

The MPLS VPN--Inter-AS Option AB feature provides the following benefits for service providers:

- Network configuration can be simplified because only one BGP session is configured for each VRF on the ASBR.
- One BGP session reduces CPU utilization.
- Networks can be scaled because a single MP-BGP session, which is enabled globally on the router, reduces the number of sessions required by multiple VPNs, while continuing to keep VPNs isolated and secured from each other.
- IP QoS functions between ASBR peers are maintained for customer SLAs.
- Dataplane traffic is isolated on a per-VRF basis for security purposes.

Option B Style Peering with Shared Link Forwarding

An enhancement to Inter-AS Option AB is the MPLS VPN—Inter-AS Option AB+ feature. This feature addresses the scalability concerns of MPLS VPN—Inter-AS Option A by using a single BGP session in the global routing table to signal VPN prefixes (as described in Inter-AS Option B).

The key difference between Option AB+ and Option B is in the route distribution between ASBRs. In Option AB+, at the ASBR, the route that is imported into the VRF (with the route distinguisher and route targets of the VRF) is distributed to the neighboring ASBR. In Option B, the original pre-import route (with the original RD and RTs) is distributed to the neighboring ASBR and not the imported route.

With Option AB+, the PE and ASBRs deploy MPLS forwarding over a global interface, similar to what is done in Option B, and the signaling is handled by a single MP-eBGP VPNv4 session. The provider edge and ASBRs thus use regular Option B style peering between them. They receive MPLS-VPN traffic over the shared link and forward the traffic as per an IP lookup in the VRF routing table. However, the traffic is MPLS encapsulated, like it is in Option B.

Route Distribution and Packet Forwarding in Non-CSC Networks

The following sections describe MPLS VPN--Inter-AS Option AB operation:

Note

All imported routes are accomplished by configuring the appropriate route targets (RTs).

The following attributes describe the topology of the sample MPLS VPN--Inter-AS Option AB network shown in the figure below:

- Customer edge 1 (CE1) and CE3 belong to VPN 1.
CE2 and CE 4 belong to VPN 2.

Provider edge 1 (PE1) uses route distinguisher 1 (RD 1) for VPN 1 (VRF 1) and RD 2 for VPN 2 (VRF 2).

PE2 uses RD 3 for VPN 1 (VRF 1) and RD 4 for VPN 2 (VRF 2).

ASBR1 has VRF 1 provisioned with RD 5 and VRF 2 provisioned with RD 6.

ASBR2 has VRF 1 provisioned with RD 7 and VRF 2 provisioned and RD 8.

ASBR1 and ASBR2 have three links between them:
- VRF 1
- VRF 2
- MP-BGP session

The VRFs configured on the ASBRs are called Option AB VRFs. The eBGP peers on the ASBRs are called Option AB Peers.

**Note**

The following process describes the route distribution process for VPN 1 in the figure above. Prefix “N” is used in this process to indicate the IP address of a VPN.

1. CE1 advertises the prefix N to PE1.
2 PE1 advertises a VPN prefix RD 1:N to ASBR1 through MP internal BGP (iBGP).
3 ASBR1 imports the prefix into VPN 1 and creates a prefix RD 5:N.
4 ASBR1 advertises the imported prefix RD 5:N to ASBR2. ASBR1 sets itself as the next hop for prefix RD 5:N and allocates a local label that is signaled with this prefix.
5 ASBR1 advertises the route with the export RT configured on the VRF rather than the originally received RTs. By default, ASBR1 does not advertise the source prefix RD 1:N to ASBR2. This advertisement is suppressed because the prefix is being imported into an Option AB VRF.

Note
In an Option 10B connection, the source prefix can be advertised to another ASBR on which ASBR1 has an Option 10B connection. An ASBR with an Option 10B connection maintains all VPNv4 routes in its BGP table.

1 ASBR2 receives the prefix RD 5:N and imports it into VPN 1 as RD 7:N.
2 ASBR2 advertises the route with the export RT configured on the VRF rather than the originally received RTs.
3 While importing the prefix, ASBR2 sets the next hop of RD 7:N to the ASBR1 interface IP address in VRF 1. The next hop table ID is also set to VRF 1. When installing the MPLS forwarding entry for RD 7:N, by default ASBR2 does not install the outgoing label in the forwarding process. This enables the traffic between the ASBRs to be IP.
4 ASBR2 advertises the imported prefix RD 7:N to PE2. It sets itself as the next hop for this prefix and also allocates a local label that is signaled with the prefix. By default, ASBR2 does not advertise the source prefix RD 5:N to PE2. This advertisement is suppressed because the prefix is being imported into an Option AB VRF.
5 PE2 imports the RD 7:N into VRF 1 as RD 3:N.

Packet Forwarding for VPN 1

The following packet forwarding process works the same as it does in an Option A scenario. The ASBR acts like the PE by terminating the VPN and then forwards its traffic as standard IP packets with no VPN label to the next PE, which in turn repeats the VPN process. Each PE router, therefore, treats the adjacent PE router as a CE router, and the standard Layer 3 MPLS VPN mechanisms are used for route redistribution with each autonomous system; that is, the PEs use external BGP (eBGP) to distribute unlabeled IPv4 addresses to each other.

Note
Prefix "N" is used in this process to indicate the IP address of a VPN.

1 CE3 sends a packet destined for N to PE2.
2 PE2 encapsulates the packet with the VPN label allocated by ASBR2 and the Interior Gateway Protocol (IGP) label needed to tunnel the packet to ASBR2.
3 The packet arrives on ASBR2 with the VPN label. ASBR2 removes the VPN label and sends the packet as IP to ASBR1 on the VRF 1 interface.
4 The IP packet arrives at ASBR1 on the VRF 1 interface. ASBR1 then encapsulates the packet with the VPN label allocated by PE1 and the IGP label needed to tunnel the packet to PE1.

5 The packet arrives on PE1 with the VPN label. PE1 disposes the VPN label and forwards the IP packet to CE1.

Route Distribution for VPN 2

The following information describes the route distribution process for VPN 2 in the figure above:

1 CE2 advertises prefix N to PE1, where N is the VPN IP address.

2 PE1 advertises a VPN prefix RD 2:N to ASBR1 through MP-iBGP.

3 ASBR1 imports the prefix into VPN 2 and creates a prefix RD 6:N.

4 ASBR1 advertises the imported prefix RD 6:N to ASBR2. It sets itself as the next hop for this prefix and also allocates a local label that is signaled with the prefix. By default, ASBR1 does not advertise the source prefix RD 2:N to ASBR2. This advertisement is suppressed as the prefix is being imported into an Option AB VRF.

Note

In the case of an Option 10B connection, the source prefix can be advertised to another ASBR on which ASBR1 has an Option 10B connection. An ASBR with an Option 10B connection maintains all VPNv4 routes in its BGP table.

1 ASBR2 receives the prefix RD 6:N and imports it into VPN 2 as RD 8:N.

2 While importing the prefix, ASBR2 sets the next hop of RD 8:N to ASBR1's interface address in VRF 2. The next hop table ID is also set to that of VRF 2. While installing the MPLS forwarding entry for RD 8:N, by default ASBR2 does not install the outgoing label in the forwarding process. This enables traffic between the ASBRs to be IP.

3 ASBR2 advertises the imported prefix RD 8:N to PE2. It sets itself as the next hop for this prefix and also allocates a local label that is signaled with the prefix. By default, ASBR2 does not advertise the source prefix RD 6:N to PE2. This advertisement is suppressed because the prefix is being imported into an Option AB VRF.

4 PE2 imports the RD 8:N into VRF 2 as RD 4:N.

Route Distribution and Packet Forwarding for CSC

The following sections describe MPLS VPN--Inter-AS Option AB operation for a CSC scenario for VPN 1. These sections are similar to those found in Route Distribution and Packet Forwarding in Non-CSC Networks for VPN 1, except for the method in which MPLS labels are handled between the two ASBRs.

Note

VPN 2 is not shown or discussed in this section.
The figure below shows how VPN 1 provides VPN service to a small customer carrier that in turn provides a VPN service to its customer. This configuration implies that VPN 1 is used to provide a label switched path (LSP) between the PE (PE 3 and PE 4) loopback interfaces of the small customer carrier.

Figure 13: MPLS VPN Inter-AS Option AB CSC Topology

**Note**
The RD, RT, VRF, and Link provisioning in this section is the same as in the Route Distribution and Packet Forwarding in Non-CSC Networks example for VPN 1.

**Route Distribution for VPN 1**

The following information describe the route distribution process for VPN 1 in Figure 1. Prefix "N" is used in these steps to indicate the IP address of a VPN.

1. CE1 advertises PE 3 loopback N to PE1.
2. PE1 advertises a VPN prefix RD 1:N to ASBR1 through MP-iBGP.
3. ASBR1 imports the prefix into VPN 1 and creates a prefix RD 5:N.
4. ASBR1 advertises the imported prefix RD 5:N to ASBR2. It sets itself as the next hop for this prefix and also allocates a local label that is signaled with the prefix.
5. ASBR1 advertises the route with the export RT configured on the VRF rather than the originally received RTs. By default, ASBR1 does not advertise the source prefix RD 1:N to ASBR2. This advertisement is suppressed as the prefix is being imported into an Option AB VRF.

**Note**
In an Option 10B connection, the source prefix can be advertised to another ASBR on which ASBR1 has an Option 10B connection. An ASBR with an Option 10B connection maintains all VPNv4 routes in its BGP table.

1. ASBR2 receives the prefix RD 5:N and imports it into VPN 1 as RD 7:N.
2. ASBR2 advertises the route with the export RT configured on the VRF rather than the originally received RTs.
3 While importing the prefix, ASBR2 sets the next hop of RD 7:N to the ASBR1 interface address in VRF 1. The next hop table ID is also set to that of VRF 1.

Note
In a CSC scenario, an outgoing MPLS label can be installed in forwarding by making a configuration change. See the How to Configure Inter-AS Option AB, on page 98.

1 While installing the MPLS forwarding entry for RD 7:N, ASBR2 installs the outgoing label during the forwarding process, which enables the traffic between the ASBRs to be MPLS traffic.

2 ASBR2 advertises the imported prefix RD 7:N to PE2. It sets itself as the next hop for this prefix and also allocates a local label that is signaled with the prefix. By default, ASBR2 does not advertise the source prefix RD 5:N to PE2. This advertisement is suppressed as the prefix is being imported into an Option AB VRF.

3 PE2 imports the RD 7:N into VRF 1 as RD 3:N.

Packet Forwarding for VPN 1

The packet forwarding process shown below works the same as it does in an Option A scenario. See the Route Distribution and Packet Forwarding in Non-CSC Networks section for more information about Option A.

1 PE 4 sends an MPLS packet destined for N to CE2.

2 CE2 swaps the MPLS label and sends a packet destined for N to PE2.

3 PE2 encapsulates the packet with the VPN label allocated by ASBR2 and the IGP label needed to tunnel the packet to ASBR2.

4 The packet arrives on ASBR2 with the VPN label. ASBR2 swaps the received VPN label with the outgoing label received from ASBR1 and sends the MPLS packet on to the VRF 1 interface.

5 The MPLS packet arrives at ASBR1 on the VRF 1 interface. ASBR1 then swaps the received MPLS label with a label stack consisting of the VPN label allocated by PE1 and the IGP label needed to tunnel the packet to PE1.

6 The packet arrives on PE1 with the VPN label. PE1 disposes the VPN label and forwards the MPLS packet to CE1. CE1 in turn swaps the label and forwards the labeled packet to PE 3.

Shared Link Forwarding in Non-CSC Networks

Note
All imported routes are accomplished by configuring the appropriate route targets (RTs).

The following attributes describe the sample network topology shown in the "Route Distribution and Packet Forwarding in Non-CSC Networks" section:

- Customer edge 1 (CE1) and CE3 belong to VPN 1.
- CE2 and CE 4 belong to VPN 2.
• Provider edge 1 (PE1) uses route distinguisher 1 (RD 1) for VPN 1 (VRF 1) and RD 2 for VPN 2 (VRF 2).
• PE2 uses RD 3 for VPN 1 (VRF 1) and RD 4 for VPN 2 (VRF 2).
• ASBR1 has VRF 1 provisioned with RD 5 and VRF 2 provisioned with RD 6.
• ASBR2 has VRF 1 provisioned with RD 7 and VRF 2 provisioned and RD 8.
• ASBR1 and ASBR2 have three links between them:
  • VRF 1
  • VRF 2
  • MP-BGP session

Note

The VRFs configured on the ASBRs are called Option AB+ VRFs. The eBGP peers on the ASBRs are called Option AB+ Peers.

The following sections describe MPLS VPN—Inter-AS Option AB+ shared link forwarding in a non-CSC network:

Route Distribution for VPN 1

The following process describe the route distribution process for VPN 1 shown in the figure in the "Route Distribution and Packet Forwarding in Non-CSC Networks" section. Prefix “N” is used in these steps to indicate the IP address of a VPN.

1 CE1 advertises PE 3 loopback N to PE1.
2 PE1 advertises a VPN prefix RD 1:N to ASBR1 through MP-iBGP.
3 ASBR1 imports the prefix into VPN 1 and creates a prefix RD 5:N.
4 ASBR1 advertises the imported prefix RD 5:N to ASBR2. ASBR1 sets itself as the next hop for prefix RD 5:N and also allocates a local label that is signaled with this prefix.
5 By default, ASBR1 does not advertise the source prefix RD 1:N to ASBR2. This advertisement is suppressed because the prefix is being imported into an Option AB+ VRF.

Note

In an Option 10B connection, the source prefix can be advertised to another ASBR on which ASBR1 has an Option 10B connection. An ASBR with an Option 10B connection maintains all VPNv4 routes in its BGP table.

1 ASBR2 receives the prefix RD 5:N and imports it into VPN 1 as RD 7:N.
2 While importing the prefix, ASBR2 retains the next hop of RD7:N as received in the BGP update from ASBR2. This is the address of ASBR1 shared interface address in the global table. The next hop tableid is also left unchanged and corresponds to that of the global table.
3. When installing the MPLS forwarding entry for RD 7:N, ASBR2 installs the outgoing label in the forwarding process. This enables the traffic between the ASBRs to be IP.

4. ASBR2 advertises the imported prefix RD 7:N to PE2. It sets itself as the next hop for this prefix and also allocates a local label that is signaled with the prefix.

5. By default, ASBR2 does not advertise the source prefix RD 5:N to PE2. This advertisement is suppressed because the prefix is being imported into an Option AB+ VRF.

6. PE2 imports the RD 7:N into VRF 1 as RD 3:N.

Packet Forwarding for VPN1

The following packet forwarding process works the same as it does in an Option B scenario.

1. CE3 sends a packet destined for N to PE2.

2. PE2 encapsulates the packet with the VPN label allocated by ASBR2 and the IGP label needed to tunnel the packet to ASBR2.

3. The packet arrives on ASBR2 with the VPN label. ASBR2 swaps the received VPN label with the outgoing label received from ASBR1 and sends the MPLS packet on the global shared link interface.

4. The MPLS packet arrives at ASBR1 on the global shared link interface. ASBR1 then swaps the received MPLS label with a label stack consisting of the VPN label allocated by PE1 and the IGP label needed to tunnel the packet to PE1.

5. The packet arrives on PE1 with the VPN label. PE1 removes the VPN label and forwards the IP packet to CE1.

How to Configure Inter-AS Option AB

The following sections describe how to configure the Inter-AS Option AB feature on an ASBR for either an MPLS VPN or an MPLS VPN that supports CSC:

Note

If Inter-AS Option AB is already deployed in your network and you want to do Option B style peering for some prefixes (that is, implement Inter-AS Option AB+), configure the `inter-as-hybrid global` command as described in the “Configuring the Routing Policy for VPNs that Need Inter-AS Connections” section.

Configuring an Inter-AS Option AB Connection

The following sections are required and describe how to configure an Inter-AS Option AB connection on an ASBR:

Note

See the Configuring MPLS Layer 3 VPNs feature module for more information on configuring PE and CE routers in an MPLS VPN.
### Configuring the VRFs on the ASBR Interface for Each VPN Customer

Use the following steps to configure the VRFs on the ASBR interface for each VPN customer so that these VPNs have connectivity over the MPLS VPN--Inter-AS Option AB network.

**Note**
The `mpls bgp forwarding` command is used only on the ASBR interface for VRFs that support CSC.

Use all of the steps in the following procedure to configure additional VRFs that need to be configured on the ASBR interface and the VRFs that need to be configured on the peer ASBR interface.

#### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `interface type number`
4. `ip vrf forwarding vrf-name`
5. `mpls bgp forwarding`
6. `end`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface type number</td>
<td>Specifies the interface to configure and enters interface configuration</td>
</tr>
<tr>
<td>Example:</td>
<td>mode.</td>
</tr>
<tr>
<td>Router(config)# interface Ethernet 5/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> ip vrf forwarding vrf-name</td>
<td>Associates a VRF with the specified interface or subinterface.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# ip vrf forwarding vpn1</td>
<td></td>
</tr>
</tbody>
</table>
### Purpose

Command or Action | Purpose
--- | ---

**Step 5**

- mpls bgp forwarding
  - Example:
    ```
    Router(config-if)# mpls bgp forwarding
    ```

(Optional) Configures BGP to enable MPLS forwarding on connecting interfaces for VRFs that must support MPLS traffic.
- This step applies to a CSC network only.

**Step 6**

- end
  - Example:
    ```
    Router(config-if)# end
    ```

(Optional) Exits to privileged EXEC mode.

---

### Configuring the MP-BGP Session Between ASBR Peers

BGP propagates reachability information for VPN-IPv4 prefixes among PE routers by means of the BGP multiprotocol extensions (see RFC 2283, *Multiprotocol Extensions for BGP-4*), which define support for address families other than IPv4. Using the extensions ensures that the routes for a given VPN are learned only by other members of that VPN, enabling members of the VPN to communicate with each other.

Follow the steps in this section to configure the MP-BGP session on the ASBR.

Use all of the steps in the following procedure to configure the MP BGP session on the peer ASBR.

### 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} inter-as-hybrid
8. exit-address-family
9. end

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures a BGP routing process and places the router in router configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# router bgp 100</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router)# neighbor 192.168.0.1 remote-as 200</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> address-family vpnv4 [unicast]</td>
<td>Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router)# address-family vpnv4</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> neighbor {ip-address</td>
<td>peer-group-name} activate</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router-af)# neighbor 192.168.0.1 activate</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> neighbor {ip-address</td>
<td>peer-group-name} inter-as-hybrid</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router-af)# neighbor 192.168.0.1 inter-as-hybrid</td>
<td></td>
</tr>
</tbody>
</table>
### Configuring the Routing Policy for VPNs that Need Inter-AS Connections

Use the steps in this section to configure VRFs for the VPNs that need Inter-AS connections between ASBR peers, by configuring the appropriate routing policy and Option AB configuration.

Use all of the steps in the following procedure to configure additional VPNs that need Inter-AS Option AB connectivity on this ASBR and the peer ASBR.

#### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `vrf definition vrf-name`
4. `rd route-distinguisher`
5. `address-family ipv4`
6. `route-target {import | export | both} route-target-ext-community`
7. For Inter-AS Option AB+, go to Step 10; otherwise, go to Step 8.
8. `inter-as-hybrid [csc]`
9. `inter-as-hybrid [csc] [next-hop ip-address]`
10. `inter-as-hybrid next-hop global`
11. `end`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
</tbody>
</table>

---

**Note**

Advertised routes have RTs that are configured on the VRF. Advertised routes do not have their original RTs.

---

**Step 8**

**Command or Action**: `exit-address-family`

**Example**: `Router(config-router-af)# exit-address-family`

**Purpose**: Exits from address family configuration mode.

**Step 9**

**Command or Action**: `end`

**Example**: `Router(config-router-af)# end`

**Purpose**: (Optional) Exits to privileged EXEC mode.
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

**Step 2**

- configure terminal

**Example:**

Router# configure terminal

- Enters global configuration mode.

**Step 3**

- vrf definition vrf-name

**Example:**

Router(config)# vrf definition

- vpn1

- Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode.

  • The vrf-name argument is the name assigned to a VRF.

**Step 4**

- rd route-distinguisher

**Example:**

Router(config-vrf)# rd 100:1

- The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter an RD in either of these formats:

  • 16-bit autonomous system number: your 32-bit number, for example, 101:3
  • 32-bit IP address: your 16-bit number, for example, 192.168.122.15:1

**Step 5**

- address-family ipv4

**Example:**

Router(config-vrf)# address-family ipv4

- Creates routing and forwarding tables.

  • The ipv4 keyword specifies an IPv4 address family for a VRF.

**Step 6**

- route-target {import | export | both} route-target-ext-community

**Example:**

Router(config-vrf-af)# route-target import 100:1

- Enters VRF address family configuration mode to specify an address family 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.

  • The route-target-ext-community argument adds the route-target extended community attributes to the VRF list of import, export, or both (import and export) route-target extended communities.
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 7</strong></td>
<td>For Inter-AS Option AB+, go to Step 10; otherwise, go to Step 8.</td>
</tr>
</tbody>
</table>
| **Step 8**       | inter-as-hybrid [csc] | Specifies the VRF as an Option AB VRF, which has the following effects:  
|                  | - Routes imported to this VRF can be advertised to Option AB peers and VPNv4 iBGP peers.  
|                  | - When routes received from Option AB peers and are imported into the VRF, the next hop table ID of the route is set to the table ID of the VRF.  
|                  | - If the csc keyword is not used, a per-VRF label is allocated for imported routes.  
|                  | - When routes are received from Option AB peers and are imported next into the VRF, the learned out label can be installed only in forwarding when the csc keyword is used.  
|                  | The csc keyword implies the following:  
|                  | - A per-prefix label is allocated for imported routes.  
|                  | - For routes received from Option AB peers that are imported into the VRF, the learned out label is installed in forwarding. |
| **Step 9**       | inter-as-hybrid [csc] [next-hop ip-address] | (Optional) Specifies the next hop IP address to be set on paths that are imported into the VRF and that are received from an Option AB peer.  
|                  | - The next hop context is also set to the VRF, which imports these paths.  
|                  | - The csc keyword implies the following:  
|                  |   - A per-prefix label is allocated for imported routes.  
|                  |   - For routes received from Option AB peers that are imported into the VRF, the learned out label is installed in forwarding. |
| **Step 10**      | inter-as-hybrid next-hop global | (For Option AB+) Enables Inter-AS Option AB+.  
|                  | - Specifies that the next-hop address for BGP updates to be set on paths that are imported to the VRF and that are received from an Option AB+ peer are placed in the global routing table.  
|                  | - The address used is the address of the interface that is at the remote end of the external BGP (eBGP) global shared link. The next-hop context is retained as global and not modified to that of the importing VRF. |
| **Step 11**      | end | (Optional) Exits to privileged EXEC mode. |
|                  | Example: | Router(config-vrf-af)# end |
Changing an Inter-AS Option A Deployment to an Option AB Deployment

In an Option A deployment, the VRF instances are back-to-back between the ASBR routers and there is direct connectivity between PE routers of different autonomous systems. The PE routers are attached by multiple physical or logical interfaces, each of which is associated with a given VPN (through a VRF instance).

In the Option AB deployment, the different autonomous systems interconnect by using a single MP-BGP session in the global routing table to carry control plane traffic.

Use the following steps to change an MPLS VPN Inter-AS Option A deployment to an Option AB deployment.

1. Configure the MP-BGP session on the ASBR. BGP multiprotocol extensions are used to define support for address families other than IPv4 so that the routes for a given VPN are learned only by other members of that VPN, enabling members of the VPN to communicate with each other. See the Configuring the MP-BGP Session Between ASBR Peers, on page 100 for detailed configuration information.

2. Identify the VRFs that need an upgrade from Option A and configure them for Option AB by using the `inter-as-hybrid` command. See the Configuring the Routing Policy for VPNs that Need Inter-AS Connections, on page 102 for detailed configuration information.

3. Use the following steps in this section to remove the configuration for the eBGP (peer ASBR) neighbor.

4. Repeat all the steps in the following procedure to remove the configuration for additional eBGP (peer ASBR) neighbors.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `address-family ipv4 vrf vrf-name`
5. `no neighbor {ip-address | peer-group-name}`
6. `exit-address-family`
7. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# configure terminal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
<th>router bgp as-number</th>
<th>Configures a BGP routing process and places the router in router configuration mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Router(config)# router bgp 100</td>
<td>- The <code>as-number</code> argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>address-family ipv4 vrf vrf-name</th>
<th>Configures each VRF that is identified in the MP-BGP session on the ASBR so that the routes for a given VPN are learned only by other members of that VPN, enabling members of the VPN to communicate with each other.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Router(config-router)# address-family ipv4 vrf vpn4</td>
<td>- Enters address family configuration mode to specify an address family for a VRF.</td>
</tr>
</tbody>
</table>

| Step 5 | no neighbor {ip-address | peer-group-name} | Removes the configuration for the exchange of information with the neighboring eBGP (ASBR) router. |
|--------|------------------|----------------------------------------------------------------------------------|
| Example: | Router(config-router-af)# no neighbor 192.168.0.1 | - The `ip-address` argument specifies the IP address of the neighbor. - The `peer-group-name` argument specifies the name of a BGP peer group. |

<table>
<thead>
<tr>
<th>Step 6</th>
<th>exit-address-family</th>
<th>Exits from address family configuration mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# exit-address-family</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 7</th>
<th>end</th>
<th>(Optional) Exits to privileged EXEC mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# end</td>
<td></td>
</tr>
</tbody>
</table>
Configuration Examples for MPLS VPN--Inter-AS Option AB

The following sections describe standard and CSC MPLS VPN configurations between two ASBR peers that use the Inter-AS AB feature:

Examples Inter-AS AB Network Configuration

The following examples show the configuration of an Inter-AS Option AB network that uses nonoverlapping IP addresses:

Example CE1

```
! ip cef distributed
! interface lo0
  ip address 192.168.13.13 255.255.255.255
  no shutdown
! interface et4/0
  ip address 192.168.36.1 255.255.255.0
  no shutdown
! router ospf 300
  nsf enforce global
  redistribute connected subnets
  auto-cost reference-bandwidth 1000
  passive-interface et4/0
  network 192.168.13.13 0.0.0.0 area 300
! router bgp 300
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart no synchronization
  neighbor 192.168.36.2 remote-as 100
  neighbor 192.168.36.2 advertisement-interval 5
  address-family ipv4 no auto-summary
  redistribute connected
  neighbor 192.168.36.2 activate
```

Example CE2

```
! ip cef distributed
! interface lo0
  ip address 192.168.14.14 255.255.255.255
  no shutdown
! interface et1/6
  ip address 192.168.37.1 255.255.255.0
  no ipv6 address
  no shutdown
! router ospf 400
  nsf enforce global
  redistribute connected subnets
  auto-cost reference-bandwidth 1000
```
passive-interface et1/6
tnetwork 192.168.14.14 0.0.0.0 area 400
!router bgp 400
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
no synchronization
neighbor 192.168.0.2 remote-as 100
neighbor 192.168.0.2 advertisement-interval 5
address-family ipv4 no auto-summary
redistribute connected
neighbor 192.168.0.2 activate
!

Example PE1

!
ip cef distributed
!
ip vrf vpn1
   rd 100:1
   route-target import 100:1
   route-target import 200:1
   route-target export 100:1
!
ip vrf vpn2
   rd 100:2
   route-target import 100:2
   route-target import 200:2
   route-target export 100:2
!
mls ldp router-id lo0 force
mls ldp graceful-restart
mls ip
mls ip propagate-ttl
mls ldp advertise-labels
mls label protocol ldp
!
interface lo0
ip address 192.168.17.17 255.255.255.255
no shutdown
!
interface gi3/1
ip vrf forwarding vpn1
ip address 192.168.36.2 255.255.255.0
no shutdown
!
interface gi3/8
mls ip
mls label protocol ldp
ip address 192.168.31.2 255.255.255.0
!
interface gi3/10
mls ip
mls label protocol ldp
ip address 192.168.40.1 255.255.255.0
no shutdown
!
interface gi3/13
ip vrf forwarding vpn2
ip address 192.168.0.2 255.0.0.0
no shutdown
!
routerr ospf 100
nsf enforce global
redistribute connected subnets
auto-cost reference-bandwidth 1000
passive-interface gi3/1
passive-interface gi3/13
network 192.168.0.0 0.0.255.255 area 10
network 192.168.17.17 0.0.0.0 area 100
network 192.168.0.0 0.0.255.255 area 100

! router bgp 100
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart
  no bgp default ipv4-unicast
  no synchronization
  neighbor 192.168.19.19 remote-as 100
  neighbor 192.168.19.19 update-source Loopback0
  address-family ipv4 vrf vpn1
  no auto-summary
  redistribute connected
  neighbor 192.168.36.1 remote-as 300
  neighbor 192.168.36.1 activate
  neighbor 192.168.36.1 advertisement-interval 5
  address-family ipv4 vrf vpn2 no auto-summary
  redistribute connected
  neighbor 192.168.37.1 remote-as 400
  neighbor 192.168.37.1 activate
  neighbor 192.168.37.1 advertisement-interval 5
  address-family vpnv4
  bgp scan-time import 5
  neighbor 192.168.19.19 activate
  neighbor 192.168.19.19 send-community extended

Example Route Reflector 1

! ip cef distributed
mpls ldp router-id lo0 force
mpls ldp graceful-restart
mpls ip
mpls ip propagate-ttl
mpls ldp advertise-labels
mpls ip
mpls label protocol ldp
!
interface lo0
  ip address 192.168.19.19 255.255.255.255
  no shutdown
!
interface gi3/3
  mpls ip
  mpls label protocol ldp
  ip address 192.168.40.2 255.255.255.0
  no shutdown
!
routing ospf 100
  nsf enforce global
  redistribute connected subnets
  auto-cost reference-bandwidth 1000
  network 192.168.19.19 0.0.0.0 area 100
  network 192.168.0.0 0.0.255.255 area 100
!
routing bgp 100
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart
  neighbor 192.168.11.11 remote-as 100
  neighbor 192.168.11.11 update-source Loopback0
  neighbor 192.168.17.17 remote-as 100
  neighbor 192.168.17.17 update-source Loopback0
  neighbor 192.168.11.11 route-reflector-client
  address-family ipv4
  no neighbor 192.168.17.17 activate
  neighbor 192.168.11.11 route-reflector-client
  address-family vpnv4

MPLS VPN--Inter-AS Option AB
Examples Inter-AS AB Network Configuration
bgp scan-time import 5
neighbor 192.168.11.11 activate
neighbor 192.168.11.11 send-community extended
neighbor 192.168.17.17 activate
neighbor 192.168.17.17 send-community extended
neighbor 192.168.11.11 route-reflector-client
neighbor 192.168.17.17 route-reflector-client

Example ASBR1

!
ip cef distributed
!
ip vrf vpn1
  rd 100:1
  route-target import 100:1
  route-target import 200:1
  route-target export 100:1
  inter-as-hybrid next-hop 192.168.32.2
exit
ip vrf vpn2
  rd 100:2
  route-target import 100:2
  route-target import 200:2
  route-target export 100:2
  inter-as-hybrid next-hop 192.168.33.2
exit
mpls ldp router-id lo0 force
mpls ip
mpls ip propagate-ttl
mpls ldp advertise-labels
mpls ip
mpls label protocol ldp
interface lo0
  ip address 192.168.11.11 255.255.255.255
  no ipv6 address
  ip route-cache distributed
  ip route-cache cef distributed
  no shutdown
interface gi3/8
mpls ip
mpls label protocol ldp
ip address 192.168.13.1 255.255.255.0
  no ipv6 address
  ip route-cache distributed
  ip route-cache cef distributed
  no shutdown
interface gi3/10
  ip vrf forwarding vpn1
  ip address 192.168.32.1 255.255.255.0
  no ipv6 address
  ip route-cache distributed
  ip route-cache cef distributed
  no shutdown
interface gi3/11
  ip vrf forwarding vpn2
  ip address 192.168.33.1 255.255.255.0
  no ipv6 address
  ip route-cache distributed
  ip route-cache cef distributed
  no shutdown
interface gi3/46
  ip address 192.168.34.1 255.255.255.0
  no ipv6 address
  ip route-cache distributed
  ip route-cache cef distributed
  no shutdown
router ospf 100
nsf enforce global
redistribute connected subnets
auto-cost reference-bandwidth 1000
passive-interface gi3/10
passive-interface gi3/11
passive-interface gi3/46
network 192.168.0.0 0.0.255.255 area 100
network 192.168.11.11 0.0.0.0 area 100

router bgp 100
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  no synchronization
  no bgp default route-target filter
  bgp router-id 192.168.11.11
  neighbor 192.168.34.2 remote-as 200
  neighbor 192.168.34.2 advertisement-interval 5
  neighbor 192.168.19.19 remote-as 100
  neighbor 192.168.19.19 update-source Loopback0
  address-family ipv4
    no auto-summary
    address-family ipv4 vrf vpn1
      no auto-summary
      address-family ipv4 vrf vpn2
        no auto-summary
        address-family vpnv4
          bgp scan-time import 5
          neighbor 192.168.34.2 activate
          neighbor 192.168.34.2 send-community both
          neighbor 192.168.34.2 inter-as-hybrid
          neighbor 192.168.19.19 activate
          neighbor 192.168.19.19 send-community extended

ip route vrf vpn1 192.168.12.12 255.255.255.255 gi3/10 192.168.32.2
ip route vrf vpn2 192.168.12.12 255.255.255.255 gi3/11 192.168.33.2

Example ASBR 3

! ip cef distributed
! ip vrf vpn1
  rd 200:1
  route-target import 100:1
  route-target export 100:1
  inter-as-hybrid next-hop 192.168.32.1
! ip vrf vpn2
  rd 200:2
  route-target import 100:2
  route-target export 100:2
  inter-as-hybrid next-hop 192.168.33.1
! mpls ldp router-id lo0 force
  mpls ldp graceful-restart
  mpls ip
  mpls ip propagate-ttl
  mpls ldp advertise-labels
  mpls label protocol ldp
! interface lo0
  ip address 192.168.12.12 255.255.255.255
  no shutdown
! interface po2/1/0
  mpls ip
  mpls label protocol ldp
Example PE2

Example PE2

ip cef distributed

ip vrf vpn1
  rd 200:1
  route-target import 100:1
  route-target import 200:1
  route-target export 200:1

ip vrf vpn2
  rd 200:2
  route-target import 100:2
route-target import 200:2
route-target export 200:2
!
mpls ldp router-id lo0 force
mpls ldp graceful-restart
mpls ip
mpls ip propagate-ttl
mpls ldp advertise-labels
mpls label protocol ldp
!
interface lo0
ip address 192.168.18.18 255.255.255.255
no shutdown
!
interface po1/0/0
mpls ip
mpls label protocol ldp
ip address 192.168.35.2 255.255.255.0
crc 16
clock source internal
no shutdown
!
interface gi3/2
ip vrf forwarding vpn1
ip address 192.168.38.2 255.255.255.0
no shutdown
!
interface gi3/8
mpls ip
mpls label protocol ldp
ip address 192.168.4.1 255.255.255.0
no shutdown
!
interface gi3/10
ip vrf forwarding vpn2
ip address 192.168.39.2 255.255.255.0
no shutdown
!
routers ospf 200
nsf enforce global
redistribute connected subnets
auto-cost reference-bandwidth 1000
passive-interface gi3/10
passive-interface gi3/2
network 192.168.0.0 0.0.255.255 area 200
network 192.168.18.18 0.0.0.0 area 200
network 192.168.0.0 0.0.255.255 area 200
!
routers bgp 200
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
no bgp default ipv4-unicast
no synchronization
neighbor 192.168.20.20 remote-as 200
neighbor 192.168.20.20 update-source Loopback0
address-family ipv4 vrf vpn1
no auto-summary
redistribute connected
neighbor 192.168.38.1 remote-as 500
neighbor 192.168.38.1 activate
neighbor 192.168.38.1 advertisement-interval 5
address-family ipv4 vrf vpn2
no auto-summary
redistribute connected
neighbor 192.168.9.1 remote-as 600
neighbor 192.168.9.1 activate
neighbor 192.168.9.1 advertisement-interval 5
address-family vipv4
bgp scan-time import 5
neighbor 192.168.20.20 activate
neighbor 192.168.20.20 send-community extended
Example CE3

```
! ip cef distributed
! interface lo0
 ip address 192.168.15.15 255.255.255.255
 no shutdown
! interface gi0/2
 ip address 192.168.38.1 255.255.255.0
 no shutdown
! router ospf 500
 nsf enforce global
 redistribute connected subnets
 auto-cost reference-bandwidth 1000
 passive-interface gi0/2
 network 192.168.15.15 0.0.0.0 area 500
! router bgp 500
 bgp graceful-restart restart-time 120
 bgp graceful-restart stalepath-time 360
 bgp graceful-restart no synchronization
 neighbor 192.168.38.2 remote-as 200
 neighbor 192.168.38.2 advertisement-interval 5
 address-family ipv4
 no auto-summary
 redistribute connected
 neighbor 192.168.38.2 activate
```

Example CE4

```
! ip cef distributed
! interface lo0
 ip address 192.168.16.16 255.255.255.255
 no shutdown
! interface et6/2
 ip address 192.168.9.1 255.255.255.0
 no shutdown
! router ospf 600
 nsf enforce global
 redistribute connected subnets
 auto-cost reference-bandwidth 1000
 passive-interface et6/2
 network 192.168.16.16 0.0.0.0 area 600
! router bgp 600
 bgp graceful-restart restart-time 120
 bgp graceful-restart stalepath-time 360
 bgp graceful-restart no synchronization
 neighbor 192.168.39.2 remote-as 200
 neighbor 192.168.39.2 advertisement-interval 5
 address-family ipv4
 no auto-summary
 redistribute connected
 neighbor 192.168.39.2 activate
```
Examples Inter-AS AB CSC Configuration

The following examples show the configuration of an Inter-AS Option AB network with CSC:

**Example CE1**

```plaintext
! ip cef distributed
!
interface Loopback0
 ip address 192.168.20.20 255.255.255.255
!
interface Ethernet3/3
 ip address 192.168.41.2 255.255.255.0
!
!
router bgp 500
 bgp router-id 192.168.20.20
 bgp log-neighbor-changes
 bgp graceful-restart restart-time 120
 bgp graceful-restart stalepath-time 360
 bgp graceful-restart neighbor 192.168.4.1 remote-as 300
!
 address-family ipv4
 redistribute connected
 neighbor 192.168.4.1 activate
 neighbor 192.168.4.1 advertisement-interval 5
 no auto-summary
 no synchronization
 exit-address-family
!
```

**Example CE2**

```plaintext
! ip cef distributed
!
interface Loopback0
 ip address 192.168.21.21 255.255.255.255
!
interface Ethernet0/0/7
 ip address 192.168.42.2 255.255.255.0
!
!
router bgp 600
 bgp log-neighbor-changes
 bgp graceful-restart restart-time 120
 bgp graceful-restart stalepath-time 360
 bgp graceful-restart neighbor 192.168.42.1 remote-as 400
!
 address-family ipv4
 redistribute connected
 neighbor 192.168.42.1 activate
 neighbor 192.168.42.1 advertisement-interval 5
 no auto-summary
 no synchronization
 exit-address-family
!
```
Example CE3

! ip cef distributed
! interface Loopback0
 ip address 192.168.22.22 255.255.255.255
! interface Ethernet6/2
 ip address 192.168.43.2 255.255.255.0
!
router bgp 500
 bgp log-neighbor-changes
 bgp graceful-restart restart-time 120
 bgp graceful-restart stalepath-time 360
 bgp graceful-restart neighbor 192.168.43.1 remote-as 300
!
 address-family ipv4
  redistribute connected
  neighbor 192.168.43.1 activate
  neighbor 192.168.43.1 advertisement-interval 5
  no auto-summary
  no synchronization
  exit-address-family
!

Example CE4

! ip cef distributed
! interface Loopback0
 ip address 192.168.23.23 255.255.255.255
!
! interface Ethernet0/0/7
 ip address 192.168.44.2 255.255.255.0
!
router bgp 600
 bgp router-id 192.168.23.23
 bgp log-neighbor-changes
 bgp graceful-restart restart-time 120
 bgp graceful-restart stalepath-time 360
 bgp graceful-restart neighbor 192.168.44.1 remote-as 400
!
 address-family ipv4
  redistribute connected
  neighbor 192.168.44.1 activate
  neighbor 192.168.44.1 advertisement-interval 5
  no auto-summary
  no synchronization
  exit-address-family
!

Example PE1

! ip cef distributed
! ip vrf vpn3
 rd 300:3
 route-target export 300:3
 route-target import 300:3
mpls ldp graceful-restart
mpls label protocol ldp
mpls ip
interface Loopback0
  ip address 192.168.192.10 255.255.255.255
interface Ethernet3/1
  ip vrf forwarding vpn3
  ip address 192.168.4.1 255.255.255.0
interface Ethernet5/3
  ip address 192.168.3.1 255.255.255.0
  mpls label protocol ldp
  mpls ip
router ospf 300
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  network 192.168.192.10 0.0.0.0 area 300
  network 192.168.0.0 0.0.255.255 area 300
router bgp 300
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart
  neighbor 192.168.19.19 remote-as 300
  neighbor 192.168.19.19 update-source Loopback0
  address-family vpnv4
    neighbor 192.168.19.19 activate
    neighbor 192.168.19.19 send-community extended
    bgp scan-time import 5
    exit-address-family
    address-family ipv4 vrf vpn3
      redistribute connected
      neighbor 192.168.41.2 remote-as 500
      neighbor 192.168.41.2 activate
      neighbor 192.168.41.2 as-override
      neighbor 192.168.41.2 advertisement-interval 5
      no auto-summary
      no synchronization
      exit-address-family
Example CSC-CE1

mpls ldp graceful-restart
mpls label protocol ldp
mpls ip
interface Loopback0
  ip address 192.168.11.11 255.255.255.255
interface Ethernet3/4
  ip address 192.168.30.2 255.255.255.0
  mpls label protocol ldp
mpls ip
!
router ospf 300
log-adjacency-changes
auto-cost reference-bandwidth 1000
redistribute connected subnets
redistribute bgp 300 metric 3 subnets
passive-interface FastEthernet1/0
network 192.168.11.11 0.0.0.0 area 300
network 192.168.0.0 0.0.255.255 area 300
distance ospf intra-area 19 inter-area 19
!
router bgp 300
bgp router-id 192.168.11.11
no bgp default ipv4-unicast
bgp log-neighbor-changes
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.13.1 remote-as 100
!
address-family ipv4
redistribute ospf 300 metric 4 match internal external 1 external 2
neighbor 192.168.13.1 activate
neighbor 192.168.13.1 send-label
no auto-summary
no synchronization
exit-address-family
!
Example CSC-PE1

!
ip vrf vpn1
rd 100:1
route-target export 100:1
route-target import 100:1
route-target import 100:5
route-target import 200:1
!
ip vrf vpn2
rd 100:2
route-target export 100:2
route-target import 100:2
route-target import 100:6
route-target import 200:2
!
mpls ldp graceful-restart
mpls label protocol ldp
!
mpls ip
!
interface Loopback0
ip address 192.168.12.12 255.255.255.255
!
interface FastEthernet4/0/0
ip address 192.168.34.1 255.255.255.0
mpls label protocol ldp
mpls ip
!
interface FastEthernet4/0/1
ip vrf forwarding vpn1
ip address 192.168.13.1 255.255.255.0
mpls bgp forwarding
!
interface FastEthernet4/1/0
ip vrf forwarding vpn2
ip address 192.168.33.1 255.255.255.0
mpls bgp forwarding
!
router ospf 100
log-adjacency-changes
auto-cost reference-bandwidth 1000
nsf enforce global
redistribute connected subnets
network 192.168.12.12 0.0.0.0 area 100
network 192.168.0.0 0.0.255.255 area 100
!
router bgp 100
bgp router-id 192.168.12.12
no bgp default ipv4-unicast
bgp log-neighbor-changes
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.15.15 remote-as 100
neighbor 192.168.15.15 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.15.15 activate
neighbor 192.168.15.15 send-community extended
bgp scan-time import 5
exit-address-family
!
address-family ipv4 vrf vpn2
neighbor 192.168.33.2 remote-as 400
neighbor 192.168.33.2 update-source FastEthernet4/1/0
neighbor 192.168.33.2 activate
neighbor 192.168.33.2 as-override
neighbor 192.168.33.2 advertisement-interval 5
neighbor 192.168.33.2 send-label
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf vpn1
neighbor 192.168.31.2 remote-as 300
neighbor 192.168.31.2 update-source FastEthernet4/0/1
neighbor 192.168.31.2 activate
neighbor 192.168.31.2 as-override
neighbor 192.168.31.2 advertisement-interval 5
neighbor 192.168.31.2 send-label
no auto-summary
no synchronization
exit-address-family
!
Example PE 2

ip cef distributed
!
ip vrf vpn4
rd 400:4
route-target export 400:4
route-target import 400:4
!
mls ldp graceful-restart
mls label protocol ldp
!
mls ip
!
interface Loopback0
ip address 192.168.13.13 255.255.255.255
!
interface Ethernet4/1/2
ip vrf forwarding vpn4
Example CSC-CE2

```plaintext
ip address 192.168.32.2 255.255.255.0
!
interface GigabitEthernet8/24
ip address 192.168.32.2 255.255.255.0
mpls label protocol ldp
mpls ip
!
router ospf 400
log-adjacency-changes
auto-cost reference-bandwidth 1000
nsf enforce global
redistribute connected subnets
network 192.168.0.0 0.0.255.255 area 400
!
router bgp 400
bgp router-id 192.168.13.13
no bgp default ipv4-unicast
bgp log-neighbor-changes
bgp graceful-restart restart-time 20
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.25.25 remote-as 400
neighbor 192.168.25.25 update-source Loopback0
!
exit-address-family
!
exit-address-family
!
Example CSC-CE2

ip cef distributed
mpls ldp graceful-restart
mpls label protocol ldp
mpls ip
interface Loopback0
ip address 192.168.14.14 255.255.255.255
!
interface GigabitEthernet8/16
ip address 192.168.33.2 255.255.255.0
mpls bgp forwarding
!
interface GigabitEthernet8/24
ip address 192.168.32.2 255.255.255.0
mpls label protocol ldp
mpls ip
!
router ospf 400
log-adjacency-changes
```
auto-cost reference-bandwidth 1000
nsf enforce global
redistribute connected subnets
redistribute bgp 400 metric 3 subnets
passive-interface GigabitEthernet8/16
network 192.168.14.14 0.0.0.0 area 400
network 192.168.0.0 0.0.255.255 area 400
distance ospf intra-area 19 inter-area 19
! router bgp 400
bgp router-id 192.168.14.14
no bgp default ipv4-unicast
bgp log-neighbor-changes
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.33.1 remote-as 100
! address-family ipv4
no synchronization
redistribute connected
redistribute ospf 400 metric 4 match internal external 1 external 2
neighbor 192.168.33.1 activate
neighbor 192.168.33.1 advertisement-interval 5
neighbor 192.168.33.1 send-label
no auto-summary
exit-address-family
!

Example ASBR1

! ip vrf vpn5
rd 100:5
route-target export 100:5
route-target import 100:5
route-target import 100:1
route-target import 200:5
inter-as-hybrid csc next-hop 192.168.35.2
!
! ip vrf vpn6
rd 100:6
route-target export 100:6
route-target import 100:6
route-target import 100:2
route-target import 200:6
inter-as-hybrid csc next-hop 192.168.36.2
!
! mpls ldp graceful-restart
mpls label protocol ldp
!
! interface Loopback0
ip address 192.168.15.15 255.255.255.255
!
! interface GigabitEthernet2/3
ip vrf forwarding vpn5
ip address 192.168.35.1 255.255.255.0
mpls bgp forwarding
!
! interface GigabitEthernet2/4
ip vrf forwarding vpn6
ip address 192.168.36.1 255.255.255.0
mpls bgp forwarding
!
! interface GigabitEthernet2/5
ip address 192.168.34.2 255.255.255.0
mpls label protocol ldp
mpls ip
interface GigabitEthernet2/16
ip address 192.168.37.1 255.255.255.0
mpls bgp forwarding

router ospf 100
log-adjacency-changes
auto-cost reference-bandwidth 1000
nsf enforce global
redistribute connected subnets
network 192.168.15.15 0.0.0.0 area 100
network 192.168.0.0 0.0.255.255 area 100

router bgp 100
bgp router-id 192.168.15.15
no bgp default ipv4-unicast
no bgp default route-target filter
bgp log-neighbor-changes
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.12.12 remote-as 100
neighbor 192.168.12.12 update-source Loopback0
neighbor 192.168.0.2 remote-as 200
neighbor 192.168.0.2 disable-connected-check

address-family ipv4
no synchronization
no auto-summary
exit-address-family

address-family vpnv4
neighbor 192.168.12.12 activate
neighbor 192.168.12.12 send-community extended
neighbor 192.168.0.2 activate
neighbor 192.168.0.2 send-community extended
neighbor 192.168.0.2 inter-as-hybrid
exit-address-family

address-family ipv4 vrf vpn5
no synchronization
exit-address-family

address-family ipv4 vrf vpn6
no synchronization
exit-address-family

ip route 192.168.16.16 255.255.255.255 GigabitEthernet2/16 192.168.0.2
ip route vrf vpn5 192.168.16.16 255.255.255.255 GigabitEthernet2/3 192.168.35.2
ip route vrf vpn6 192.168.16.16 255.255.255.255 GigabitEthernet2/4 192.168.36.2

ip vrf vpn5
rd 200:5
route-target export 200:5
route-target import 200:5
route-target export 200:1
route-target import 200:1
route-target import 100:5
inter-as-hybrid csc next-hop 192.168.35.1

ip vrf vpn6
rd 200:6
route-target export 200:6
route-target import 200:6
route-target export 200:2
route-target import 200:2
route-target import 100:6
inter-as-hybrid csc next-hop 192.168.36.1

mpls ldp graceful-restart
mpls label protocol ldp
interface Loopback0
  ip address 192.168.16.16 255.255.255.255
!

interface GigabitEthernet3/1
  ip vrf forwarding vpn5
  ip address 192.168.35.2 255.255.255.0
  mpls bgp forwarding

interface GigabitEthernet3/2
  ip vrf forwarding vpn6
  ip address 192.168.36.2 255.255.255.0
  mpls bgp forwarding
!

interface GigabitEthernet3/14
  ip address 192.168.0.2 255.0.0.0
  mpls bgp forwarding
!

interface GigabitEthernet3/15
  ip address 192.168.38.2 255.255.255.0
  mpls label protocol ldp
  mpls ip
!
router ospf 200
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  nsf enforce global
  redistribute connected subnets
  network 192.168.16.16 0.0.0.0 area 200
  network 192.168.0.0 0.0.255.255 area 200
!
router bgp 200
  bgp router-id 192.168.16.16
  no bgp default ipv4-unicast
  no bgp default route-target filter
  bgp log-neighbor-changes
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart neighbor 192.168.17.17 remote-as 200
  neighbor 192.168.17.17 update-source Loopback0
  neighbor 192.168.37.1 remote-as 100
  neighbor 192.168.37.1 disable-connected-check
!
address-family ipv4
  no synchronization
  no auto-summary
  exit-address-family
!
address-family vpnv4
  neighbor 192.168.17.17 activate
  neighbor 192.168.17.17 send-community extended
  neighbor 192.168.37.1 activate
  neighbor 192.168.37.1 send-community extended
  neighbor 192.168.37.1 inter-as-hybrid
  exit-address-family
!
address-family ipv4 vrf vpn5
  no synchronization
  exit-address-family
!
address-family ipv4 vrf vpn6
  no synchronization
  exit-address-family
!
ip route 192.168.15.15 255.255.255.255 GigabitEthernet3/14 192.168.37.1
ip route vrf vpn5 192.168.15.15 255.255.255.255 GigabitEthernet3/1 192.168.35.1
ip route vrf vpn6 192.168.15.15 255.255.255.255 GigabitEthernet3/2 192.168.36.1
Example CSC-PE 3

ip vrf vpn1
  rd 200:1
  route-target export 200:1
  route-target import 200:1
  route-target import 200:5
  route-target import 100:1
ip vrf vpn2
  rd 200:2
  route-target export 200:2
  route-target import 200:2
  route-target import 200:6
  route-target import 100:2
!
mpls ldp graceful-restart
mpls label protocol ldp
!
mpls ip
!
interface Loopback0
  ip address 192.168.17.17 255.255.255.255
!
interface FastEthernet4/0/2
  ip vrf forwarding vpn2
  ip address 192.168.5.1 255.255.255.0
  mpls bgp forwarding
!
interface FastEthernet4/0/4
  ip vrf forwarding vpn1
  ip address 192.168.9.1 255.255.255.0
  mpls bgp forwarding
!
interface FastEthernet4/0/7
  ip address 192.168.38.1 255.255.255.0
  mpls label protocol ldp
  mpls ip
!
routing ospf 200
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  nsf enforce global
  redistribute connected subnets
  network 192.168.17.17 0.0.0.0 area 200
  network 192.168.0.0 0.0.255.255 area 200
!
routing bgp 200
  bgp router-id 192.168.17.17
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart
  neighbor 192.168.16.16 remote-as 200
  neighbor 192.168.16.16 update-source Loopback0
!
address-family vpnv4
  neighbor 192.168.16.16 activate
  neighbor 192.168.16.16 send-community extended
  bgp scan-time import 5
  exit-address-family
!
address-family ipv4 vrf vpn2
  neighbor 192.168.55.0 remote-as 400
  neighbor 192.168.55.0 update-source FastEthernet4/0/2
  neighbor 192.168.55.0 activate
  neighbor 192.168.55.0 as-override
neighbor 192.168.55.0 advertisement-interval 5
neighbor 192.168.55.0 send-label
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf vpn1
neighbor 192.168.39.2 remote-as 300
neighbor 192.168.39.2 update-source FastEthernet4/0/4
neighbor 192.168.39.2 activate
neighbor 192.168.39.2 as-override
neighbor 192.168.39.2 advertisement-interval 5
neighbor 192.168.39.2 send-label
no auto-summary
no synchronization
exit-address-family
!

Example CSC-CE3

!
interface Loopback0
  ip address 192.168.18.18 255.255.255.255
!
!
interface Ethernet3/3
  ip address 192.168.40.2 255.255.255.0
  mpls label protocol ldp
  mpls ip
!
interface FastEthernet5/0
  ip address 192.168.39.2 255.255.255.0
  mpls bgp forwarding
!
router ospf 300
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  redistribute bgp 300 metric 3 subnets
  network 192.168.18.18 0.0.0.0 area 300
  network 192.168.0.0 0.0.255.255 area 300
  distance ospf intra-area 19 inter-area 19
!
router bgp 300
  bgp log-neighbor-changes
  bgp graceful-restart restart-time 120
  bgp graceful-restart stalepath-time 360
  bgp graceful-restart
  neighbor 192.168.9.1 remote-as 200
!
address-family ipv4
  redistribute connected
  redistribute ospf 300 metric 4 match internal external 1 external 2
  neighbor 192.168.9.1 activate
  neighbor 192.168.9.1 advertisement-interval 5
  neighbor 192.168.9.1 send-label
  no auto-summary
  no synchronization
  exit-address-family
!

Example CSC-CE4

!
ip cef distributed
mpls ldp graceful-restart
mpls label protocol ldp

interface Loopback0
  ip address 192.168.24.24 255.255.255.255

interface FastEthernet1/1
  ip address 192.168.55.0 255.255.255.0
mpls bgp forwarding

interface Ethernet3/5
  ip address 192.168.56.2 255.255.255.0
mpls label protocol ldp
mpls ip

router ospf 400
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  redistribute bgp 400 metric 3 subnets
  network 192.168.24.24 0.0.0.0 area 400
  network 192.168.0.0 0.0.255.255 area 400

router bgp 400
  bgp log-neighbor-changes
  neighbor 192.168.5.1 remote-as 200
  address-family ipv4
    redistribute connected
    redistribute ospf 400 metric 4 match internal external 1 external 2
    neighbor 192.168.5.1 activate
    neighbor 192.168.5.1 advertisement-interval 5
    neighbor 192.168.5.1 send-label
    no auto-summary
    no synchronization
  exit-address-family

Example PE 3

ip cef distributed
ip vrf vpn3
  rd 300:3
  route-target export 300:3
  route-target import 300:3
mpls ip

mpls ldp graceful-restart
mpls label protocol ldp

interface Loopback0
  ip address 192.168.19.19 255.255.255.255

interface Ethernet5/1/1
  ip vrf forwarding vpn3
  ip address 192.168.43.1 255.255.255.0

interface Ethernet5/1/4
  ip address 192.168.40.1 255.255.255.0
mpls label protocol ldp
mpls ip
!
router ospf 300
log-adjacency-changes
auto-cost reference-bandwidth 1000
nsf enforce global
redistribute connected subnets
network 192.168.19.19 0.0.0.0 area 300
network 192.168.0.0 0.0.255.255 area 300
network 192.168.0.0 0.0.255.255 area 300
!
router bgp 300
bgp router-id 192.168.19.19
bgp log-neighbor-changes
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.192.10 remote-as 300
neighbor 192.168.192.10 update-source Loopback0
!
address-family ipv4
 no neighbor 192.168.192.10 activate
 no auto-summary
 no synchronization
 exit-address-family
!
address-family vpnv4
 neighbor 192.168.192.10 activate
 neighbor 192.168.192.10 send-community extended
 bgp scan-time import 5
 exit-address-family
!
address-family ipv4 vrf vpn3
 neighbor 192.168.43.2 remote-as 500
 neighbor 192.168.43.2 activate
 neighbor 192.168.43.2 as-override
 neighbor 192.168.43.2 advertisement-interval 5
 no auto-summary
 no synchronization
 exit-address-family

Example PE 4

!
ip cef distributed
!
ip vrf vpn4
 rd 400:4
  route-target export 400:4
  route-target import 400:4
!
 mpls ldp graceful-restart
 mpls ldp protocol ldp
!
 mpls ip
!
 interface Loopback0
     ip address 192.168.25.25 255.255.255.255
!
!
 interface Ethernet 5/0/4
     ip address 192.168.56.1 255.255.255.0
     mpls label protocol ldp
     mpls ip
!
 interface Ethernet 5/0/7
     ip vrf forwarding vpn4
ip address 192.168.44.1 255.255.255.0
!
router ospf 400
log-adjacency-changes
auto-cost reference-bandwidth 1000
nsf enforce global
redistribute connected subnets
network 192.168.25.25 0.0.0.0 area 400
network 192.168.0.0 0.0.255.255 area 400
!
router bgp 400
bgp router-id 192.168.25.25
bgp log-neighbor-changes
bgp graceful-restart restart-time 120
bgp graceful-restart stalepath-time 360
bgp graceful-restart
neighbor 192.168.13.13 remote-as 400
neighbor 192.168.13.13 ebgp-multihop 7
neighbor 192.168.13.13 update-source Loopback0
!
address-family ipv4
no neighbor 192.168.13.13 activate
no auto-summary
no synchronization
exit-address-family
!
address-family vrf vpnv4
neighbor 192.168.13.13 activate
neighbor 192.168.13.13 send-community extended
bgp scan-time import 5
exit-address-family
!
address-family ipv4 vrf vpn4
neighbor 192.168.44.2 remote-as 600
neighbor 192.168.44.2 activate
neighbor 192.168.44.2 as-override
neighbor 192.168.44.2 advertisement-interval 5
no auto-summary
no synchronization
exit-address-family
!

Additional References

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco IOS commands</td>
<td>Cisco IOS Master Commands List, All Releases</td>
</tr>
<tr>
<td>MPLS commands</td>
<td>Cisco IOS Multiprotocol Label Switching Command Reference</td>
</tr>
<tr>
<td>MPLS VPNs</td>
<td>Configuring MPLS Layer 3 VPNs</td>
</tr>
<tr>
<td>MPLS VPN interautonomous systems</td>
<td>• MPLS VPN Inter-AS with ASBRs Exchanging VPN-IPv4 Addresses</td>
</tr>
<tr>
<td></td>
<td>• MPLS VPN Inter-AS with ASBRs Exchanging IPv4 Routes and MPLS Labels</td>
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Standards

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<tr>
<th>Standard</th>
<th>Title</th>
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<tr>
<td>No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.</td>
<td>--</td>
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MIBs

<table>
<thead>
<tr>
<th>MIB</th>
<th>MIBs Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.</td>
<td>To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
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RFCs

<table>
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<tr>
<th>RFC</th>
<th>Title</th>
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<tbody>
<tr>
<td>RFC 2283</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 4364</td>
<td>BGP/MPLS IP Virtual Private Networks</td>
</tr>
</tbody>
</table>

Technical Assistance

<table>
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<tr>
<th>Description</th>
<th>Link</th>
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<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>
Feature Information for MPLS VPN--Inter-AS Option AB

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

**Table 5: Feature Information for MPLS VPN--Inter-AS Option AB**

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Release</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS VPN--Inter-AS Option AB</td>
<td>12.2(33)SRC</td>
<td>This feature combines the best functionality of an Inter-AS Option 10 A and Inter-AS Option 10 B network to allow an MPLS VPN service provider to interconnect different autonomous systems to provide VPN services. In Cisco IOS Release 12.2(33)SRC, this feature was introduced.</td>
</tr>
<tr>
<td></td>
<td>15.0(1)M</td>
<td>In Cisco IOS Release 15.0(1)M, this feature was implemented on Cisco 1900, 2900, 3800, and 3900 series routers.</td>
</tr>
<tr>
<td></td>
<td>15.0(1)S</td>
<td>In Cisco IOS Release 15.0(1)M, this feature was implemented on the Cisco ASR 1000 Series Routers.</td>
</tr>
<tr>
<td></td>
<td>15.0(1)SY</td>
<td>In Cisco IOS Release 15.0(1)M, this feature was implemented on the Cisco ASR 1000 Series Routers.</td>
</tr>
<tr>
<td></td>
<td>Cisco IOS XE Release 2.4</td>
<td>In Cisco IOS Release 2.4, this feature was implemented on the Cisco ASR 1000 Series Routers.</td>
</tr>
<tr>
<td></td>
<td>Cisco IOS XE Release 3.8S</td>
<td>In Cisco IOS Release 3.8S, support was added for the Cisco ISR 4400 Series Routers.</td>
</tr>
<tr>
<td></td>
<td>Cisco IOS XE Release 3.9S</td>
<td>In Cisco IOS Release 3.9S, support was added for the Cisco CSR 1000V.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>These commands were introduced or modified: neighbor inter-as-hybrid, inter-as-hybrid.</td>
</tr>
<tr>
<td>Feature Name</td>
<td>Release</td>
<td>Feature Information</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MPLS VPN—Inter-AS Option AB+</td>
<td>15.0(1)SY</td>
<td>The MPLS VPN—Inter-AS Option AB+ feature addresses the scalability concerns of MPLS VPN—Inter-AS Option A by using a single BGP session to signal VPN prefixes (as described in Inter-AS Option B). In an Inter-AS AB+ deployment, the forwarding connections between the ASBRs are maintained on a per-VRF basis while the control plane information is exchanged by a single Multiprotocol BGP session. In Cisco IOS Release 15.0(1)SY, this feature was introduced. These commands were introduced or modified: inter-as-hybrid.</td>
</tr>
</tbody>
</table>

**Glossary**

**ASBR** -- Autonomous System Boundary router. A router that connects one autonomous system to another.

**autonomous system** -- A collection of networks under a common administration sharing a common routing strategy.

**BGP** -- Border Gateway Protocol. An interdomain routing protocol that exchanges network reachability information with other BGP systems (which may be within the same autonomous system or between multiple autonomous systems).

**CE router** -- customer edge router. A router that is part of a customer network and that interfaces to a provider edge (PE) router. CE routers do not recognize associated MPLS VPNs.

**CSC** -- Carrier Supporting Carrier. A hierarchical VPN model that allows small service providers, or customer carriers, to interconnect their IP or MPLS networks over an MPLS backbone. This eliminates the need for customer carriers to build and maintain their own MPLS backbone.

**eBGP** -- external Border Gateway Protocol. A BGP between routers located within different autonomous systems. When two routers, located in different autonomous systems, are more than one hop away from one another, the eBGP session between the two routers is considered a multihop BGP.

**edge router** -- A router that is at the edge of the network. It defines the boundary of the MPLS network. It receives and transmits packets. Also referred to as edge label switch router and label edge router.

**iBGP** -- internal Border Gateway Protocol. A BGP between routers within the same autonomous system.

**IGP** -- Interior Gateway Protocol. Internet protocol used to exchange routing information within a single autonomous system. Examples of common Internet IGP protocols include IGRP, OSPF, IS-IS, and RIP.

**IP** -- Internet Protocol. Network layer protocol in the TCP/IP stack offering a connectionless internetwork service. IP provides features for addressing, type-of-service specification, fragmentation and reassembly, and security. Defined in RFC 791.
LDP -- Label Distribution Protocol. A standard protocol between MPLS-enabled routers to negotiate the labels (addresses) used to forward packets.

LFIB -- Label Forwarding Information Base. Data structure used in MPLS to hold information about incoming and outgoing labels and associated Forwarding Equivalence Class (FEC) packets.

MP-BGP -- Multiprotocol BGP.

MPLS -- Multiprotocol Label Switching. The name of the IETF working group responsible for label switching, and the name of the label switching approach it has standardized.

NLRI -- Network Layer Reachability Information. The BGP sends routing update messages containing NLRI to describe a route and how to get there. In this context, an NLRI is a prefix. A BGP update message carries one or more NLRI prefixes and the attributes of a route for the NLRI prefixes; the route attributes include a BGP next hop gateway address and extended community values.

NSF -- Nonstop forwarding enables routers to continuously forward IP packets following a Route Processor takeover or switchover to another Route Processor. NSF maintains and updates Layer 3 routing and forwarding information in the backup Route Processor to ensure that IP packets and routing protocol information are forwarded continuously during the switchover and route convergence process.

PE router -- provider edge router. A router that is part of a service provider’s network. It is connected to a customer edge (CE) router. All MPLS VPN processing occurs in the PE router.

QoS -- quality of service. Measure of performance for a transmission system that indicates its transmission quality and service availability.

RD -- route distinguisher. An 8-byte value that is concatenated with an IPv4 prefix to create a unique VPN-IPv4 prefix.

RT -- route target. Extended community attribute used to identify the VRF routing table into which a prefix is imported.

SLA -- Service Level Agreement given to VPN subscribers.

VPN -- Virtual Private Network. A secure MPLS-based network that shares resources on one or more physical networks (typically implemented by one or more service providers). A VPN contains geographically dispersed sites that can communicate securely over a shared backbone network.

VRF -- VPN routing and forwarding instance. Routing information that defines a VPN site that is attached to a PE router. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table.
CHAPTER 5

MPLS VPN Carrier Supporting Carrier Using LDP and an IGP

Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) Carrier Supporting Carrier (CSC) enables one MPLS VPN-based service provider to allow other service providers to use a segment of its backbone network. This module explains how to configure the MPLS VPN CSC network using MPLS Label Distribution Protocol (LDP) to distribute MPLS labels and an Interior Gateway Protocol (IGP) to distribute routes.

- Finding Feature Information, page 133
- Prerequisites for MPLS VPN CSC with LDP and IGP, page 134
- Restrictions for MPLS VPN CSC with LDP and IGP, page 135
- Information About MPLS VPN CSC with LDP and IGP, page 135
- How to Configure MPLS VPN CSC with LDP and IGP, page 141
- Configuration Examples for MPLS VPN CSC with LDP and IGP, page 152
- Additional References for MPLS VPN Carrier Supporting Carrier Using LDP and an IGP, page 193
- Feature Information for MPLS VPN CSC with LDP and IGP, page 194
- Glossary, page 194

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
Prerequisites for MPLS VPN CSC with LDP and IGP

- The provider edge (PE) routers of the backbone carrier require 128 MB of memory.
- The backbone carrier must enable the PE router to check that the packets it receives from the customer edge (CE) router contain only the labels that the PE router advertised to the CE router. This prevents data spoofing, which occurs when a packet from an unrecognized IP address is sent to a router.

Restrictions for MPLS VPN CSC with LDP and IGP

The following features are not supported with this feature:

- ATM MPLS
- Carrier supporting carrier traffic engineering
- Carrier supporting carrier quality of service (QoS)
- RSVP aggregation
- VPN Multicast between the customer carrier and the backbone carrier network

The following router platforms are supported on the edge of the MPLS VPN:

- Cisco 7200 series
- Cisco 7500 series
- Cisco 12000 series

See the table below for Cisco 12000 series line card support added for Cisco IOS releases.

### Table 6: Cisco12000 Series Line Card Support Added for Cisco IOS Releases

<table>
<thead>
<tr>
<th>Type</th>
<th>Line Cards</th>
<th>Cisco IOS Release Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet over SONET (POS)</td>
<td>4-Port OC-3 POS</td>
<td>12.0(16)ST</td>
</tr>
<tr>
<td></td>
<td>1-Port OC-12 POS</td>
<td>12.0(21)ST</td>
</tr>
<tr>
<td></td>
<td>8-Port OC-3 POS</td>
<td>12.0(22)S</td>
</tr>
<tr>
<td></td>
<td>16-Port OC-3 POS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-Port OC-12 POS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-Port OC-48 POS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-Port OC-3 POS ISE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8-Port OC-3 POS ISE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 x OC-3 POS ISE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Port OC-12 POS ISE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-Port OC-48 POS ISE</td>
<td></td>
</tr>
</tbody>
</table>
### Information About MPLS VPN CSC with LDP and IGP

#### MPLS VPN CSC Introduction

Carrier supporting carrier is where one service provider allows another service provider to use a segment of its backbone network. The service provider that provides the segment of the backbone network to the other provider is called the backbone carrier. The service provider that uses the segment of the backbone network is called the customer carrier.

A backbone carrier offers Border Gateway Protocol and Multiprotocol Label Switching (BGP/MPLS) VPN services. The customer carrier can be either:

- An Internet service provider (ISP)
- A BGP/MPLS VPN service provider

#### Benefits of Implementing MPLS VPN CSC

The MPLS VPN CSC network provides the following benefits to service providers who are backbone carriers and to customer carriers.

**Benefits to the Backbone Carrier**

- The backbone carrier can accommodate many customer carriers and give them access to its backbone.
- The backbone carrier does not need to create and maintain separate backbones for its customer carriers.
- Using one backbone network to support multiple customer carriers simplifies the backbone carrier’s

---

<table>
<thead>
<tr>
<th>Type</th>
<th>Line Cards</th>
<th>Cisco IOS Release Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Interface</td>
<td>6- Port DS3</td>
<td>12.0(16)ST</td>
</tr>
<tr>
<td></td>
<td>12- Port DS3</td>
<td>12.0(21)ST</td>
</tr>
<tr>
<td></td>
<td>6-Port E3</td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>4-Port OC-3 ATM</td>
<td>12.0(22)S</td>
</tr>
<tr>
<td></td>
<td>1-Port OC12 ATM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-Port OC-12 ATM</td>
<td></td>
</tr>
<tr>
<td>Channelized Interface</td>
<td>2-Port CHOC-3</td>
<td>12.0(22)S</td>
</tr>
<tr>
<td></td>
<td>6-Port Ch T3 (DS1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-Port CHOC-12 (DS3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-Port CHOC-12 (OC-3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-Port CHOC-12 ISE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-Port CHOC-48 ISE</td>
<td></td>
</tr>
</tbody>
</table>
VPN operations. The backbone carrier uses a consistent method for managing and maintaining the backbone network. This is also cheaper and more efficient than maintaining separate backbones.

• The MPLS VPN carrier supporting carrier feature is scalable. Carrier supporting carrier can change the VPN to meet changing bandwidth and connectivity needs. The feature can accommodate unplanned growth and changes. The carrier supporting carrier feature enables tens of thousands of VPNs to be set up over the same network, and it allows a service provider to offer both VPN and Internet services.

• The MPLS VPN carrier supporting carrier feature is a flexible solution. The backbone carrier can accommodate many types of customer carriers. The backbone carrier can accept customer carriers who are ISPs or VPN service providers or both. The backbone carrier can accommodate customer carriers that require security and various bandwidths.

Benefits to the Customer Carriers

• The MPLS VPN carrier supporting carrier feature removes from the customer carrier the burden of configuring, operating, and maintaining its own backbone. The customer carrier uses the backbone network of a backbone carrier, but the backbone carrier is responsible for network maintenance and operation.

• Customer carriers who use the VPN services provided by the backbone carrier receive the same level of security that Frame Relay or ATM-based VPNs provide. Customer carriers can also use IPSec in their VPNs for a higher level of security; it is completely transparent to the backbone carrier.

• Customer carriers can use any link layer technology (SONET, DSL, Frame Relay, and so on) to connect the CE routers to the PE routers and the PE routers to the P routers. The MPLS VPN carrier supporting carrier feature is link layer independent. The CE routers and PE routers use IP to communicate, and the backbone carrier uses MPLS.

• The customer carrier can use any addressing scheme and still be supported by a backbone carrier. The customer address space and routing information are independent of the address space and routing information of other customer carriers or the backbone provider.

Configuration Options for MPLS VPN CSC with LDP and IGP

The backbone carrier offers BGP and MPLS VPN services. The customer carrier can be one of the two types of service providers described in the following sections, which explain how the backbone and customer carriers distribute IPv4 routes and MPLS labels.

Customer Carrier Is an ISP

This section explains how a BGP/MPLS VPN service provider (backbone carrier) can provide a segment of its backbone network to a customer who is an ISP.

Consider the following example:
An ISP has two sites: one in California, the other in Maine. Each site is a point of presence (POP). The ISP wants to connect these sites using a VPN service provided by a backbone carrier. The figure below illustrates this situation.

**Figure 14: Sample BGP/MPLS Backbone Carrier Supporting an ISP**

![Diagram of BGP/MPLS backbone carrier supporting an ISP]

---

**Note**

The CE routers in the figures are CE routers to the backbone carrier. However, they are PE routers to the customer carrier.

In this example, only the backbone carrier uses MPLS. The customer carrier (ISP) uses only IP. As a result, the backbone carrier must carry all the Internet routes of the customer carrier, which could be as many as 100,000 routes. This poses a scalability problem for the backbone carrier. To solve the scalability problem, the backbone carrier is configured as follows:

- The backbone carrier allows only internal routes of the customer carrier (IGP routes) to be exchanged between the CE routers of the customer carrier and the PE routers of the backbone carrier.
- MPLS is enabled on the interface between the CE router of the customer carrier and the PE router of the backbone carrier.

Internal and external routes are differentiated this way:

- Internal routes go to any of the routers within the ISP.
- External routes go to the Internet.

The number of internal routes is much lower than the number of external routes. Restricting the routes between the CE routers of the customer carrier and the PE routers of the backbone carrier significantly reduces the number of routes that the PE router needs to maintain.

Because the PE routers do not have to carry external routes in the VRF routing table, they can use the incoming label in the packet to forward the customer carrier Internet traffic. Adding MPLS to the routers provides a consistent method of transporting packets from the customer carrier to the backbone carrier. MPLS allows the exchange of an MPLS label between the PE and the CE routers for every internal customer carrier route. The routers in the customer carrier have all the external routes either through internal Border Gateway Protocol
(iBGP) or route redistribution to provide Internet connectivity. The figure below shows how information is exchanged when the network is configured in this manner.

Figure 15: Backbone Carrier Exchanging Routing Information with a Customer Carrier Who Is an ISP

In the figure below, routes are created between the backbone carrier and the customer carrier sites. ASBR2 receives an Internet route that originated outside the network. All routers in the ISP sites have all the external routes through IBGP connections among them.

Figure 16: Establishing a Route Between a Backbone Carrier and a Customer Carrier Who Is an ISP

The table below describes the process of establishing the route, which can be divided into two distinct steps:

- The backbone carrier propagates the IGP information of the customer carrier, which enables the customer carrier routers to reach all the customer carrier routers in the remote sites.

- Once the routers of the customer carriers in different sites are reachable, external routes can be propagated in the customer carrier sites, using IBGP without using the backbone carrier routers.
Table 7: Establishing a Route Between the Backbone Carrier and the Customer Carrier ISP

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CSC-CE2 sends the internal routes within site 2 to CSC-PE2. The routes include the route to ASBR2.</td>
</tr>
<tr>
<td>2</td>
<td>CSC-PE2 sends the routing information for site 2 to CSC-PE1, using MPLS VPN processes. CSC-PE1 gets one label (called L3), which is associated with the route to the VPN-IP address for ASBR2. CSC-PE1 gets another label (called L2), which is associated with the route to CSC-PE2.</td>
</tr>
<tr>
<td>3</td>
<td>CSC-PE1 sends the routing information associated with internal routes from site 2 to CSC-CE1. CSC-PE1 also sends the label binding information. As a result, CSC-CE1 gets the route to ASBR2 with CSC-PE1 as the next hop. The label associated with that route is called L1.</td>
</tr>
<tr>
<td>4</td>
<td>CSC-CE1 distributes the routing information through site 1. Every router in site 1 gets a route for every internal destination in site 2. Therefore, every router in site 1 can reach routers in site 2 and learn external routes through IBGP.</td>
</tr>
<tr>
<td>5</td>
<td>ASBR2 receives an Internet route.</td>
</tr>
<tr>
<td>6</td>
<td>The IBGP sessions exchange the external routing information of the ISP, including a route to the Internet. Every router in site 1 knows a route to the Internet, with ASBR2 as the next hop of that route.</td>
</tr>
</tbody>
</table>

Customer Carrier Is a BGP MPLS VPN Service Provider

When a backbone carrier and the customer carrier both provide BGP/MPLS VPN services, the method of transporting data is different from when a customer carrier provides only ISP services. The following list highlights those differences:

- When a customer carrier provides BGP/MPLS VPN services, its external routes are VPN-IPv4 routes. When a customer carrier is an ISP, its external routes are IP routes.

- When a customer carrier provides BGP/MPLS VPN services, every site within the customer carrier must use MPLS. When a customer carrier is an ISP, the sites do not need to use MPLS.
The figure below shows how information is exchanged when MPLS VPN services reside on all customer carrier sites and on the backbone carrier.

**Figure 17: Backbone Carrier Exchanging Information with a Customer Carrier Who Is an MPLS VPN Service Provider**

Exterior Router Information (VPN-IPv4 NLRI)

![Diagram showing backbone carrier exchanging information with customer carrier.]

In the example shown in the figure below, routes are created between the backbone carrier and the customer carrier sites.

**Figure 18: Establishing a Route Between a Backbone Carrier and a Customer Carrier Who Is an MPLS VPN Service Provider**

![Diagram showing establishment of route.]

The table below describes the process of establishing the route.

**Table 8: Establishing a Route Between the Backbone Carrier and Customer Carrier Site**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CE2 sends all the internal routes within site 2 to CSC-PE2.</td>
</tr>
</tbody>
</table>
Step | Description
--- | ---
2 | CSC-PE2 sends the routing information for site 2 to CSC-PE1, using MPLS VPN processes. CSC-PE1 gets one label (called L3), which is associated with the route to the VPN-IP address for PE2. CSC-PE1 gets another label (called L2), which is associated with the route to CSC-PE2.
3 | CSC-PE1 sends the routing information associated with internal routes from site 2 to CSC-CE1. CSC-PE1 also sends the label binding information. As a result, CSC-CE1 gets the route to PE2 with CSC-PE1 as the next hop. The label associated with that route is called L1.
4 | CE1 distributes the routing and labeling information through site 1. Every router in site 1 gets a route for every internal destination in site 2. Therefore, PE1 can establish an MP-IBGP session with PE2.
5 | CE2 advertises the internal routes of MPLS VPN site 2 to PE2.
6 | PE2 allocates labels for all the VPN routes (regular MPLS VPN functionality) and advertises the labels to PE1, using MP-IBGP.
7 | PE1 can forward traffic from VPN site 1 that is destined for VPN site 2.

How to Configure MPLS VPN CSC with LDP and IGP

Configuring the Backbone Carrier Core

Configuring the backbone carrier core requires configuring connectivity and routing functions for the CSC core and the CSC-PE routers.

Configuring and verifying the CSC core (backbone carrier) involves the following tasks:

Prerequisites

Before you configure a backbone carrier core, configure the following on the CSC core routers:

- An IGP routing protocol--BGP, OSPF, IS-IS, EIGRP, static, and so on. For information, see Configuring a Basic BGP Network, Configuring OSPF, Configuring a Basic IS-IS Network, and Configuring EIGRP.

How to Configure MPLS VPN CSC with LDP and IGP
Label Distribution Protocol (LDP). For information, see MPLS Label Distribution Protocol.

Verifying IP Connectivity and LDP Configuration in the CSC Core
Perform this task to verify IP connectivity and LDP configuration in the CSC core. For a configuration example for this task, see the Verifying IP Connectivity and LDP Configuration in the CSC Core, on page 142.

SUMMARY STEPS

1. enable
2. ping [protocol] {host-name | system-address}
3. trace [protocol] [destination]
4. show mpls forwarding-table [network {mask | length} | labels label [-label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]] [vrf vrf-name] [detail]
5. show mpls ldp discovery [vrf vrf-name | all]
6. show mpls ldp neighbor [[vrf vrf-name] [address | interface] [detail] | all]
7. show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]
8. show mpls interfaces [[vrf vrf-name] [interface] [detail] | all]
9. show ip route
10. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Step 2</strong> ping [protocol] {host-name</td>
<td>system-address}</td>
</tr>
<tr>
<td><strong>Step 3</strong> trace [protocol] [destination]</td>
<td>(Optional) Discovers the routes that packets will actually take when traveling to their destination.</td>
</tr>
<tr>
<td><strong>Step 4</strong> show mpls forwarding-table [network {mask</td>
<td>length}</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Usethe</strong> <code>show mpls forwarding-table</code> command to verify that MPLS packets are being forwarded.</td>
<td><strong>Usethe</strong> <code>show mpls forwarding-table</code> command to verify that MPLS packets are being forwarded.</td>
</tr>
<tr>
<td><strong>Step 5</strong> <code>show mpls ldp discovery</code></td>
<td>(Optional) Displays the status of the LDP discovery process.</td>
</tr>
<tr>
<td><strong>Step 6</strong> <code>show mpls ldp neighbor</code></td>
<td>(Optional) Displays the status of LDP sessions.</td>
</tr>
<tr>
<td><strong>Step 7</strong> <code>show ip cef</code></td>
<td>(Optional) Displays entries in the forwarding Information Base (FIB).</td>
</tr>
<tr>
<td><strong>Step 8</strong> <code>show mpls interfaces</code></td>
<td>(Optional) Displays information about one or more or all interfaces that are configured for label switching.</td>
</tr>
<tr>
<td><strong>Step 9</strong> <code>show ip route</code></td>
<td>(Optional) Displays IP routing table entries.</td>
</tr>
<tr>
<td><strong>Step 10</strong> <code>disable</code></td>
<td>(Optional) Returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>

**Example:**
```
Router# show mpls forwarding-table
```

```
Router# show mpls ldp discovery
```

```
Router# show mpls ldp neighbor
```

```
Router# show ip cef
```

```
Router# show mpls interfaces
```

```
Router# show ip route
```

```
Router# disable
```
Troubleshooting Tips

You can use the `ping` and `trace` commands to verify complete MPLS connectivity in the core. You also get useful troubleshooting information from the additional `show` commands.

Configuring VRFs for CSC-PE Routers

Perform this task to configure VPN routing and forwarding (VRF) instances for the backbone carrier edge (CSC-PE) routers.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `ip vrf vrf-name`
4. `rd route-distinguisher`
5. `route-target {import | export | both} route-target-ext-community`
6. `import map route-map`
7. `exit`
8. `interface type number`
9. `ip vrf forwarding vrf-name`
10. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode.</td>
</tr>
<tr>
<td><code>ip vrf vrf-name</code></td>
<td>• The <code>vrf-name</code> argument is the name assigned to a VRF.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# ip vrf vpn1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Creates routing and forwarding tables.</td>
</tr>
<tr>
<td><code>rd route-distinguisher</code></td>
<td>Creates routing and forwarding tables.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| `Router(config-vrf)# rd 100:1` | - The `route-distinguisher` argument adds an 8-byte value to an IPv4 prefix to create a VPN-IPv4 prefix. You can enter an RD in either of these formats:  
  - 16-bit AS number: your 32-bit number, for example, 101:3  
  - 32-bit IP address: your 16-bit number, for example, 192.168.122.15:1 |
| **Step 5**        |         |
| `route-target {import | export | both} route-target-ext-community` | 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.  
  - The `route-target-ext-community` argument adds the route-target extended community attributes to the VRF's list of import, export, or both (import and export) route-target extended communities. |
| **Example:**     |         |
| `Router(config-vrf)# route-target import 100:1` |         |
| **Step 6**        |         |
| `import map route-map` | (Optional) Configures an import route map for a VRF.  
  - The `route-map` argument specifies the route map to be used as an import route map for the VRF. |
| **Example:**     |         |
| `Router(config-vrf)# import map vpn1-route-map` |         |
| **Step 7**        |         |
| `exit` | (Optional) Exits to global configuration mode. |
| **Example:**     |         |
| `Router(config-vrf)# exit` |         |
| **Step 8**        |         |
| `interface type number` | 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. |
| **Example:**     |         |
| `Router(config)# interface Ethernet5/0` |         |
| **Step 9**        |         |
| `ip vrf forwarding vrf-name` | Associates a VRF with the specified interface or subinterface.  
  - The `vrf-name` argument is the name assigned to a VRF. |
| **Example:**     |         |
| `Router(config-if)# ip vrf forwarding vpn1` |         |
### Troubleshooting Tips

Enter a `show ip vrf detail` command and make sure the MPLS VPN is up and associated with the right interfaces.

### Configuring Multiprotocol BGP for VPN Connectivity in the Backbone Carrier

Perform this task to configure Multiprotocol BGP (MP-BGP) connectivity in the backbone carrier.

#### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `no bgp default ipv4-unicast`
5. `neighbor {ip-address | peer-group-name} remote-as as-number`
6. `neighbor {ip-address | peer-group-name} update-source interface-type`
7. `address-family vpnv4 [unicast]`
8. `neighbor {ip-address | peer-group-name} send-community extended`
9. `neighbor {ip-address | peer-group-name} activate`
10. `end`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step 3</th>
<th><strong>router bgp</strong> <em>as-number</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config)# router bgp 100</td>
</tr>
</tbody>
</table>

**Purpose:**
Configures a BGP routing process and enters router configuration mode.

- **as-number** argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.

<table>
<thead>
<tr>
<th>Step 4</th>
<th><strong>no bgp default ipv4-unicast</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router)# no bgp default ipv4-unicast</td>
</tr>
</tbody>
</table>

**Purpose:**
(Optional) Disables the IPv4 unicast address family on all neighbors.

- Use the **no bgp default-unicast** command if you are using this neighbor for MPLS routes only.

| Step 5 | **neighbor** *(ip-address | peer-group-name)* *remote-as* *as-number* |
|--------|-------------------------------------------|
| **Example:** | Router(config-router)# neighbor 10.5.5.5 remote-as 100 |

**Purpose:**
Adds an entry to the BGP or multiprotocol BGP neighbor table.

- **ip-address** argument specifies the IP address of the neighbor.
- **peer-group-name** argument specifies the name of a BGP peer group.
- **as-number** argument specifies the autonomous system to which the neighbor belongs.

| Step 6 | **neighbor** *(ip-address | peer-group-name)* *update-source* *interface-type* |
|--------|---------------------------------------------------|
| **Example:** | Router(config-router)# neighbor 10.2.0.0 update-source loopback0 |

**Purpose:**
Allows BGP sessions to use a specific operational interface for TCP connections.

- **ip-address** argument specifies the IP address of the BGP-speaking neighbor.
- **peer-group-name** argument specifies the name of a BGP peer group.
- **interface-type** argument specifies the interface to be used as the source.

<table>
<thead>
<tr>
<th>Step 7</th>
<th><strong>address-family vpnv4 [unicast]</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-router)# address-family vpnv4</td>
</tr>
</tbody>
</table>

**Purpose:**
Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPv4 address prefixes.

- The optional **unicast** keyword specifies VPv4 unicast address prefixes.

| Step 8 | **neighbor** *(ip-address | peer-group-name)* *send-community extended* |
|--------|--------------------------------------------------|
| **Example:** | Router(config-router-af)# neighbor 10.0.0.1 send-community extended |

**Purpose:**
Specifies that a communities attribute should be sent to a BGP neighbor.

- **ip-address** argument specifies the IP address of the BGP-speaking neighbor.
- **peer-group-name** argument specifies the name of a BGP peer group.
### Configuring the CSC-PE and CSC-CE Routers

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 9</strong></td>
<td></td>
</tr>
<tr>
<td>neighbor {ip-address</td>
<td>peer-group-name} activate</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-router-af)# neighbor 10.4.0.0 activate</td>
<td></td>
</tr>
<tr>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighbor.</td>
<td></td>
</tr>
<tr>
<td>• The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
<td></td>
</tr>
</tbody>
</table>

| **Step 10**       | (Optional) Exits to privileged EXEC mode. |
| **Example:**      |         |
| Router(config-router-af)# end |         |

**Troubleshooting Tips**

You can enter a `show ip bgp neighbor` command to verify that the neighbors are up and running. If this command generates an error message, enter a `debug ip bgp x.x.x.x events` command, where `x.x.x.x` is the IP address of the neighbor.

### Configuring the CSC-PE and CSC-CE Routers

To enable the CSC-PE and CSC-CE routers to distribute routes and MPLS labels, perform the following tasks:

**Prerequisites**

Before you configure the CSC-PE and CSC-CE routers, you must configure an IGP on the CSC-PE and CSC-CE routers. A routing protocol is required between the PE and CE routers that connect the backbone carrier to the customer carrier. The routing protocol enables the customer carrier to exchange IGP routing information with the backbone carrier. Use the same routing protocol that the customer carrier uses. You can choose RIP, OSPF, or static routing as the routing protocol. BGP is not supported. For the configuration steps, see Configuring MPLS Layer 3 VPNs.

**Configuring LDP on the CSC-PE and CSC-CE Routers**

MPLS LDP is required between the PE and CE routers that connect the backbone carrier to the customer carrier. You can configure LDP as the default label distribution protocol for the entire router or just for the PE-to-CE interface for VRF.
**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `mpls label protocol ldp`
4. `interface type number`
5. `mpls label protocol ldp`
6. `exit`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> <code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> <code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> <code>mpls label protocol ldp</code></td>
<td>Specifies MPLS LDP as the default label distribution protocol for the router.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# mpls label protocol ldp</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> <code>interface type number</code></td>
<td>(Optional) Specifies the interface to configure and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface Ethernet5/0</td>
<td>• The <code>type</code> argument specifies the type of interface to be configured.</td>
</tr>
<tr>
<td></td>
<td>• The <code>number</code> argument specifies the port, connector, or interface card number.</td>
</tr>
<tr>
<td><strong>Step 5</strong> <code>mpls label protocol ldp</code></td>
<td>(Optional) Specifies MPLS LDP as the default label distribution protocol for the interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# mpls label protocol ldp</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> <code>exit</code></td>
<td>(Optional) Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
</tbody>
</table>
Enabling MPLS Encapsulation on the CSC-PE and CSC-CE Routers

Every packet that crosses the backbone carrier must be encapsulated, so that the packet includes MPLS labels. You can enable MPLS encapsulation for the entire router or just on the interface of the PE or CE router. To enable the encapsulation of packets, perform the following task.

SUMMARY STEPS

1. enable
2. configure terminal
3. mpls ip
4. interface type number
5. mpls ip
6. exit

DETAILED STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td>3</td>
<td>mpls ip</td>
<td>Enables MPLS encapsulation for the router.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>Router(config)# mpls ip</td>
</tr>
<tr>
<td>4</td>
<td>interface type number</td>
<td>(Optional) Specifies the interface to configure and enters interface configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>• The type argument specifies the type of interface to be configured.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The number argument specifies the port, connector, or interface card number.</td>
</tr>
<tr>
<td></td>
<td>Router(config)# interface Ethernet5/0</td>
<td></td>
</tr>
</tbody>
</table>
Purpose

Command or Action | Purpose
--- | ---
Step 5 | mpls ip

(Optional) Enables MPLS encapsulation for the specified interface.

Example:

```
Router(config-if)# mpls ip
```

Step 6 | exit

(Optional) Exits to privileged EXEC mode.

Example:

```
Router(config-if)# exit
```

---

### Verifying the Carrier Supporting Carrier Configuration

The following commands verify the status of LDP sessions that were configured between the backbone carrier and customer carrier. Now the customer carrier ISP sites appear as a VPN customer to the backbone carrier.

**SUMMARY STEPS**

1. `show mpls ldp discovery vrf vrf-name`
2. `show mpls ldp discovery all`

**DETAILED STEPS**

**Step 1**

`show mpls ldp discovery vrf vrf-name`

Use this command to show that the LDP sessions are in VRF VPN1 of the PE router of the backbone carrier, for example:

Example:

```
Router# show mpls ldp discovery vrf vpn1
Local LDP Identifier:
10.0.0.0:0
Discovery Sources:
 Interfaces:
   Ethernet1/0 (ldp): xmit/recv
   LDP Id: 10.0.0.1:0
   POS6/0 (ldp): xmit
```

**Step 2**

`show mpls ldp discovery all`

Use this command to list all LDP sessions in a router, for example:

Example:

```
Router# show mpls ldp discovery all
Local LDP Identifier:
10.10.10.10:0
```
Discovery Sources:
  Interfaces:
   Ethernet1/5 (ldp): xmit/recv
   LDP Id: 10.5.5.5:0
  VRF vpn1: Local LDP Identifier:
   10.0.0.1:0
Discovery Sources:
  Interfaces:
   Ethernet1/0 (ldp): xmit/recv
   LDP Id: 10.0.0.1:0
   POS6/0 (ldp): xmit

The Local LDP Identifier field shows the LDP identifier for the local label switching router for this session. The Interfaces field displays the interfaces engaging in LDP discovery activity:

- xmit indicates that the interface is transmitting LDP discovery hello packets.
- recv indicates that the interface is receiving LDP discovery hello packets.

---

Configuration Examples for MPLS VPN CSC with LDP and IGP

MPLS VPN CSC Network with a Customer Who Is an ISP Example

The figure below shows a carrier supporting carrier network configuration where the customer carrier is an ISP. The customer carrier has two sites, each of which is a POP. The customer carrier connects these sites using a VPN service provided by the backbone carrier. The backbone carrier uses MPLS. The ISP sites use IP. To enable packet transfer between the ISP sites and the backbone carrier, the CE routers that connect the ISPs to the backbone carrier run MPLS.

![Figure 19: Carrier Supporting Carrier Network with a Customer Carrier Who Is an ISP](image)

The following examples show the configuration of each router in the carrier supporting carrier network. OSPF is used to connect the customer carrier to the backbone carrier.

CSC-CE1 Configuration

```
mpls label protocol ldp
!
interface Loopback0
  no ip directed-broadcast
  no ip route-cache
```
no ip mroute-cache
!
interface ATM1/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet atm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM1/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snp
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip
!
interface ATM2/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet atm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM2/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snp
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip
!
router ospf 200
log-adjacency-changes
redistribute connected subnets
network 10.14.14.14 0.0.0.0 area 200
network 10.15.0.0 0.255.255.255 area 200
network 10.16.0.0 0.255.255.255 area 200

CSC-PE1 Configuration

ip cef distributed
!
ip vrf vpn1
rd 100:0
route-target export 100:0
route-target import 100:0
mpls label protocol ldp
no mpls aggregate-statistics
!
interface Loopback0
ip address 10.11.11.11 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface Loopback100
ip vrf forwarding vpn1
ip address 10.19.19.19 255.255.255.255
no ip directed-broadcast
!
interface ATM1/1/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
no atm enable-ilmi-trap
no atm ilmi-keepalive

interface ATM1/1/0.1
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip

interface ATM3/0/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive

interface ATM3/0/0.1 point-to-point
ip vrf forwarding vpn1
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip

router ospf 100
log-adjacency-changes
passive-interface ATM3/0/0.1
passive-interface Loopback100
network 10.11.11.11 0.0.0.0 area 100
network 10.0.0.0 0.255.255.255 area 100

router ospf 200 vrf vpn1
log-adjacency-changes
redistribute bgp 100 metric-type 1 subnets
network 10.19.19.19 0.0.0.0 area 200
network 10.0.0.0 0.255.255.255 area 200

router bgp 100
bgp log-neighbor-changes
timers bgp 10 30
neighbor 10.12.12.12 remote-as 100
neighbor 10.12.12.12 update-source Loopback0
! address-family ipv4
neighbor 10.12.12.12 activate
neighbor 10.12.12.12 send-community extended
no synchronization
exit-address-family
! address-family vpv4
neighbor 10.12.12.12 activate
neighbor 10.12.12.12 send-community extended
exit-address-family
! address-family ipv4 vrf vpn1
redistribute ospf 200 match internal external 1 external 2
no auto-summary
no synchronization
exit-address-family

CSC-PE2 Configuration

ip cef distributed
!
ip vrf vpn1
rd 100:0
route-target export 100:0
route-target import 100:0
mpls label protocol ldp
no mpls aggregate-statistics
!
interface Loopback0
  ip address 10.12.12.12 255.255.255.255
  no ip directed-broadcast
  no ip route-cache
  no ip mroutecache
!
interface Loopback100
  ip vrf forwarding vpn1
  ip address 10.20.20.20 255.255.255.255
  no ip directed-broadcast
!
interface ATM0/1/0
  no ip address
  no ip directed-broadcast
  no ip route-cache distributed
  no ip mroutecache
  atm clock INTERNAL
  atm sonet stm-1
  no atm enable-ilmi-trap
  no atm ilmi-keepalive
!
interface ATM0/1/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 50 aal5snap
  no atm enable-ilmi-trap
  mpls label protocol ldp
  mpls ip
!
interface ATM3/0/0
  no ip address
  no ip directed-broadcast
  no ip route-cache distributed
  no ip mroutecache
  atm clock INTERNAL
  atm sonet atm-1
  no atm enable-ilmi-trap
  no atm ilmi-keepalive
!
interface ATM3/0/0.1 point-to-point
  ip vrf forwarding vpn1
  ip address 10.0.0.1 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 50 aal5snap
  no atm enable-ilmi-trap
  mpls label protocol ldp
  mpls ip
!
routing ospf 100
  log-adjacency-changes
  passive-interface ATM3/0/0.1
  passive-interface Loopback100
  network 10.12.12.12 0.0.0.0 area 100
  network 10.0.0.0 0.255.255.255 area 100
!
routing ospf 200 vrf vpn1
  log-adjacency-changes
  redistribute bgp 100 metric-type 1 subnets
  network 10.20.20.20 0.0.0.0 area 200
  network 10.0.0.0 0.255.255.255 area 200
!
routing bgp 100
  bgp log-neighbor-changes
  timers bgp 10 30
  neighbor 10.11.11.11 remote-as 100
  neighbor 10.11.11.11 update-source Loopback0
!
address-family ipv4
neighbor 10.11.11.11 activate
neighbor 10.11.11.11 send-community extended
no synchronization
exit-address-family

address-family vpnv4
neighbor 10.11.11.11 activate
neighbor 10.11.11.11 send-community extended
exit-address-family

address-family ipv4 vrf vpn1
redistribute ospf 200 match internal external 1 external 2
no auto-summary
no synchronization
exit-address-family

CSC-CE2 Configuration

ip cef

mpls label protocol ldp

interface Loopback0
ip address 10.16.16.16 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache

interface ATM1/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet stm-1
no atm enable-imi-trap
no atm ilmi-keepalive

interface ATM1/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-imi-trap
mpls label protocol ldp
mpls ip

interface ATM5/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet stm-1
no atm enable-imi-trap
no atm ilmi-keepalive

interface ATM5/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-imi-trap
mpls label protocol ldp
mpls ip

router ospf 200
log-adjacency-changes
redistribute connected subnets
network 10.16.16.16 0.0.0.0 area 200
network 10.0.0.0 0.255.255.255 area 200
network 10.0.0.0 0.255.255.255 area 200
MPLS VPN CSC Network with a Customer Who Is an MPLS VPN Provider Example

The figure below shows a carrier supporting carrier network configuration where the customer carrier is an MPLS VPN provider. The customer carrier has two sites. The backbone carrier and the customer carrier use MPLS. The IBGP sessions exchange the external routing information of the ISP.

**Figure 20: Carrier Supporting Carrier Network with a Customer Carrier Who Is an MPLS VPN Provider**

The following configuration examples show the configuration of each router in the carrier supporting carrier network. OSPF is the protocol used to connect the customer carrier to the backbone carrier.

**CE1 Configuration**

```conf
ip cef
!
interface Loopback0
 ip address 10.17.17.17 255.255.255.255
 no ip directed-broadcast
!
interface Ethernet0/1
 ip address 10.0.0.2 255.0.0.0
 no ip directed-broadcast
!
router ospf 300
 log-adjacency-changes
 redistribute bgp 300 subnets
 passive-interface Ethernet0/1
 network 10.17.17.17 0.0.0.0 area 300
!
router bgp 300
 no synchronization
 bgp log-neighbor-changes
 timers bgp 10 30
 redistribute connected
 redistribute ospf 300 match internal external 1 external 2
 neighbor 10.0.0.1 remote-as 200
 neighbor 10.0.0.1 advertisement-interval 5
 no auto-summary
```
PE1 Configuration

ip cef
ip vrf vpn2
   rd 200:1
   route-target export 200:1
   route-target import 200:1
mpls label protocol ldp

interface Loopback0
   ip address 10.13.13.13 255.255.255.255
   no ip directed-broadcast
   no ip route-cache
   no ip mroute-cache

interface ATM1/0
   no ip address
   no ip directed-broadcast
   no ip mroute-cache
   atm clock INTERNAL
   atm sonet s1
   no atm enable-ilmi-trap
   no atm keepalive

interface ATM1/0.1 point-to-point
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   atm pvc 100 0 50 aal5snap
   no atm enable-ilmi-trap
   mpls label protocol ldp
   mpls ip

interface Ethernet3/0
   ip vrf forwarding vpn2
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   no ip mroute-cache

router ospf 200
   log-adjacency-changes
   redistribute connected subnets
   passive-interface Ethernet3/0
   network 10.13.13.13 0.0.0.0 area 200
   network 10.0.0.0 255.255.255.255 area 200

router bgp 200
   no bgp default ipv4-unicast
   bgp log-neighbor-changes
   timers bgp 10 30
   neighbor 10.15.15.15 remote-as 200
   neighbor 10.15.15.15 update-source Loopback0
   address-family ipv4
   neighbor 10.15.15.15 activate
   neighbor 10.15.15.15 send-community extended
   no synchronization
   exit-address-family
   address-family vpnv4
   neighbor 10.15.15.15 activate
   neighbor 10.15.15.15 send-community extended
   exit-address-family
   address-family ipv4 vrf vpn2
   neighbor 10.0.0.2 remote-as 300
   neighbor 10.0.0.2 activate
   neighbor 10.0.0.2 as-override
   neighbor 10.0.0.2 advertisement-interval 5
   no auto-summary
CSC-CE1 Configuration

mpls label protocol ldp

interface Loopback0
  no ip directed-broadcast
  no ip mroute-cache

interface ATM1/0
  no ip address
  no ip directed-broadcast
  no ip mroute-cache
  atm clock INTERNAL
  atm sonet stm-1
  no atm enable-ilm-trap
  no atm ilmi-keepalive

interface ATM1/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 101 0 51 aal5snap
  no atm enable-ilm-trap
  mpls label protocol ldp
  mpls ip

interface ATM2/0
  no ip address
  no ip directed-broadcast
  no ip mroute-cache
  atm clock INTERNAL
  atm sonet stm-1
  no atm enable-ilm-trap
  no atm ilmi-keepalive

interface ATM2/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 50 aal5snap
  no atm enable-ilm-trap
  mpls label protocol ldp
  mpls ip

router ospf 200
  log-adjacency-changes
  redistribute connected subnets
  network 10.14.14.14 0.0.0.0 area 200
  network 10.0.0.0 0.255.255.255 area 200
  network 10.0.0.0 0.255.255.255 area 200

CSC-PE1 Configuration

ip cef distributed

ip vrf vpn1
  rd 100:0
  route-target export 100:0
  route-target import 100:0
  mpls label protocol ldp
  no mpls aggregate-statistics

interface Loopback0
  ip address 11.11.11.11 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface Loopback100
ip vrf forwarding vpn1
ip address 10.19.19.19 255.255.255.255
no ip directed-broadcast
!
interface ATM1/1/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
no atm enable-imi-trap
no atm ilmi-keepalive
!
interface ATM1/1/0.1 point-to-point
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-imi-trap
mpls label protocol ldp
mpls
!
interface ATM3/0/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ili-trap
no atm ilmi-keepalive
!
interface ATM3/0/0.1 point-to-point
ip vrf forwarding vpn1
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls
!
routing ospf 100
log-adjacency-changes
passive-interface ATM3/0/0.1
passive-interface Loopback100
network 10.11.11.11 0.0.0.0 area 100
network 10.0.0.0 0.255.255.255 area 100
!
routing ospf 200 vrf vpn1
log-adjacency-changes
redistribute bgp 100 metric-type 1 subnets
network 10.19.19.19 0.0.0.0 area 200
network 10.0.0.0 0.255.255.255 area 200
!
routing bgp 100
bgp log-neighbor-changes
timers bgp 10 30
neighbor 10.12.12.12 remote-as 100
neighbor 10.12.12.12 update-source Loopback0
!
address-family ipv4
neighbor 10.12.12.12 activate
neighbor 10.12.12.12 send-community extended
no synchronization
exit-address-family
!
address-family vpnv4
neighbor 10.12.12.12 activate
neighbor 10.12.12.12 send-community extended
exit-address-family
!
address-family ipv4 vrf vpn1
redistribute ospf 200 match internal external 1 external 2
no auto-summary
no synchronization
exit-address-family

### CSC-PE2 Configuration

```plaintext
ip cef distributed

! ip vrf vpn1
   rd 100:0
   route-target export 100:0
   route-target import 100:0
   mpls label protocol ldp
   no mpls aggregate-statistics
!
interface Loopback0
   ip address 10.12.12.12 255.255.255.255
   no ip directed-broadcast
   no ip route-cache
   no ip mroute-cache
!
interface Loopback100
   ip vrf forwarding vpn1
   ip address 10.20.20.20 255.255.255.255
   no ip directed-broadcast
!
interface ATM0/1/0
   no ip address
   no ip directed-broadcast
   no ip route-cache distributed
   no ip mroute-cache
   atm clock INTERNAL
   atm sonet stm-1
   no atm enable-ilmi-trap
   no atm ilmi-keepalive
!
interface ATM0/1/0.1 point-to-point
   ip address 10.0.0.2 255.0.0.0
   no ip directed-broadcast
   atm pvc 100 0 50 aal5snap
   no atm enable-ilmi-trap
   mpls label protocol ldp
   mpls ip
!
interface ATM3/0/0
   no ip address
   no ip directed-broadcast
   no ip route-cache distributed
   no ip mroute-cache
   atm clock INTERNAL
   atm sonet stm-1
   no atm enable-ilmi-trap
   no atm ilmi-keepalive
!
interface ATM3/0/0.1 point-to-point
   ip vrf forwarding vpn1
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   atm pvc 100 0 50 aal5snap
   no atm enable-ilmi-trap
   mpls label protocol ldp
   mpls ip
!
router ospf 100
   log-adjacency-changes
   passive-interface ATM3/0/0.1
   passive-interface Loopback100
   network 10.12.12.12 0.0.0.0 area 100
```

MPLS Layer 3 VPNs Inter-AS and CSC Configuration Guide, Cisco IOS XE Release 3S
network 10.0.0.0 0.255.255.255 area 100
router ospf 200 vrf vpn1
  log-adjacency-changes
  redistribute bgp 100 metric-type 1 subnets
  network 10.20.20.20 0.0.0.0 area 200
  network 10.0.0.0 0.255.255.255 area 200
router bgp 100
  bgp log-neighbor-changes
  timers bgp 10 30
  neighbor 10.11.11.11 remote-as 100
  neighbor 10.11.11.11 update-source Loopback0
  address-family ipv4
  neighbor 10.11.11.11 activate
  neighbor 10.11.11.11 send-community extended
  no synchronization
  exit-address-family
  address-family vpnv4
  neighbor 10.11.11.11 activate
  neighbor 10.11.11.11 send-community extended
  exit-address-family
  address-family ipv4 vrf vpn1
  redistribute ospf 200 match internal external 1 external 2
  no auto-summary
  no synchronization
  exit-address-family
CSC-CE2 Configuration
ip cef
!
mls label protocol ldp
!
interface Loopback0
  ip address 10.16.16.16 255.255.255.255
  no ip directed-broadcast
  no ip route-cache
  no ip mroute-cache
!
interface ATM1/0
  no ip address
  no ip directed-broadcast
  no ip mroute-cache
  atm clock INTERNAL
  atm sonet stm-1
  no atm enable-ilmi-trap
  no atm ilmi-keepalive
!
interface ATM1/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 50 aal5snap
  no atm enable-ilmi-trap
  mpls label protocol ldp
  mpls ip
!
interface ATM5/0
  no ip address
  no ip directed-broadcast
  no ip mroute-cache
  atm clock INTERNAL
  atm sonet stm-1
  no atm enable-ilmi-trap
  no atm ilmi-keepalive
!
interface ATM5/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip
!
router ospf 200
log-adjacency-changes
redistribute connected subnets
network 10.0.0.0 0.255.255.255 area 200
network 10.0.0.0 0.255.255.255 area 200

PE2 Configuration

    ip cef
    ip cef accounting non-recursive
    !
    ip vrf vpn2
    rd 200:1
    route-target export 200:1
    route-target import 200:1
    mpls label protocol ldp
    !
    interface Loopback0
    ip address 10.15.15.15 255.255.255.255
    no ip directed-broadcast
    !
    interface Ethernet3/0
    ip vrf forwarding vpn2
    ip address 10.0.0.1 255.0.0.0
    no ip directed-broadcast
    !
    interface ATM5/0
    no ip address
    no ip directed-broadcast
    atm clock INTERNAL
    atm sonet atm-1
    no atm enable-ilmi-trap
    no atm ilmi-keepalive
    !
    interface ATM5/0.1 point-to-point
    ip address 10.0.0.1 255.0.0.0
    no ip directed-broadcast
    atm pvc 100 0 50 aal5snap
    no atm enable-ilmi-trap
    mpls label protocol ldp
    mpls ip
    !
    router ospf 200
    log-adjacency-changes
    redistribute connected subnets
    passive-interface Ethernet3/0
    network 10.15.15.15 0.0.0.0 area 200
    network 10.0.0.0 0.255.255.255 area 200
    !
    router bgp 200
    no bgp default ipv4-unicast
    bgp log-neighbor-changes
timers bgp 10 30
    neighbor 10.13.13.13 remote-as 200
    neighbor 10.13.13.13 update-source Loopback0
    !
    address-family ipv4
    neighbor 10.13.13.13 activate
    neighbor 10.13.13.13 send-community extended
    no synchronization
    exit-address-family
    !
address-family vpnv4
neighbor 10.13.13.13 activate
neighbor 10.13.13.13 send-community extended
exit-address-family
!
address-family ipv4 vrf vpn2
neighbor 10.0.0.2 remote-as 300
neighbor 10.0.0.2 activate
neighbor 10.0.0.2 as-override
neighbor 10.0.0.2 advertisement-interval 5
no auto-summary
no synchronization
exit-address-family

CE2 Configuration

ip cef
!
interface Loopback0
  ip address 10.18.18.18 255.255.255.255
  no ip directed-broadcast
!
interface Ethernet0/1
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
!
router ospf 300
  log-adjacency-changes
  redistribute bgp 300 subnets
  passive-interface Ethernet0/1
  network 10.18.18.18 0.0.0.0 area 300
!
router bgp 300
  no synchronization
  bgp log-neighbor-changes
  timers bgp 10 30
  redistribute connected
  redistribute ospf 300 match internal external 1 external 2
  neighbor 10.0.0.1 remote-as 200
  neighbor 10.0.0.1 advertisement-interval 5
  no auto-summary
MPLS VPN CSC Network That Contains Route Reflectors Example

The figure below shows a carrier supporting carrier network configuration that contains route reflectors. The customer carrier has two sites.

**Figure 21: Carrier Supporting Carrier Network that Contains Route Reflectors**

A connection between route reflectors (RRs) is not necessary.

The following configuration examples show the configuration of each router in the carrier supporting carrier network. Note the following:

- The router IP addresses are abbreviated for ease of reading. For example, the loopback address for PE 1 is 25, which is equivalent to 10.25.25.25.
- The following list shows the loopback addresses for the CSC-PE routers:
  - CSC-PE1 (75K-37-3): loopback 0 = 10.15.15.15, loopback 1 = 10.18.18.18
  - CSC-PE2 (75K-38-3): loopback 0 = 10.16.16.16, loopback 1 = 10.20.20.20
Backbone Carrier Configuration

Route Reflector 1 (72K-37-1) Configuration

```
interface Loopback0
 ip address 10.13.13.13 255.255.255.255
 no ip directed-broadcast
 no ip route-cache
 no ip mroute-cache
!
interface ATM1/0
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM1/0.1 mpls
 ip address 10.0.0.2 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 mpls label protocol ldp
 mpls atm vpi 2-5
 mpls ip
!
interface ATM1/1
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM1/1.1 mpls
 ip address 10.0.0.1 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 mpls label protocol ldp
 mpls atm vpi 2-5
 mpls ip
!
router ospf 100
 auto-cost reference-bandwidth 10000
 network 10.0.0.0 0.255.255.255 area 100
 network 10.1.0.0 0.255.255.255 area 100
 network 10.2.0.0 0.255.255.255 area 100
!
router bgp 100
 no synchronization
 no bgp default ipv4-unicast
 bgp cluster-id 1
 redistribute static
 neighbor 10.15.15.15 remote-as 100
 neighbor 10.15.15.15 update-source Loopback0
 neighbor 10.16.16.16 remote-as 100
 neighbor 10.16.16.16 update-source Loopback0
 !
 address-family ipv4 vrf vpn1
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 10.15.15.15 activate
 neighbor 10.15.15.15 route-reflector-client
 neighbor 10.15.15.15 send-community extended
 neighbor 10.16.16.16 activate
 neighbor 10.16.16.16 route-reflector-client
 neighbor 10.16.16.16 send-community extended
```
Route Reflector 2 (72K-38-1) Configuration

interface Loopback0
 no ip directed-broadcast
 no ip mrroute-cache
!
interface ATM1/0
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM1/0.1 mpls
 ip address 10.0.0.1 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 mpls label protocol ldp
 mpls atm vpi 2-5
 mpls ip
!
interface ATM1/1
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM1/1.1 mpls
 ip address 10.0.0.2 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 mpls label protocol ldp
 mpls atm vpi 2-5
 mpls ip
!
router ospf 100
 auto-cost reference-bandwidth 10000
 network 10.0.0.0 0.255.255.255 area 100
 network 10.1.0 0.255.255.255 area 100
 network 10.2.0.0 0.255.255.255 area 100
!
router bgp 100
 no synchronization
 no bgp default ipv4-unicast
 bgp cluster-id 1
 redistribute static
 neighbor 10.15.15.15 remote-as 100
 neighbor 10.15.15.15 update-source Loopback0
 neighbor 10.16.16.16 remote-as 100
 neighbor 10.16.16.16 update-source Loopback0
!
address-family ipv4 vrf vpn1
 no auto-summary
 no synchronization
 exit-address-family
!
address-family vpnv4
 neighbor 10.15.15.15 activate
 neighbor 10.15.15.15 route-reflector-client
 neighbor 10.15.15.15 send-community extended
 neighbor 10.16.16.16 activate
 neighbor 10.16.16.16 route-reflector-client
 neighbor 10.16.16.16 send-community extended
 bgp scan-time import 5
 exit-address-family

bgp scan-time import 5
exit-address-family
CSC-PE1 (75K-37-3) Configuration

ip cef distributed
ip vrf vpn1
   rd 100:1
   route-target export 100:1
   route-target import 100:1
interface Loopback0
    ip address 10.15.15.15 255.255.255.255
    no ip directed-broadcast
interface Loopback1
    ip vrf forwarding vpn1
    ip address 10.18.18.18 255.255.255.255
    no ip directed-broadcast
interface Ethernet0/0/1
    ip vrf forwarding vpn1
    ip address 10.0.0.2 255.0.0.0
    no ip directed-broadcast
    no ip route-cache distributed
    mpls label protocol ldp
    mpls ip
interface ATM1/1/0
    no ip address
    no ip directed-broadcast
    no ip route-cache distributed
    atm clock INTERNAL
    atm sonet stm-1
    no atm enable-ilmi-trap
    no atm ilmi-keepalive
interface ATM1/1/0.1 mpls
    ip address 10.0.0.1 255.0.0.0
    no ip directed-broadcast
    no atm enable-ilmi-trap
    mpla label protocol ldp
    mpla atm vpi 2-5
    mpla ip
interface ATM3/0/0
    no ip address
    no ip directed-broadcast
    no ip route-cache distributed
    atm clock INTERNAL
    atm sonet stm-1
    no atm enable-ilmi-trap
    no atm ilmi-keepalive
interface ATM3/0/0.1 point-to-point
    ip vrf forwarding vpn1
    ip address 10.0.0.2 255.0.0.0
    no ip directed-broadcast
    atm pvc 100 6 32 aal5snap
    no atm enable-ilmi-trap
    mpla label protocol ldp
    mpla ip
interface ATM3/1/0
    no ip address
    no ip directed-broadcast
    no ip route-cache distributed
    atm clock INTERNAL
    atm sonet stm-1
    no atm enable-ilmi-trap
    no atm ilmi-keepalive

interface ATM3/1/0
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
no atm enable-ilmi-trap
mpls label protocol ldp
mpls atm vpi 2-5
mpls ip
!
router ospf 100
auto-cost reference-bandwidth 10000
network 10.0.0.0 0.255.255.255 area 100
network 10.1.0.0 0.255.255.255 area 100
network 10.2.0.0 0.255.255.255 area 100
network 10.3.0.0 0.255.255.255 area 100
network 10.4.0.0 0.255.255.255 area 100
!
router ospf 1 vrf vpn1
redistribute bgp 100 metric-type 1 subnets
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
!
router bgp 100
no bgp default ipv4-unicast
bgp log-neighbor-changes
neighbor 10.13.13.13 remote-as 100
neighbor 10.13.13.13 update-source Loopback0
neighbor 10.14.14.14 remote-as 100
!
address-family ipv4
redistribute static
no synchronization
exit-address-family
!
address-family vpnv4
neighbor 10.13.13.13 activate
neighbor 10.13.13.13 send-community extended
exit-address-family
!
address-family ipv4 vrf vpn1
redistribute ospf 1 match internal external 1 external 2
no auto-summary
no synchronization
exit-address-family

CSC-PE2 (75K-38-3) Configuration

ip cef distributed
!
ip vrf vpn1
 rd 100:1
 route-target export 100:1
 route-target import 100:1
!
interface Loopback0
 ip address 10.16.16.16 255.255.255.255
 no ip directed-broadcast
!
interface Loopback1
 ip vrf forwarding vpn1
 ip address 10.20.20.20 255.255.255.255
 no ip directed-broadcast
!
interface ATM0/1/0
 no ip address
 no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM0/1/0 mpls
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
no atm enable-ilmi-trap
mpls label protocol ldp
mpls atm vpi 2-5
mpls ip
!
interface ATM2/1/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM2/1/0 mpls
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
no atm enable-ilmi-trap
mpls label protocol ldp
mpls atm vpi 2-5
mpls ip
!
interface ATM3/0/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM3/0/0 point-to-point
ip vrf forwarding vpn1
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 100 6 32 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip
!
interface ATM3/1/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM3/1/0 point-to-point
ip vrf forwarding vpn1
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 101 6 33 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls ip
!
routerr ospf 100
auto-cost reference-bandwidth 10000
network 10.0.0.0 0.255.255.255 area 100
network 10.0.0.0 0.255.255.255 area 100
network 10.0.0.0 0.255.255.255 area 100
network 10.0.0.0 0.255.255.255 area 100
network 10.0.0.0 0.255.255.255 area 100
!
router ospf 1 vrf vpn1
redistribute bgp 100 metric-type 1 subnets
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
!
router bgp 100
no bgp default ipv4-unicast
bgp log-neighbor-changes
neighbor 10.13.13.13 remote-as 100
neighbor 10.13.13.13 update-source Loopback0
neighbor 10.14.14.14 remote-as 100
!
address-family ipv4
redistribute static
no synchronization
exit-address-family
!
address-family vpnv4
neighbor 10.13.13.13 activate
neighbor 10.13.13.13 send-community extended
exit-address-family
!
address-family ipv4 vrf vpn1
redistribute ospf 1 match internal external 1 external 2
no auto-summary
no synchronization
exit-address-family

Customer Carrier Site 1 Configuration

PE1 (72K-36-8) Configuration

  ip cef
  !
  ip vrf vpn2
  rd 200:1
  route-target export 200:1
  route-target import 200:1
  no mpls ip propagate-ttl
  !
  interface Loopback0
  ip address 10.25.25.25 255.255.255.255
  no ip directed-broadcast
  no ip route-cache
  no ip mroute-cache
  !
  interface ATM1/0
  no ip address
  no ip directed-broadcast
  no ip mroute-cache
  atm clock INTERNAL
  no atm ilmi-keepalive
  !
  interface ATM1/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 50 aal5snap
  mpls label protocol ldp
  mpls ip
  !
  interface Ethernet3/0
ip vrf forwarding vpn2
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
no ip mroute-cache

interface Ethernet3/1
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
no ip mroute-cache
mpls label protocol ldp
mpls ip

interface Ethernet3/2
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
no ip mroute-cache
mpls label protocol ldp
mpls ip

router ospf 1
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101

router bgp 200
neighbor 10.22.22.22 remote-as 200
neighbor 10.22.22.22 update-source Loopback0
neighbor 10.23.23.23 remote-as 200
neighbor 10.23.23.23 update-source Loopback0

address-family ipv4 vrf vpn2
redistribute connected
neighbor 10.0.0.2 remote-as 300
neighbor 10.0.0.2 activate
neighbor 10.0.0.2 as-override
no auto-summary
no synchronization
exit-address-family

address-family vpnv4
neighbor 10.22.22.22 activate
neighbor 10.22.22.22 send-community extended
neighbor 10.23.23.23 activate
neighbor 10.23.23.23 send-community extended
exit-address-family

CSC-CE1 (72K-36-9) Configuration

ip cef
no ip domain-lookup

interface Loopback0
ip address 10.11.11.11 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache

interface ATM1/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
no atm ilmi-keepalive

interface ATM1/0.1 point-to-point
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 100 6 32 aal5snap
mpls label protocol ldp
interface ATM2/0
   no ip address
   no ip directed-broadcast
   atm clock INTERNAL
   !
interface ATM2/0.1 point-to-point
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   atm pvc 100 0 50 aal5snap
   mpls label protocol ldp
   mpls ip
!
interface Ethernet3/0
   ip address 10.0.0.2 255.0.0.0
   no ip directed-broadcast
   mpls label protocol ldp
   mpls ip
!
interface Ethernet3/1
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   mpls label protocol ldp
   mpls ip
!
router ospf 1
   network 10.0.0.0 0.255.255.255 area 101
   network 10.0.0.0 0.255.255.255 area 101
   network 10.0.0.0 0.255.255.255 area 101
   network 10.0.0.0 0.255.255.255 area 101
   network 10.0.0.0 0.255.255.255 area 101
!
interface Ethernet3/2
   ip address 10.0.0.2 255.0.0.0
   no ip directed-broadcast
   no ip mroute-cache

PE2 (72K-36-7) Configuration

ip cef
!
ip vrf vpn2
   rd 200:1
   route-target export 200:1
   route-target import 200:1
   no mpls ip propagate-ttl
!
interface Loopback0
   ip address 10.24.24.24 255.255.255.255
   no ip directed-broadcast
   no ip route-cache
   no ip mroute-cache
!
interface Ethernet3/0
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   no ip mroute-cache
   mpls label protocol ldp
   mpls ip
!
interface Ethernet3/1
   ip vrf forwarding vpn2
   ip address 10.0.0.1 255.0.0.0
   no ip directed-broadcast
   no ip mroute-cache
!
interface Ethernet3/2
   ip address 10.0.0.2 255.0.0.0
   no ip directed-broadcast
   no ip mroute-cache
mpls label protocol ldp
mpls ip

interface Ethernet3/3
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
no ip mroutecache
mpls label protocol ldp
mpls ip

router ospf 1
network 10.0.0.0.0.255.255.255 area 101
network 10.0.0.0.0.255.255.255 area 101
network 10.0.0.0.0.255.255.255 area 101
network 10.0.0.0.0.255.255.255 area 101

router bgp 200
neighbor 10.22.22.22 remote-as 200
neighbor 10.22.22.22 update-source Loopback0
neighbor 10.23.23.23 remote-as 200
neighbor 10.23.23.23 update-source Loopback0

address-family ipv4 vrf vpn2
neighbor 10.0.0.2 remote-as 300
neighbor 10.0.0.2 activate
neighbor 10.0.0.2 as-overide
no auto-summary
no synchronization
exit-address-family

address-family vpnv4
neighbor 10.22.22.22 activate
neighbor 10.22.22.22 send-community extended
neighbor 10.23.23.23 activate
neighbor 10.23.23.23 send-community extended
exit-address-family

Route Reflector 3 (36K-38-4) Configuration

ip cef

interface Loopback0
ip address 10.23.23.23 255.255.255.255

interface Ethernet1/1
ip address 10.0.0.1 255.0.0.0
mpls label protocol ldp
mpls ip

interface Ethernet1/2
ip address 10.0.0.1 255.0.0.0
mpls label protocol ldp
mpls ip

interface ATM3/0
no ip address
no ip mroutecache
atm clock INTERNAL
no atm scrambling cell-payload
no atm ilmi-keepalive

interface ATM3/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
atm pvc 100 0 55 aal5snap
mpls label protocol ldp
mpls ip

router ospf 1
log-adjacency-changes
network 10.0.0.0.0.255.255.255 area 101
network 10.1.0.0 0.255.255.255 area 101
network 10.2.0.0 0.255.255.255 area 101
network 10.3.0.0 0.255.255.255 area 101
!
router bgp 200
  no synchronization
  no bgp default ipv4-unicast
  bgp cluster-id 2
  redistribute static
  neighbor 10.21.21.21 remote-as 200
  neighbor 10.21.21.21 update-source Loopback0
  neighbor 10.24.24.24 remote-as 200
  neighbor 10.24.24.24 update-source Loopback0
  neighbor 10.25.25.25 remote-as 200
  neighbor 10.25.25.25 update-source Loopback0
!
address-family ipv4 vrf vpn2
  no auto-summary
  no synchronization
  exit-address-family
!
address-family vpnv4
  neighbor 10.21.21.21 activate
  neighbor 10.21.21.21 route-reflector-client
  neighbor 10.21.21.21 send-community extended
  neighbor 10.24.24.24 activate
  neighbor 10.24.24.24 route-reflector-client
  neighbor 10.24.24.24 send-community extended
  neighbor 10.25.25.25 activate
  neighbor 10.25.25.25 route-reflector-client
  neighbor 10.25.25.25 send-community extended
  exit-address-family

CE1 (36K-36-1) Configuration

ip cef
!
interface Loopback0
  ip address 10.28.28.28 255.255.255.255
  no ip directed-broadcast
!
interface Ethernet0/1
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
!
interface Ethernet0/2
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
!
router bgp 300
  network 10.0.0.0
  network 10.0.0.0
  network 10.0.0.0
  neighbor 10.0.0.1 remote-as 200
  neighbor 10.0.0.1 remote-as 200

Customer Carrier Site 2 Configuration

CSC-CE3 (72K-36-6) Configuration

ip cef
!
interface Loopback0
  ip address 10.12.12.12 255.255.255.255
  no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface ATM1/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
no atm ilmi-keepalive
!
interface ATM1/0.1 point-to-point
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
atm pvc 100 6 32 aal5snap
mpls label protocol ldp
mpls ip
!
interface POS2/0
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
encapsulation ppp
mpls label protocol ldp
mpls ip
!
interface ATM5/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
no atm ilmi-keepalive
!
interface ATM5/0.1 point-to-point
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
atm pvc 100 0 40 aal5snap
mpls ip
!
router ospf 1
network 10.0.0.0 0.255.255.255 area 101
network 10.1.0.0 0.255.255.255 area 101
network 10.2.0.0 0.255.255.255 area 101
network 10.3.0.0 0.255.255.255 area 101

PE3 (72K-36-4) Configuration

ip cef
!
ip vrf vpn2
rd 200:1
route-target export 200:1
route-target import 200:1
!
interface Loopback0
ip address 10.21.21.21 255.255.255.255
no ip directed-broadcast
!
interface Ethernet3/0
ip vrf forwarding vpn2
ip address 10.0.0.0 255.0.0.0
no ip directed-broadcast
!
interface Ethernet3/1
ip vrf forwarding vpn2
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
!
interface Ethernet3/2
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
mpls label protocol ldp
mpls ip
!
interface ATM5/0
  no ip address
  no ip directed-broadcast
  atm clock INTERNAL
  no atm ilmi-keepalive
!
interface ATM5/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 40 aal5snap
mpls label protocol ldp
mpls ip
!
interface ATM6/0
  no ip address
  no ip directed-broadcast
  atm clock INTERNAL
  no atm ilmi-keepalive
!
interface ATM6/0.1 point-to-point
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
  atm pvc 100 0 20 aal5snap
mpls label protocol ldp
mpls ip
!
router ospf 1
  network 10.0.0.0 0.255.255.255 area 101
  network 10.1.0.0 0.255.255.255 area 101
  network 10.2.0.0 0.255.255.255 area 101
  network 10.3.0.0 0.255.255.255 area 101
!
router bgp 200
  neighbor 10.22.22.22 remote-as 200
  neighbor 10.22.22.22 update-source Loopback0
  neighbor 10.23.23.23 remote-as 200
  neighbor 10.23.23.23 update-source Loopback0
  !
  address-family ipv4 vrf vpn2
  redistribute connected
  neighbor 10.0.0.2 remote-as 300
  neighbor 10.0.0.2 activate
  neighbor 10.0.0.2 as-override
  neighbor 10.0.0.2 remote-as 300
  neighbor 10.0.0.2 activate
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
  neighbor 10.22.22.22 activate
  neighbor 10.22.22.22 send-community extended
  neighbor 10.23.23.23 activate
  neighbor 10.23.23.23 send-community extended
  exit-address-family
!
ip cef
!
interface Loopback0
  ip address 10.10.10.10 255.255.255.255
  no ip directed-broadcast
!
interface POS4/0
  ip address 10.0.0.1 255.0.0.0
  no ip directed-broadcast

CSC-CE4 (72K-36-5) Configuration
encapsulation ppp
mpls label protocol ldp
mpls ip
clock source internal

! interface ATM5/0
    no ip address
    no ip directed-broadcast
    atm clock INTERNAL
    no atm ilmi-keepalive

! interface ATM5/0.1 point-to-point
    ip address 10.0.0.1 255.0.0.0
    no ip directed-broadcast
    atm pvc 100 0 20 aal5snap
    mpls label protocol ldp
    mpls ip

! interface ATM6/0
    no ip address
    no ip directed-broadcast
    atm clock INTERNAL
    no atm ilmi-keepalive

! interface ATM6/0.1 point-to-point
    ip address 10.0.0.2 255.0.0.0
    no ip directed-broadcast
    atm pvc 100 6 33 aal5snap
    mpls label protocol ldp
    mpls ip

! router ospf 1
    network 10.0.0.0 0.255.255.255 area 101
    network 10.1.0.0 0.255.255.255 area 101
    network 10.2.0.0 0.255.255.255 area 101
    network 10.3.0.0 0.255.255.255 area 101

Route Reflector 4 (36K-38-5) Configuration

ip cef

! interface Loopback0
    ip address 10.22.22.22 255.255.255.255

! interface Ethernet0/1
    ip address 10.0.0.2 255.0.0.0
    mpls label protocol ldp
    mpls ip

! interface ATM2/0
    no ip address
    no ip mroute-cache
    atm clock INTERNAL
    no atm scrambling cell-payload
    no atm ilmi-keepalive

! interface ATM2/0.1 point-to-point
    ip address 10.0.0.1 255.0.0.0
    atm pvc 100 5 55 aal5snap
    mpls label protocol ldp
    mpls ip

! router ospf 1
    log-adjacency-changes
    network 10.0.0.0 0.255.255.255 area 101
    network 10.1.0.0 0.255.255.255 area 101
    network 10.2.0.0 0.255.255.255 area 101

! router bgp 200
    no synchronization
no bgp default ipv4-unicast
bgp cluster-id 2
redistribute static
neighbor 10.21.21.21 remote-as 200
neighbor 10.21.21.21 update-source Loopback0
neighbor 10.24.24.24 remote-as 200
neighbor 10.24.24.24 update-source Loopback0
neighbor 10.25.25.25 remote-as 200
neighbor 10.25.25.25 update-source Loopback0
!
address-family ipv4 vrf vpn2
no auto-summary
no synchronization
exit-address-family
!
address-family vpnv4
neighbor 10.21.21.21 activate
neighbor 10.21.21.21 route-reflector-client
neighbor 10.21.21.21 send-community extended
neighbor 10.24.24.24 activate
neighbor 10.24.24.24 route-reflector-client
neighbor 10.24.24.24 send-community extended
neighbor 10.25.25.25 activate
neighbor 10.25.25.25 route-reflector-client
neighbor 10.25.25.25 send-community extended
exit-address-family

CE2 (36K-36-2) Configuration

ip cef
!
interface Loopback0
  ip address 10.26.26.26 255.255.255.255
  no ip directed-broadcast
!
interface Ethernet0/1
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
!
interface Ethernet0/2
  ip address 10.0.0.1 255.0.0.0
  no ip directed-broadcast
!
routerr ospf 300
redistribute bgp 300
  network 10.0.0.0 0.255.255.255 area 300
  network 10.1.0.0 0.255.255.255 area 300
!
router bgp 300
  network 10.0.0.0
  network 10.1.0.0
  network 10.2.0.0
  neighbor 10.0.0.1 remote-as 200

CE3 (36K-36-3) Configuration

ip cef
!
interface Loopback0
  ip address 10.27.27.27 255.255.255.255
  no ip directed-broadcast
!
interface Ethernet1/1
  ip address 10.0.0.2 255.0.0.0
  no ip directed-broadcast
!
interface Ethernet1/2
  ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast

router ospf 300
redistribute bgp 300
network 10.0.0.0 0.255.255.255 area 300
network 10.0.0.0 0.255.255.255 area 300

router bgp 300
network 10.0.0.0
network 10.1.0.0
network 10.2.0.0
neighbor 10.0.0.1 remote-as 200

MPLS VPN CSC Network with a Customer Who Has VPNs at the Network Edge Example

The figure below shows a carrier supporting carrier network configuration where the customer carrier has VPNs at the network edge.

Figure 22: Carrier Supporting Carrier Network
Backbone Carrier Configuration

CSC-PE1 (72K-36-9) Configuration

```plaintext
ip cef
!
ip vrf vpn1
rd 100:0
route-target export 100:0
route-target import 100:0
mpls label protocol ldp
!
interface Loopback0
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface Loopback100
ip vrf forwarding vpn1
ip address 10.22.22.22 255.255.255.255
no ip directed-broadcast
!
interface ATM1/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM1/0.1 point-to-point
ip address 10.1.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM1/0.2 point-to-point
ip address 10.2.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM1/0.3 point-to-point
ip address 10.3.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM2/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM2/0.1 point-to-point
ip vrf forwarding vpn1
ip address 10.15.0.2 255.255.0.0
no ip directed-broadcast
```

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P1 (75K-37-3) Configuration

`ip cef distributed`

---
mpls label protocol ldp
!
interface Loopback0
ip address 10.12.12.12 255.255.255.255
no ip directed-broadcast
no ip route-cache
tag-switching ip
!
interface ATM1/1/0
no ip address
no ip directed-broadcast
ip route-cache distributed
atm clock INTERNAL
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM1/1/0.1 point-to-point
ip address 10.7.0.1 255.255.255.0
no ip directed-broadcast
atm pvc 103 0 53 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM1/1/0.2 point-to-point
ip address 10.8.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 104 0 54 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM1/1/0.3 point-to-point
ip address 10.9.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 105 0 55 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM3/0/0
no ip address
no ip directed-broadcast
ip route-cache distributed
atm pvc 100 0 50 aal5snap
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM3/0/0.1 point-to-point
ip address 10.1.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
mpls accounting experimental input
tag-switching ip
!
interface ATM3/0/0.2 point-to-point
ip address 10.2.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM3/0/0.3 point-to-point
ip address 10.3.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip

router ospf 100
log-adjacency-changes
redistribute connected subnets
network 10.12.12.12 0.0.0.0 area 100
network 10.1.0.0 0.0.255.255 area 100
network 10.2.0.0 0.0.255.255 area 100
network 10.3.0.0 0.0.255.255 area 100
network 10.4.0.0 0.0.255.255 area 100
network 10.5.0.0 0.0.255.255 area 100
network 10.6.0.0 0.0.255.255 area 100
network 10.7.0.0 0.0.255.255 area 100
network 10.8.0.0 0.0.255.255 area 100
network 10.9.0.0 0.0.255.255 area 100

P2 (75K-38-3) Configuration

ip cef distributed
mpls label protocol ldp

interface Loopback0
ip address 10.13.13.13 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache

interface ATM0/1/0
no ip address
no ip directed-broadcast
ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive

interface ATM0/1/0.1 point-to-point
ip address 10.7.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 103 0 53 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip

interface ATM0/1/0.2 point-to-point
ip address 10.8.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 104 0 54 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip

interface ATM0/1/0.3 point-to-point
ip address 10.9.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 105 0 55 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip

interface ATM3/1/0
no ip address
no ip directed-broadcast
ip route-cache distributed
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive

interface ATM3/1/0.1 point-to-point
ip address 10.4.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM3/1/0.2 point-to-point
ip address 10.5.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM3/1/0.3 point-to-point
ip address 10.6.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
router ospf 100
log-adjacency-changes
redistribute connected subnets
network 10.13.13.13 0.0.0.0 area 100
network 10.4.0.0 0.0.255.255 area 100
network 10.5.0.0 0.0.255.255 area 100
network 10.6.0.0 0.0.255.255 area 100
network 10.7.0.0 0.0.255.255 area 100
network 10.8.0.0 0.0.255.255 area 100
network 10.9.0.0 0.0.255.255 area 100
!
CSC-PE2 (72K-36-5) Configuration

ip cef
!
ip vrf vpn1
rd 100:0
route-target export 100:0
route-target import 100:0
mpls label protocol ldp
!
interface Loopback0
ip address 10.11.11.11 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface Loopback100
ip vrf forwarding vpn1
ip address 10.12.12.12 255.255.255.255
no ip directed-broadcast
!
interface ATM5/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM5/0.1 point-to-point
ip vrf forwarding vpn1
ip address 10.13.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
interface ATM5/0.2 point-to-point
ip vrf forwarding vpn1
ip address 10.19.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
interface ATM5/0.3 point-to-point
ip vrf forwarding vpn1
ip address 10.20.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
interface ATM6/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
interface ATM6/0.1 point-to-point
ip address 10.4.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
interface ATM6/0.2 point-to-point
ip address 10.5.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
interface ATM6/0.3 point-to-point
ip address 10.6.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
router ospf 100
log-adjacency-changes
redistribute connected subnets
passive-interface ATM5/0.1
passive-interface ATM5/0.2
passive-interface ATM5/0.3
passive-interface Loopback100
network 10.11.11.11 0.0.0.0 area 100
network 10.4.0.0 0.0.255.255 area 100
network 10.5.0.0 0.0.255.255 area 100
network 10.6.0.0 0.0.255.255 area 100
router ospf 200 vrf vpn1
log-adjacency-changes
redistribute connected subnets
redistribute bgp 100 metric-type 1 subnets
network 10.23.23.23 0.0.0.0 area 200
network 10.18.0.0 0.0.255.255 area 200
network 10.19.0.0 0.0.255.255 area 200
network 10.20.0.0 0.0.255.255 area 200
MPLS VPN CSC Network with a Customer Who Has VPNs at the Network Edge Example

Customer Carrier Site 1 Configuration

CSC-CE1 (72K-36-8) Configuration

ip cef
!
mls label protocol ldp
!
interface Loopback0
ip address 10.15.15.15 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface ATM1/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM1/0.1 point-to-point
ip address 10.15.0.1 255.255.255.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mls label protocol ldp
tag-switching ip
!
interface ATM1/0.2 point-to-point
ip address 10.16.0.1 255.255.255.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mls label protocol ldp
tag-switching ip
!
interface ATM1/0.3 point-to-point
ip address 10.17.0.1 255.255.255.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap

MPLS Layer 3 VPNs Inter-AS and CSC Configuration Guide, Cisco IOS XE Release 3S
mpls label protocol ldp
tag-switching ip
!
interface Ethernet3/1
ip address 10.10.0.2 255.255.0.0
no ip directed-broadcast
no ip mroute-cache
mpls label protocol ldp
tag-switching ip
!
router ospf 200
log-adjacency-changes
redistribute connected subnets
network 10.15.15.15 0.0.0.0 area 200
network 10.10.0.0 0.0.255.255 area 200
network 10.15.0.0 0.0.255.255 area 200
network 10.16.0.0 0.0.255.255 area 200
network 10.17.0.0 0.0.255.255 area 200

PE2 (72K-36-7) Configuration

ip cef
!
ip vrf vpn2
   rd 200:1
   route-target export 200:1
   route-target import 200:1
no mpls ip propagate-ttl
!
interface Loopback0
ip address 10.24.24.24 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface Ethernet3/0
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
no ip mroute-cache
mpls label protocol ldp
mpls ip
!
interface Ethernet3/1
ip vrf forwarding vpn2
ip address 10.0.0.1 255.0.0.0
no ip directed-broadcast
no ip mroute-cache
!
interface Ethernet3/2
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
no ip mroute-cache
mpls label protocol ldp
mpls ip
!
interface Ethernet3/3
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
no ip mroute-cache
mpls label protocol ldp
mpls ip
!
router ospf 1
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
network 10.0.0.0 0.255.255.255 area 101
!
router bgp 200
neighbor 10.22.22.22 remote-as 200
neighbor 10.22.22.22 update-source Loopback0
neighbor 10.23.23.23 remote-as 200
neighbor 10.23.23.23 update-source Loopback0

address-family ipv4 vrf vpn2
neighbor 10.0.0.2 remote-as 300
neighbor 10.0.0.2 activate
neighbor 10.0.0.2 as-override
no auto-summary
no synchronization
exit-address-family

address-family vpnv4
neighbor 10.22.22.22 activate
neighbor 10.22.22.22 send-community extended
neighbor 10.23.23.23 activate
neighbor 10.23.23.23 send-community extended
exit-address-family

CE1 (36K-36-1) Configuration

ip cef
!
interface Loopback0
ip address 10.19.19.19 255.255.255.255
no ip directed-broadcast
!
interface Ethernet0/2
ip address 30.35.0.1 255.255.0.0
no ip directed-broadcast
!
router ospf 300
log-adjacency-changes
redistribute connected subnets
redistribute bgp 300 subnets
passive-interface Ethernet0/2
network 10.19.19.19 0.0.0.0 area 300
!
router bgp 300
no synchronization
bgp log-neighbor-changes
timers bgp 10 30
redistribute connected
redistribute ospf 300 match internal external 1 external 2
neighbor 10.35.0.2 remote-as 200
neighbor 10.35.0.2 advertisement-interval 5
no auto-summary

Customer Carrier Site 2 Configuration

CSC-CE2 (72K-36-4) Configuration

ip cef
!
mls label protocol ldp
!
interface Loopback0
ip address 10.17.17.17 255.255.255.255
no ip directed-broadcast
!
interface ATM5/0
no ip address
no ip directed-broadcast
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM5/0.1 point-to-point
ip address 10.11.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM5/0.2 point-to-point
ip address 10.12.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM5/0.3 point-to-point
ip address 10.13.0.2 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM6/0
no ip address
no ip directed-broadcast
atm clock INTERNAL
atm sonet stm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM6/0.1 point-to-point
ip address 10.18.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM6/0.2 point-to-point
ip address 10.19.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM6/0.3 point-to-point
ip address 10.20.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-ilmi-trap
mpls label protocol ldp
tag-switching ip
!
router ospf 200
log-adjacency-changes
redistribute connected subnets
network 10.17.17.17 0.0.0.0 area 200
network 10.11.0.0 0.0.255.255 area 200
network 10.12.0.0 0.0.255.255 area 200
network 10.13.0.0 0.0.255.255 area 200
network 10.18.0.0 0.0.255.255 area 200
network 10.19.0.0 0.0.255.255 area 200
network 10.20.0.0 0.0.255.255 area 200
PE2 (72K-36-6) Configuration

ip cef
!
ip vrf customersite
rd 200:1
route-target export 200:1
route-target import 200:1
mpls label protocol ldp
!
interface Loopback0
ip address 10.18.18.18 255.255.255.255
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
!
interface Ethernet3/0
ip vrf forwarding customersite
ip address 10.29.0.2 255.255.0.0
no ip directed-broadcast
!
interface Ethernet3/1
ip vrf forwarding customersite
ip address 10.30.0.2 255.255.0.0
no ip directed-broadcast
!
interface ATM5/0
no ip address
no ip directed-broadcast
no ip mroute-cache
atm clock INTERNAL
atm monet atm-1
no atm enable-ilmi-trap
no atm ilmi-keepalive
!
interface ATM5/0.1 point-to-point
ip address 10.11.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 100 0 50 aal5snap
no atm enable-1imi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM5/0.2 point-to-point
ip address 10.12.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 101 0 51 aal5snap
no atm enable-1imi-trap
mpls label protocol ldp
tag-switching ip
!
interface ATM5/0.3 point-to-point
ip address 10.13.0.1 255.255.0.0
no ip directed-broadcast
atm pvc 102 0 52 aal5snap
no atm enable-1imi-trap
mpls label protocol ldp
tag-switching ip
!
router ospf 200
log-adjacency-changes
redistribute connected subnets
passive-interface Ethernet3/0
passive-interface Ethernet3/1
network 10.18.18.18 0.0.0.0 area 200
network 10.11.0.0 0.0.255.255 area 200
network 10.12.0.0 0.0.255.255 area 200
network 10.13.0.0 0.0.255.255 area 200
!
router bgp 200
no bgp default ipv4-unicast
bgp log-neighbor-changes
timers bgp 10 30
neighbor 10.16.16.16 remote-as 200
neighbor 10.16.16.16 update-source Loopback0

address-family ipv4
neighbor 10.16.16.16 activate
neighbor 10.16.16.16 send-community extended
no synchronization
exit-address-family

address-family vpnv4
neighbor 10.16.16.16 activate
neighbor 10.16.16.16 send-community extended
exit-address-family

address-family ipv4 vrf customersite
neighbor 10.29.0.1 remote-as 300
neighbor 10.29.0.1 activate
neighbor 10.29.0.1 as-override
neighbor 10.30.0.1 advertisement-interval 5
neighbor 10.30.0.1 remote-as 300
neighbor 10.30.0.1 activate
neighbor 10.30.0.1 as-override
neighbor 10.30.0.1 advertisement-interval 5
no auto-summary
no synchronization
exit-address-family

CE2 (36K-38-4) Configuration

ip cef

interface Loopback0
ip address 10.21.21.21 255.255.255.255

interface Ethernet1/3
ip address 10.29.0.1 255.255.0.0

interface Ethernet5/0
ip address 10.14.0.1 255.255.0.0

router ospf 300
log-adjacency-changes
redistribute connected subnets
redistribute bgp 300 subnets
passive-interface Ethernet1/3
network 10.21.21.21 0.0.0.0 area 300
network 10.14.0.0 0.0.255.255 area 300

router bgp 300
no synchronization
timers bgp 10 30
redistribute connected
redistribute ospf 300 match internal external 1 external 2
neighbor 10.29.0.2 remote-as 200
neighbor 10.29.0.2 advertisement-interval 5
no auto-summary

CE3 (36K-38-5) Configuration

ip cef

interface Loopback0
ip address 10.20.20.20 255.255.255.255
no ip directed-broadcast

interface Ethernet0/2
ip address 10.30.0.1 255.255.0.0
no ip directed-broadcast
!
interface Ethernet0/3
ip address 10.14.0.2 255.255.0.0
no ip directed-broadcast
!
router ospf 300
log-adjacency-changes
redistribute connected subnets
redistribute bgp 300 subnets
passive-interface Ethernet0/2
network 10.20.20.0 0.0.0.0 area 300
network 10.14.0.0 0.0.255.255 area 300
!
router bgp 300
no synchronization
bgp log-neighbor-changes
timers bgp 10 30
redistribute connected
redistribute ospf 300 match internal external 1 external 2
neighbor 10.30.0.2 remote-as 200
neighbor 10.30.0.2 advertisement-interval 5
no auto-summary

### Additional References for MPLS VPN Carrier Supporting Carrier Using LDP and an IGP

#### Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
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</thead>
<tbody>
<tr>
<td>MPLS</td>
<td>MPLS Product Literature</td>
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</table>

#### RFCs

<table>
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<tr>
<th>RFC</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 2547</td>
<td>BGP/MPLS VPNs</td>
</tr>
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</table>

#### Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support and Documentation website provides online resources to</td>
<td><a href="http://www.cisco.com/cisco/web/">http://www.cisco.com/cisco/web/</a></td>
</tr>
<tr>
<td>download documentation, software, and tools. Use these resources to install</td>
<td>support/index.html</td>
</tr>
<tr>
<td>and configure the software and to troubleshoot and resolve technical issues</td>
<td></td>
</tr>
<tr>
<td>with Cisco products and technologies. Access to most tools on the Cisco</td>
<td></td>
</tr>
<tr>
<td>Support and Documentation website requires a Cisco.com user ID and password</td>
<td></td>
</tr>
</tbody>
</table>
Feature Information for MPLS VPN CSC with LDP and IGP

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 9: Feature Information for MPLS VPN CSC with LDP and IGP

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Configuration Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS VPN Carrier Supporting Carrier</td>
<td>12.0(14)ST 12.0(16)ST 12.2(8)T 12.0(21)ST 12.0(22)S 12.0(23)S Cisco IOS XE Release 2.2</td>
<td>This feature enables you to set up and create an MPLS VPN CSC network that uses LDP to transport MPLS labels and an IGP to transport routes. In 12.0(14)ST, this feature was introduced. In 12.0(16)ST, this feature was integrated. In 12.2(8)T, this feature was integrated. In 12.0(21)ST, this feature was integrated. In 12.0(22)S, this feature was integrated. In 12.0(23)S, this feature was integrated. In Cisco IOS XE Release 2.2, this feature was implemented on the Cisco ASR 1000 Series Routers. This feature uses no new or modified commands.</td>
</tr>
</tbody>
</table>

Glossary

ASBR -- Autonomous System Boundary router. A router that connects one autonomous system to another. autonomous system -- A collection of networks under a common administration sharing a common routing strategy.
**BGP** -- Border Gateway Protocol. An interdomain routing protocol that exchanges network reachability information with other BGP systems (which may be within the same autonomous system or between multiple autonomous systems).

**CE router** -- customer edge router. A router that is part of a customer network and that interfaces to a provider edge (PE) router. CE routers do not recognize associated MPLS VPNs.

**CSC** -- Carrier Supporting Carrier. A hierarchical VPN model that allows small service providers, or customer carriers, to interconnect their IP or MPLS networks over an MPLS backbone. This eliminates the need for customer carriers to build and maintain their own MPLS backbone.

**eBGP** -- external Border Gateway Protocol. A BGP between routers located within different autonomous systems. When two routers, located in different autonomous systems, are more than one hop away from one another, the eBGP session between the two routers is considered a multihop BGP.

**edge router** -- A router that is at the edge of the network. It defines the boundary of the MPLS network. It receives and transmits packets. Also referred to as edge label switch router and label edge router.

**iBGP** -- internal Border Gateway Protocol. A BGP between routers within the same autonomous system.

**IGP** -- Interior Gateway Protocol. Internet protocol used to exchange routing information within a single autonomous system. Examples of common Internet IGP protocols include IGRP, OSPF, IS-IS, and RIP.

**IP** -- Internet Protocol. Network layer protocol in the TCP/IP stack offering a connectionless internetwork service. IP provides features for addressing, type-of-service specification, fragmentation and reassembly, and security. Defined in RFC 791.

**LDP** -- Label Distribution Protocol. A standard protocol between MPLS-enabled routers to negotiate the labels (addresses) used to forward packets.

**LFIB** -- Label Forwarding Information Base. Data structure used in MPLS to hold information about incoming and outgoing labels and associated Forwarding Equivalence Class (FEC) packets.

**MP-BGP** -- Multiprotocol BGP.

**MPLS** -- Multiprotocol Label Switching. The name of the IETF working group responsible for label switching, and the name of the label switching approach it has standardized.

**NLRI** -- Network Layer Reachability Information. The BGP sends routing update messages containing NLRI to describe a route and how to get there. In this context, an NLRI is a prefix. A BGP update message carries one or more NLRI prefixes and the attributes of a route for the NLRI prefixes; the route attributes include a BGP next hop gateway address and extended community values.

**NSF** -- Nonstop forwarding enables routers to continuously forward IP packets following a Route Processor takeover or switchover to another Route Processor. NSF maintains and updates Layer 3 routing and forwarding information in the backup Route Processor to ensure that IP packets and routing protocol information are forwarded continuously during the switchover and route convergence process.

**PE router** -- provider edge router. A router that is part of a service provider’s network. It is connected to a customer edge (CE) router. All MPLS VPN processing occurs in the PE router.

**QoS** -- quality of service. Measure of performance for a transmission system that indicates its transmission quality and service availability.

**RD** -- route distinguisher. An 8-byte value that is concatenated with an IPv4 prefix to create a unique VPN-IPv4 prefix.

**RT** -- route target. Extended community attribute used to identify the VRF routing table into which a prefix is imported.

**SLA** -- Service Level Agreement given to VPN subscribers.
VPN -- Virtual Private Network. A secure MPLS-based network that shares resources on one or more physical networks (typically implemented by one or more service providers). A VPN contains geographically dispersed sites that can communicate securely over a shared backbone network.

VRF -- VPN routing and forwarding instance. Routing information that defines a VPN site that is attached to a PE router. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table.
CHAPTER 6

MPLS VPN Carrier Supporting Carrier with BGP

Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) Carrier Supporting Carrier (CSC) enables one MPLS VPN-based service provider to allow other service providers to use a segment of its backbone network. This module explains how to configure an MPLS VPN CSC network that uses Border Gateway Protocol (BGP) to distribute routes and MPLS labels.

- Finding Feature Information, page 197
- Prerequisites for MPLS VPN CSC with BGP, page 198
- Restrictions for MPLS VPN CSC with BGP, page 198
- Information About MPLS VPN CSC with BGP, page 198
- How to Configure MPLS VPN CSC with BGP, page 201
- Configuration Examples for MPLS VPN CSC with BGP, page 230
- Additional References, page 243
- Feature Information for MPLS VPN CSC with BGP, page 244
- Glossary, page 245

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
Prerequisites for MPLS VPN CSC with BGP

- You should be able to configure MPLS VPNs with end-to-end (CE-to-CE router) pings working. To accomplish this, you need to know how to configure Interior Gateway Protocols (IGPs), MPLS Label Distribution Protocol (LDP), and Multiprotocol Border Gateway Protocol (MP-BGP).

- Make sure that the CSC-PE routers and the CSC-CE routers run images that support BGP label distribution. Otherwise, you cannot run external BGP (EBGP) between them. Ensure that connectivity between the customer carrier and the backbone carrier. EBGP-based label distribution is configured on these links to enable MPLS between the customer and backbone carriers.

Restrictions for MPLS VPN CSC with BGP

On a provider edge (PE) router, you can configure an interface for either BGP with labels or LDP. You cannot enable both types of label distribution on the same interface. If you switch from one protocol to the other, then you must disable the existing protocol on all interfaces before enabling the other protocol.

This feature does not support the following:

- EBGP multihop between CSC-PE and CSC-CE routers
- EIBGP multipath load sharing

The physical interfaces that connect the BGP speakers must support Cisco Express Forwarding or distributed Cisco Express Forwarding and MPLS.

Information About MPLS VPN CSC with BGP

MPLS VPN CSC Introduction

Carrier supporting carrier is where one service provider allows another service provider to use a segment of its backbone network. The service provider that provides the segment of the backbone network to the other provider is called the backbone carrier. The service provider that uses the segment of the backbone network is called the customer carrier.

A backbone carrier offers Border Gateway Protocol and Multiprotocol Label Switching (BGP/MPLS) VPN services. The customer carrier can be either:

- An Internet service provider (ISP)
- A BGP/MPLS VPN service provider

Benefits of Implementing MPLS VPN CSC

The MPLS VPN CSC network provides the following benefits to service providers who are backbone carriers and to customer carriers.
Benefits to the Backbone Carrier

- The backbone carrier can accommodate many customer carriers and give them access to its backbone. The backbone carrier does not need to create and maintain separate backbones for its customer carriers. Using one backbone network to support multiple customer carriers simplifies the backbone carrier’s VPN operations. The backbone carrier uses a consistent method for managing and maintaining the backbone network. This is also cheaper and more efficient than maintaining separate backbones.

- The MPLS VPN carrier supporting carrier feature is scalable. Carrier supporting carrier can change the VPN to meet changing bandwidth and connectivity needs. The feature can accommodate unplanned growth and changes. The carrier supporting carrier feature enables tens of thousands of VPNs to be set up over the same network, and it allows a service provider to offer both VPN and Internet services.

- The MPLS VPN carrier supporting carrier feature is a flexible solution. The backbone carrier can accommodate many types of customer carriers. The backbone carrier can accept customer carriers who are ISPs or VPN service providers or both. The backbone carrier can accommodate customer carriers that require security and various bandwidths.

Benefits to the Customer Carriers

- The MPLS VPN carrier supporting carrier feature removes from the customer carrier the burden of configuring, operating, and maintaining its own backbone. The customer carrier uses the backbone network of a backbone carrier, but the backbone carrier is responsible for network maintenance and operation.

- Customer carriers who use the VPN services provided by the backbone carrier receive the same level of security that Frame Relay or ATM-based VPNs provide. Customer carriers can also use IPSec in their VPNs for a higher level of security; it is completely transparent to the backbone carrier.

- Customer carriers can use any link layer technology (SONET, DSL, Frame Relay, and so on) to connect the CE routers to the PE routers and the PE routers to the P routers. The MPLS VPN carrier supporting carrier feature is link layer independent. The CE routers and PE routers use IP to communicate, and the backbone carrier uses MPLS.

- The customer carrier can use any addressing scheme and still be supported by a backbone carrier. The customer address space and routing information are independent of the address space and routing information of other customer carriers or the backbone provider.

Benefits of Implementing MPLS VPN CSC with BGP

You can configure your CSC network to enable BGP to transport routes and MPLS labels between the backbone carrier PE routers and the customer carrier CE routers using multiple paths. The benefits of using BGP to distribute IPv4 routes and MPLS label routes are:

- BGP takes the place of an IGP and LDP in a VPN forwarding/routing instance (VRF) table. You can use BGP to distribute routes and MPLS labels. Using a single protocol instead of two simplifies the configuration and troubleshooting.

- BGP is the preferred routing protocol for connecting two ISPs, mainly because of its routing policies and ability to scale. ISPs commonly use BGP between two providers. This feature enables those ISPs to use BGP.
Configuration Options for MPLS VPN CSC with BGP

The following sections explain how the backbone and customer carriers distribute IPv4 routes and MPLS labels. The backbone carrier offers BGP and MPLS VPN services. The customer carrier can be either of the following:

Customer Carrier Is an ISP with an IP Core

The figure below shows a network configuration where the customer carrier is an ISP. The customer carrier has two sites, each of which is a point of presence (POP). The customer carrier connects these sites using a VPN service provided by the backbone carrier. The backbone carrier uses MPLS. The ISP sites use IP.

Figure 23: Network Where the Customer Carrier Is an ISP

The links between the CE and PE routers use EBGP to distribute IPv4 routes and MPLS labels. Between the links, the PE routers use multiprotocol IBGP to distribute VPNv4 routes.

Note
If a router other than a Cisco router is used as a CSC-PE or CSC-CE, that router must support IPv4 BGP label distribution (RFC 3107). Otherwise, you cannot run EBGP with labels between the routers.
Customer Carrier Is an MPLS Service Provider With or Without VPN Services

The figure below shows a network configuration where the backbone carrier and the customer carrier are BGP/MPLS VPN service providers. This is known as hierarchical VPNs. The customer carrier has two sites. Both the backbone carrier and the customer carrier use MPLS in their networks.

Figure 24: Network Where the Customer Carrier Is an MPLS VPN Service Provider

In this configuration, the customer carrier can configure its network in one of the following ways:

- The customer carrier can run IGP and LDP in its core network. In this case, the CSC-CE1 router in the customer carrier redistributes the EBGP routes it learns from the CSC-PE1 router of the backbone carrier to IGP.

- The CSC-CE1 router of the customer carrier system can run an IPv4 and labels IBGP session with the PE1 router.

How to Configure MPLS VPN CSC with BGP

Identifying the Carrier Supporting Carrier Topology

Before you configure the MPLS VPN CSC with BGP, you need to identify both the backbone and customer carrier topology.

For hierarchical VPNs, the customer carrier of the MPLS VPN network provides MPLS VPN services to its own customers. In this instance, you need to identify the type of customer carrier as well as the topology of the customer carriers. Hierarchical VPNs require extra configuration steps, which are noted in the configuration sections.

Note

You can connect multiple CSC-CE routers to the same PE, or you can connect a single CSC-CE router to CSC-PEs using more than one interface to provide redundancy and multiple path support in CSC topology.
Perform this task to identify the carrier supporting carrier topology.

SUMMARY STEPS

1. Identify the type of customer carrier, ISP or MPLS VPN service provider.
2. (For hierarchical VPNs only) Identify the CE routers.
3. (For hierarchical VPNs only) Identify the customer carrier core router configuration.
4. Identify the customer carrier edge (CSC-CE) routers.
5. Identify the backbone carrier router configuration.

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1**        | Identify the type of customer carrier, ISP or MPLS VPN service provider. Sets up requirements for configuration of carrier supporting carrier network.  
• For an ISP, customer site configuration is not required.  
• For an MPLS VPN service provider, the customer site needs to be configured, as well as any task or step designated "for hierarchical VPNs only." |
| **Step 2**        | (For hierarchical VPNs only) Identify the CE routers. Sets up requirements for configuration of CE to PE connections. |
| **Step 3**        | (For hierarchical VPNs only) Identify the customer carrier core router configuration. Sets up requirements for connection configuration between core (P) routers and between P routers and edge routers (PE and CSC-CE routers). |
| **Step 4**        | Identify the customer carrier edge (CSC-CE) routers. Sets up requirements for configuration of CSC-CE to CSC-PE connections. |
| **Step 5**        | Identify the backbone carrier router configuration. Sets up requirements for connection configuration between CSC core routers and between CSC core routers and edge routers (CSC-CE and CSC-PE routers). |

What to Do Next

Set up your carrier supporting carrier networks with the Configuring the Backbone Carrier Core, on page 202.

Configuring the Backbone Carrier Core

Configuring the backbone carrier core requires setting up connectivity and routing functions for the CSC core and the CSC-PE routers.

Configuring and verifying the CSC core (backbone carrier) involves the following tasks:
Prerequisites

Before you configure a backbone carrier core, configure the following on the CSC core routers:

- An IGP routing protocol--BGP, OSPF, IS-IS, EIGRP, static, and so on.
- Label Distribution Protocol (LDP). For information, see How to Configure MPLS LDP.

Verifying IP Connectivity and LDP Configuration in the CSC Core

Perform this task to verify IP connectivity and LDP configuration in the CSC core.

SUMMARY STEPS

1. enable
2. ping [protocol] {host-name | system-address}
3. trace [protocol] [destination]
4. show mpls forwarding-table [vrf vrf-name] [{network {mask | length} | labels label [- label]} | interface interface | next-hop address | lsp-tunnel [tunnel-id]}] [detail]
5. show mpls ldp discovery [vrf vrf-name | all]
6. show mpls ldp neighbor [[vrf vrf-name] [address | interface] [detail] | all]
7. show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]
8. show mpls interfaces [[vrf vrf-name] [interface] [detail] | all]
9. show ip route
10. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td>Step 2 ping [protocol] {host-name</td>
<td>system-address}</td>
</tr>
<tr>
<td>Example:</td>
<td>Use the ping ip command to verify the connectivity from one CSC core router to another.</td>
</tr>
<tr>
<td>Step 3 trace [protocol] [destination]</td>
<td>(Optional) Discovers the routes that packets will actually take when traveling to their destination.</td>
</tr>
<tr>
<td>Example:</td>
<td>Use the trace command to verify the path that a packet goes through before reaching the final destination. The trace</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>show mpls forwarding-table [vrf vrf-name] [network</td>
</tr>
<tr>
<td></td>
<td>(Optional) Displays the contents of the MPLS label forwarding information base (LFIB).</td>
</tr>
<tr>
<td></td>
<td>• Use the show mpls forwarding-table command to verify that MPLS packets are being forwarded.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show mpls forwarding-table</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>show mpls ldp discovery [vrf vrf-name</td>
</tr>
<tr>
<td></td>
<td>(Optional) Displays the status of the LDP discovery process.</td>
</tr>
<tr>
<td></td>
<td>• Use the show mpls ldp discovery command to verify that LDP is operational in the CSC core.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show mpls ldp discovery</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>show mpls ldp neighbor [vrf vrf-name] [address</td>
</tr>
<tr>
<td></td>
<td>(Optional) Displays the status of LDP sessions.</td>
</tr>
<tr>
<td></td>
<td>• Use the show mpls ldp neighbor command to verify LDP configuration in the CSC core.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show mpls ldp neighbor</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>show ip cef [vrf vrf-name] [network</td>
</tr>
<tr>
<td></td>
<td>(Optional) Displays entries in the forwarding information base (FIB).</td>
</tr>
<tr>
<td></td>
<td>• Use the show ip cef command to check the forwarding table (prefixes, next hops, and interfaces).</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show ip cef</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td>show mpls interfaces [vrf vrf-name] [interface] [detail]</td>
</tr>
<tr>
<td></td>
<td>(Optional) Displays information about one or more or all interfaces that are configured for label switching.</td>
</tr>
<tr>
<td></td>
<td>• Use the show mpls interfaces command to verify that the interfaces are configured to use LDP.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show mpls interfaces</td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td>show ip route</td>
</tr>
<tr>
<td></td>
<td>(Optional) Displays IP routing table entries.</td>
</tr>
<tr>
<td></td>
<td>• Use the show ip route command to display the entire routing table, including host IP address, next hop, interface, and so forth.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show ip route</td>
</tr>
<tr>
<td><strong>Step 10</strong></td>
<td>disable</td>
</tr>
<tr>
<td></td>
<td>(Optional) Returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# disable</td>
</tr>
</tbody>
</table>
Troubleshooting Tips

You can use the `ping` and `trace` commands to verify complete MPLS connectivity in the core. You also get useful troubleshooting information from the additional `show` commands.

Configuring VRFs for CSC-PE Routers

Perform this task to configure VPN forwarding/routing instances (VRFs) for the backbone carrier edge (CSC-PE) routers.

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip vrf vrf-name`
4. `rd route-distinguisher`
5. `route-target {import | export | both} route-target-ext-community`
6. `import map route-map`
7. `exit`
8. `interface type number`
9. `ip vrf forwarding vrf-name`
10. `end`

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><strong>enable</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Enters privileged EXEC mode.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><strong>configure terminal</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><strong>ip vrf vrf-name</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Defines the VPN routing instance by assigning a VRF name and enters</td>
</tr>
<tr>
<td>Router(config)# ip vrf vpn1</td>
<td>VRF configuration mode.</td>
</tr>
<tr>
<td></td>
<td>• The <code>vrf-name</code> argument is the name assigned to a VRF.</td>
</tr>
<tr>
<td>Step</td>
<td>Command or Action</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
</tr>
</tbody>
</table>
| 4    | `rd route-distinguisher` | 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 an 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, 192.168.122.15:1 |
| 5    | `route-target {import | export | both} route-target-ext-community` | 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.  
  - The `route-target-ext-community` argument adds the route-target extended community attributes to the VRF's list of import, export, or both (import and export) route-target extended communities. |
| 6    | `import map route-map` | (Optional) Configures an import route map for a VRF.  
  - The `route-map` argument specifies the route map to be used as an import route map for the VRF. |
| 7    | `exit` | (Optional) Exits to global configuration mode. |
| 8    | `interface type number` | Specifies the interface to configure.  
  - The `type` argument specifies the type of interface to be configured.  
  - The `number` argument specifies the port, connector, or interface card number. |
| 9    | `ip vrf forwarding vrf-name` | Associates a VRF with the specified interface or subinterface.  
  - The `vrf-name` argument is the name assigned to a VRF. |
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 10</strong> end</td>
<td>(Optional) Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# end</td>
<td></td>
</tr>
</tbody>
</table>

**Troubleshooting Tips**
Enter a `show ip vrf detail` command and make sure the MPLS VPN is up and associated with the right interfaces.

**Configuring Multiprotocol BGP for VPN Connectivity in the Backbone Carrier**
Perform this task to configure Multiprotocol BGP (MP-BGP) connectivity in the backbone carrier.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `no bgp default ipv4-unicast`
5. `neighbor {ip-address | peer-group-name} remote-as as-number`
6. `neighbor {ip-address | peer-group-name} update-source interface-type`
7. `address-family vpnv4 [unicast]`
8. `neighbor {ip-address | peer-group-name} send-community extended`
9. `neighbor {ip-address | peer-group-name} activate`
10. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> <code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> <code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>router bgp as-number</td>
</tr>
<tr>
<td>Example:</td>
<td>Configures a BGP routing process and enters router configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Router(config)# router bgp 100</td>
</tr>
<tr>
<td></td>
<td>The <em>as-number</em> argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>no bgp default ipv4-unicast</td>
</tr>
<tr>
<td>Example:</td>
<td>(Optional) Disables the IPv4 unicast address family on all neighbors.</td>
</tr>
<tr>
<td></td>
<td>Router(config-router)# no bgp default ipv4-unicast</td>
</tr>
<tr>
<td></td>
<td>Use the no bgp default-unicast command if you are using this neighbor for MPLS routes only.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>neighbor {ip-address</td>
</tr>
<tr>
<td>Example:</td>
<td>Adds an entry to the BGP or multiprotocol BGP neighbor table.</td>
</tr>
<tr>
<td></td>
<td>Router(config-router)# neighbor 10.5.5.5 remote-as 100</td>
</tr>
<tr>
<td></td>
<td>The <em>ip-address</em> argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td></td>
<td>The <em>as-number</em> argument specifies the autonomous system to which the neighbor belongs.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>neighbor {ip-address</td>
</tr>
<tr>
<td>Example:</td>
<td>Allows BGP sessions to use a specific operational interface for TCP connections.</td>
</tr>
<tr>
<td></td>
<td>Router(config-router)# neighbor 10.2.0.0 update-source loopback0</td>
</tr>
<tr>
<td></td>
<td>The <em>ip-address</em> argument specifies the IP address of the BGP-speaking neighbor.</td>
</tr>
<tr>
<td></td>
<td>The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td></td>
<td>The <em>interface-type</em> argument specifies the interface to be used as the source.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>address-family vpnv4 [unicast]</td>
</tr>
<tr>
<td>Example:</td>
<td>Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.</td>
</tr>
<tr>
<td></td>
<td>Router(config-router)# address-family vpnv4</td>
</tr>
<tr>
<td></td>
<td>The optional <em>unicast</em> keyword specifies VPNv4 unicast address prefixes.</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td>neighbor {ip-address</td>
</tr>
<tr>
<td>Example:</td>
<td>Specifies that a communities attribute should be sent to a BGP neighbor.</td>
</tr>
<tr>
<td></td>
<td>Router(config-router-af)# neighbor 10.0.0.1 send-community extended</td>
</tr>
<tr>
<td></td>
<td>The <em>ip-address</em> argument specifies the IP address of the BGP-speaking neighbor.</td>
</tr>
<tr>
<td></td>
<td>The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 9** neighbor \{ip-address | peer-group-name\} activate | Enables the exchange of information with a neighboring BGP router.  
  - The *ip-address* argument specifies the IP address of the neighbor.  
  - The *peer-group-name* argument specifies the name of a BGP peer group. |
| **Example:** | Router(config-router-af)# neighbor 10.4.0.0 activate |
| **Step 10** end | (Optional) Exits to privileged EXEC mode. |
| **Example:** | Router(config-router-af)# end |

**Troubleshooting Tips**

You can enter a `show ip bgp neighbor` command to verify that the neighbors are up and running. If this command is not successful, enter a `debug ip bgp x.x.x.x events` command, where `x.x.x.x` is the IP address of the neighbor.

**Configuring the CSC-PE and CSC-CE Routers**

Perform the following tasks to configure and verify links between a CSC-PE router and the carrier CSC-CE router for an MPLS VPN CSC network that uses BGP to distribute routes and MPLS labels.

The figure below shows the configuration for the peering with directly connected interfaces between CSC-PE and CSC-CE routers. This configuration is used as the example in the tasks that follow.

*Figure 25: Configuration for Peering with Directly Connected Interfaces Between CSC-PE and CSC-CE Routers*

![Figure 25](image)

**Configuring CSC-PE Routers**

Perform this task to configure the CSC-PE routers.
SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp as-number
4. address-family ipv4 [ multicast | unicast | vrf vrf-name ]
5. neighbor {ip-address | peer-group-name} remote-as as-number
6. neighbor {ip-address | peer-group-name} activate
7. neighbor ip-address as-override
8. neighbor ip-address send-label
9. exit-address-family
10. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures a BGP routing process and enters router configuration mode.</td>
</tr>
<tr>
<td>Example: Router(config)# router bgp 100</td>
<td>• The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td><strong>Step 4</strong> address-family ipv4 [ multicast</td>
<td>unicast</td>
</tr>
<tr>
<td>Example: Router(config-router)# address-family ipv4 vrf vpl1</td>
<td>• The multicast keyword specifies IPv4 multicast address prefixes.</td>
</tr>
<tr>
<td></td>
<td>• The unicast keyword specifies IPv4 unicast address prefixes.</td>
</tr>
<tr>
<td></td>
<td>• The vrf vrf-name keyword and argument specify the name of the VRF to associate with subsequent IPv4 address family configuration mode commands.</td>
</tr>
<tr>
<td><strong>Step 5</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number</td>
</tr>
</tbody>
</table>
## Command or Action

### Purpose

- **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.**

### Example:

```
Router(config-router-af)# neighbor 10.0.0.1 remote-as 200
```

### Step 6

**neighbor {ip-address | peer-group-name} activate**

Enables the exchange of information with a neighboring BGP router.

- **The ip-address argument specifies the IP address of the neighbor.**
- **The peer-group-name argument specifies the name of a BGP peer group.**

```
Example:
Router(config-router-af)# neighbor 10.0.0.2 activate
```

### Step 7

**neighbor ip-address as-override**

Configures a PE router to override the autonomous system number (ASN) of a site with the ASN of a provider.

- **The ip-address argument specifies the IP address of the router that is to be overridden with the ASN provided.**

```
Example:
Router(config-router-af)# neighbor 10.0.0.2 as-override
```

### Step 8

**neighbor ip-address send-label**

Enables a BGP router to send MPLS labels with BGP routes to a neighboring BGP router.

- **The ip-address argument specifies the IP address of the neighboring router.**

```
Example:
Router(config-router-af)# neighbor 10.0.0.2 send-label
```

### Step 9

**exit-address-family**

Exits address family configuration mode.

```
Example:
Router(config-router-af)# exit-address-family
```

### Step 10

**end**

(Optional) Exits to privileged EXEC mode.

```
Example:
Router(config-router)# end
```

---

### Troubleshooting Tips

Enter a `show ip bgp neighbor` command to verify that the neighbors are up and running. Make sure you see the following line in the command output under Neighbor capabilities:

```
IPv4 MPLS Label capability: advertised and received
```
## Configuring CSC-CE Routers

Perform this task to configure the CSC-CE routers.

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `address-family ipv4 [multicast | unicast | vrf vrf-name]`
5. `redistribute protocol`
6. `neighbor {ip-address | peer-group-name} remote-as as-number`
7. `neighbor {ip-address | peer-group-name} activate`
8. `neighbor ip-address send-label`
9. `exit-address-family`
10. `end`

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures a BGP routing process and enters router configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# router bgp 200</td>
<td>- The <em>as-number</em> argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td><strong>Step 4</strong> address-family ipv4 [multicast</td>
<td>unicast</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-router)# address-family ipv4</td>
<td>- The <em>multicast</em> keyword specifies IPv4 multicast address prefixes.</td>
</tr>
<tr>
<td></td>
<td>- The <em>unicast</em> keyword specifies IPv4 unicast address prefixes.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>redistribute protocol</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# redistribute static</td>
</tr>
<tr>
<td></td>
<td>• The <em>vrf vrf-name</em> keyword and argument specify the name of the VRF to associate with subsequent IPv4 address family configuration mode commands.</td>
</tr>
<tr>
<td></td>
<td>• The <em>protocol</em> argument specifies the source protocol from which routes are being redistributed. It can be one of the following keywords: bgp, egp, igrp, isis, ospf, mobile, static [ip], connected, and rip.</td>
</tr>
<tr>
<td></td>
<td>• The <em>static [ip]</em> keyword redistributes IP static routes. The optional <em>ip</em> keyword is used when you redistribute static routes into IS-IS.</td>
</tr>
<tr>
<td></td>
<td>• The <em>connected</em> keyword refers to routes which are established automatically when IP is enabled on an interface. For routing protocols such as OSPF and IS-IS, these routes are redistributed as external to the autonomous system.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>**neighbor {ip-address</td>
</tr>
<tr>
<td></td>
<td>remote-as <strong>as-number</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# neighbor 10.5.0.2 remote-as 100</td>
</tr>
<tr>
<td></td>
<td>• The *ip-address argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>• The *peer-group-name argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td></td>
<td>• The *as-number argument specifies the autonomous system to which the neighbor belongs.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>**neighbor {ip-address</td>
</tr>
<tr>
<td></td>
<td><strong>activate</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# neighbor 10.3.0.2 activate</td>
</tr>
<tr>
<td></td>
<td>• The *ip-address argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>• The *peer-group-name argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>neighbor ip-address</strong></td>
</tr>
<tr>
<td></td>
<td><strong>send-label</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# neighbor 10.0.0.2 send-label</td>
</tr>
<tr>
<td></td>
<td>• The *ip-address argument specifies the IP address of the neighboring router.</td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td><strong>exit-address-family</strong></td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router-af)# exit-address-family</td>
</tr>
<tr>
<td></td>
<td>• Exits from the address family configuration mode.</td>
</tr>
</tbody>
</table>
Verifying Labels in the CSC-PE Routers

Perform this task to verify the labels in the CSC-PE routers.

**SUMMARY STEPS**

1. `enable`
2. `show ip bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name} [summary] [labels]`
3. `show mpls interfaces [all]`
4. `show ip route vrf vrf-name [prefix]`
5. `show ip bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name} [summary] [labels]`
6. `show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail]`
7. `show mpls forwarding-table [vrf vrf-name] [network [mask | length] | labels label [label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]] [detail]`
8. `traceroute vrf [vrf-name] ip-address`
9. `disable`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td>`show ip bgp vpnv4 {all</td>
<td>rd route-distinguisher</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# show ip bgp vpnv4 all summary</code></td>
<td>Use the <code>show ip bgp vpnv4 all summary</code> command to check that the BGP session is up and running between the CSC-PE routers and the CSC-CE routers. Check the data in the State/PfxRcd column to verify that prefixes are learned during each session.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 3** show mpls interfaces [all] | (Optional) Displays information about one or more interfaces that have been configured for label switching.  
  - Use the `show mpls interfaces all` command to check that MPLS interfaces are up and running, and that LDP-enabled interfaces show that LDP is up and running. Check that LDP is turned off on the VRF because EBGP distributes the labels. |
| Example: | Router# show mpls interfaces all |
| **Step 4** show ip route vrf vrf-name [prefix] | (Optional) Displays the IP routing table associated with a VRF.  
  - Use the `show ip route vrf` command to check that the prefixes for the PE routers are in the routing table of the CSC-PE routers. |
| Example: | Router# show ip route vrf vpn1 10.5.5.5 |
| **Step 5** show bgp vpnv4 {all | rd route-distinguisher | vrf vrf-name} [summary] [labels] | (Optional) Displays VPN address information from the BGP table.  
  - Use the `show ip bgp vpnv4 vrf vrf-name labels` command to check that the prefixes for the customer carrier MPLS service provider networks are in the BGP table and have the appropriate labels. |
| Example: | Router# show ip bgp vpnv4 vrf vpn1 labels |
| **Step 6** show ip cef [vrf vrf-name] [network [mask]] [longer-prefixes] [detail] | (Optional) Displays entries in the forwarding information base (FIB) or displays a summary of the FIB.  
  - Use the `show ip cef vrf` and the `show ip cef vrf detail` commands to check that the prefixes of the PE routers are in the CEF table. |
| Example: | Router# show ip cef vrf vpn1 10.1.0.0 detail |
| **Step 7** show mpls forwarding-table [vrf vrf-name] [[network {mask | length} | labels label [label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]]] [detail] | (Optional) Displays the contents of the MPLS table forwarding information base (LFIB).  
  - Use the `show mpls forwarding-table` command with the `vrf` keyword and both the `vrf` and `detail` keywords to check that the prefixes for the PE routers in the local customer MPLS VPN service provider are in the LFIB. |
| Example: | Router# show mpls forwarding-table vrf vpn1 10.1.0.0 detail |
| **Step 8** traceroute vrf vrf-name ip-address | Shows the routes that packets follow traveling through a network to their destination.  
  - Use the `traceroute vrf` command to check the data path and transport labels from a PE to a destination CE router. |
| Example: | Router# traceroute vrf vpn2 10.2.0.0 |
### Purpose

**Command or Action**

<table>
<thead>
<tr>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>This command works with MPLS-aware traceroute only if the backbone routers are configured to propagate and generate IP Time to Live (TTL) information. For more information, see the documentation on the <code>mpls ip propagate-ttl</code> command.</td>
</tr>
</tbody>
</table>

**Note**

If you have multiple paths configured between CSC-PE and CSC-CE, verify that the multiple routes for the same destination learned from the CSC-CE are installed in the corresponding VRF table.

### Step 9

<table>
<thead>
<tr>
<th>disable</th>
</tr>
</thead>
</table>

*(Optional)* Exits to user EXEC mode.

**Example:**

Router# disable

### Verifying Labels in the CSC-CE Routers

Perform this task to verify the labels in the CSC-CE routers.

#### SUMMARY STEPS

1. `enable`
2. `show ip bgp summary`
3. `show ip route [address]`
4. `show mpls ldp bindings [network {mask | length}]`
5. `show ip cef [network [mask]] [longer-prefixes] [detail]`
6. `show mpls forwarding table [vrf vrf-name] [[network [mask | length] | labels label [- label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]]] [detail]`
7. `show ip bgp labels`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> <code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> <code>show ip bgp summary</code></td>
<td><em>(Optional)</em> Displays the status of all BGP connections.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# show ip bgp summary</td>
<td>• Use the <code>show ip bgp summary</code> command to check that the BGP session is up and running on the CSC-CE routers.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 3</strong> show ip route [address]</td>
<td>(Optional) Displays IP routing table entries. • Use the <code>show ip route</code> to check that the loopback address of the local and remote PE routers are in the routing table.</td>
</tr>
<tr>
<td>Example: Router# show ip route 10.1.0.0</td>
<td>Note: If you have multiple paths configured between CSC-PE and CSC-CE, verify that the multiple routes for the same destination learned from the CSC-CE are installed in the corresponding VRF table.</td>
</tr>
<tr>
<td><strong>Step 4</strong> show mpls ldp bindings [network {mask</td>
<td>length}]</td>
</tr>
<tr>
<td>Example: Router# show mpls ldp bindings 10.2.0.0 255.255.255.255</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> show ip cef [network [mask]] [longer-prefixes] [detail]</td>
<td>(Optional) Displays entries in the forwarding information base (FIB) or a summary of the FIB. • Use the <code>show ip cef</code> and the <code>show ip cef detail</code> commands to check that the prefixes of the local and remote PE routers are in the Cisco Express Forwarding table.</td>
</tr>
<tr>
<td>Example: Router# show ip cef 10.5.0.0 detail</td>
<td>Note: If you have multiple paths configured between CSC-PE and CSC-CE, verify that the multiple routes and labels for the same destination learned from the CSC-CE are installed in the corresponding VRF table.</td>
</tr>
<tr>
<td><strong>Step 6</strong> show mpls forwarding table [vrf vrf-name] [{network [mask</td>
<td>length]</td>
</tr>
<tr>
<td>Example: Router# show mpls forwarding-table 10.2.0.0 detail</td>
<td>Note: If you have multiple paths configured between CSC-PE and CSC-CE, verify that the multiple routes and labels for the same destination learned from the CSC-CE are installed in the corresponding VRF routing table.</td>
</tr>
<tr>
<td><strong>Step 7</strong> show ip bgp labels</td>
<td>(Optional) Displays information about MPLS labels from the EBGP route table. • Use the <code>show ip bgp labels</code> command to check that the BGP routing table contains labels for prefixes in the customer carrier MPLS VPN service provider networks.</td>
</tr>
<tr>
<td>Example: Router# show ip bgp labels</td>
<td></td>
</tr>
</tbody>
</table>
Configuring the Customer Carrier Network

Perform the following tasks to configure and verify the customer carrier network. This requires setting up connectivity and routing functions for the customer carrier core (P) routers and the customer carrier edge (PE) routers.

Prerequisites

Before you configure an MPLS VPN CSC network that uses BGP to distribute routes and MPLS labels, you must configure the following on your customer carrier routers:

- An IGP routing protocol—BGP, OSPF, IS-IS, EIGRP, static, and so on. For information, see Configuring a Basic BGP Network, Configuring OSPF, Configuring a Basic IS-IS Network, and Configuring EIGRP.
- MPLS VPN functionality on the PE routers (for hierarchical VPNs only).
- Label Distribution Protocol (LDP) on P and PE routers (for hierarchical VPNs only). For information, see How to Configure MPLS LDP.

Note

You must configure the items in the preceding list before performing the tasks in this section.

Verifying IP Connectivity in the Customer Carrier

Perform this task to verify IP connectivity in the customer carrier.

SUMMARY STEPS

1. enable
2. ping [protocol] {host-name | system-address}
3. trace [protocol] [destination]
4. show ip route
5. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> ping [protocol] {host-name</td>
<td>system-address}</td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the <strong>ping</strong> command to verify the connectivity from one customer carrier core router to another.</td>
</tr>
</tbody>
</table>

**Example:**

```
Router# ping ip 10.2.0.0
```

### Step 3

**trace [protocol] [destination]**

- **Purpose:** Discovers the routes that packets will actually take when traveling to their destination.
- **Example:**
  
  ```
  Router# trace ip 10.1.0.0
  ```
  
  • Use the **trace** command to verify the path that a packet goes through before reaching the final destination. The **trace** command can help isolate a trouble spot if two routers cannot communicate.

### Step 4

**show ip route**

- **Purpose:** Displays IP routing table entries.
- **Example:**
  
  ```
  Router# show ip route
  ```
  
  • Use the **show ip route** command to display the entire routing table, including host IP address, next hop, interface, and so forth.

### Step 5

**disable**

- **Purpose:** Returns to user mode.
- **Example:**
  
  ```
  Router# disable
  ```

---

**Configuring a Customer Carrier Core Router as a Route Reflector**

Perform this task to configure a customer carrier core (P) router as a route reflector of multiprotocol BGP prefixes.

**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 route-reflector-client**
8. **exit-address-family**
9. **end**
## DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1**        | Enables privileged EXEC mode.  
| `enable`          | • Enter your password if prompted. |
| **Example:**      |         |
| `Router> enable`  |         |
| **Step 2**        | Enters global configuration mode. |
| `configure terminal` |         |
| **Example:**      |         |
| `Router# configure terminal` |         |
| **Step 3**        | Configures a BGP routing process and enters router configuration mode. |
| `router bgp as-number` | • The `as-number` argument indicates the number of an autonomous system that identifies the router to other BGP routers and labels the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535. |
| **Example:**      |         |
| `Router(config)# router bgp 200` |         |
| **Step 4**        | Adds an entry to the BGP or multiprotocol BGP neighbor table. |
| `neighbor {ip-address | peer-group-name} remote-as as-number` | • The `ip-address` argument specifies the IP address of the neighbor.  
| **Example:**      | • The `peer-group-name` argument specifies the name of a BGP peer group.  
| `Router(config-router)# neighbor 10.1.1.1 remote-as 100` | • The `as-number` argument specifies the autonomous system to which the neighbor belongs. |
| **Step 5**        | Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes. |
| `address-family vpnv4 [unicast]` | • The optional `unicast` keyword specifies VPNv4 unicast address prefixes. |
| **Example:**      |         |
| `Router(config-router)# address-family vpnv4` |         |
| **Step 6**        | Enables the exchange of information with a neighboring BGP router. |
| `neighbor {ip-address | peer-group-name} activate` | • The `ip-address` argument specifies the IP address of the neighbor.  
| **Example:**      | • The `peer-group-name` argument specifies the name of a BGP peer group. |
| `Router(config-router-af)# neighbor 10.1.1.1 activate` |         |
### Command or Action

**Step 7**

**neighbor ip-address route-reflector-client**

**Example:**

```
Router(config-router-af)# neighbor 10.1.1.1 route-reflector-client
```

**Purpose:** Configures the router as a BGP route reflector and configures the specified neighbor as its client.

- The `ip-address` argument specifies the IP address of the BGP neighbor being identified as a client.

**Step 8**

**exit-address-family**

**Example:**

```
Router(config-router-af)# exit-address-family
```

**Purpose:** Exits address family configuration mode.

**Step 9**

**end**

**Example:**

```
Router(config-router)# end
```

(Optional) Exits to privileged EXEC mode.

### Troubleshooting Tips

By default, neighbors that are defined using the `neighbor remote-as` command in router configuration mode exchange only unicast address prefixes. For neighbors to exchange other address prefix types, such as multicast and VPNv4, you must also activate neighbors using the `neighbor activate` command in address family configuration mode, as shown.

Route reflectors and clients (neighbors or internal BGP peer groups) that are defined in router configuration mode using the `neighbor route-reflector-client` command reflect unicast address prefixes to and from those clients by default. To cause them to reflect prefixes for other address families, such as multicast, define the reflectors and clients in address family configuration mode, using the `neighbor route-reflector-client` command, as shown.

### Configuring the Customer Site for Hierarchical VPNs

**Note**

This section applies only to customer carrier networks that use BGP to distribute routes and MPLS labels.

Perform the following tasks to configure and verify the customer site for hierarchical VPNs:

**Note**

This section applies to hierarchical VPNs only.
### Defining VPNs on PE Routers for Hierarchical VPNs

Perform this task to define VPNs on PE routers.

#### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip vrf vrf-name`
4. `rd route-distinguisher`
5. `route-target {import | export | both} route-target-ext-community`
6. `import map route-map`
7. `ip vrf forwarding vrf-name`
8. `exit`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
- Enter your password if prompted. |
| **Example:** Router> enable |  |
| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:** Router# configure terminal |  |
| **Step 3** ip vrf vrf-name | Creates a VRF routing table and a Cisco Express Forwarding table and enters VRF configuration mode.  
- The `vrf-name` argument is a name you assign to a VRF. |
| **Example:** Router(config)# ip vrf vpn2 |  |
| **Step 4** rd route-distinguisher | Creates routing and forwarding tables for a VRF.  
- The `route-distinguisher` argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. |
| **Example:** Router(config-vrf)# rd 200:1 |  |
| **Step 5** route-target {import | export | both} route-target-ext-community | 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. |
<p>| <strong>Example:</strong> Router(config-vrf)# route-target export 200:1 |  |</p>
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• The <strong>both</strong> keyword imports routing information from and export routing information to the target VPN extended community.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>route-target-ext-community</strong> argument adds the route-target extended community attributes to the VRF's list of import, export, or both (import and export) route-target extended communities.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>import map route-map</strong></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-vrf)# import map map23</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>ip vrf forwarding vrf-name</strong></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-vrf)# ip vrf forwarding vpn2</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>exit</strong></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-vrf)# exit</td>
</tr>
</tbody>
</table>

### Configuring BGP Routing Sessions on the PE Routers for Hierarchical VPNs

Perform this task to configure BGP routing sessions on the PE routers for PE-to-CE router communication.

#### SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp as-number
4. address-family ipv4 [multicast | unicast | vrf vrf-name]
5. neighbor {ip-address | peer-group-name} remote-as as-number
6. neighbor {ip-address | peer-group-name} activate
7. end

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><strong>enable</strong></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

**Step 2**

**configure terminal**

Example: Router# configure terminal

Enters global configuration mode.

**Step 3**

**router bgp as-number**

Example: Router(config)# router bgp 200

Configures the router to run a BGP process and enters router configuration mode.

• The `as-number` argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.

**Step 4**

**address-family ipv4 [multicast | unicast | vrf vrf-name]**

Example: Router(config-router)# address-family ipv4 multicast

Specifies the IPv4 address family type and enters address family configuration mode.

• The `multicast` keyword specifies IPv4 multicast address prefixes.
• The `unicast` keyword specifies IPv4 unicast address prefixes.
• The `vrf vrf-name` keyword and argument specify the name of the VRF to associate with subsequent IPv4 address family configuration mode commands.

**Step 5**

**neighbor {ip-address | peer-group-name} remote-as as-number**

Example: Router(config-router-af)# neighbor 10.5.5.5 remote-as 300

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 6**

**neighbor {ip-address | peer-group-name} activate**

Example: Router(config-router-af)# neighbor 10.1.0.0 activate

Enables the exchange of information with a neighboring router.

• The `ip-address` argument specifies the IP address of the neighbor.
• The `peer-group-name` argument specifies the name of a BGP peer group.
Verifying Labels in Each PE Router for Hierarchical VPNs

Perform this task to verify labels in each PE router for hierarchical VPNs.

**SUMMARY STEPS**

1. `enable`
2. `show ip route vrf vrf-name [prefix]`
3. `show mpls forwarding-table [vrf vrf-name] [prefix] [detail]`
4. `show ip cef [network [mask [longer-prefix]]] [detail]`
5. `show ip cef vrf vrf-name [ip-prefix]`
6. `exit`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> show ip route vrf vrf-name [prefix]</td>
<td>(Optional) Displays the IP routing table associated with a VRF.</td>
</tr>
<tr>
<td>Example: Router# show ip route vrf vpn2 10.5.5.5</td>
<td>• Use the <code>show ip route vrf</code> command to check that the loopback addresses of the local and remote CE routers are in the routing table of the PE routers.</td>
</tr>
<tr>
<td><strong>Step 3</strong> show mpls forwarding-table [vrf vrf-name] [prefix] [detail]</td>
<td>(Optional) Displays the contents of the LFIB.</td>
</tr>
<tr>
<td>Example: Router# show mpls forwarding-table vrf vpn2 10.1.0.0</td>
<td>• Use the <code>show mpls forwarding-table</code> command to check that the prefixes for the local and remote CE routers are in the MPLS forwarding table, and that the specified prefix is untagged.</td>
</tr>
<tr>
<td><strong>Step 4</strong> show ip cef [network [mask [longer-prefix]]] [detail]</td>
<td>(Optional) Displays specific entries in the FIB based on IP address information.</td>
</tr>
</tbody>
</table>
### Purpose

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>• Use the <code>show ip cef</code> command to check that the prefixes of the local and remote PE routers are in the Cisco Express Forwarding table.</td>
</tr>
</tbody>
</table>

### Step 5

**show ip cef vrf** `vrf-name [ip-prefix]`  

**Example:**
```
Router# show ip cef vrf vpn2 10.3.0.0
```

(Optional) Displays the Cisco Express Forwarding table associated with a VRF.  
• Use the `show ip cef vrf` command to check that the prefix of the remote CE router is in the Cisco Express Forwarding table.

### Step 6

**exit**  

**Example:**
```
Router# exit
```

(Optional) Exits to user EXEC mode.

---

### Configuring CE Routers for Hierarchical VPNs

Perform this task to configure CE routers for hierarchical VPNs. This configuration is the same as that for an MPLS VPN that is not in a hierarchical topology.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `ip cef [distributed]`
4. `interface type number`
5. `ip address ip-address mask [secondary]`
6. `exit`
7. `router bgp as-number`
8. `redistribute protocol`
9. `neighbor {ip-address | peer-group-name} remote-as as-number`
10. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 <code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Step 2**

**configure terminal**

Enters global configuration mode.

**Example:**

Router# configure terminal

**Step 3**

**ip cef [distributed]**

Enables Cisco Express Forwarding on the route processor card.

- The distributed keyword enables distributed Cisco Express Forwarding operation. Cisco Express Forwarding information is distributed to the line cards. Line cards perform express forwarding.

**Note** For the Cisco ASR 1000 Series Aggregation Services Router, the distributed keyword is required.

**Example:**

Router(config)# ip cef distributed

**Step 4**

**interface type number**

Configures an interface type and enters interface configuration mode.

- The type argument specifies the type of interface to be configured.
  - A loopback interface indicates a software-only interface that emulates an interface that is always up. It is a virtual interface supported on all platforms.

- The number argument is the number of the loopback interface that you want to create or configure. There is no limit on the number of loopback interfaces you can create.

**Example:**

Router(config)# interface loopback 0

**Step 5**

**ip address ip-address mask [secondary]**

Sets a primary or secondary IP address for an interface.

- The ip-address argument is the IP address.

- The mask argument is the mask for the associated IP subnet.

- The secondary keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.

**Example:**

Router(config-if)# ip address 10.8.0.0 255.255.255.255

**Step 6**

**exit**

Exits interface configuration mode.

**Example:**

Router(config-if)# exit

**Step 7**

**router bgp as-number**

Configures a BGP routing process and enters router configuration mode.
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Router(config)# router bgp 100</td>
<td>• The <em>as-number</em> argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td>Step 8</td>
<td>redistribute <em>protocol</em></td>
<td>Redistributes routes from one routing domain into another routing domain.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router)# redistribute connected</td>
<td>• The <em>protocol</em> argument specifies the source protocol from which routes are being redistributed. It can be one of the following keywords: <em>bgp, connected, egp, igrp, isis, mobile, ospf, static [ip]</em>, or <em>rip</em>. The <em>connected</em> keyword refers to routes that are established automatically when IP is enabled on an interface. For routing protocols such as Open Shortest Path First (OSPF) and IS-IS, these routes are redistributed as external to the autonomous system.</td>
</tr>
<tr>
<td>Step 9</td>
<td>neighbor <em>ip-address</em></td>
<td>Adds the IP address of the neighbor in the remote autonomous system to the multiprotocol BGP neighbor table of the local router.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router)# neighbor 10.8.0.0 remote-as 100</td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighbor. • The <em>peer-group-name</em> argument specifies the name of a BGP peer group. • The <em>as-number</em> argument specifies the autonomous system to which the neighbor belongs.</td>
</tr>
<tr>
<td>Step 10</td>
<td>end</td>
<td>(Optional) Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-router)# end</td>
<td></td>
</tr>
</tbody>
</table>

### Verifying IP Connectivity in the Customer Site

Perform this task to verify IP connectivity in the customer site.

### SUMMARY STEPS

1. `enable`
2. `show ip route [ip-address [mask]] [longer-prefixes] [protocol [process-id]] list [access-list-number | access-list-name ] | static download`
3. `ping [protocol] [host-name | system-address]`
4. `trace [protocol] [destination]`
5. `disable`
## DETAILED STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** | `enable` | Enables privileged EXEC mode.  
  **Example:**  
  Router> enable |
| **Step 2** | `show ip route [ip-address [mask]] [longer-prefixes] | protocol [process-id] | list [access-list-number | access-list-name ] | static download` | *(Optional)* Displays the current state of the routing table.  
  **Example:**  
  Router# show ip route 10.5.5.5 |
| **Step 3** | `ping [protocol] {host-name | system-address}` | Diagnoses basic network connectivity on Apollo, AppleTalk,  
  Connectionless Network Service (CLNS), DECnet, IP, Novell IPX,  
  VINES, or XNS networks.  
  **Example:**  
  Router# ping 10.5.5.5 |
| **Step 4** | `trace [protocol] [destination]` | Discovers the routes that packets will actually take when traveling to  
  their destination.  
  **Example:**  
  Router# trace ip 10.5.5.5 |
| **Step 5** | `disable` | *(Optional)* Exits to user EXEC mode.  
  **Example:**  
  Router# disable |
Configuration Examples for MPLS VPN CSC with BGP

The figure below shows a sample CSC topology for exchanging IPv4 routes and MPLS labels. Use this figure as a reference for configuring and verifying carrier supporting carrier routers to exchange IPv4 routes and MPLS labels.

Figure 26: Sample CSC Topology for Exchanging IPv4 Routes and MPLS Labels

The table below describes the sample configuration shown in the figure above.

Table 10: Description of Sample Configuration Shown in figure 1

<table>
<thead>
<tr>
<th>Routers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE1 and CE2</td>
<td>Belong to an end customer. CE1 and CE2 routers exchange routes learned from PE routers. The end customer is purchasing VPN services from a customer carrier.</td>
</tr>
<tr>
<td>PE1 and PE2</td>
<td>Part of a customer carrier network that is configured to provide MPLS VPN services. PE1 and PE2 are peering with a VPNv4 IBGP session to form an MPLS VPN network.</td>
</tr>
<tr>
<td>CSC-CE1 and CSC-CE2</td>
<td>Part of a customer carrier network. CSC-CE1 and CSC-CE2 routers exchange IPv4 BGP updates with MPLS labels and redistribute PE loopback addressees to and from the IGP (OSPF in this example). The customer carrier is purchasing carrier supporting carrier VPN services from a backbone carrier.</td>
</tr>
</tbody>
</table>
Routers | Description
--- | ---
CSC-PE1 and CSC-PE2 | Part of the backbone carrier’s network configured to provide carrier supporting carrier VPN services. CSC-PE1 and CSC-PE2 are peering with a VPNv4 IP BGP session to form the MPLS VPN network. In the VRF, CSC-PE1 and CSC-PE2 are peering with the CSC-CE routers, which are configured for carrying MPLS labels with the routes, with an IPv4 EBGP session.

### Configuring the Backbone Carrier Core Examples

Configuration and verification examples for the backbone carrier core included in this section are as follows:

#### Verifying IP Connectivity and LDP Configuration in the CSC Core Example

Check that CSC-PE2 is reachable from CSC-PE1 by entering the following command on CSC-CE1:

```bash
Router# ping 10.5.5.5
```

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.5.5.5, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms

Verify the path from CSC-PE1 to CSC-PE2 by entering the following command on CSC-CE1:

```bash
Router# trace 10.5.5.5
```

Verify that CSC-PE router prefixes are in the MPLS forwarding table:

```bash
Router# show mpls forwarding-table
```

Check the status of LDP discovery processes in the core:

```bash
Router# show mpls ldp discovery
```

Check the status of LDP sessions in the core:

```bash
Router# show mpls ldp neighbor
```
Peer LDP Ident: dd.dd.dd.dd:1; Local LDP Ident ee.ee.ee.ee:1
TCP connection: dd.dd.dd.dd.646 - ee.ee.ee.ee.11007
State: Oper;.Msgs sent/rcvd: 20/21; Downstream on demand
Up time: 00:14:56
LDP discovery sources:
ATM2/1/0.1, Src IP addr: dd.dd.dd.dd

Check the forwarding table (prefixes, next-hops, and interfaces):

```
Router# show ip cef
Prefix       Next Hop       Interface
0.0.0.0/0     drop          Null0 (default route handler entry)
0.0.0.0/32    receive       
dd.dd.dd.dd/32 dd.dd.dd.dd   ATM2/1/0.1
ee.ee.ee.ee/32 receive       
224.0.0.0/4    drop          
224.0.0.0/24    receive       
255.255.255.255/32 receive
```

Also see the Verifying Labels in the CSC-CE Routers Examples, on page 237.

Verify that interfaces are configured to use LDP:

```
Router# show mpls interfaces
Interface IP Tunnel Operational
Ethernet0/1 Yes (ldp) No Yes
```

Display the entire routing table, including host IP address, next hop, interface, and so forth:

```
Router# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
Gateway of last resort is not set
dd.0.0.0/32 is subnetted, 1 subnets
O  dd.dd.dd.dd [110/7] via dd.dd.dd.dd, 00:16:42, ATM2/1/0.1
O  ee.ee.ee.ee is directly connected, Loopback0
```

### Configuring VRFs for CSC-PE Routers Example

The following example shows how to configure a VPN routing and forwarding (VRF) instance for a CSC-PE router:

```
ip cef distributed
ip vrf vpn1
rd 100:1
route target both 100:1
```

### Configuring Multiprotocol BGP for VPN Connectivity in the Backbone Carrier Example

The following example shows how to configure Multiprotocol BGP (MP-BGP) for VPN connectivity in the backbone carrier:

```
ip cef distributed
ip vrf vpn1
rd 100:1
```
route target both 100:1
hostname csc-pe1
!
router bgp 100
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  timers bgp 10 30
  neighbor ee.ee.ee.ee remote-as 100
  neighbor ee.ee.ee.ee update-source Loopback0
  no auto-summary
  !
  address-family vpnv4
  neighbor ee.ee.ee.ee activate
  neighbor ee.ee.ee.ee send-community extended
  bgp dampening 30
  exit-address-family
  !
router bgp 100
  !
  ! (BGP IPv4 to CSC-CE router from CSC-PE router)
  !
  address-family ipv4 vrf vpn1
  neighbor ss.0.0.2 remote-as 200
  neighbor ss.0.0.2 activate
  neighbor ss.0.0.2 as-override
  neighbor ss.0.0.2 advertisement-interval 5
  neighbor ss.0.0.2 send-label
  no auto-summary
  no synchronization
  bgp dampening 30
  exit-address-family

Configuring the Links Between CSC-PE and CSC-CE Routers Examples

This section contains the following examples:

Configuring the CSC-PE Routers Examples

The following example shows how to configure a CSC-PE router:

ip cef
!
ip vrf vpn1
  rd 100:1
  route-target export 100:1
  route-target import 100:1
mpls label protocol ldp
!
interface Loopback0
  ip address dd.dd.dd.dd 255.255.255.255
!
interface Ethernet3/1
  ip vrf forwarding vpn1
  ip address pp.0.0.2 255.0.0.0
!
interface ATM0/1/0
  no ip address
  no ip directed-broadcast
  no ip route-cache distributed
  atm clock INTERNAL
  no atm enable-ilmi-trap
  no atm ilmi-keepalive
!
interface ATM0/1/0.1 mpls
  ip unnumbered Loopback0
  no ip directed-broadcast
Configuring the CSC-CE Routers Examples

The following example shows how to configure a CSC-CE router:

```conf
no atm enable-imi-trap
mpls label protocol ldp
mpls atm vpi 2-5
mpls ip
!
router ospf 100
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  passive-interface Ethernet3/1
  network dd.dd.dd.dd 0.0.0.0 area 100
!
router bgp 100
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  timers bgp 10 30
  neighbor ee.ee.ee.ee remote-as 100
  neighbor ee.ee.ee.ee update-source Loopback0
!
address-family vpnv4
  !VPNv4 session with CSC-PE2
  neighbor ee.ee.ee.ee activate
  neighbor ee.ee.ee.ee send-community extended
  bgp dampening 30
  exit-address-family
!
address-family ipv4 vrf vpn1
  neighbor pp.0.0.1 remote-as 200
  neighbor pp.0.0.1 activate
  neighbor pp.0.0.1 as-override
  neighbor pp.0.0.1 advertisement-interval 5
  neighbor pp.0.0.1 send-label
  no auto-summary
  no synchronization
  bgp dampening 30
  exit-address-family
```

Configuring the CSC-CE Routers Examples

The following example shows how to configure a CSC-CE router:

```conf
ip cef
!
mpls label protocol ldp
!
interface Loopback0
  ip address cc.cc.cc.cc 255.255.255.255
!
interface Ethernet3/0
  ip address pp.0.0.1 255.0.0.0
!
interface Ethernet4/0
  ip address nn.0.0.2 255.0.0.0
  no ip directed-broadcast
  no ip mrouting
  mpls label protocol ldp
  mpls ip
!
router ospf 200
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets !Exchange routes
  redistribute bgp 200 metric 3 subnets !learned from PE1
  passive-interface ATM1/0
  passive-interface Ethernet3/0
  network cc.cc.cc.cc 0.0.0.0 area 200
  network nn.0.0.0 0.255.255.255 area 200
!
router bgp 200
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
```
timers bgp 10 30
neighbor pp.0.0.2 remote-as 100
neighbor pp.0.0.2 update-source Ethernet3/0
no auto-summary

address-family ipv4
  redistribute connected
  redistribute ospf 200 metric 4 match internal
  neighbor pp.0.0.2 activate
  neighbor pp.0.0.2 send-label
  no auto-summary
  no synchronization
  bgp dampening 30
exit-address-family

Verifying Labels in the CSC-PE Routers Examples

The following examples show how to verify the configurations of the CSC-PE routers.

Verify that the BGP session is up and running between the CSC-PE router and the CSC-CE router. Check the data in the State/PfxRcd column to verify that prefixes are learned during each session.

Router# show ip bgp vpnv4 all summary
BBGP router identifier 10.5.5.5, local AS number 100
BGP table version is 52, main routing table version 52
12 network entries and 13 paths using 2232 bytes of memory
6 BGP path attribute entries using 336 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
1 BGP extended community entries using 24 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
Dampening enabled. 0 history paths, 0 dampened paths
BGP activity 16/4 prefixes, 27/14 paths, scan interval 5 secs
Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd
10.5.5.5 4 100 7685 7686 52 0 0 21:17:04 6
10.0.0.2 4 200 7676 7678 52 0 0 21:16:43 7

Verify that the MPLS interfaces are up and running, and that LDP-enabled interfaces show that LDP is up and running. LDP is turned off on the VRF because EBGP distributes the labels.

Router# show mpls interfaces all
Interface IP Tunnel Operational
GigabitEthernet6/0 Yes (ldp) No Yes
VRF vpn1:
Ethernet3/1 No No Yes

Verify that the prefix for the local PE router is in the routing table of the CSC-PE router:

Router# show ip route vrf vpn2 10.5.5.5
Routing entry for 10.5.5.5/32
  Known via "bgp 100", distance 20, metric 4
  Tag 200, type external
  Last update from pp.0.0.2 21:28:39 ago
Routing Descriptor Blocks:
  * pp.0.0.2, from pp.0.0.2, 21:28:39 ago
    Route metric is 4, traffic share count is 1
AS Hops 1, BGP network version 0

Verify that the prefix for the remote PE router is in the routing table of the CSC-PE router:

Router# show ip route vrf vpn2 10.5.5.5
Routing entry for 10.5.5.5/32
  Known via "bgp 100", distance 200, metric 4
  Tag 200, type internal
  Last update from 10.1.0.0 21:27:39 ago
Routing Descriptor Blocks:
  * 10.1.0.0 (Default-IP-Routing-Table), from 10.1.0.0, 21:27:39 ago
    Route metric is 4, traffic share count is 1
AS Hops 1, BGP network version 0
Verify that the prefixes for the customer carrier MPLS VPN service provider networks are in the BGP table, and have appropriate labels:

```
Router# show ip bgp vpnv4 vrf vpn2 labels

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
<th>In label/Out label</th>
</tr>
</thead>
<tbody>
<tr>
<td>cc.cc.cc.cc/32</td>
<td>pp.0.0.2</td>
<td>22/imp-null</td>
</tr>
<tr>
<td>bb.bb.bb.bb/32</td>
<td>pp.0.0.2</td>
<td>27/20</td>
</tr>
<tr>
<td>hh.hh.hh.hh/32</td>
<td>ee.ee.ee.ee</td>
<td>34/35</td>
</tr>
<tr>
<td>gg.gg.gg.gg/32</td>
<td>ee.ee.ee.ee</td>
<td>30/30</td>
</tr>
<tr>
<td>nn.0.0.0</td>
<td>pp.0.0.2</td>
<td>23/imp-null</td>
</tr>
<tr>
<td>ss.0.0.0</td>
<td>ee.ee.ee.ee</td>
<td>33/34</td>
</tr>
<tr>
<td>pp.0.0.0</td>
<td>pp.0.0.2</td>
<td>25/aggregate(vpn1)</td>
</tr>
</tbody>
</table>
```

Verify that the prefix of the PE router in the local customer carrier MPLS VPN service provider is in the Cisco Express Forwarding table:

```
Router# show ip cef vrf vpn2 10.1.0.0
10.1.0.0/32, version 19, cached adjacency pp.0.0.2
0 packets, 0 bytes
tag information set
  local tag: 27
  fast tag rewrite with Et3/1, pp.0.0.2, tags imposed {20}
  via pp.0.0.2, 0 dependencies, recursive
    next hop pp.0.0.2, Ethernet3/1 via pp.0.0.2/32
    valid cached adjacency
    tag rewrite with Et3/1, pp.0.0.2, tags imposed {20}

Router# show ip cef vrf vpn2 10.1.0.0 detail
10.1.0.0/32, version 19, cached adjacency pp.0.0.2
0 packets, 0 bytes
tag information set
  local tag: 27
  fast tag rewrite with Et3/1, pp.0.0.2, tags imposed {20}
  via pp.0.0.2, 0 dependencies, recursive
    next hop pp.0.0.2, Ethernet3/1 via pp.0.0.2/32
    valid cached adjacency
    tag rewrite with Et3/1, pp.0.0.2, tags imposed {20}
```

Verify that the prefix of the PE router in the remote customer carrier MPLS VPN service provider is in the Cisco Express Forwarding table:

```
Router# show ip cef vrf vpn2 10.3.0.0
10.3.0.0/32, version 25, cached adjacency rr.0.0.2
0 packets, 0 bytes
tag information set
  local tag: 34
  fast tag rewrite with Gi6/0, rr.0.0.2, tags imposed {35}
  via ee.ee.ee.ee, 0 dependencies, recursive
    next hop rr.0.0.2, GigabitEthernet6/0 via ee.ee.ee.ee/32
    valid cached adjacency
```
tag rewrite with Gi6/0, rr.0.0.2, tags imposed {35}

Router# show ip cef vrf vpn2 10.3.0.0 detail
hh.hh.hh.hh/32, version 25, cached adjacency rr.0.0.2
0 packets, 0 bytes
  tag information set
    local tag: 34
    fast tag rewrite with Gi6/0, rr.0.0.2, tags imposed {35}
    via ee.ee.ee.ee, 0 dependencies, recursive
    next hop rr.0.0.2, GigabitEthernet6/0 via ee.ee.ee.ee/32
    valid cached adjacency
  tag rewrite with Gi6/0, rr.0.0.2, tags imposed {35}

Verify that the prefix of the PE router in the remote customer carrier MPLS VPN service provider is in the MPLS forwarding table:

Router# show mpls forwarding-table vrf vpn2 10.3.0.0
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
34 35 hh.hh.hh.hh/32 [V] 139034 Gi6/0 rr.0.0.2

Verifying Labels in the CSC-CE Routers Examples

The following examples show how to verify the configurations of the CSC-CE routers.

Verify that the BGP session is up and running:

Router# show ip bgp summary
BGP router identifier cc.cc.cc.cc, local AS number 200
BGP table version is 35, main routing table version 35
14 network entries and 14 paths using 2030 bytes of memory
3 BGP path attribute entries using 168 bytes of memory
1 BGP AS-PATH entries using 24 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
Dampening enabled. 1 history paths, 0 dampened paths
BGP activity 17/67 prefixes, 29/15 paths, scan interval 60 secs
Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd
pp.0.0.1 4 100 7615 7613 35 0 0 21:06:19 5

Verify that the loopback address of the local PE router is in the routing table:

Router# show ip route 10.1.0.0
Routing entry for 10.1.0.0/32
  Known via "ospf 200", distance 110, metric 101, type intra area
  Redistributing via bgp 200
  Advertised by bgp 200 metric 4 match internal
  Last update from nn.0.0.1 on Ethernet4/0, 00:34:08 ago
  Routing Descriptor Blocks:
  * nn.0.0.1, from bb.b.b.b.b, 00:34:08 ago, via Ethernet4/0
  Route metric is 101, traffic share count is 1

Verify that the loopback address of the remote PE router is in the routing table:

Router# show ip route 10.5.5.5
Routing entry for 10.5.5.5/32
  Known via "bgp 200", distance 20, metric 0
  Tag 100, type external
  Redistributing via ospf 200
Advertised by ospf 200 metric 3 subnets
Last update from pp.0.0.1 00:45:16 ago
Routing Descriptor Blocks:
  * pp.0.0.1, from pp.0.0.1, 00:45:16 ago
  Route metric is 0, traffic share count is 1
AS Hops 2, BGP network version 0

Verify that the prefix of the local PE router is in the MPLS LDP bindings:

Router# show mpls ldp bindings 10.1.0.0 255.255.255.255
tib entry: 10.1.0.0/32, rev 20
  local binding: tag: 20
  remote binding: tsr: 10.1.0.0:0, tag: imp-null

Verify that the prefix of the local PE router is in the Cisco Express Forwarding table:

Router# show ip cef 10.1.0.0
10.1.0.0/32, version 46, cached adjacency nn.0.0.1
0 packets, 0 bytes
tag information set
  local tag: 20
  via nn.0.0.1, Ethernet4/0, 0 dependencies
  next hop nn.0.0.1, Ethernet4/0
  unresolved
  valid cached adjacency
tag rewrite with Et4/0, nn.0.0.1, tags imposed {}

Verify that the prefix of the local PE router is in the MPLS forwarding table:

Router# show mpls forwarding-table 10.1.0.0
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
20 Pop tag bb.bb.bb.bb/32 893397 Et4/0 nn.0.0.1

Router# show mpls forwarding-table 10.1.0.0 detail
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
20 Pop tag bb.bb.bb.bb/32 893524 Et4/0 nn.0.0.1
  MAC/Encaps=14/14, MTU=1504, Tag Stack{}
  00074F83685400B04A74A0708847
  No output feature configured
  Per-packet load-sharing, slots: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Verify that the BGP routing table contains labels for prefixes in the customer carrier MPLS VPN service provider networks:

Router# show ip bgp labels
Network Next Hop In Label/Out Label
cc.cc.cc.cc/32 0.0.0.0 imp-null/exp-null
bb.bb.bb.bb/32 nn.0.0.1 20/exp-null
hh.hh.hh.hh/32 pp.0.0.1 26/34
gg.gg.gg.gg/32 pp.0.0.1 23/30
nn.0.0.0 0.0.0.0 imp-null/exp-null
ss.0.0.0 pp.0.0.1 25/33
pp.0.0.0 0.0.0.0 imp-null/exp-null
pp.0.0.1/32 0.0.0.0 16/exp-null

Verify that the prefix of the remote PE router is in the Cisco Express Forwarding table:

Router# show ip cef 10.5.5.5
10.5.5.5/32, version 54, cached adjacency pp.0.0.1
0 packets, 0 bytes
tag information set
  local tag: 26
    fast tag rewrite with Et3/0, pp.0.0.1, tags imposed {34}
    via pp.0.0.1, 0 dependencies, recursive
    next hop pp.0.0.1, Ethernet3/0 via pp.0.0.1/32
    valid cached adjacency
tag rewrite with Et3/0, pp.0.0.1, tags imposed {34}
Verify that the prefix of the remote PE router is in the MPLS forwarding table:

```
Router# show mpls forwarding-table 10.5.5.5
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag or VC or Tunnel Id switched interface
26 34 hh.hh.hh.hh/32 81786 Et3/0 pp.0.0.1
```

```
Router# show mpls forwarding-table 10.5.5.5 detail
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag or VC or Tunnel Id switched interface
26 34 hh.hh.hh.hh/32 81863 Et3/0 pp.0.0.1
MAC/Encaps=14/18, MTU=1500, Tag Stack{34}
00B0C26E105500B04A74A0548847 00022000
No output feature configured
Per-packet load-sharing, slots: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
```

### Configuring the Customer Carrier Network Examples

Customer carrier configuration and verification examples in this section include:

#### Verifying IP Connectivity in the Customer Carrier Example

Verify the connectivity from one customer carrier core router to another (from CE1 to CE2) by entering the following command:

```
Router# ping 10.2.0.0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to jj.jj.jj.jj, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/9/12 ms
```

Verify the path that a packet goes through on its way to its final destination from CE1 to CE2:

```
Router# trace 10.2.0.0
Type escape sequence to abort.
Tracing the route to 10.2.0.0
  1 mm.0.0.2 0 msec 0 msec 4 msec
  2 nn.0.0.2 [MPLS: Labels 20/21 Exp 0] 8 msec 8 msec 12 msec
  3 pp.0.0.2 [MPLS: Labels 28/21 Exp 0] 8 msec 8 msec 12 msec
  4 ss.0.0.1 [MPLS: Labels 17/21 Exp 0] 8 msec 8 msec 12 msec
  5 ss.0.0.2 [MPLS: Labels 16/21 Exp 0] 8 msec 8 msec 12 msec
  6 tt.0.0.1 [AS 200] [MPLS: Label 21 Exp 0] 8 msec 0 msec 8 msec
     7 tt.0.0.2 [AS 200] 8 msec 4 msec *
```

Verify the path that a packet goes through on its way to its final destination from CE2 to CE1:

```
Router# trace 10.1.0.0
Type escape sequence to abort.
Tracing the route to 10.1.0.0
  1 tt.0.0.1 0 msec 0 msec 0 msec
  2 qq.0.0.2 [MPLS: Labels 18/21 Exp 0] 8 msec 12 msec 12 msec
  3 ss.0.0.1 [MPLS: Labels 28/21 Exp 0] 8 msec 8 msec 8 msec
  4 pp.0.0.2 [MPLS: Labels 17/21 Exp 0] 12 msec 8 msec 8 msec
  5 pp.0.0.1 [MPLS: Labels 16/21 Exp 0] 12 msec 12 msec 8 msec
  6 mm.0.0.2 [AS 200] [MPLS: Label 21 Exp 0] 12 msec 8 msec 12 msec
     7 mm.0.0.1 [AS 200] 4 msec 4 msec *
```
Configuring a Customer Carrier Core Router as a Route Reflector Example

The following example shows how to use an address family to configure internal BGP peer 10.1.1.1 as a route-reflector client for both unicast and multicast prefixes:

```
router bgp 200
  address-family vpnv4
  neighbor 10.1.1.1 activate
  neighbor 10.1.1.1 route-reflector-client

router bgp 100
  address-family vpnv4
  neighbor xx.xx.xx.xx activate
  neighbor xx.xx.xx.xx route-reflector-client
  ! xx.xx.xx.xx is a PE router
  neighbor xx.xx.xx.xx send-community extended
  exit address-family
  ! You need to configure your peer BGP neighbor.
```

Configuring the Customer Site for Hierarchical VPNs Examples

This section contains the following configuration and verification examples for the customer site:

Configuring PE Routers for Hierarchical VPNs Examples

This example shows how to configure a PE router:

```
ip cef
ip vrf vpn2
  rd 200:1
  route-target export 200:1
  route-target import 200:1
mpls label protocol ldp
  ! interface Loopback0
  ip address bb.bb.bb.bb 255.255.255.255
  ! interface Ethernet3/0
  ip address nn.0.0.1 255.0.0.0
  no ip directed-broadcast
  no ip mroute-cache
  mpls label protocol ldp
  mpls ip
  ! interface Ethernet3/3
  ip vrf forwarding vpn2
  ip address mm.0.0.2 255.0.0.0
  no ip directed-broadcast
  no ip mroute-cache
  ! router ospf 200
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  passive-interface Ethernet3/3
  network bb.bb.bb.bb 0.0.0.0 area 200
  network nn.0.0.0 0.255.255.255 area 200
  ! router bgp 200
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  timers bgp 10 30
```
Verifying Labels in Each PE Router for Hierarchical VPNs Examples

The following examples show how to verify the configuration of PE router in hierarchical VPNs.

Verify that the loopback address of the local CE router is in the routing table of the PE1 router:

```
Router# show ip route vrf vpn2 10.2.2.2
Routing entry for 10.2.2.2/32
Known via "bgp 200", distance 20, metric 0
Last update from mm.0.0.2 20:36:59 ago
Routing Descriptor Blocks:
  * mm.0.0.2, from mm.0.0.2, 20:36:59 ago
Route metric is 0, traffic share count is 1
AS Hops 1, BGP network version 0
```

Verify that the prefix for the local CE router is in the MPLS forwarding table, and that the prefix is untagged:

```
Router# show mpls forwarding-table vrf vpn2 10.2.2.2
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
23 Untagged aa.aa.aa.aa/32[V] 0 Et3/3 mm.0.0.2
```

Verify that the prefix of the remote PE router is in the Cisco Express Forwarding table:

```
Router# show ip cef 10.5.5.5
10.5.5.5/32, version 31, cached adjacency nn.0.0.2
0 packets, 0 bytes
local tag: 31
fast tag rewrite with Et3/0, nn.0.0.2, tags imposed {26}
via nn.0.0.2, Ethernet3/0, 2 dependencies
next hop nn.0.0.2, Ethernet3/0
unresolved
valid cached adjacency
tag rewrite with Et3/0, nn.0.0.2, tags imposed {26}
```

Verify that the loopback address of the remote CE router is in the routing table:

```
Router# show ip route vrf vpn2 10.2.0.0
Routing entry for 10.2.0.0/32
Known via "bgp 200", distance 200, metric 0
Last update from hh.hh.hh.hh 20:38:49 ago
Routing Descriptor Blocks:
  * hh.hh.hh.hh (Default-IP-Routing-Table), from hh.hh.hh.hh, 20:38:49 ago
Route metric is 0, traffic share count is 1
AS Hops 1, BGP network version 0
```
Verify that the prefix of the remote CE router is in the MPLS forwarding table, and that an outgoing interface exists:

```
Router# show mpls forwarding-table vrf vpn2 10.2.0.0
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag or VC or Tunnel Id switched interface
None 26 jj.jj.jj.jj/32 0 Et3/0 nn.0.0.2
```

Verify that the prefix of the remote CE router is in the Cisco Express Forwarding table:

```
Router# show ip cef vrf vpn2 10.2.0.0
10.2.0.0/32, version 12, cached adjacency nn.0.0.2
0 packets, 0 bytes
tag information set
  local tag: VPN route head
    fast tag rewrite with Et3/0, nn.0.0.2, tags imposed {26 32}
    via hh.hh.hh.hh, 0 dependencies, recursive
    next hop nn.0.0.2, Ethernet3/0 via hh.hh.hh.hh/32
    valid cached adjacency
    tag rewrite with Et3/0, nn.0.0.2, tags imposed {26 32}
```

Verify that the prefix of the local PE router is in the Cisco Express Forwarding table:

```
Router# show ip cef 10.1.0.0
10.1.0.0/32, version 9, connected, receive
  tag information set
    local tag: implicit-null
```

### Configuring CE Routers for Hierarchical VPNs Examples

The following example shows how to configure a CE router:

```conf
ip cef distributed
interface Loopback0
  ip address 10.3.0.0 255.255.255.255
interface FastEthernet0/3/3
  ip address mm.0.0.1 255.0.0.0
router bgp 300
  no synchronization
  bgp log-neighbor-changes
timers bgp 10 30
  redistribute connected !Redistributing routes into BGP
neighbor mm.0.0.2 remote-as 200 !to send to PE1
neighbor mm.0.0.2 advertisement-interval 5
  no auto-summary
```

### Verifying IP Connectivity in the Customer Site Examples

The following examples show how to verify IP connectivity at the customer site.

Verify that the loopback address of the remote CE router, learned from the PE router, is in the routing table of the local router:

```
Router# show ip route 10.2.0.0
Routing entry for 10.2.0.0/32
  Known via "bgp 300", distance 20, metric 0
  Tag 200, type external
  Redistributing via ospf 300
  Advertised by ospf 300 subnets
  Last update from mm.0.0.1 20:29:35 ago
  Routing Descriptor Blocks:
    * mm.0.0.1, from mm.0.0.1, 20:29:35 ago
```
## Additional References

### Related Documents

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<tr>
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<th>Document Title</th>
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</tr>
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<td>MPLS</td>
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### Standards

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<th>Standard</th>
<th>Title</th>
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<tr>
<td></td>
<td>No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.</td>
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### MIBs

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<th>MIB</th>
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<td></td>
<td>To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
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### RFCs

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<tr>
<td>RFC 1164</td>
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<td>RFC 1171</td>
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<td>RFC 1700</td>
<td>Assigned Numbers</td>
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<td>RFC 1966</td>
<td>BGP Route Reflection: An Alternative to Full Mesh IBGP</td>
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<td>RFC 2283</td>
<td>Multiprotocol Extensions for BGP-4</td>
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### RFC

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<th>RFC</th>
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<tr>
<td>RFC 2547</td>
<td>BGP/MPLS VPNs</td>
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<td>RFC 2858</td>
<td>Multiprotocol Extensions for BGP-4</td>
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<tr>
<td>RFC 3107</td>
<td>Carrying Label Information in BGP-4</td>
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</tbody>
</table>

### Technical Assistance

**Description**

The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.

To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.

Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.

**Link**

http://www.cisco.com/techsupport

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**Feature Information for MPLS VPN CSC with BGP**

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.
### Table 11: Feature Information for MPLS VPN CSC with BGP

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
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<tr>
<td>MPLS VPN--Carrier Supporting Carrier--IPv4 BGP Label Distribution</td>
<td>12.0(21)ST, 12.0(22)S, 12.0(23)S, 12.2(13)T, 12.0(24)S, 12.2(14)S, 12.0(27)S, 12.0(29)S, Cisco IOS XE Release 2.2</td>
<td>This feature enables you to create an MPLS VPN CSC network that uses BGP to transport routes and MPLS labels. In 12.0(21)ST, this feature was introduced. In 12.0(22)S, this feature was integrated. In 12.0(23)S, this feature was integrated. In 12.2(13)T, this feature was integrated. In 12.0(24)S, this feature was integrated. In 12.2(14)S, this feature was integrated. In 12.0(27)S, this feature was integrated. In 12.0(29)S, this feature was integrated. In Cisco IOS XE Release 2.2, this feature was implemented on the Cisco ASR 1000 Series Routers. This feature uses no new or modified commands.</td>
</tr>
</tbody>
</table>

### Glossary

**ASBR** -- Autonomous System Boundary router. A router that connects one autonomous system to another.

**autonomous system** -- A collection of networks under a common administration sharing a common routing strategy.

**BGP** -- Border Gateway Protocol. An interdomain routing protocol that exchanges network reachability information with other BGP systems (which may be within the same autonomous system or between multiple autonomous systems).

**CE router** -- customer edge router. A router that is part of a customer network and that interfaces to a provider edge (PE) router. CE routers do not recognize associated MPLS VPNs.

**CSC** -- Carrier Supporting Carrier. A hierarchical VPN model that allows small service providers, or customer carriers, to interconnect their IP or MPLS networks over an MPLS backbone. This eliminates the need for customer carriers to build and maintain their own MPLS backbone.
eBGP -- external Border Gateway Protocol. A BGP between routers located within different autonomous systems. When two routers, located in different autonomous systems, are more than one hop away from one another, the eBGP session between the two routers is considered a multihop BGP.

data router -- A router that is at the edge of the network. It defines the boundary of the MPLS network. It receives and transmits packets. Also referred to as edge label switch router and label edge router.

iBGP -- internal Border Gateway Protocol. A BGP between routers within the same autonomous system.

IGP -- Interior Gateway Protocol. Internet protocol used to exchange routing information within a single autonomous system. Examples of common Internet IGP protocols include IGRP, OSPF, IS-IS, and RIP.


LDP -- Label Distribution Protocol. A standard protocol between MPLS-enabled routers to negotiate the labels (addresses) used to forward packets.

LFIB -- Label Forwarding Information Base. Data structure used in MPLS to hold information about incoming and outgoing labels and associated Forwarding Equivalence Class (FEC) packets.

MP-BGP -- Multiprotocol BGP.

MPLS -- Multiprotocol Label Switching. The name of the IETF working group responsible for label switching, and the name of the label switching approach it has standardized.

NLRI -- Network Layer Reachability Information. The BGP sends routing update messages containing NLRI to describe a route and how to get there. In this context, an NLRI is a prefix. A BGP update message carries one or more NLRI prefixes and the attributes of a route for the NLRI prefixes; the route attributes include a BGP next hop gateway address and extended community values.

NSF -- Nonstop forwarding enables routers to continuously forward IP packets following a Route Processor takeover or switchover to another Route Processor. NSF maintains and updates Layer 3 routing and forwarding information in the backup Route Processor to ensure that IP packets and routing protocol information are forwarded continuously during the switchover and route convergence process.

PE router -- provider edge router. A router that is part of a service provider’s network. It is connected to a customer edge (CE) router. All MPLS VPN processing occurs in the PE router.

QoS -- quality of service. Measure of performance for a transmission system that indicates its transmission quality and service availability.

RD -- route distinguisher. An 8-byte value that is concatenated with an IPv4 prefix to create a unique VPN-IPv4 prefix.

RT -- route target. Extended community attribute used to identify the VRF routing table into which a prefix is imported.

SLA -- Service Level Agreement given to VPN subscribers.

VPN -- Virtual Private Network. A secure MPLS-based network that shares resources on one or more physical networks (typically implemented by one or more service providers). A VPN contains geographically dispersed sites that can communicate securely over a shared backbone network.

VRF -- VPN routing and forwarding instance. Routing information that defines a VPN site that is attached to a PE router. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table.
CHAPTER 7

MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs

The MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs feature allows MPLS VPN interautonomous (Inter-AS) and MPLS VPN Carrier Supporting Carrier (CSC) networks to load share traffic between adjacent label switch routers (LSRs) that are connected by multiple links. The LSRs can be a pair of Autonomous System Boundary Routers (ASBRs) or a CSC-provider edge (PE) and a CSC-customer edge (CE) device. Using directly connected loopback peering allows load sharing at the Interior Gateway Protocol (IGP) level so only one Border Gateway Protocol (BGP) session is needed between the LSRs. No other label distribution mechanism is needed between the adjacent LSRs except BGP.

- Finding Feature Information, page 247
- Prerequisites for MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs, page 248
- Restrictions for MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs, page 248
- Information About MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs, page 250
- How to Configure MPLS VPN Load Balancing Support for Inter-AS and CSC VPN, page 251
- Configuration Examples for MPLS VPN Load Balancing Support for Inter-AS and CSC VPN, page 281
- Additional References, page 282
- Feature Information for MPLS VPN Load Balancing Support for Inter-AS and CSC VPN, page 283

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
Prerequisites for MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs

Ensure that your Multiprotocol Label Switching (MPLS) virtual private network (VPN) network, including MPLS VPN interautonomous system (Inter-AS) or Carrier Supporting Carrier (CSC), is configured and working properly.

Restrictions for MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs

Load sharing using directly connected loopback peering does not apply to Carrier Supported Carrier (CSC) networks that use the Label Distribution Protocol (LDP) and an Interior Gateway Protocol (IGP) to distribute routes and Multiprotocol Label Switching (MPLS) labels.

The software does not support load balancing in interautonomous system (Inter-AS) and CSC when there are multiple links between provider edge (PE) or Autonomous System Boundary Router (ASBR) devices.

When you configure static routes in an MPLS or MPLS virtual private network (VPN) environment, some variations of the `ip route` and `ip route vrf` commands are not supported. These variations of the commands are not supported in Cisco software releases that support the Tag Forwarding Information Base (TFIB). The TFIB cannot resolve prefixes when the recursive route over which the prefixes travel disappears and then reappears. However, the command variations are supported in Cisco software releases that support the MPLS Forwarding Infrastructure (MFI). 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 VPN 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` command is not supported when you configure static routes in an MPLS VPN 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` and `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 associated with the same virtual routing and forwarding (VRF) instance:

• `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 global` (This command is supported when the next hop and the 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 interfaces:

• `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`
• `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.

\[
\textit{ip route vrf vrf-name destination-prefix mask interface next-hop-address}
\]

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 interfaces:

\[
\begin{align*}
\textit{ip route} & \textit{destination-prefix mask interface1 nexthop1} \\
\textit{ip route} & \textit{destination-prefix mask interface2 nexthop2}
\end{align*}
\]

Information About MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs

Load Sharing Using Directly Connected Loopback Peering

You use the MPLS VPN Load Balancing Support for Inter-AS and CSC VPN feature to load share traffic between adjacent label switched routers (LSRs) that are connected by multiple links. The LSRs could be a pair of Autonomous System Boundary Routers (ASBRs) or a carrier supporting carrier provider edge (CSC-PE) and a CSC-customer edge (CE).

Using directly connected loopback peering allows load sharing at the Interior Gateway Protocol (IGP) level so only one Border Gateway Protocol (BGP) session is needed between the LSRs. No other label distribution mechanism is needed between the adjacent LSRs except BGP.

Directly connected loopback peering enables load sharing of traffic as follows:

\[
\begin{align*}
\text{A BGP session is established, using the loopback addresses of the LSRs.} \\
\text{Multiprotocol Label Switching (MPLS) is enabled on the connecting links.} \\
\text{Multiple static routes to the loopback address of the adjacent LSR allow IGP load sharing.} \\
\text{The outgoing label to the loopback address of the adjacent LSR is an implicit null label and is inferred by the LSR.} \\
\text{Because IGP load sharing is enabled on the loopback address of the adjacent LSR, any traffic destined to a prefix that is learned over the BGP session (and recurses over the loopback) is load shared.}
\end{align*}
\]

Information About MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs
How to Configure MPLS VPN Load Balancing Support for Inter-AS and CSC VPN

Configuring Directly Connected Loopback Peering for MPLS VPN Inter-AS using ASBRs to Exchange VPN-IPv4 Addresses

This section describes the following tasks you need to do to configure peering of loopback interfaces of directly connected Autonomous System Boundary Routers (ASBRs):

The figure below shows the loopback configuration for directly connected ASBR1 and ASBR2. This configuration is used as the example in the tasks that follow.

![Figure 27: Loopback Interface Configuration for Directly Connected ASBR1 and ASBR2](image)

Configuring Loopback Interface Addresses for Directly Connected ASBRs

Perform this task to configure loopback interface addresses for directly connected Autonomous System Boundary Routers (ASBRs).

Note

Loopback addresses need to be configured for each directly connected ASBR. That is, configure a loopback address for ASBR1 and for ASBR2 in the example shown in the figure above.

SUMMARY STEPS

1. enable
2. configure terminal
3. interface loopback interface-number
4. ip address ip-address mask [secondary]
5. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step 2</th>
<th>configure terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Device# configure terminal</td>
</tr>
</tbody>
</table>

### Purpose

- Enters global configuration mode.

### Step 3

**interface loopback** *interface-number*

| Example: | Device(config)# interface loopback 0 |

### Purpose

- Configures a software-only virtual interface that emulates an interface that is always up and enters interface configuration mode.
  - The *interface-number* argument is the number of the loopback interface that you want to create or configure. There is no limit on the number of loopback interfaces that you can create.

### Step 4

**ip address** *ip-address* *mask* [*secondary*]

| Example: | Device(config-if)# ip address 10.10.10.10 255.255.255.255 |

### Purpose

- Sets a primary or secondary IP address for an interface.
  - The *ip-address* argument is the IP address.
  - The *mask* argument is the mask for the associated IP subnet.
  - The *secondary* keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.

### Step 5

**end**

| Example: | Device(config-if)# end |

### Purpose

- Exits to privileged EXEC mode.

---

### Configuring /32 Static Routes to the eBGP Neighbor Loopback

Perform this task to configure /32 static routes to the external Border Gateway Protocol (eBGP) neighbor loopback.

---

**Note**

You need to configure /32 static routes on each of the directly connected ASBRs.
### SUMMARY STEPS

1. enable
2. configure terminal
3. ip route prefix mask {ip-address | interface-type interface-number [ip-address]} [distance] [name] [permanent] [tag tag]
4. end

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> ip route prefix mask {ip-address</td>
<td>interface-type interface-number [ip-address]} [distance] [name] [permanent] [tag tag]</td>
</tr>
<tr>
<td>Example: Device(config)# ip route 10.20.20.20 255.255.255.255 Ethernet 1/0 172.16.0.1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> end</td>
<td>Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device(config)# end</td>
<td></td>
</tr>
</tbody>
</table>
Configuring Forwarding on Connecting Loopback Interfaces

Perform this task to configure forwarding on the connecting loopback interfaces.

This task is required for sessions between loopbacks. In the "Configuring /32 Static Routes to the eBGP Neighbor Loopback" section, Ethernet 1/0 and Ethernet 0/0 are the connecting interfaces.

SUMMARY STEPS

1. enable
2. configure terminal
3. interface type slot/port
4. mpls bgp forwarding
5. exit
6. Repeat Steps 3 and 4 for another connecting interface (Ethernet 0/0).
7. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>interface type slot/port</td>
<td>Configures an interface type and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td>• The type argument is the type of interface to be configured.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The slot argument is the slot number. Refer to the appropriate hardware manual for slot and port information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The /port argument is the port number. Refer to the appropriate hardware manual for slot and port information.</td>
</tr>
</tbody>
</table>
Purpose
Command or Action | Purpose |
---|---|
**Step 4** | mpls bgp forwarding | Configures the Border Gateway Protocol (BGP) to enable Multiprotocol Label Switching (MPLS) forwarding on connecting interfaces. |
Example: Device(config-if)# mpls bgp forwarding |
**Step 5** | exit | Exits to global configuration mode. |
Example: Device(config-if)# exit |
**Step 6** | Repeat Steps 3 and 4 for another connecting interface (Ethernet 0/0). |
**Step 7** | end | Exits to privileged EXEC mode. |
Example: Device(config)# end |

### Configuring an eBGP Session Between the Loopbacks

Perform this task to configure an external Border Gateway Protocol (eBGP) session between the loopbacks.

**Note**
You need to configure an eBGP session between loopbacks on each directly connected Autonomous System Boundary Router (ASBR).

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp as-number**
4. **no bgp default route-target filter**
5. **neighbor {ip-address | peer-group-name} remote-as as-number**
6. **neighbor {ip-address | peer-group-name} disable-connected-check**
7. **neighbor {ip-address | ipv6-address | peer-group-name} update-source interface-type interface-number**
8. **address-family vpnv4 [unicast]**
9. **neighbor {ip-address | peer-group-name | ipv6-address} activate**
10. **neighbor {ip-address | peer-group-name} send-community [both | standard extended]**
11. **end**
## DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td>• Enter your password if prompted.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures the BGP routing process.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device(config)# router bgp 200</code></td>
<td>The <em>as-number</em> indicates the number of an autonomous system that identifies the device to other BGP routers and tags the routing information passed along.</td>
</tr>
<tr>
<td><strong>Step 4</strong> no bgp default route-target filter</td>
<td>Disables BGP route-target filtering, and enters router configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device(config)# no bgp default route-target filter</code></td>
<td>All received BGP VPN-IPv4 routes are accepted by the device.</td>
</tr>
<tr>
<td><strong>Step 5</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device(config-router)# neighbor 10.20.20.20 remote-as 100</code></td>
<td>The <em>ip-address</em> argument is the IP address of the neighbor.</td>
</tr>
<tr>
<td>• The <em>peer-group-name</em> argument is the name of a BGP peer group.</td>
<td>The <em>as-number</em> argument is the autonomous system to which the neighbor belongs.</td>
</tr>
<tr>
<td><strong>Step 6</strong> neighbor {ip-address</td>
<td>peer-group-name} disable-connected-check</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device(config-router)# neighbor 10.20.20.20 disable-connected-check</code></td>
<td>The <em>ip-address</em> argument is the IP address of the neighbor.</td>
</tr>
<tr>
<td>• The <em>peer-group-name</em> argument is the name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> neighbor {ip-address</td>
<td>ipv6-address</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><code>Device(config-router)# neighbor 10.20.20.20 update-source Loopback 0</code></td>
<td>The <em>ip-address</em> argument is the IPv4 address of the BGP-speaking neighbor.</td>
</tr>
<tr>
<td>• The <em>ipv6-address</em> argument is the IPv6 address of the BGP-speaking neighbor.</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Purpose</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>This argument must be in the form documented in RFC 2373, where the address is specified in hexadecimal using 16-bit values between colons.</td>
<td></td>
</tr>
<tr>
<td>• The peer-group-name argument is the name of a BGP peer group.</td>
<td></td>
</tr>
<tr>
<td>• The interface-type argument is the interface type.</td>
<td></td>
</tr>
<tr>
<td>• The interface-number argument is the interface number.</td>
<td></td>
</tr>
</tbody>
</table>

### Step 8

**address-family vpng4 [unicast]**

- **Example:**
  
  Device(config-router)# address-family vpng4

### Step 9

**neighbor {ip-address | peer-group-name | ipv6-address} activate**

- **Example:**
  
  Device(config-router-af)# neighbor 10.20.20.20 activate

### Step 10

**neighbor {ip-address | peer-group-name} send-community [both | standard extended]**

- **Example:**
  
  Device(config-router-af)# neighbor 10.20.20.20 send-community extended

### Step 11

**end**

- **Example:**
  
  Device(config)# end
Verifying That Load Sharing Occurs Between Loopbacks

Perform this task to verify that load sharing occurs between loopbacks. You need to ensure that the Multiprotocol Label Switching (MPLS) Label Forwarding Information Base (LFIB) entry for the neighbor route lists the available paths and interfaces.

SUMMARY STEPS

1. enable
2. show mpls forwarding-table {mask | length} | labels label [network label] | interface interface | next-hop address | lsp-tunnel [tunnel-id] | vrf vrf-name | [detail]
3. disable

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | (Optional) Enables privileged EXEC mode.  
  • Enter your password if prompted. |
| Example: Device> enable | |
| **Step 2** show mpls forwarding-table {mask | length} | labels label [network label] | interface interface | next-hop address | lsp-tunnel [tunnel-id] | vrf vrf-name | [detail] | Displays the contents of the MPLS LFIB.  
  • Enter an optional keyword or argument if desired. |
| Example: Device# show mpls forwarding-table | |
| **Step 3** disable | Exits to user EXEC mode. |
| Example: Device# disable | |

Configuring Directly Connected Loopback Peering for MPLS VPN Inter-AS Using ASBRs to Exchange IPv4 Routes and Labels

The following sections describe how to configure peering of loopback interfaces of directly connected Autonomous System Boundary Routers (ASBRs) to achieve load sharing in an interautonomous system network:
The figure below shows the loopback configuration for directly connected ASBR1 and ASBR2. This configuration is used as the example in the tasks that follow.

**Figure 28: Loopback Interface Configuration for Directly Connected ASBR1 and ASBR2**

---

### Configuring Loopback Interface Addresses for Directly Connected ASBRs

**Note**

Loopback addresses need to be configured for each directly connected Autonomous System Boundary Router (ASBR). That is, configure a loopback address for ASBR1 and for ASBR2 as in the example shown in the figure above.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface loopback** `interface number`
4. **ip address** `ip-address [mask [secondary]]`
5. **end**

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface loopback <code>interface number</code></td>
<td>Configures a software-only virtual interface that emulates an interface that is always up and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device(config)# interface loopback 0</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step 4</th>
<th>ip address ip-address [mask [secondary]]</th>
</tr>
</thead>
</table>

**Example:**

Device(config-if)# ip address 10.10.10.10 255.255.255.255

Sets a primary or secondary IP address for an interface.

- The `ip-address` argument is the IP address.
- The `mask` argument is the mask for the associated IP subnet.
- The `secondary` keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.

<table>
<thead>
<tr>
<th>Step 5</th>
<th>end</th>
</tr>
</thead>
</table>

**Example:**

Device(config-if)# end

Exits to privileged EXEC mode.

### Configuring /32 Static Routes to the eBGP Neighbor Loopback

Perform this task to configure /32 static routes to the external Border Gateway Protocol (eBGP) neighbor loopback.

**Note**

You need to configure /32 static routes on each of the directly connected Autonomous System Boundary Routers (ASBRs).

### SUMMARY STEPS

1. enable
2. configure terminal
3. ip route prefix mask {ip-address | interface-type interface-number [ip-address]} [distance] [name] [permanent] [tag tag]
4. end

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
</tbody>
</table>

- Enter your password if prompted.
### Command or Action

<table>
<thead>
<tr>
<th>Step 2</th>
<th>configure terminal</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Device# configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
</tbody>
</table>

### Example:

**Step 3**

**ip route** *prefix* *mask* *{ip-address | interface-type interface-number [ip-address]}* [*distance*] [*name*] [*permanent*] [*tag* *

**Example:**

Device(config)# ip route 10.20.20.20 255.255.255.255 Ethernet 1/0 172.16.0.1

Establishes static routes.

- The *prefix* argument is the IP route prefix for the destination.
- The *mask* argument is the prefix mask for the destination.
- The *ip-address* argument is the IP address of the next hop that you can use to reach the specified network.
- The *interface-type* and *interface-number* arguments are the network interface type and interface number.
- The *distance* argument is an administrative distance.
- The *name* argument applies a name to the specified route.
- The *permanent* keyword specifies that the route is not to be removed, even if the interface shuts down.
- The *tag tag* keyword and argument name a tag value that can be used as a "match" value for controlling redistribution through the use of route maps.

**Step 4**

**end**

**Example:**

Device(config)# end

Exits to privileged EXEC mode.

### Configuring Forwarding on Connecting Loopback Interfaces

This task is required for sessions between loopbacks. In the "Configuring /32 Static Routes to the eBGP Neighbor Loopback" task, Ethernet1/0 and Ethernet0/0 are the connecting interfaces.
SUMMARY STEPS

1. enable
2. configure terminal
3. interface type slot/port
4. mpls bgp forwarding
5. exit
6. Repeat Steps 3 and 4 for another connecting interface (Ethernet 0/0).
7. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Enters privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>interface type slot/port</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Configures an interface type and enters interface configuration mode.</td>
</tr>
<tr>
<td></td>
<td>• The type argument is the type of interface to be configured.</td>
</tr>
<tr>
<td></td>
<td>• The slot argument is the slot number. Refer to the appropriate hardware manual for slot and port information.</td>
</tr>
<tr>
<td></td>
<td>• The port argument is the port number. Refer to the appropriate hardware manual for slot and port information.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>mpls bgp forwarding</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Configures BGP to enable MPLS forwarding on connecting interfaces.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>exit</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Exits to global configuration mode.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>Repeat Steps 3 and 4 for another connecting interface (Ethernet 0/0).</td>
</tr>
</tbody>
</table>
### Configuring an eBGP Session Between the Loopbacks

**Note**
You need to configure an external Border Gateway Protocol (eBGP) session between loopbacks on each directly connected Autonomous System Boundary Router (ASBR).

#### SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp as-number
4. bgp log-neighbor-changes
5. neighbor {ip-address | peer-group-name} remote-as as-number
6. neighbor {ip-address | peer-group-name} disable-connected-check
7. neighbor {ip-address | peer-group-name} ebgp-multihop [ttl]
8. neighbor {ip-address | ipv6-address | peer-group-name} update-source interface-type interface-number
9. address-family ipv4 [unicast] vrf vrf-name
10. neighbor {ip-address | peer-group-name | ipv6-address} activate
11. neighbor {ip-address | peer-group-name} send-community [both | standard | extended
12. end

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><strong>configure terminal</strong></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device# configure terminal</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><strong>router bgp as-number</strong></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config)# router bgp 200</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Configures the BGP routing process, and enters router configuration mode.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td><strong>bgp log-neighbor-changes</strong></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router)# bgp log-neighbor-changes</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Enables logging of BGP neighbor resets.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>**neighbor {ip-address</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router)# neighbor 10.20.20.20 remote-as 100</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Adds an entry to the BGP or multiprotocol BGP neighbor table.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>**neighbor {ip-address</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router)# neighbor 10.20.20.20 disable-connected-check</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Allows peering between loopbacks.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>**neighbor {ip-address</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router)# neighbor bb.bb.bb.bb ebgp-multihop 255</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Accepts and attempts BGP connections to external peers residing on networks that are not directly connected.</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td>**neighbor {ip-address</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Allows BGP sessions to use any operational interface for TCP connections.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Example:** Device(config-router)# neighbor 10.20.20.20 update-source Loopback 0 | • The *ipv6-address* argument is the IPv6 address of the BGP-speaking neighbor.  
  
  **Note** This argument must be in the form documented in RFC 2373, where the address is specified in hexadecimal using 16-bit values between colons.  
  • The *peer-group-name* argument is the name of a BGP peer group.  
  • The *interface-type* argument is the interface type.  
  • The *interface-number* argument is the interface number. |
| **Step 9** address-family ipv4 [unicast] vrf vrf-name | Enters address family configuration mode for configuring routing protocols such as BGP, Routing Information Protocol (RIP), and static routing.  
  • The *unicast* keyword specifies unicast prefixes.  
  • The *vrf* *vrf-name* keyword and argument specify the name of a VPN routing/forwarding instance (VRF) to associate with submode commands. |
| **Example:** Device(config-router)# address-family ipv4 | |
| **Step 10** neighbor {ip-address | peer-group-name | ipv6-address} activate | Enables the exchange of information with a BGP neighbor.  
  • The *ip-address* argument is the IP address of the neighboring device.  
  • The *peer-group-name* argument is the name of the BGP peer group.  
  • The *ipv6-address* argument is the IPv6 address of the BGP-speaking neighbor.  
  
  **Note** This argument must be in the form documented in RFC 2373, where the address is specified in hexadecimal using 16-bit values between colons. |
| **Example:** Device(config-router-af)# neighbor 10.20.20.20 activate | |
| **Step 11** neighbor {ip-address | peer-group-name} send-community [both | standard | extended] | Specifies that a communities attribute should be sent to a BGP neighbor.  
  • The *ip-address* argument is the IP address of the neighboring device.  
  • The *peer-group-name* argument is the name of the BGP peer group.  
  • The *both* keyword specifies that both standard and extended communities will be sent.  
  • The *standard* keyword specifies that only standard communities will be sent.  
  • The *extended* keyword specifies that only extended communities will be sent. |
| **Example:** Device(config-router-af)# neighbor 10.20.20.20 send-community extended | |
### Verifying That Load Sharing Occurs Between Loopbacks

To verify that load sharing can occur between loopbacks, ensure that the Multiprotocol Label Switching (MPLS) Label Forwarding Information Base (LFIB) entry for the neighbor route lists the available paths and interfaces.

**SUMMARY STEPS**

1. `enable`
2. `show mpls forwarding-table [network {mask|length} | labels label [label] | interface interface | next-hop address | lsp-tunnel [tunnel-id]] [vrf vrf-name] [detail]`
3. `disable`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><strong>Command or Action</strong></td>
</tr>
<tr>
<td></td>
<td><code>enable</code></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>disable</code></td>
</tr>
<tr>
<td>Example:</td>
<td>Device&gt; enable</td>
</tr>
<tr>
<td>Example:</td>
<td>Device# show mpls forwarding-table</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>`show mpls forwarding-table [network {mask</td>
</tr>
<tr>
<td>Example:</td>
<td>Device# show mpls forwarding-table</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><code>disable</code></td>
</tr>
<tr>
<td>Example:</td>
<td>Device# disable</td>
</tr>
</tbody>
</table>
Configuring Directly Connected Loopback Peering on MPLS VPN Carrier Supporting Carrier

The following sections explain how to load balance Carrier Supporting Carrier (CSC) traffic by peering loopback interfaces of directly connected CSC-provider edge (PE) and CSC-customer edge (CE) devices:

The figure below shows the loopback configuration for directly connected CSC-PE and CSC-CE devices. This configuration is used as the example in the tasks that follow.

Figure 29: Loopback Interface Configuration for Directly Connected CSC-PE and CSC-CE Devices

---

Configuring Loopback Interface Addresses on CSC-PE Devices

**Note**

Configuration of a loopback interface address on the Carrier Supporting Carrier (CSC)-provider edge (PE) device requires the enabling of a virtual routing and forwarding (VRF) instance. The CSC-customer edge (CE) device loopback interface does not require enabling a VRF.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface loopback interface number`
4. `ip vrf forwarding vrf-name`
5. `ip address ip-address mask [secondary]`
6. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal</td>
</tr>
<tr>
<td>Example:</td>
<td>Device# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>interface loopback interface number</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config)# interface loopback 0</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>ip vrf forwarding vrf-name</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-if)# ip vrf forwarding vrf1</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>ip address ip-address mask [secondary]</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-if)# ip address 10.20.20.20 255.255.255.255</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>end</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config)# end</td>
</tr>
</tbody>
</table>

### Configuring Loopback Interface Addresses for CSC-CE Routers

**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface loopback interface-number
4. ip address ip-address mask [secondary]
5. end
**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1 enable</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2 configure terminal</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3 interface loopback interface-number</strong></td>
<td>Configures a software-only virtual interface that emulates an interface that is always up.</td>
</tr>
<tr>
<td>Example:</td>
<td>• The <code>interface-number</code> argument is the number of the loopback interface that you want to create or configure. There is no limit on the number of loopback interfaces that you can create.</td>
</tr>
<tr>
<td>Device(config)# interface loopback 0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4 ip address ip-address mask [secondary]</strong></td>
<td>Sets a primary or secondary IP address for an interface.</td>
</tr>
<tr>
<td>Example:</td>
<td>• The <code>ip-address</code> argument is the IP address.</td>
</tr>
<tr>
<td>Device(config-if)# ip address 10.10.10.10 255.255.255.255</td>
<td>• The <code>mask</code> argument is the mask for the associated IP subnet.</td>
</tr>
<tr>
<td></td>
<td>• The <code>secondary</code> keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.</td>
</tr>
<tr>
<td><strong>Step 5 end</strong></td>
<td>Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Device(config-if)# end</td>
<td></td>
</tr>
</tbody>
</table>
### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> ip route vrf vrf-name prefix mask {ip-address</td>
<td>interface-type interface-number [ip-address]} [global] [distance] [name] [permanent] [tag tag]</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config)# ip route vrf vpn1 10.10.10.10 255.255.255.255 Ethernet 1/0 172.16.0.2</td>
<td>• The <strong>vrf-name</strong> argument is the name of the VRF for the static route.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>prefix</strong> argument is the IP route prefix for the destination.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>mask</strong> argument is the prefix mask for the destination.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>ip-address</strong> argument is the IP address of the next hop that you can use to reach the destination network.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>interface-type</strong> and <strong>interface-number</strong> arguments are the network interface type and interface number.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>global</strong> keyword specifies that the given next hop address is in the nonVRF routing table.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>distance</strong> argument is an administrative distance.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>name</strong> argument applies a name to the specified route.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>permanent</strong> keyword specifies that the route is not to be removed, even if the interface shuts down.</td>
</tr>
<tr>
<td></td>
<td>• The <strong>tag tag</strong> keyword and argument name a tag value that can be used as a “match” value for controlling redistribution via route maps.</td>
</tr>
<tr>
<td><strong>Step 4</strong> end</td>
<td>Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config)# end</td>
<td></td>
</tr>
</tbody>
</table>
Configuring /32 Static Routes to the eBGP Neighbor Loopback on the CSC-CE Device

SUMMARY STEPS

1. enable
2. configure terminal
3. ip route prefix mask {ip-address | interface-type interface-number [ip-address]} [distance] [name] [permanent] [tag tag]
4. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> ip route prefix mask {ip-address</td>
<td>interface-type interface-number [ip-address]} [distance] [name] [permanent] [tag tag]</td>
</tr>
<tr>
<td>Example: Device(config)# ip route 10.20.20.20 255.255.255.255 Ethernet 1/0 172.16.0.1</td>
<td>• The prefix argument is the IP route prefix for the destination.</td>
</tr>
<tr>
<td></td>
<td>• The mask argument is the prefix mask for the destination.</td>
</tr>
<tr>
<td></td>
<td>• The ip-address argument is the IP address of the next hop that you can use to reach the destination network.</td>
</tr>
<tr>
<td></td>
<td>• The interface-type and interface-number arguments are the network interface type and interface number.</td>
</tr>
<tr>
<td></td>
<td>• The distance argument is an administrative distance.</td>
</tr>
<tr>
<td></td>
<td>• The name argument applies a name to the specified route.</td>
</tr>
<tr>
<td></td>
<td>• The permanent keyword specifies that the route is not to be removed, even if the interface shuts down.</td>
</tr>
<tr>
<td></td>
<td>• The tag tag keyword and argument name a tag value that can be used as a “match” value for controlling redistribution via route maps.</td>
</tr>
<tr>
<td><strong>Step 4</strong> end</td>
<td>Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device(config)# end</td>
<td></td>
</tr>
</tbody>
</table>
Configuring Forwarding on CSC-PE Interfaces That Connect to the CSC-CE Loopback

SUMMARY STEPS

1. enable
2. configure terminal
3. interface type slot/port
4. ip vrf forwarding vrf-name
5. ip address ip-address mask [secondary]
6. mpls bgp forwarding
7. exit
8. Repeat Steps 3 through 6 for another connecting interface (Ethernet 0/0).
9. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Device&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2 configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3 interface type slot/port</td>
<td>Configures an interface type and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• The type argument is the type of interface to be configured.</td>
</tr>
<tr>
<td>Device(config)# interface ethernet 1/0</td>
<td>• The slot argument is the slot number. Refer to the appropriate</td>
</tr>
<tr>
<td></td>
<td>• The /port argument is the port number. Refer to the appropriate</td>
</tr>
<tr>
<td></td>
<td>hardware manual for slot and port information.</td>
</tr>
<tr>
<td>Step 4 ip vrf forwarding vrf-name</td>
<td>Associates a virtual routing and forwarding (VRF) instance with an</td>
</tr>
<tr>
<td>Example:</td>
<td>• The vrf-name argument is the name assigned to a VRF.</td>
</tr>
<tr>
<td>Device(config-if)# ip vrf forwarding vpn1</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 5** | **ip address ip-address mask [secondary]**<br>| Sets a primary or secondary IP address for an interface.<br>• The *ip-address* argument is the IP address.<br>• The *mask* argument is the mask for the associated IP subnet.<br>• The *secondary* keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.
| **Example:**<br>Device(config-if)# ip address 172.16.0.1 255.255.255.255 | |

| **Step 6** | **mpls bgp forwarding**<br>| Configures the Border Gateway Protocol (BGP) to enable Multiprotocol Label Switching (MPLS) forwarding on connecting interfaces.<br>
| **Example:**<br>Device(config-if)# mpls bgp forwarding | |

| **Step 7** | **exit**<br>| Exits to global configuration mode.<br>
| **Example:**<br>Device(config-if)# exit | |

| **Step 8** | Repeat Steps 3 through 6 for another connecting interface (Ethernet 0/0). |

| **Step 9** | **end**<br>| Exits to privileged EXEC mode.<br>
| **Example:**<br>Device(config)# end | |

### Configuring Forwarding on CSC-CE Interfaces That Connect to the CSC-PE Loopback

**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface typeslot/port
4. mpls bgp forwarding
5. exit
6. Repeat Steps 3 and 4 for another connecting interface (Ethernet 0/0).
7. end
### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Device&gt; enable</td>
<td>Step 2</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Configures an interface type and enters interface configuration mode.</td>
</tr>
<tr>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Device# configure terminal</td>
<td>Step 3</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Configures the Border Gateway Protocol (BGP) to enable Multiprotocol Label Switching (MPLS) forwarding on connecting interfaces.</td>
</tr>
<tr>
<td>interface typeslot/port</td>
<td>Configures an interface type and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example: Device(config)# interface ethernet 1/0</td>
<td>Step 4</td>
</tr>
<tr>
<td>mpls bgp forwarding</td>
<td>Configures the Border Gateway Protocol (BGP) to enable Multiprotocol Label Switching (MPLS) forwarding on connecting interfaces.</td>
</tr>
<tr>
<td>Example: Device(config-if)# mpls bgp forwarding</td>
<td>Step 5</td>
</tr>
<tr>
<td>exit</td>
<td>Exits to global configuration mode.</td>
</tr>
<tr>
<td>Example: Device(config-if)# exit</td>
<td>Step 6</td>
</tr>
<tr>
<td>Repeat Steps 3 and 4 for another connecting interface (Ethernet 0/0).</td>
<td>Step 7</td>
</tr>
<tr>
<td>end</td>
<td>Exits to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device(config)# end</td>
<td></td>
</tr>
</tbody>
</table>
Configuring an eBGP Session Between the CSC-PE Device and the CSC-CE Loopback

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `router bgp as-number`
4. `bgp log-neighbor-changes`
5. `neighbor {ip-address | peer-group-name} remote-as as-number`
6. `neighbor {ip-address | peer-group-name} disable-connected-check`
7. `neighbor {ip-address | ipv6-address | peer-group-name} update-source interface-type interface-number`
8. `address-family ipv4 [unicast] vrf vrf-name`
9. `ip vrf forwarding vrf-name`
10. `neighbor {ip-address | peer-group-name | ipv6-address} activate`
11. `neighbor ip-address send-label`
12. `end`

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures the Border Gateway Protocol (BGP) routing process.</td>
</tr>
<tr>
<td>Example: Device(config)# router bgp 200</td>
<td>• The <code>as-number</code> argument indicates the number of an autonomous system that identifies the device to other BGP routers and tags the routing information passed along.</td>
</tr>
<tr>
<td><strong>Step 4</strong> bgp log-neighbor-changes</td>
<td>Enables logging of BGP neighbor resets.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number</td>
</tr>
<tr>
<td></td>
<td>• The <code>ip-address</code> argument is the IP address of the neighbor.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Device(config-router)# neighbor 10.10.10.10 remote-as 100 | • The `peer-group-name` argument is the name of a BGP peer group.  
• The `as-number` argument is the autonomous system to which the neighbor belongs. |

**Step 6**

neighbor `{ip-address | peer-group-name}`
```bash
disable-connected-check
```

Example:
```bash
Device(config-router)# neighbor 10.10.10.10 disable-connected-check
```

Allows peering between loopbacks.

• The `ip-address` argument is the IP address of the neighbor.
• The `peer-group-name` argument is the name of a BGP peer group.

**Step 7**

neighbor `{ip-address | ipv6-address | peer-group-name}`
```bash
update-source interface-type interface-number
```

Example:
```bash
Device(config-router)# neighbor 10.10.10.10 update-source Loopback 0
```

Allows BGP sessions to use any operational interface for TCP connections.

• The `ip-address` argument is the IPv4 address of the BGP-speaking neighbor.
• The `ipv6-address` argument is the IPv6 address of the BGP-speaking neighbor.

This argument must be in the form documented in RFC 2373, where the address is specified in hexadecimal using 16-bit values between colons.

• The `peer-group-name` argument is the name of a BGP peer group.
• The `interface-type` argument is the interface type.
• The `interface-number` argument is the interface number.

**Step 8**

address-family ipv4 [unicast] vrf vrf-name
```bash
Example:
Device(config-router)# address-family ipv4 vrf vpn1
```

Enters address family configuration mode for configuring routing protocols such as BGP, Routing Information Protocol (RIP), and static routing.

• The `ipv4` keyword configures sessions that carry standard IPv4 address prefixes.
• The `unicast` keyword specifies unicast prefixes.
• The `vrf vrf-name` keyword and argument specify the name of a virtual routing and forwarding (VRF) instance to associate with submode commands.

**Step 9**

ip vrf forwarding vrf-name
```bash
Example:
Device(config-router-af)# ip vrf forwarding vpn1
```

Associates a VRF with an interface or subinterface.

• The `vrf-name` argument is the name assigned to a VRF.
<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| Step 10 | **neighbor** `{ip-address | peer-group-name | ipv6-address}` **activate** | Enables the exchange of information with a BGP neighbor.  
  - The `ip-address` argument is the IP address of the neighboring device.  
  - The `peer-group-name` argument is the name of the BGP peer group.  
  - The `ipv6-address` argument is the IPv6 address of the BGP-speaking neighbor. |
|      | **Example:** Device(config-router-af)# neighbor 10.10.10.10 activate | |
| Step 11 | **neighbor** `ip-address` **send-label** | Enables a BGP device to send MPLS labels with BGP routes to a neighboring BGP device.  
  - The `ip-address` argument is the IP address of the neighboring device. |
|      | **Example:** Device(config-router-af)# neighbor 10.10.10.10 send-label | |
| Step 12 | **end** | Exits to privileged EXEC mode. |
|      | **Example:** Device(config)# end | |

### Configuring an eBGP Session Between the CSC-CE Device and the CSC-PE Loopback

**SUMMARY STEPS**

1. **enable**
2. **configure terminal**
3. **router bgp** `as-number`
4. **bgp log-neighbor-changes**
5. **neighbor** `{ip-address | peer-group-name}` **remote-as** `as-number`
6. **neighbor** `{ip-address | peer-group-name}` **disable-connected-check**
7. **neighbor** `{ip-address | ipv6-address | peer-group-name}` **update-source** interface-type interface-number
8. **address-family ipv4** `{unicast | [vrf vrf-name]}`
9. **neighbor** `{ip-address | peer-group-name | ipv6-address}` **activate**
10. **neighbor** `ip-address` **send-label**
11. **end**
**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device&gt; enable</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device# configure terminal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures the Border Gateway Protocol (BGP) routing process.</td>
<td>• The <em>as-number</em> argument indicates the number of an autonomous system that identifies the device to other BGP routers and tags the routing information passed along.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device(config)# router bgp 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> bgp log-neighbor-changes</td>
<td>Enables logging of BGP neighbor resets.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device(config-router)# bgp log-neighbor-changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number</td>
<td>Adds an entry to the BGP or multiprotocol BGP neighbor table.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td>• The <em>peer-group-name</em> argument is the name of a BGP peer group.</td>
</tr>
<tr>
<td>Device(config-router)# neighbor 10.20.20.20 remote-as 100</td>
<td></td>
<td>• The <em>as-number</em> argument is the autonomous system to which the neighbor belongs.</td>
</tr>
<tr>
<td><strong>Step 6</strong> neighbor {ip-address</td>
<td>peer-group-name} disable-connected-check</td>
<td>Allows peering between loopbacks.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td>• The <em>peer-group-name</em> argument is the name of a BGP peer group.</td>
</tr>
<tr>
<td>Device(config-router)# neighbor 10.20.20.20 disable-connected-check</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> neighbor {ip-address</td>
<td>ipv6-address</td>
<td>peer-group-name} update-source interface-type interface-number</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td>• The <em>ipv6-address</em> argument is the IPv6 address of the BGP-speaking neighbor.</td>
</tr>
<tr>
<td>Device(config-router)# neighbor 10.20.20.20 update-source Loopback 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>This argument must be in the form documented in RFC 2373, where the address is specified in hexadecimal using 16-bit values between colons.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The <code>peer-group-name</code> argument is the name of a BGP peer group.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The <code>interface-type</code> argument is the interface type.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The <code>interface-number</code> argument is the interface number.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Step 8**  
**address-family ipv4 [unicast] [vrf vrf-name]**  
Example:

Device(config-router)# address-family ipv4

- The **ipv4** keyword configures sessions that carry standard IPv4 address prefixes.  
- The **unicast** keyword specifies unicast prefixes.  
- The **vrf vrf-name** keyword and argument specify the name of a virtual routing and forwarding (VRF) instance to associate with submode commands.

**Step 9**  
**neighbor [ip-address | peer-group-name|ipv6-address] activate**  
Example:

Device(config-router-af)# neighbor 10.20.20.20 activate

- The **ip-address** argument is the IP address of the neighboring device.  
- The **peer-group-name** argument is the name of the BGP peer group.  
- The **ipv6-address** argument is the IPv6 address of the BGP-speaking neighbor.  

**Note**  
This argument must be in the form documented in RFC 2373, where the address is specified in hexadecimal using 16-bit values between colons.

**Step 10**  
**neighbor ip-address send-label**  
Example:

Device(config-router-af)# neighbor 10.20.20.20 send-label

- Enables a BGP device to send Multiprotocol Label Switching (MPLS) labels with BGP routes to a neighboring BGP device.  

**Step 11**  
**end**  
Example:

Device(config)# end

- Exits to privileged EXEC mode.
Verifying That Load Sharing Occurs Between Loopbacks

To verify that load sharing occurs between loopbacks, ensure that the Multiprotocol Label Switching (MPLS) Label Forwarding Information Base (LFIB) entry for the neighbor route lists the available paths and interfaces.

**SUMMARY STEPS**

1. `enable`
2. `show mpls forwarding-table [vrf vrf-name] {network {mask | length} | labels label [-label] | [interface] interface | next-hop address | lsp-tunnel [tunnel-id}] [detail]`
3. `disable`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td>`show mpls forwarding-table [vrf vrf-name] {network {mask</td>
<td>length}</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device# show mpls forwarding-table</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td><code>disable</code></td>
<td>Exits to user EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device# disable</td>
<td></td>
</tr>
</tbody>
</table>
Configuration Examples for MPLS VPN Load Balancing Support for Inter-AS and CSC VPN

Examples: Configuring a 32 Static Route from an ASBR to the Loopback Address of Another ASBR

The following example configures a /32 static route from ASBR1 to the loopback address of ASBR2:

```
Device# configure terminal
Device(config)# ip route 10.20.20.20 255.255.255.255 e1/0 168.192.0.1
Device(config)# ip route 10.20.20.20 255.255.255.255 e0/0 168.192.2.1
```

The following example configures a /32 static route from ASBR2 to the loopback address of ASBR1:

```
Device# configure terminal
Device(config)# ip route vrf vpn1 10.10.10.10 255.255.255.255 e1/0 168.192.0.2
Device(config)# ip route vrf vpn1 10.10.10.10 255.255.255.255 e0/0 168.192.2.2
```

Example: Configuring BGP MPLS Forwarding on the Interfaces Connecting ASBRs

The following example configures the Border Gateway Protocol (BGP) and Multiprotocol Label Switching (MPLS) forwarding on the interfaces connecting ASBR2 with ASBR1:

```
Device# configure terminal
Device(config)# interface ethernet 1/0
Device(config-if)# ip vrf forwarding vpn1
Device(config-if)# ip address 168.192.0.1 255.255.255.255
Device(config-if)# mpls bgp forwarding
Device(config-if)# exit
Device(config)# interface ethernet 0/0
Device(config-if)# ip vrf forwarding vpn1
Device(config-if)# ip address 168.192.2.1 255.255.255.255
Device(config-if)# mpls bgp forwarding
Device(config-if)# exit
```

Example: Configuring VPNv4 Sessions on an ASBR

The following example configures VPNv4 sessions on ASBR2:

```
Device# configure terminal
Device(config)# router bgp 200
Device(config-router)# bgp log-neighbor-changes
Device(config-router)# neighbor 10.10.10.10 remote-as 100
Device(config-router)# neighbor 10.10.10.10 disable-connected-check
Device(config-router)# neighbor bb.bb.bb.bb ebgp-multihop 255
Device(config-router)# neighbor 10.10.10.10 update-source Loopback0
Device(config-router)# address-family vpnv4
Device(config-router-af)# neighbor 10.10.10.10 activate
Device(config-router-af)# neighbor 10.10.10.10 send-community extended
Device(config-router-af)# end
```
## Additional References

### Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco IOS commands</td>
<td>Cisco IOS Master Command List, All Releases</td>
</tr>
<tr>
<td>MPLS commands</td>
<td>Cisco IOS Multiprotocol Label Switching Command Reference</td>
</tr>
<tr>
<td>Configuring MPLS VPN CSC with BGP</td>
<td>&quot;MPLS VPN Carrier Supporting Carrier with BGP&quot; module in the MPLS: Layer 3 VPNs: Inter-AS and CSC Configuration Guide</td>
</tr>
<tr>
<td>Configuring BGP</td>
<td>&quot;Configuring BGP&quot; module in the IP Routing: BGP Configuration Guide</td>
</tr>
<tr>
<td>Configuring BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN</td>
<td>&quot;BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN&quot; module in the IP Routing: BGP Configuration Guide</td>
</tr>
</tbody>
</table>

### RFCs

<table>
<thead>
<tr>
<th>RFC</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 1164</td>
<td>Application of the Border Gateway Protocol in the Internet</td>
</tr>
<tr>
<td>RFC 1171</td>
<td>A Border Gateway Protocol 4</td>
</tr>
<tr>
<td>RFC 1700</td>
<td>Assigned Numbers</td>
</tr>
<tr>
<td>RFC 1966</td>
<td>BGP Route Reflection: An Alternative to Full Mesh IBGP</td>
</tr>
<tr>
<td>RFC 2283</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 2373</td>
<td>IP Version 6 Addressing Architecture</td>
</tr>
<tr>
<td>RFC 2547</td>
<td>BGP/MPLS VPNs</td>
</tr>
<tr>
<td>RFC 2842</td>
<td>Capabilities Advertisement with BGP-4</td>
</tr>
<tr>
<td>RFC 2858</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 3107</td>
<td>Carrying Label Information in BGP-4</td>
</tr>
</tbody>
</table>
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

Feature Information for MPLS VPN Load Balancing Support for Inter-AS and CSC 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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
Table 12: Feature Information for MPLS VPN Load Balancing Support for Inter-AS and CSC VPN

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs</td>
<td>12.0(29)S, 12.4(20)T, 12.2(33)SRA, 12.2(33)SXH, Cisco IOS XE Release 2.2</td>
<td>The MPLS VPN Load Balancing Support for Inter-AS and CSC VPNs feature allows MPLS VPN Inter-AS and MPLS VPN CSC networks to load share traffic between adjacent LSRs that are connected by multiple links. The LSRs can be a pair of ASBRs or a CSC-PE and a CSC-CE. Using directly connected loopback peering allows load sharing at the IGP level, so more than one BGP session is not needed between the LSRs. No other label distribution mechanism is needed between the adjacent LSRs than BGP. In Cisco IOS Release 12.0(29)S, this feature was introduced. In Cisco IOS Release 12.4(20)T, 12.2(33)SRA, and 12.2(33)SXH, this feature was integrated. In Cisco IOS XE Release 2.2, this feature was implemented on the Cisco ASR 1000 Series Routers. No commands were introduced or modified.</td>
</tr>
</tbody>
</table>
MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

The MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs feature enables you to configure external Border Gateway Protocol (eBGP) multipath with IPv4 labels. This creates an entry in the Multiprotocol Label Switching (MPLS) forwarding table with label information for each outgoing path installed in the routing table thereby allowing redundant connectivity and load balancing. Without this feature, the MPLS forwarding table contains the labels only for the BGP best path even though the routing table has more than one path for the prefix.

- Finding Feature Information, page 285
- Prerequisites for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs, page 286
- Restrictions for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs, page 286
- Information About MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs, page 288
- How to Configure MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs, page 288
- Configuration Examples for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs, page 296
- Additional References, page 297
- Feature Information for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs, page 298

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
Prerequisites for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

Ensure that your Multiprotocol Label Switching (MPLS) virtual private network (VPN) network, including MPLS VPN interautonomous system (Inter-AS) or Carrier Supporting Carrier (CSC), is configured and working properly.

Restrictions for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

The MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs feature is not supported on Multiprotocol Label Switching (MPLS) virtual private network (VPN) interautonomous system (Inter-AS) with Autonomous System Boundary Routers (ASBRs) that exchange VPNv4 routes.

When you configure static routes in an MPLS or MPLS virtual private network (VPN) environment, some variations of the `ip route` and `ip route vrf` commands are not supported. These variations of the commands are not supported in Cisco software releases that support the Tag Forwarding Information Base (TFIB). The TFIB cannot resolve prefixes when the recursive route over which the prefixes travel disappears and then reappears. However, the command variations are supported in Cisco software releases that support the MPLS Forwarding Infrastructure (MFI). 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 VPN 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` command is not supported when you configure static routes in an MPLS VPN 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` and `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 associated with the same virtual routing and forwarding (VRF) instance:

- `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 the 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 interfaces:

- `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`
- `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 interfaces:

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

Information About MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

Overview of MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

When a device learns two identical external Border Gateway Protocol (eBGP) paths for a prefix from a neighboring autonomous system, it chooses the path with the lower route ID as the best path. This best path is installed in the IP routing table. You can enable eBGP multipath, which installs multiple paths in the IP routing table (instead of picking one best path) when the eBGP paths are learned from a neighboring autonomous system.

During packet switching, depending on the switching mode, either per-packet or per-destination load sharing is performed among the multiple paths. The `maximum-paths` router configuration command controls the number of paths allowed. By default, BGP installs only one path to the IP routing table.

How to Configure MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

Configuring MPLS VPN eBGP Multipath Load Sharing with Inter-AS MPLS VPNs

Perform this task on the Autonomous System Boundary Routers (ASBRs) to configure external Border Gateway Protocol (eBGP) multipath for Multiprotocol Label Switching (MPLS) virtual private network (VPN) interautonomous systems with ASBRs exchanging IPv4 routes and MPLS labels.
### 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 ipv4 [multicast | unicast | vrf vrf-name]`
6. `maximum-paths number-paths`
7. `neighbor {ip-address | peer-group-name} activate`
8. `neighbor ip-address send-label`
9. `exit-address-family`
10. `end`

### DETAILED STEPS

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<th>Purpose</th>
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</thead>
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<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Device&gt; enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Device# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td><code>router bgp as-number</code></td>
<td>Configures a BGP routing process and places the device in router configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Device(config)# router bgp 100</code></td>
<td>• The <code>as-number</code> argument indicates the number of an autonomous system that identifies the device to other BGP routers and tags the routing information passed along. The range is 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
</tr>
<tr>
<td>`neighbor {ip-address</td>
<td>peer-group-name} remote-as as-number`</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Device(config-router)# neighbor 10.0.0.1 remote-as 200</code></td>
<td>• The <code>ip-address</code> argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td></td>
</tr>
<tr>
<td>`address-family ipv4 [multicast</td>
<td>unicast</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Example:** Device(config-router)# address-family ipv4 | • The `multicast` keyword specifies IPv4 multicast address prefixes.  
• The `unicast` keyword specifies IPv4 unicast address prefixes.  
• The `vrf vrf-name` keyword and argument specify the name of the VRF to associate with subsequent IPv4 address family configuration mode commands. |
| **Step 6** `maximum-paths number-paths` | (Optional) Controls the maximum number of parallel routes an IP routing protocol can support.  
• The `number-paths` argument specifies the maximum number of parallel routes an IP routing protocol installs in a routing table. |
| **Example:** Device(config-router-af)# maximum-paths 2 | |
| **Step 7** `neighbor {ip-address | peer-group-name} activate` | Enables the exchange of information with a neighboring 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. |
| **Example:** Device(config-router-af)# neighbor 10.0.0.1 activate | |
| **Step 8** `neighbor ip-address send-label` | Enables a BGP device to send MPLS labels with BGP routes to a neighboring BGP device.  
• The `ip-address` argument specifies the IP address of the neighboring device. |
| **Example:** Device(config-router-af)# neighbor 10.0.0.1 send-label | |
| **Step 9** `exit-address-family` | Exits address family configuration mode. |
| **Example:** Device(config-router-af)# exit-address-family | |
| **Step 10** `end` | (Optional) Exits to privileged EXEC mode. |
| **Example:** Device(config-router-af)# end | |
Configuring MPLS VPN eBGP Multipath Load Sharing with Carrier Supporting Carrier on the CSC-PE Devices

Perform this task to configure external Border Gateway Protocol (eBGP) multipath load sharing on the carrier supporting carrier-provider edge (CSC-PE) devices that distribute BGP routes with Multiprotocol Label Switching (MPLS) labels.

SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp as-number
4. address-family ipv4 [multicast | unicast | vrf vrf-name]
5. maximum-paths number-paths
6. neighbor {ip-address | peer-group-name} remote-as as-number
7. neighbor {ip-address | peer-group-name} activate
8. neighbor ip-address as-override
9. neighbor ip-address send-label
10. exit-address-family
11. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable</td>
</tr>
<tr>
<td>Example:</td>
<td>Device&gt; enable</td>
</tr>
<tr>
<td></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal</td>
</tr>
<tr>
<td>Example:</td>
<td>Device# configure terminal</td>
</tr>
<tr>
<td></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>router bgp as-number</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config)# router bgp 100</td>
</tr>
<tr>
<td></td>
<td>Configures a BGP routing process and enters router configuration mode.</td>
</tr>
<tr>
<td></td>
<td>• The as-number argument indicates the number of an autonomous system that identifies the device to other BGP routers and tags the routing information passed along. The range is 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>address-family ipv4 [multicast</td>
</tr>
<tr>
<td></td>
<td>Specifies the IPv4 address family type and enters address family configuration mode.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router)# address-family ipv4 vrf vpn1</td>
<td>• The <em>multicast</em> keyword specifies IPv4 multicast address prefixes.</td>
</tr>
<tr>
<td></td>
<td>• The <em>unicast</em> keyword specifies IPv4 unicast address prefixes.</td>
</tr>
<tr>
<td></td>
<td>• The <em>vrf vrf-name</em> keyword and argument specify the name of the VRF to associate with subsequent IPv4 address family configuration mode commands.</td>
</tr>
<tr>
<td><strong>Step 5</strong> maximum-paths <em>number-paths</em></td>
<td>(Optional) Controls the maximum number of parallel routes an IP routing protocol can support.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# maximum-paths 2</td>
<td>• On the CSC-PE device, this command is enabled in address family configuration mode.</td>
</tr>
<tr>
<td></td>
<td>• The <em>number-paths</em> argument specifies the maximum number of parallel routes an IP routing protocol installs in a routing table.</td>
</tr>
<tr>
<td><strong>Step 6</strong> neighbor {ip-address</td>
<td>peer-group-name} remote-as <em>as-number</em></td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.0.0.1 remote-as 200</td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>• The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td></td>
<td>• The <em>as-number</em> argument specifies the autonomous system to which the neighbor belongs.</td>
</tr>
<tr>
<td><strong>Step 7</strong> neighbor {ip-address</td>
<td>peer-group-name} activate</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.0.0.1 activate</td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighbor.</td>
</tr>
<tr>
<td></td>
<td>• The <em>peer-group-name</em> argument specifies the name of a BGP peer group.</td>
</tr>
<tr>
<td><strong>Step 8</strong> neighbor <em>ip-address</em> as-override</td>
<td>Configures a PE device to override the autonomous system number (ASN) of a site with the ASN of a provider.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.0.0.1 as-override</td>
<td>• The <em>ip-address</em> argument specifies the IP address of the device that is to be overridden with the ASN provided.</td>
</tr>
<tr>
<td><strong>Step 9</strong> neighbor <em>ip-address</em> send-label</td>
<td>Enables a BGP device to send MPLS labels with BGP routes to a neighboring BGP device.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device(config-router-af)# neighbor 10.0.0.1 send-label</td>
<td>• The <em>ip-address</em> argument specifies the IP address of the neighboring device.</td>
</tr>
</tbody>
</table>
### Configuring MPLS VPN eBGP Multipath Load Sharing with Carrier Supporting Carrier on the CSC-CE Devices

Perform this task to configure external Border Gateway Protocol (eBGP) multipath load sharing on the carrier supporting carrier-customer edge (CSC-CE) devices.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. router bgp as-number
4. maximum-paths number-paths
5. address-family ipv4 [multicast | unicast | vrf vrf-name]
6. redistribute protocol
7. neighbor {ip-address | peer-group-name} remote-as as-number
8. neighbor {ip-address | peer-group-name} activate
9. neighbor ip-address send-label
10. exit-address-family
11. end

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Step 10</th>
<th>exit-address-family</th>
<th>Exits address family configuration mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Device(config-router-af)# exit-address-family</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Step 11</th>
<th>end</th>
<th>(Optional) Exits to privileged EXEC mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Device(config-router)# end</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> router bgp as-number</td>
<td>Configures a BGP routing process and enters router configuration mode.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config)# router bgp 200</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> maximum-paths number-paths</td>
<td>(Optional) Controls the maximum number of parallel routes an IP routing protocol can support.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router)# maximum-paths 2</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> address-family ipv4 [multicast</td>
<td>unicast</td>
<td>vrf vrf-name]</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router)# address-family ipv4</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> redistribute protocol</td>
<td>Redistributes routes from one routing domain into another routing domain.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-router-af)# redistribute static</td>
<td></td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>The optional \textit{ip} keyword is used when you redistribute static routes into Intermediate System-to-Intermediate System (IS-IS).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The \textit{connected} keyword refers to routes that are established automatically when IP is enabled on an interface.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• For routing protocols such as Open Shortest Path First (OSPF) and Intermediate System-to-Intermediate System (IS-IS), these routes are redistributed as external to the autonomous system.</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

**Step 7**

- `neighbor {ip-address|peer-group-name} remote-as as-number`

*Example:*

```
Device(config-router-af)# neighbor 10.0.0.2 remote-as 100
```

**Purpose**

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 8**

- `neighbor {ip-address|peer-group-name} activate`

*Example:*

```
Device(config-router-af)# neighbor 10.0.0.2 activate
```

**Purpose**

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 9**

- `neighbor ip-address send-label`

*Example:*

```
Device(config-router-af)# neighbor 10.0.0.2 send-label
```

**Purpose**

Enables a BGP device to send Multiprotocol Label Switching (MPLS) labels with BGP routes to a neighboring BGP device.

- The `ip-address` argument specifies the IP address of the neighboring device.

**Step 10**

- `exit-address-family`

*Example:*

```
Device(config-router-af)# exit-address-family
```

**Purpose**

Exits address family configuration mode.

**Step 11**

- `end`

*Example:*

```
Device(config-router)# end
```

(Optional) Exits to privileged EXEC mode.
Configuration Examples for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

Example: Configuring MPLS VPN eBGP Multipath Load Sharing with MPLS VPN Inter-AS

The following example shows how to configure external Border Gateway Protocol (eBGP) multipath for Multiprotocol Label Switching (MPLS) virtual private network (VPN) interautonomous systems with Autonomous System Boundary Routers (ASBRs) exchanging IPv4 routes and MPLS labels:

Device# configure terminal
Device(config)# router bgp 100
Device(config-router)# neighbor 10.0.0.1 remote-as 200
Device(config-router)# address-family ipv4
Device(config-router-af)# maximum-paths 2
Device(config-router-af)# neighbor 10.0.0.1 activate
Device(config-router-af)# neighbor 10.0.0.1 send-label
Device(config-router-af)# exit-address-family
Device(config-router-af)# end

Example: Configuring MPLS VPN eBGP Multipath Load Sharing with MPLS VPN Carrier Supporting Carrier on the CSC-PE Devices

The following example shows how to configure external Border Gateway Protocol (eBGP) multipath load sharing on the carrier supporting carrier-provider edge (CSC-PE) devices that distribute BGP routes with Multiprotocol Label Switching (MPLS) labels:

Device# configure terminal
Device(config)# router bgp 100
Device(config-router)# address-family ipv4 vrf vpn1
Device(config-router-af)# maximum-paths 2
Device(config-router-af)# neighbor 10.0.0.1 remote-as 200
Device(config-router-af)# neighbor 10.0.0.1 activate
Device(config-router-af)# neighbor 10.0.0.1 as-override
Device(config-router-af)# neighbor 10.0.0.1 send-label
Device(config-router-af)# exit-address-family
Device(config-router)# end

Example: Configuring MPLS VPN eBGP Multipath Load Sharing with MPLS VPN Carrier Supporting Carrier on the CSC-CE Devices

The following example shows how to configure external Border Gateway Protocol (eBGP) multipath load sharing on the carrier supporting carrier-customer edge (CSC-CE) devices:

Device# configure terminal
Device(config)# router bgp 200
Device(config-router)# maximum-paths 2
Device(config-router)# address-family ipv4
Device(config-router-af)# redistribute static
Device(config-router-af)# neighbor 10.0.0.2 remote-as 100
Device(config-router-af)# neighbor 10.0.0.2 activate
Device(config-router-af)# neighbor 10.0.0.2 send-label
Device(config-router-af)# exit-address-family
Device(config-router)# end

Additional References

Related Documents

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<td>&quot;Configuring BGP&quot; module in the <em>IP Routing: BGP Configuration Guide</em></td>
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<tr>
<td>Configuring BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN</td>
<td>&quot;BGP Multipath Load Sharing for Both eBGP and iBGP in an MPLS VPN&quot; module in the <em>IP Routing: BGP Configuration Guide</em></td>
</tr>
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RFCs

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<td>Assigned Numbers</td>
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<td>RFC 1966</td>
<td>BGP Route Reflection: An Alternative to Full Mesh IBGP</td>
</tr>
<tr>
<td>RFC 2283</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 2373</td>
<td>IP Version 6 Addressing Architecture</td>
</tr>
<tr>
<td>RFC 2547</td>
<td>BGP/MPLS VPNs</td>
</tr>
<tr>
<td>RFC 2842</td>
<td>Capabilities Advertisement with BGP-4</td>
</tr>
</tbody>
</table>
**Technical Assistance**

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

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**Feature Information for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs**

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.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.
### Table 13: Feature Information for MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs</td>
<td>12.0(27)S</td>
<td>The MPLS VPN eBGP Multipath Support for CSC and Inter-AS MPLS VPNs feature installs multiple paths in the IP routing table when the eBGP paths are learned from a neighboring Autonomous System (AS), instead of picking one best path.</td>
</tr>
<tr>
<td></td>
<td>12.2(30)S</td>
<td>In Cisco IOS Release 12.0(27)S, this feature was introduced.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRA</td>
<td>In Cisco IOS Release 12.2(30)S, 12.2(33)SRA, and 12.2(33)SXH, this feature was integrated.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SXH</td>
<td>In Cisco IOS XE Release 2.2, this feature was implemented on the Cisco ASR 1000 Series Routers. No commands were introduced or modified.</td>
</tr>
<tr>
<td></td>
<td>Cisco IOS XE Release 2.2</td>
<td></td>
</tr>
</tbody>
</table>
MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

The MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session feature provides a method to advertise explicit null in a Border Gateway Protocol (BGP) label session for a carrier supporting carrier (CSC) customer edge (CE) device.

- Prerequisites for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 301
- Restrictions for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 302
- Information About MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 302
- How to Configure MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 303
- Configuration Examples for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 305
- Additional References for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 306
- Feature Information for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session, page 307
- Glossary, page 308

Prerequisites for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

- You must configure your network for Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN).
- You must configure the Border Gateway Protocol (BGP) to distribute labels between the carrier supporting carrier (CSC) customer edge (CE) device (CSC-CE) and CSC-provider edge (PE) devices.
Restrictions for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

- Configure an explicit null label only in a carrier supporting carrier (CSC) customer edge (CE) device (CSC-CE) topology.
- Configure an explicit null label only on a per-neighbor basis.

Information About MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

Feature Design of MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

On a carrier supporting carrier (CSC) customer edge (CE) device (CSC-CE) with Border Gateway Protocol (BGP) IPv4 label distribution, BGP advertises an implicit null label for directly connected routes. This causes the previous hop (penultimate) device to do penultimate hop popping (PHP).

The MPLS VPN Explicit Null Label Support BGP IPv4 Label Session feature makes the penultimate device swap the incoming label for (or impose) the explicit null label. This action forces the egress device to process the explicit null label by popping it and inspecting the packet that remains.

Benefits of MPLS VPN Explicit Null Label Support BGP IPv4 Label Session

The explicit null label helps to preserve quality of service (QoS) bits from one Service Level Agreement (SLA) to another until the packets reach their carrier supporting carrier (CSC) customer edge (CE) destination.
How to Configure MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

Configuring CSC with BGP

SUMMARY STEPS

1. enable
2. configure terminal
3. router bgp autonomous-system-number
4. address-family ipv4 [unicast]
5. neighbor ip-address send-label explicit-null
6. neighbor {ip-address | peer-group-name} activate
7. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Device&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

| Step 2 | configure terminal | Enters global configuration mode. |
|        | Example: |
|        | Device# configure terminal |

| Step 3 | router bgp autonomous-system-number | Enters router configuration mode and configures the device to run a Border Gateway Protocol (BGP) process. |
|        | Example: |
|        | Device(config)# router bgp 100 |

| Step 4 | address-family ipv4 [unicast] | Enters address family configuration mode for the IPv4 address family from which you can configure routing sessions that use standard IPv4 address prefixes. |
|        | Example: |
|        | Device(config-router)# address-family ipv4 |
Verifying the Explicit Null Configuration

SUMMARY STEPS

1. enable
2. show ip bgp neighbors [ip-address [advertised-routes | dampened-routes | flap-statistics | paths [regexp] | received prefix-filter | received-routes | routes]]

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Device&gt; enable</td>
<td>Enter your password if prompted.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong> show ip bgp neighbors [ip-address [advertised-routes</td>
<td>dampened-routes</td>
</tr>
<tr>
<td></td>
<td>• The optional ip-address argument displays the IP address of the neighbor whose routes you have learned If you omit this argument, all neighbors are displayed.</td>
</tr>
<tr>
<td></td>
<td>• The optional advertised-routes keyword displays all the routes the device has advertised to the neighbor.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Example:** Device# show ip bgp neighbors | • The optional **dampened-routes** keyword displays the dampened routes to the neighbor at the IP address specified.  
• The optional **flap-statistics** keyword displays the flap statistics of the routes learned from the specified neighbor (external BGP [eBGP] peers only).  
• The optional **path** *regexp* keyword and argument displays autonomous system paths learned from the specified neighbor. An optional regular expression can be used to filter the output.  
• The optional **received prefix-filter** keyword displays the configured prefix list filter for the specified IP address.  
• The optional **received-routes** keyword displays all received routes (both accepted and rejected) from the specified neighbor.  
• The optional **routes** keyword displays all routes that are received and accepted. This is a subset of the output from the **received-routes** keyword. |

**What to Do Next**

**Configuration Examples for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session**

**Example: Configuring CSC-CE with BGP**

In the following example, the carrier supporting carrier (CSC) is configured with the Border Gateway Protocol (BGP) to distribute labels and to advertise explicit null for all its connected routes:

```
neighbor 10.0.0.0 send-label explicit-null  
router bgp 100  
  bgp log-neighbor-changes  
  neighbor 10.0.0.0 remote-as 200  
!  
address-family ipv4  
neighbor 10.0.0.0 activate  
neighbor 10.0.0.0 send-label explicit-null  
no auto-summary  
no synchronization  
ext-address-family
```
Example: Verifying the Explicit Null Configuration

In this example, the `show ip bgp neighbors` command displays information about connected Border Gateway Protocol (BGP) neighbors, including IP addresses, version numbers, neighbor capabilities, message statistics, and address family statistics that show if explicit null is configured:

```
Device# show ip bgp neighbors
BGP neighbor is 10.0.0.2, remote AS 300, external link
BGP version 4, remote router ID 10.0.0.20
Last read 00:00:16, hold time is 180, keepalive interval is 60 seconds
Neighbor capabilities:
  Route refresh: advertised and received(new)
  Address family IPv4 Unicast: advertised and received
ipv4 MPLS Label capability: advertised and received
Message statistics:
  InQ depth is 0
  OutQ depth is 0
      Sent  Rcvd
  Opens:   1    1
  Notifications: 0    0
  Updates:  1    2
  Keepalives: 47   47
  Route Refresh: 0    0
  Total:   49   50
Default minimum time between advertisement runs is 30 seconds

For address family: IPv4 Unicast
  BGP table version 9, neighbor version 9/0
  Output queue sizes : 0 self, 0 replicated
  Index 1, Offset 0, Mask 0x2
  Member of update-group 1
  My AS number is allowed for 3 number of times
  AF-dependant capabilities:
    Outbound Route Filter (ORF) type (128) Prefix-list:
      Sending Prefix & Label(advertise explicit-null set) !Explicit null is configured

Prefix activity:     ----- ----- (Consumes 144 bytes)
Prefixes Current:   3      3
Prefixes Total:     3      6
Implicit Withdraw:  0      3
Explicit Withdraw:  0      0

...........

...........

Additional References for MPLS VPN Explicit Null Label with BGP IPv4 Label Session

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco IOS commands</td>
<td>Cisco IOS Master Commands List, All Releases</td>
</tr>
<tr>
<td>MPLS commands</td>
<td>Cisco IOS Multiprotocol Label Switching Command Reference</td>
</tr>
<tr>
<td>BGP configuration tasks</td>
<td>IP Routing: BGP Configuration Guide</td>
</tr>
</tbody>
</table>
Feature Information for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

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.

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Table 14: Feature Information for MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session</td>
<td>12.0(27)S</td>
<td>The MPLS VPN Explicit Null Label Support with BGP IPv4 Label Session feature provides a method to advertise explicit null in a BGP label session for a carrier supporting carrier (CSC) customer edge (CE) device.</td>
</tr>
<tr>
<td></td>
<td>12.0(27)S1</td>
<td>In 12.0(27)S, this feature was introduced.</td>
</tr>
<tr>
<td></td>
<td>12.2(27)SBA</td>
<td>In 12.0(27)S1, support was added for the Cisco 12000 series Internet routers.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRA</td>
<td>In 12.2(27)SBA, support was added for the Cisco 10000 series router.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SXH</td>
<td>This feature was integrated into Cisco IOS Release 12.2(33)SRA.</td>
</tr>
<tr>
<td></td>
<td>Cisco IOS XE Release 2.3</td>
<td>This feature was integrated into Cisco IOS Release 12.2(33)SXH.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Cisco IOS XE Release 2.3, support was added for the Cisco ASR 1000 Series Routers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following commands were introduced or modified: <code>debug ip bgp</code>, <code>neighbor send-label explicit-null</code>, <code>show ip bgp neighbors</code>, <code>show ip bgp vpnv4</code>, <code>show mpls forwarding-table</code></td>
</tr>
</tbody>
</table>

Glossary

**BGP**

Border Gateway Protocol. The exterior Border Gateway Protocol used to exchange routing information between devices in separate autonomous systems. BGP uses TCP. Because TCP is a reliable protocol, BGP does not experience problems with dropped or fragmented data packets.

**CE device**

customer edge device. A device on the border between a VPN provider and a VPN customer that belongs to the customer.
eBGP
external Border Gateway Protocol. A BGP session between devices in different autonomous systems.
When a pair of devices in different autonomous systems are more than one IP hop away from each
other, an external BGP session between those two devices is called multihop external BGP.

label
A short, fixed-length data identifier that tells switching nodes how to forward data (packets or cells).

label distribution
The techniques and processes used to cause routed traffic to travel through the network on a path other
than the one that would have been chosen if standard routing methods had been used.

LDP
Label Distribution Protocol. The protocol that supports MPLS hop-by-hop forwarding by distributing
bindings between labels and network prefixes. The Cisco proprietary version of this protocol is the Tag
Distribution Protocol (TDP).

LSP
label switched path. A configured connection between two devices, in which MPLS is used to carry
packets. A path created by the concatenation of one or more label switched hops, allowing a packet to
be forwarded by swapping labels from an MPLS node to another MPLS node.

MPLS
Multiprotocol Label Switching. A method for directing packets primarily through Layer 2 switching
rather than Layer 3 routing. In MPLS, packets are assigned short, fixed-length labels at the ingress to
an MPLS cloud by using the concept of forwarding equivalence classes. Within the MPLS domain, the
labels are used to make forwarding decisions mostly without recourse to the original packet headers;
formerly known as tag switching.

NLRI
Network Layer Reachability Information. BGP sends routing update messages containing NLRI, which
describes the route. In this context, an NLRI is a prefix. A BGP update message carries one or more
NLRI prefixes and the attributes of a route for the NLRI prefixes. The route attributes include a BGP
next hop gateway address, community values, and other information.

PE device
provider edge device. A device on the border between a VPN provider and a VPN customer that belongs
to the provider.

QoS
quality of service. A measure of performance for a transmission system that reflects its transmission
quality and service availability.
**router**

A network layer device that uses one or more metrics to determine the optimal path along which network traffic should be forwarded. Routers forward packets from one network to another based on network layer information.

**VPN**

Virtual Private Network. A secure IP-based network that shares resources on one or more physical networks. A VPN contains geographically dispersed sites that can communicate securely over a shared backbone.