MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

This feature enables you to configure your carrier supporting carrier network to enable Border Gateway Protocol (BGP) to transport routes and Multiprotocol Label Switching (MPLS) labels between the backbone carrier provider edge (PE) routers and the customer carrier customer edge (CE) routers. Previously you had to use Label Distribution Protocol (LDP) to carry the labels and an Internal Gateway Protocol (IGP) to carry the routes between PE and CE routers to achieve the same goal.

The benefits of using BGP to distribute IPv4 routes and MPLS label routes are that:

- 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.

This feature is an extension of the Carrier Supporting Carrier feature, introduced in Cisco IOS Release 12.0(14)ST, which was based on LDP.

Feature Specifications for MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

Feature History	
Release	**Modification**
12.0(21)ST	This feature was introduced.
12.0(22)S	This feature was implemented on the Cisco 12000 series router (see Table 1 for the line cards supported) and integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	Support was added for the Cisco 12000 Series Eight-Port OC-3c/STM-1c ATM Line Card (8-Port OC-3 ATM) and the Cisco 12000 Series Three-Port Gigabit Ethernet Line Card (3-Port GbE).
12.2(13)T	This feature was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This feature was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

CISCO SYSTEMS

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Supported Platforms
Cisco 7200 series, Cisco 7500 series, Cisco 12000 series, and Cisco 10000 series routers. For specific Cisco 12000 series line cards supported on Cisco IOS S and ST releases, see Table 1.

Determining Platform Support Through Cisco Feature Navigator

Cisco IOS software is packaged in feature sets that are supported on specific platforms. To obtain updated information about platform support for this feature, access Cisco Feature Navigator. Cisco Feature Navigator dynamically updates the list of supported platforms as new platform support is added for the feature.

Cisco Feature Navigator is a web-based tool that enables you to quickly determine which Cisco IOS software images support a specific set of features and which features are supported in a specific Cisco IOS image. You can search by feature or release. In the release section, you can compare releases side by side to display both the features unique to each software release and the features that releases have in common.

To access Cisco Feature Navigator, you must have an account on Cisco.com. If you have forgotten or lost your account information, send a blank e-mail to cco-locksmith@cisco.com. An automatic check will verify that your e-mail address is registered with Cisco.com. If the check is successful, account details with a new random password will be e-mailed to you. Qualified users can establish an account on Cisco.com by following the directions found at this URL:

http://www.cisco.com/register

Cisco Feature Navigator is updated regularly when major Cisco IOS software releases and technology releases occur. For the most current information, go to the Cisco Feature Navigator home page at the following URL:

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

Availability of Cisco IOS Software Images

Platform support for particular Cisco IOS software releases is dependent on the availability of the software images for those platforms. Software images for some platforms may be deferred, delayed, or changed without prior notice. For updated information about platform support and availability of software images for each Cisco IOS software release, refer to the online release notes or, if supported, Cisco Feature Navigator.

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Prerequisites for MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

You should be able to configure Multiprotocol Virtual Private Networks (MPLS VPNs) with end-to-end (CE-to-CE router) pings working. To accomplish this, you need to know how to configure IGP routing protocols, LDP, and Multiprotocol Border Gateway Protocol (MP-BGP).

Make sure that the carrier supporting carrier provider edge (CSC-PE) routers and the carrier supporting carrier customer edge (CSC-CE) routers run images that support BGP label distribution. Otherwise, you cannot run external BGP (EBGP) between them.

Table 1 lists the Cisco 12000 series line cards support for Cisco IOS S and ST releases.

Table 1 Cisco I2000 Series Line Card Support for Cisco IOS S and ST Releases

Type	Line Cards	Cisco IOS Release Supported
Packet Over SONET (POS)	4-Port OC-3 POS 8-Port OC-3 POS 16-Port OC-3 POS 1-Port OC-12 POS 4-Port OC-12 POS 1-Port OC-48 POS 4-Port OC-3 POS ISE 8-Port OC-3 POS ISE 16-Port OC-3 POS ISE 4-Port OC-12 POS ISE 1-Port OC-48 POS ISE	12.0(22)S, 12.0(23)S
Electrical Interface	6-Port DS3 12-Port DS3 6-Port E3 12-Port E3	12.0(22)S, 12.0(23)S
Ethernet	3-Port GbE	12.0(23)S
Asynchronous Transfer Mode (ATM)	4-Port OC-3 ATM 1-Port OC12 ATM 4-Port OC-12 ATM 8-Port OC-3 ATM	12.0(22)S, 12.0(23)S 12.0(23)S
Channelized Interface	2-Port CHOC-3 6-Port Ch T3 (DS1) 1-Port CHOC-12 (DS3) 1-Port CHOC-12 (OC-3) 4-Port CHOC-12 ISE 1-Port CHOC-48 ISE	12.0(22)S, 12.0(23)S

Restrictions for MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

On a 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:

- Multiple BGP routes to a given destination with different MPLS labels as described in Section 4 of RFC 3107
- 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 (CEF) or distributed Cisco Express Forwarding (DCEF) and MPLS.

Information About MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

To configure a carrier supporting carrier network that uses BGP to distribute routes and MPLS labels between the PE and CE routers of a backbone carrier and a customer carrier, you need to understand the following concepts:

- Major Components of MPLS VPNs, page 4
- BGP Label Distribution, page 5
- Carrier Supporting Carrier Networks Supported for IPv4 BGP Label Distribution, page 6

Major Components of MPLS VPNs

An MPLS-based VPN network has three major components:

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

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

An MPLS VPN consists of a set of sites that are interconnected by means of an MPLS provider core network. At each customer site, one or more CE routers attaches to one or more PE routers. The PE routers use the MP-BGP to dynamically communicate with each other.

BGP Label Distribution

This section contains the following topics:

- BGP Routing Information, page 5
- Types of BGP Messages, page 5
- How BGP Sends MPLS Labels with Routes, page 5

BGP Routing Information

BGP routing information includes the following items:

- A network number (prefix)—The IP address of the destination.
- Autonomous system (AS) path—A list of other ASs through which a route passes on its way to the local router. The first AS in the list is closest to the local router; the last AS in the list is farthest from the local router and usually the AS where the route began.
- Path attributes—Descriptors that provide other information about the AS path, for example, the next hop.

Types of BGP Messages

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

- Open Messages—After a router establishes a TCP connection with a neighboring router, the routers exchange open messages. This message contains the AS number to which the router belongs and the IP address of the router who 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 Network Layer Reachability Information (NLRI), which lists the IP addresses of the usable routes. The update message also 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 VPNv4 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.
- 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 only contains a message header.
- Notification Messages—When a router detects an error, it sends a notification message.

How BGP Sends MPLS Labels with Routes

When BGP (both 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 BPG 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.

Carrier Supporting Carrier Networks Supported for IPv4 BGP Label Distribution

This feature enables you to configure a carrier supporting carrier network that uses BGP to distribute routes and MPLS labels between the PE and CE routers of a backbone carrier and a customer carrier. The backbone carrier offers BGP and MPLS VPN services. The customer carrier can be either of the following:

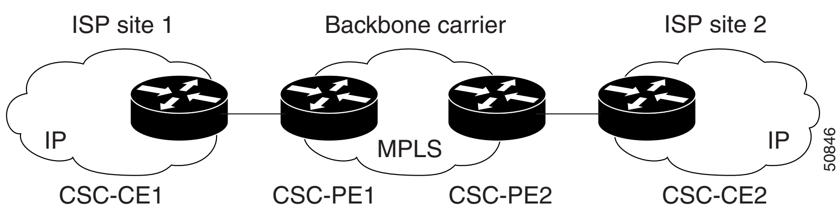
- Customer Carrier Is an Internet Service Provider with an IP Core, page 6
- Customer Carrier is an MPLS Service Provider With or Without VPN Services, page 6

This document describes how to use BGP to distribute MPLS labels and routes for both types of customer carrier.

Customer Carrier Is an Internet Service Provider with an IP Core

Figure 1 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 1 Network Where the Customer Carrier Is an ISP



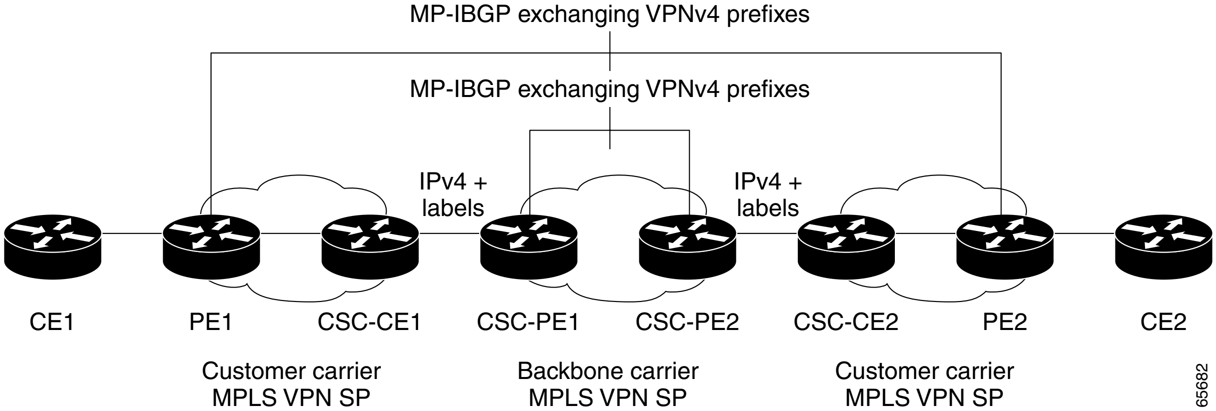
In this configuration, the links between the CE and PE routers use EBGP to distribute IPv4 routes and MPLS labels. Between the links, the PE routers use multiprotocol IBGP to distribute VPNv4 routes.

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

Figure 2 shows a network configuration where the backbone carrier and the customer carrier are BGP/MPLS VPN service providers. The customer carrier has two sites. Both the backbone carrier and the customer carrier use MPLS in their networks.

Figure 2 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 can run an IPv4 and labels IBGP session with the PE1 router.

How to Configure and Verify MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

This section contains the following tasks and processes that explain how to configure and verify the MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution feature:

- Identify the Carrier Supporting Carrier Topology, page 7 (required)
- Configure and Verify the Backbone Carrier Core, page 8
- Configure and Verify the Links Between CSC-PE and CSC-CE Routers, page 15
- Configure and Verify the Customer Carrier Network, page 29
- Configure and Verify the Customer Site for Hierarchical VPNs, page 33

Note Configuration tasks are required. Verification tasks are optional.

Identify the Carrier Supporting Carrier Topology

Before you configure the MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution feature, you need to identify both the backbone and customer carrier topology.

The main concern of this feature is the 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. MPLS VPNs described in the *MPLS Virtual Private Networks (VPNs)* feature module do not use MPLS on these carrier connections.

You need to identify the type of customer carrier as well as the topology of the carriers

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 backbone carrier router configuration.

DETAILED STEPS

	Command or Action	Purpose
Step 1	Identify the type of customer carrier, ISP or MPLS VPN service provider.	Sets up requirements for configuration of carrier supporting carrier with IPv4 and BGP label distribution. • 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 backbone carrier router configuration.	Sets up requirements for connection configuration between core (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 for the MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution feature starting with the "Configure and Verify the Backbone Carrier Core" section on page 8.

Configure and Verify the Backbone Carrier Core

Configuring the backbone carrier core in an MPLS VPN carrier supporting carrier network with BGP label distribution requires setting up connectivity and routing functions for the CSC-Core and the CSC-PE routers.

Prerequisites

Before you configure a backbone carrier core for the MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution feature, you must configure the following on the CSC-Core routers:

- An IGP routing protocol—BGP, OSPF, IS-IS, EIGRP, static, and so on. For information, see the "IP Routing Protocols" chapter in the *Cisco IOS IP Configuration Guide,* Release 12.2.
- Label Distribution Protocol (LDP). For information, see the *MPLS Label Distribution Protocol (LDP)*.

Note These prerequisites must be configured first.

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

- Verify IP Connectivity and LDP Configuration in the CSC-Core, page 9 (optional)
- Configure VRFs for CSC-PE Routers, page 11 (required)
- Configure Multiprotocol BGP for VPN Connectivity in the Backbone Carrier, page 13 (required)

Verify 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** *vpn-name*] [{*network* {*mask* | *length*} | **labels** *label* [- *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]}] [**detail**]
5. **show mpls ldp discovery** [[**vrf** *vpn-name*] | [**all**]]
6. **show mpls ldp neighbor** [[**vrf** *vpn-name*] [*address* | *interface*] [**detail**] | [**all**]]
7. **show ip cef** [**vrf** *vrf-name*] [*network* [*mask*]] [**longer-prefixes**] [**detail**]
8. **show mpls interfaces** [[**vrf** *vpn-name*] [*interface*] [**detail**] | [**all**]]
9. **show ip route**
10. **disable**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Router> enable	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**ping** [*protocol*] {*host-name* | system *address*} **Example:** Router# ping ip <CSC-Core-address>	(Optional) Diagnoses basic network connectivity on AppleTalk, CLNS, IP, Novell, Apollo, VINES, DECnet, or XNS networks. • Use the **ping ip** command to verify the connectivity from one CSC-Core router to another.
Step 3	**trace** [*protocol*] [*destination*] **Example:** Router# trace ip destination-address	(Optional) Discovers the routes that packets will actually take when traveling to their destination. • 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 mpls forwarding-table** [**vrf** *vpn-name*] [{*network* {*mask* | *length*} | **labels** *label* [- *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]}] [**detail**] **Example:** Router# show mpls forwarding-table	(Optional) Display the contents of the MPLS forwarding information base (LFIB). • Use the **show mpls forwarding-table** command to verify that MPLS packets are being forwarded.
Step 5	**show mpls ldp discovery** [[**vrf** *vpn-name*] | [**all**]] **Example:** Router# show mpls ldp discovery	(Optional) Displays the status of the LDP discovery process. • Use the **show mpls ldp discovery** command to verify that LDP is operational in the CSC-Core.
Step 6	**show mpls ldp neighbor** [[**vrf** *vpn-name*] [*address* | *interface*] [**detail**] |[**all**]] **Example:** Router# show mpls ldp neighbor	(Optional) Displays the status of LDP sessions. • Use the **show mpls ldp neighbor** command to verify LDP configuration in the CSC-Core.
Step 7	**show ip cef** [**vrf** *vrf-name*] [*network* [*mask*]] [**longer-prefixes**] [**detail**] **Example:** Router# show ip cef	(Optional) Displays entries in the forwarding information base (FIB). • Use the **show ip cef** command to check the forwarding table (prefixes, next-hops, and interfaces).
Step 8	**show mpls interfaces** [[**vrf** *vpn-name*] [*interface*] [**detail**] | [**all**]] **Example:** Router# show mpls interfaces	(Optional) Displays information about one or more or all interfaces that are configured for label switching. • Use the **show mpls interfaces** command to verify that the interfaces are configured to use LDP.

	Command or Action	Purpose
Step 9	**show ip route** **Example:** `Router# show ip route`	(Optional) Displays IP routing table entries. • Use the **show ip route** command to display the entire routing table, including host IP address, next hop, interface, and so forth.
Step 10	**disable** **Example:** `Router# disable`	(Optional) Returns to user mode.

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.

Additional Information

For a configuration example for this task, see the "Verifying IP Connectivity and LDP Configuration in the CSC-Core Example" section on page 43.

Configure 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** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip vrf** *vrf-name* **Example:** `Router(config)# ip vrf 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`	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
Step 5	**route-target** {**import** |**export** | **both**} *route-target-ext-community* **Example:** `Router(config-vrf)# route-target import 100:1`	Creates a route-target extended community for a VRF. • The **import** keyword imports routing information from the target VPN extended community. • The **export** keyword exports routing information to the target VPN extended community. • The **both** keyword imports both import and export 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.
Step 6	**import map** *route-map* **Example:** `Router(config-vrf)# import map vpn1-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.
Step 7	**exit** **Example:** `Router(config-vrf)# exit`	Exits to global configuration mode.

	Command or Action	Purpose
Step 8	**interface** *type number* **Example:** `Router(config)# interface Ethernet5/0`	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.
Step 9	**ip vrf forwarding** *vrf-name* **Example:** `Router(config-if)# ip vrf forwarding vpn1`	Associates a VRF with an interface or subinterface. • The *vrf-name* argument is the name assigned to a VRF.
Step 10	**end** `Router(config-if)# end`	(Optional) Exits to privileged EXEC mode.

Troubleshooting Tips

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

Additional Information

For a configuration example for this task, see the "Configuring VRFs for CSC-PE Routers Example" section on page 45.

Configure 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** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**`enable`** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**`configure`** {**`terminal`** | **`memory`** | **`network`**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**`router bgp`** *`as-number`* **Example:** `Router(config)# router bgp 100`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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	**`no bgp default ipv4-unicast`** **Example:** `Router(config-router)# no bgp default ipv4-unicast`	(Optional) Disables the IPv4 unicast address family on all neighbors. • Use the **no** form of the **bgp default-unicast** command if you are using this neighbor for only MPLS routes.
Step 5	**`neighbor`** {*`ip-address`* | *`peer-group-name`*} **`remote-as`** *`as-number`* **Example:** `Router(config-router)# neighbor <CSC-Core-ip-address> remote-as 100`	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* specifies the name of a BGP peer group. • The *as-number* 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 <CSC-Core-ip-address> update-source loopback0`	Allows BGP sessions to use a specific operational interface for TCP connections. • The *ip-address* argument specifies the IP address of the BGP-speaking neighbor. • The *peer-group-name* argument specifies the name of a BGP peer group. • The *interface-typ*e argument specifies the interface to be used as the source.

	Command or Action	Purpose
Step 7	**address-family vpnv4** [**unicast**] **Example:** `Router(config-router)# address-family vpnv4`	Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes. • The optional **unicast** keyword specifies VPNv4 unicast address prefixes.
Step 8	**neighbor** {*ip-address* | *peer-group-name*} **send-community extended** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor. • The *ip-address* argument specifies the IP address of the BGP-speaking neighbor. • The *peer-group-name* argument specifies the name of a BGP peer group.
Step 9	**neighbor** {*ip-address* | *peer-group-name*} **activate** **Example:** `Router(config-router-af)# neighbor <CSC-Core-ip-address> 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* specifies the name of a BGP peer group.
Step 10	**end** **Example:** `Router(config-router-af)# end`	(Optional) Exits to privileged EXEC mode.

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.

Additional Information

For a configuration example for this task, see the "Configuring Multiprotocol BGP for VPN Connectivity in the Backbone Carrier Example" section on page 45.

Configure and Verify the Links Between CSC-PE and CSC-CE Routers

Configuring and verifying the links between the carrier supporting carrier backbone edge (CSC-PE) router and the carrier supporting carrier customer edge router (CSC-CE) router involves the following tasks:

- Configure EBGP with send-label Option for Carrier Supporting Carrier on CSC-PE Routers, page 16 (required)
- Configure EGBP with send-label Option for Carrier Supporting Carrier on CSC-CE Routers, page 18 (required)

- Verify Labels in the CSC-PE Routers, page 20 (optional)
- Verify Labels in the CSC-CE Routers, page 22 (optional)
- Configure Route Maps on the CSC-PE Routers, page 24 (optional)

Configure EBGP with send-label Option for Carrier Supporting Carrier on CSC-PE Routers

Perform this task to configure the carrier supporting carrier (CSC) on the CSC-PE routers so that they can distribute BGP routes with MPLS labels.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *as-number* **Example:** `Router(config)# router bgp 100`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.

	Command or Action	Purpose
Step 4	**address-family ipv4** [**multicast** | **unicast** | **vrf** *vrf-name*] **Example:** `Router(config-router)# address-family ipv4`	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 specifies 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 pp.0.0.1 remote-as 200`	Adds an entry to the BGP or multiprotocol BGP neighbor table. • The *ip-address* argument specifies the IP address of the neighbor. • The *peer-group-name* specifies the name of a BGP peer group. • The *as-number* specifies the autonomous system to which the neighbor belongs.
Step 6	**neighbor** {*ip-address* | *peer-group-name*} **activate** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 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* specifies the name of a BGP peer group.
Step 7	**neighbor** *ip-address* **as-override** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 as-override`	Configures a PE router to override the 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.
Step 8	**neighbor** *ip-address* **send-label** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 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.
Step 9	**exit-address-family** **Example:** `Router(config-router-af)# exit-address-family`	Exits address family configuration mode.
Step 10	**end** **Example:** `Router(config-router)# end`	(Optional) Exits to privileged EXEC mode.

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
```

Additional Information

For a configuration example for this task, see the "Configuring EBGP Link with send-label Option for Carrier Supporting Carrier on CSC-PE Routers Examples" section on page 46.

Configure EGBP with send-label Option for Carrier Supporting Carrier on CSC-CE Routers

Perform this task to configure the carrier supporting carrier on the CSC-CE routers so that they can distribute BGP routes with MPLS labels.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	`router bgp` *as-number* **Example:** `Router(config)# router bgp 200`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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`	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 specifies the name of the VRF to associate with subsequent IPv4 address family configuration mode commands.
Step 5	`redistribute` *protocol* **Example:** `Router(config-router)# redistribute static`	Redistributes routes from one routing domain into another routing domain. • The *protocol* 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**. • The **static** [**ip**] keyword redistributes IP static routes. The optional **ip** keyword is used when you redistribute static routes into IS-IS. • The **connected** keyword refers to routes which are established automatically by virtue of having enabled IP on an interface. For routing protocols such as OSPF and IS-IS, these routes will be redistributed as external to the autonomous system.
Step 6	`neighbor` {*ip-address* | *peer-group-name*} `remote-as` *as-number* **Example:** `Router(config-router-af)# neighbor pp.0.0.2 remote-as 100`	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* specifies the name of a BGP peer group. • The *as-number* specifies the autonomous system to which the neighbor belongs.

	Command or Action	Purpose
Step 7	**neighbor** {*ip-address* | *peer-group-name*} **activate** **Example:** `Router(config-router-af)# neighbor pp.0.0.2 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* specifies the name of a BGP peer group.
Step 8	**neighbor** *ip-address* **send-label** **Example:** `Router(config-router-af)# neighbor pp.0.0.2 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.
Step 9	**exit-address-family** **Example:** `Router(config-router-af)# exit-address-family`	Exits from the address family submode.
Step 10	**end** **Example:** `Router(config-router)# end`	(Optional) Exits to privileged EXEC mode.

Additional Information

For a configuration example for this task, see the "Configuring EBGP Link with send-label Option for Carrier Supporting Carrier on CSC-CE Routers Examples" section on page 48.

Verify 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** *vpn-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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**show ip bgp vpnv4** {**all** | **rd** *route-distinguisher* | **vrf** *vrf-name*} [**summary**] [**labels**] **Example:** `Router# show ip bgp vpnv4 all summary`	(Optional) Displays VPN address information from the BGP table. • Use the **show ip bgp vpnv4 all summary** 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.
Step 3	**show mpls interfaces** [**all**] **Example:** `Router# 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.
Step 4	**show ip route vrf** *vrf-name* [*prefix*] **Example:** `Router# show ip route vrf vpn1 <PE-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.
Step 5	**show ip bgp vpnv4** {**all** | **rd** *route-distinguisher* | **vrf** *vrf-name*} [**summary**] [**labels**] **Example:** `Router# show ip bgp vpnv4 vrf vpn1 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.

Step 6	**show ip cef** [**vrf** *vrf-name*] [*network* [*mask*]] [**longer-prefixes**] [**detail**]
	
	Example:
	`Router# show ip cef vrf vpn1 <PE-prefix>`
	
	`Router# show ip cef vrf vpn1 <PE-prefix> 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.

	Command or Action	Purpose

Step 7	**show mpls forwarding-table** [**vrf** *vpn-name*] [{*network* {*mask* | *length*} | **labels** *label* [- *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]}] [**detail**]
	
	Example:
	`Router# show mpls forwarding-table vrf vpn1 <PE-prefix>`
	
	`Router# show mpls forwarding-table vrf vpn1 <PE-prefix> detail`
		(Optional) Displays the contents of the MPLS forwarding information base (LFIB).
		• Use the **show mpls forwarding-table** command with the **vrf** and **vrf detail** keywords to check that the prefixes for the PE routers in the local customer MPLS VPN service provider are in the LFIB.

Step 8	**traceroute VRF** [*vrf-name*] *ip-address* **Example:** `Router# traceroute vrf vpn2 jj.jj.jj.jj`	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. **Note** This command only works with MPLS-aware traceroute if the backbone routers are configured to propagate and generate IP Time to Live (TTL) information. For more information, see the documentation on the **mpls ip propagate-ttl** command.
Step 9	**disable** **Example:** `Router# disable`	(Optional) Exits to user EXEC mode.

Additional Information

For a configuration example for this task, see the "Verifying Labels in the CSC-PE Routers Examples" section on page 50.

Verify 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** [**vrf** *vrf-name*] [*network* [*mask*]] [**longer-prefixes**] [**detail**]
6. **show mpls forwarding-table** [**vrf** *vpn-name*] [{*network* {*mask* | *length*} | **labels** *label* [- *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]}] [**detail**]
7. **show ip bgp labels**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Router> enable	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**show ip bgp summary** **Example:** Router# show ip bgp summary	(Optional) Displays the status of all BGP connections. • Use the **show ip bgp summary** command to check that the BGP session is up and running on the CSC-CE routers.
Step 3	**show ip route** [*address*] **Example:** Router# show ip route *PE-address*	(Optional) Displays IP routing table entries. • Use the **show ip route** command to check that the loopback address of the local and remote PE routers are in the routing table.
Step 4	**show mpls ldp bindings** [*network* {*mask* | *length*}] **Example:** Router# show mpls ldp bindings *PE-prefix* 255.255.255.255	(Optional) Displays the contents of the label information base (LIB). • Use the **show mpls ldp bindings** command to check that the prefix of the local PE router is in the MPLS LDP bindings.
Step 5	**show ip cef** [**vrf** *vrf-name*] [*network* [*mask*]] [**longer-prefixes**] [**detail**] **Example:** Router# show ip cef <PE-prefix> Router# show ip cef <PE-prefix> detail	(Optional) Displays entries in the forwarding information base (FIB) or a summary of the FIB. • Use the **show ip cef** and the **show ip cef detail** commands to check that the prefixes of the local and remote PE routers are in the CEF table.
Step 6	**show mpls forwarding-table** [**vrf** *vpn-name*] [{*network* {*mask* | *length*} | **labels** *label* [- *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]}] [**detail**] **Example:** Router# show mpls forwarding-table <PE-prefix> Router# show mpls forwarding-table <PE-prefix> detail	(Optional) Displays the contents of the MPLS forwarding information base (LFIB). • Use the **show mpls forwarding-table** and **show mpls forwarding-table detail** commands to check that the prefixes of the local and remote PE routers are in the MPLS forwarding table.
Step 7	**show ip bgp labels** **Example:** Router# show ip bgp labels	(Optional) Displays information about MPLS labels from the EBGP route table. • Use the **show ip bgp labels** command to check that the BGP routing table contains labels for prefixes in the customer carrier MPLS VPN service provider networks.

Additional Information

For a configuration example for this task, see the "Verifying Labels in the CSC-CE Routers Examples" section on page 56.

Configure Route Maps on the CSC-PE Routers

The following tasks describe how to enable routers to send MPLS labels with the routes specified in the route maps:

- Configure a Route Map for Arriving Routes, page 24 (optional)
- Configure a Route Map for Departing Routes, page 26 (optional)
- Apply the Route Maps to the CSC-PE and CSC-CE Routers, page 27 (optional)

To configure route maps on routers, specifically carrier edge routers, you need to understand how to use route maps to filter routes.

Using Route Maps to Filter Routes

When routers are configured to distribute routes with MPLS labels, all the routes are encoded with the multiprotocol extensions and contain an MPLS label. You can use a route map to control the distribution of MPLS labels between routers.

Route maps enable you to specify which routes are distributed with MPLS labels. Route maps also enable you to specify which routes with MPLS labels a router receives and adds to its BGP table.

Route maps work with access control lists (ACLs). You enter the routes into an ACL and then specify the ACL when you configure the route map. The routers accept only routes that are specified in the route map. The routers check the routes listed in the BGP update message against the list of routes in the ACL specified. If a route in the BGP update message matches a route in the ACL, the route is accepted and added to the BGP table.

Prerequisites

Before you configure and apply route maps for the CSC-PE routers, you need to create an ACL and specify the routes that the router should distribute with MPLS labels.

Configure a Route Map for Arriving Routes

This configuration is optional.

Perform this task to configure a route map to filter for arriving routes.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
3. **router bgp** *as-number*
4. **route-map** *map-name* [**permit** | **deny**] *sequence-number*
5. **match ip address** {*access-list-number* | *access-list-name*} [... *access-list-number* |... *access-list-name*]
6. **match mpls-label**
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *as-number* **Example:** `Router(config)# router bgp 100`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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	**route-map** *map-name* [**permit** | **deny**] *sequence-number* **Example:** `Router(config-router)# route-map csc-mpls-routes-in permit`	Creates a route map with the name you specify. • The *map-name* argument identifies the name of the route map. • The **permit** keyword allows the actions to happen if all conditions are met. • A **deny** keyword prevents any actions from happening if all conditions are met. • The *sequence-number* parameter allows you to prioritize route maps. If you have multiple route maps and want to prioritize them, assign each one a number. The route map with the lowest number is implemented first, followed by the route map with the second lowest number, and so on.
Step 5	**match ip address** {*access-list-number* | *access-list-name*} [... *access-list-number* |... *access-list-name*] **Example:** `Router(config-route-map)# match ip address acl-in`	Distributes any routes that have a destination network number address that is permitted by a standard or extended access list, or to perform policy routing on packets. • The *access-list-number* argument is a number of a standard or extended access list. It can be an integer from 1 to 199. • The *access-list-name* argument is a name of a standard or extended access list. It can be an integer from 1 to 199.

	Command or Action	Purpose
Step 6	**match mpls-label** **Example:** `Router(config-route-map)# match mpls-label`	Redistributes routes that include MPLS labels if the routes meet the conditions specified in the route map.
Step 7	**exit** `Router(config-router-map)# exit`	Exits route map configuration mode and return to global configuration mode.

Configure a Route Map for Departing Routes

This configuration is optional.

Perform this task to configure a route map to filter for departing routes.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
3. **router bgp** *as-number*
4. **route-map** *map-name* [**permit** | **deny**] *sequence-number*
5. **match ip address** {*access-list-number* | *access-list-name*} [... *access-list-number* |... *access-list-name*]
6. **set mpls-label**
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *as-number* **Example:** `Router(config)# router bgp 100`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.

	Command or Action	Purpose
Step 4	**route-map** *map-name* [**permit** | **deny**] *sequence-number* **Example:** `Router(config-router)# route-map csc-mpls-routes-out permit`	Creates a route map with the name you specify. • The *map-name* argument identifies the name of the route map. • The **permit** keyword allows the actions to happen if all conditions are met. • A **deny** keyword prevents any actions from happening if all conditions are met. • The *sequence-number* parameter allows you to prioritize route maps. If you have multiple route maps and want to prioritize them, assign each one a number. The route map with the lowest number is implemented first, followed by the route map with the second lowest number, and so on.
Step 5	**match ip address** {*access-list-number* | *access-list-name*} [... *access-list-number* | ... *access-list-name*] **Example:** `Router(config-route-map)# match ip address acl-out`	Distributes any routes that have a destination network number address that is permitted by a standard or extended access list, or to perform policy routing on packets. • The *access-list-number* argument is a number of a standard or extended access list. It can be an integer from 1 to 199. • The *access-list-name* argument is a name of a standard or extended access list. It can be an integer from 1 to 199.
Step 6	**set mpls-label** **Example:** `Router(config-route-map)# set mpls-label`	Enables a route to be distributed with an MPLS label if the route matches the conditions specified in the route map.
Step 7	**exit** `Router(config-router-map)# exit`	Exits route map configuration mode and return to global configuration mode.

Apply the Route Maps to the CSC-PE and CSC-CE Routers

This configuration is optional.

Perform this task to enable the CSC-PE and the CSC-CE routers to use the route maps.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
3. **router bgp** *as-number*
4. **address-family ipv4** [**multicast** | **unicast** | **vrf** *vrf-name*}
5. **neighbor** *ip-address* **route-map** *route-map-name* **in**
6. **neighbor** *ip-address* **route-map** *route-map-name* **out**
7. **neighbor** *ip-address* **send-label**

8. **exit-address-family**
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *as-number* **Example:** `Router(config)# router bgp 100`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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 vrf vpn1`	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 specifies the name of the VRF to associate with subsequent IPv4 address family configuration mode commands.
Step 5	**neighbor** *ip-address* **route-map** *map-name* **in** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 route-map csc-mpls-routes-in in`	Applies a route map to incoming routes. • The *ip-address* argument specifies the router to which the route map is to be applied. • The *map-name* argument specifies the name of the route map. • The **in** keyword applies the route map to incoming routes.

	Command or Action	Purpose
Step 6	**neighbor** *ip-address* **route-map** *map-name* **out** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 route-map csc-mpls-route-out out`	Applies a route map to outgoing routes. • The *ip-address* argument specifies the router to which the route map is to be applied. • The *map-name* argument specifies the name of the route map. • The **out** keyword applies the route map to outgoing routes.
Step 7	**neighbor** *ip-address* **send-label** **Example:** `Router(config-router-af)# neighbor pp.0.0.1 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.
Step 8	**exit-address-family** **Example:** `Router(config-router-af)# exit-address-family`	Exits from the address family submode.
Step 9	**end** **Example:** `Router(config-router)# end`	(Optional) Exits to privileged EXEC mode.

Troubleshooting Tips

You can enter a **show route-map** *map-name* command to verify that the route map is applied to the CSC-CE and the CSC-PE routers.

Note After you make any changes to a route map, you need to reset the BGP connection.

Additional Information

For a configuration example for this task, see the "Configuring Route Maps on the CSC-PE Routers Example" section on page 61.

Configure and Verify the Customer Carrier Network

Configuring and verifying the customer carrier network 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 a customer carrier network for the MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution feature, 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 *IP Routing Protocols* in the *Cisco IOS IP Configuration Guide,* Release 12.2.

- MPLS VPN functionality on the PE routers (for hierarchical VPNs only). For information, see the *MPLS Virtual Private Networks (VPNs)* or the *MPLS Virtual Private Network Enhancements*.
- Label Distribution Protocol (LDP) on P and PE routers (for hierarchical VPNs only). For information, see the *MPLS Label Distribution Protocol (LDP)*.

Note These prerequisites must be configured first.

Additional configuration and verification of the customer carrier network involves the following optional tasks:

- Verify IP Connectivity in the Customer Carrier, page 30 (optional)
- Configure a Customer Carrier Core Router as a Route Reflector, page 31 (optional)

Verify 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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**ping** [*protocol*] {*host-name* | *system-address*} **Example:** `Router# ping ip <P-address>`	Diagnoses basic network connectivity on AppleTalk, CLNS, IP, Novell, Apollo, VINES, DECnet, or XNS networks. • Use the **ping** command to verify the connectivity from one customer carrier core router to another.
Step 3	**trace** [*protocol*] [*destination*] **Example:** `Router# trace ip destination-address`	Discovers the routes that packets will actually take when traveling to their destination. • 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.

	Command or Action	Purpose
Step 4	**show ip route** **Example:** `Router# show ip route`	Displays IP routing table entries. • 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** **Example:** `Router# disable`	Returns to user mode.

Additional Information

For a configuration example for this task, see the "Verifying IP Connectivity in the Customer Carrier Example" section on page 61.

Configure 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** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**router bgp** *as-number* **Example:** `Router(config)# router bgp 200`	Configures a BGP routing process and enters router configuration mode. • The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and 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.
Step 4	**neighbor** {*ip-address* | *peer-group-name*} **remote-as** *as-number* **Example:** `Router(config-router)# neighbor 10.1.1.1 remote-as 100`	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* specifies the name of a BGP peer group. • The *as-number* argument specifies the autonomous system to which the neighbor belongs.
Step 5	**address-family vpnv4** [**unicast**] **Example:** `Router(config-router)# address-family vpnv4`	Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes. • The optional **unicast** keyword specifies VPNv4 unicast address prefixes.
Step 6	**neighbor** {*ip-address* | *peer-group-name*} **activate** **Example:** `Router(config-router-af)# neighbor 10.1.1.1 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* specifies the name of a BGP peer group.
Step 7	**neighbor** *ip-address* **route-reflector-client** **Example:** `Router(config-router-af)# neighbor 10.1.1.1 route-reflector-client`	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`	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. To exchange other address prefix types, such as multicast and VPNv4, neighbors must also be activated 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 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.

Additional Information

For a configuration example for this task, see the "Configuring a Customer Carrier Core Router as a Route Reflector Example" section on page 62.

Configure and Verify the Customer Site for Hierarchical VPNs

The following tasks describe how to configure and verify the customer site for hierarchical VPNs:

- Configure Provider Edge Routers for Hierarchical VPNs, page 33
- Verify Labels in Each Provider Edge Router for Hierarchical VPNs, page 37
- Configure Customer Edge Routers for Hierarchical VPNs, page 38
- Verify IP Connectivity in the Customer Site, page 40

Note This section applies to hierarchical VPNs only.

Configure Provider Edge Routers for Hierarchical VPNs

The following tasks describe how to configure PE routers for hierarchical VPNs:

- Define VPNs on the Provider Edge Routers, page 33
- Configure BGP Routing Sessions on the Provider Edge Routers, page 35

Define VPNs on the Provider Edge Routers

Perform this task to define VPNs on the PE routers.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip vrf** *vrf-name* **Example:** `Router(config)# ip vrf vpn2`	Creates a VRF routing table and a CEF forwarding table and enters VRF configuration mode. • The *vrf-name* argument is a name assigned to a VRF.
Step 4	**rd** *route-distinguisher* **Example:** `Router(config-vrf)# rd 200:1`	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.
Step 5	**route-target** {**import** |**export** | **both**} *route-target-ext-community* **Example:** `Router(config-vrf)# route-target export 200:1`	Creates a route-target extended community for a VRF. • The **import** keyword imports routing information from the target VPN extended community. • The **export** keyword exports routing information to the target VPN extended community. • The **both** keyword imports both import and export 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.
Step 6	**import map** *route-map* **Example:** `Router(config-vrf)# import map` *route-map*	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.

	Command or Action	Purpose
Step 7	**ip vrf forwarding** *vrf-name* **Example:** `Router(config-vrf)# ip vrf forwarding vpn2`	Associates a VPN VRF instance with an interface or subinterface. • The *vrf-name* argument is the name assigned to a VRF.
Step 8	**exit** **Example:** `Router(config-vrf)# exit`	Exits to global configuration mode.

Additional Information

For a configuration example for this task, see the "Configuring Provider Edge Routers for Hierarchical VPNs Examples" section on page 63.

Configure BGP Routing Sessions on the Provider Edge Routers

Perform this task to configure BGP routing sessions on the provider edge (PE) routers for PE-to-CE router communication.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**configure** {**terminal** | **memory** | **network**} **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
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 specifies the name of theVRF to associate with subsequent IPv4 address family configuration mode commands.
Step 5	**neighbor** {*ip-address* | *peer-group-name*} **remote-as** *number* **Example:** `Router(config-router-af)# neighbor <remote-pe-ip-address> 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 <CE-ip-address> 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.
Step 7	**end** **Example:** `Router(config-router-af)# end`	(Optional) Exits to privileged EXEC mode.

Additional Information

For a configuration example for this task, see the "Configuring Provider Edge Routers for Hierarchical VPNs Examples" section on page 63.

Verify Labels in Each Provider Edge 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

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**show ip route vrf** *vrf-name* [*prefix*] **Example:** `Router# show ip route vrf vpn2 <CE-prefix>`	(Optional) Displays the IP routing table associated with a VRF. • Use the **show ip route vrf** command to check that the loopback address of the local and remote CE routers are in the routing table of the PE routers.

Step 3	**show mpls forwarding-table** [**vrf** *vrf-name*] [*prefix*] [**detail**]
	
	Example:
	`Router# show mpls forwarding-table vrf vpn2 <CE-prefix>`
	
	`Router# show mpls forwarding-table vrf vpn2 <CE-prefix> detail`
		(Optional) Displays the contents of the LFIB.
		
		• Use the **show mpls forwarding-table** command to check that the prefixes for the local and remote CE routers are in the MPLS forwarding table, and that the prefix is untagged.

Step 4	**show ip cef** [*network* [*mask* [**longer-prefix**]]] [**detail**]
	
	Example:
	`Router# show ip cef <PE-prefix>`
	
	`Router# show ip cef <PE-prefix> detail`
		(Optional) Displays specific entries in the FIB based on IP address information.
		
		• Use the **show ip cef** command to check that the prefixes of the local and remote PE routers are in the CEF table.

	Command or Action	Purpose
Step 5	**`show ip cef vrf`** *`vrf-name`* `[`*`ip-prefix`*`]` **Example:** `Router# show ip cef vrf vpn2 <CE-prefix>`	(Optional) Displays the CEF 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 CEF table.
Step 6	**`exit`** **Example:** `Router# exit`	(Optional) Exits to user EXEC mode.

Additional Information

For a configuration example for this task, see the "Verifying Labels in Each Provider Edge Router for Hierarchical VPNs Examples" section on page 65.

Configure Customer Edge 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 an hierarchical topology.

SUMMARY STEPS

1. **enable**
2. **configure** {**terminal** | **memory** | **network**}
3. **ip cef** [**distributed**]
4. **interface** *type number*
5. **ip address** *ip-address mask* [**secondary**]
6. **router bgp** *as-number*
7. **redistribute** *protocol*
8. **neighbor** {*ip-address* | *peer-group-name*} **remote-as** *as-number*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`enable`** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**`configure`** `{`**`terminal`** `|` **`memory`** `|` **`network`**`}` **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose

Step 3	`ip cef [distributed]`
	
	Example:
	`Router(config)# ip cef distributed`
		Enables Cisco Express Forwarding (CEF) on the route processor card.
		• The **distributed** keyword enables distributed CEF (dCEF) operation. Distributes CEF information to line cards. Line cards perform express forwarding.

Step 4	`interface type number`
	
	Example:
	`Router(config)# interface loopback 0`
		Configures an interface type and enters interface configuration mode.
		• The *type* **loopback** keyword is a software-only loopback 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.

Step 5	`ip address ip-address mask [secondary]`
	
	Example:
	`Router(config-if)# ip address aa.aa.aa.aa 255.255.2355.255`
		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.

Step 6	`router bgp as-number`
	
	Example:
	`Router(config)# router bgp 100`
		Configures a BGP routing process and enters router configuration mode.
		• The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along.
		Valid numbers are from 0 to 65535. Private autonomous system numbers that can be used in internal networks range from 64512 to 65535.

Step 7	`redistribute protocol`
	
	Example:
	`Router(config-router)# redistribute connected`
		Redistributes routes from one routing domain into another routing domain.
		• The *protocol* argument specifies the source protocol from which routes are being redistributed. It can be one of the following keywords: **bgp**, **connected**, **egp**, **igrp**, **isis**, **mobile**, **ospf**, **static** [**ip**], or **rip**.
		The **connected** keyword refers to routes that are established automatically by virtue of having enabled IP on an interface. For routing protocols such as Open Shortest Path First (OSPF) and IS-IS, these routes will be redistributed as external to the autonomous system.

	Command or Action	Purpose
Step 8	**neighbor** {*ip-address* | *peer-group-name*} **remote-as** *as-number* **Example:** `Router(config-router)# neighbor <CSC-Core-ip-address> remote-as 100`	Adds the IP address of the neighbor in the remote autonomous system to the multiprotocol BGP neighbor table of the local router. • The *ip-address* argument specifies the IP address of the neighbor. • The *peer-group-name* specifies the name of a BGP peer group. • The *as-number* specifies the autonomous system to which the neighbor belongs.
Step 9	**end** **Example:** `Router(config-vrf)# end`	(Optional) Exits to privileged EXEC mode.

Additional Information

For a configuration example for this task, see the "Configuring Customer Edge Routers for Hierarchical VPNs Examples" section on page 68.

Verify 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*}]
3. **ping** [*protocol*] {*host-name* | *system-address*}
4. **trace** [*protocol*] [*destination*]
5. **disable**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables higher privilege levels, such as privileged EXEC mode. Enter your password if prompted.
Step 2	**show ip route** [*ip-address* [*mask*] [**longer-prefixes**]] | [*protocol* [*process-id*]] | [**list** {*access-list-number* | *access-list-name*}] **Example:** `Router# show ip route <remote-CE-address>`	(Optional) Displays the current state of the routing table. • Use the **show ip route** *ip-address* command to check that the loopback addresses of the remote CE routers learned through the PE router is in the routing table of the local CE routers.
Step 3	**ping** [*protocol*] {*host* | *address*} **Example:** `Router# ping ip address`	Diagnoses basic network connectivity on Apollo, AppleTalk, Connectionless Network Service (CLNS), DECnet, IP, Novell IPX, VINES, or XNS networks. • Use the **ping** command to check connectivity between customer site routers.
Step 4	**trace** [*protocol*] [*destination*] **Example:** `Router# trace ip <destination-ip-address>`	Discovers the routes that packets will actually take when traveling to their destination. • Use the **trace** command to follow the path of the packets in the customer site. • To use nondefault parameters and invoke an extended **trace** test, enter the command without a destination argument. You will be stepped through a dialog to select the desired parameters.
Step 5	**disable** **Example:** `Router# disable`	(Optional) Exits to use EXEC mode.

Additional Information

For a configuration example for this task, see the "Verifying IP Connectivity in the Customer Site Examples" section on page 69.

Configuration Examples for MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution

Configuration examples for the MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution feature include the following:

- Configuring and Verifying the Backbone Carrier Core Examples, page 43
- Configuring and Verifying the Links Between CSC-PE and CSC-CE Routers Examples, page 46
- Configuring and Verifying the Customer Carrier Network Examples, page 61
- Configuring and Verifying the Customer Site for Hierarchical VPNs Examples, page 63

Figure 3 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 3 Sample CSC Topology for Exchanging IPv4 Routes and MPLS Labels

Table 2 describes the sample configuration shown in Figure 3.

Table 2 Description of Sample Configuration Shown in Figure 3

Routers	Description
CE1 and CE2	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.
PE1 and PE2	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.

Table 2 Description of Sample Configuration Shown in Figure 3 (continued)

Routers	Description
CSC-CE1 and CSC-CE2	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.
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 and Verifying 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, page 43
- Configuring VRFs for CSC-PE Routers Example, page 45
- Configuring Multiprotocol BGP for VPN Connectivity in the Backbone Carrier Example, page 45

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:

```
Router# ping ee.ee.ee.ee

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to ee.ee.ee.ee, 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-PE 1 to CSC-PE2 by entering the following command on CSC-CE1:

```
Router# trace ee.ee.ee.ee

Type escape sequence to abort.
Tracing the route to ee.ee.ee.ee

  1 ee.ee.ee.ee 0 msec 0 msec *
```

Check that CSC-PE router prefixes are in the MPLS forwarding table:

```
Router# show ip forwarding-table

Local     Outgoing     Prefix or          Bytes tag    Outgoing       Next Hop
tag       tag or VC    Tunnel Id          switched     interface
16        2/nn         dd.dd.dd.dd/32       0          AT2/1/0.1      point2point
17        16           bb.bb.bb.bb/32[V]    30204      Et1/0          pp.0.0.1
21        Pop tag      cc.cc.cc.cc/32[V]    0          Et1/0          pp.0.0.1
22        Pop tag      nn.0.0.0/8[V]        570        Et1/0          pp.0.0.1
23        Aggregate    pp.0.0.0/8[V]        0
2         2/nn         gg.gg.gg.gg/32[V]    0          AT3/0.1        point2point
```

```
8        2/nn          hh.hh.hh.hh/32[V]    15452      AT3/0.1       point2point
29       2/nn          qq.0.0.0/8[V]        0          AT3/0.1       point2point
30       2/nn          ss.0.0.0/8[V]        0          AT3/0.1       point2point
```

Check the status of LDP discovery processes in the core:

```
Router# show mpls ldp discovery

Local LDP Identifier:
  ee.ee.ee.ee:0
  Discovery Sources:
  Interfaces:
    ATM2/1/0.1 (ldp): xmit/recv
      TDP Id: dd.dd.dd.dd:1
```

Check the status of LDP sessions in the core:

```
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
```

Note Also see the "CSC-PE2 Router Verification Examples" section on page 53.

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
     ee.0.0.0/32 is subnetted, 1 subnets
C       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/forwarding instance (VRF) 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 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.0.0.1 remote-as 200
 neighbor ss.0.0.1 activate
 neighbor ss.0.0.1 as-override
 neighbor ss.0.0.1 advertisement-interval 5
 neighbor ss.0.0.1 send-label
 no auto-summary
 no synchronization
 bgp dampening 30
 exit-address-family
!
```

Configuring and Verifying the Links Between CSC-PE and CSC-CE Routers Examples

This section contains the following examples:

- Configuring EBGP Link with send-label Option for Carrier Supporting Carrier on CSC-PE Routers Examples, page 46
- Configuring EBGP Link with send-label Option for Carrier Supporting Carrier on CSC-CE Routers Examples, page 48
- Verifying Labels in the CSC-PE Routers Examples, page 50
- Verifying Labels in the CSC-CE Routers Examples, page 56
- Configuring Route Maps on the CSC-PE Routers Example, page 61

Configuring EBGP Link with send-label Option for Carrier Supporting Carrier on CSC-PE Routers Examples

CSC-PE configuration examples in this section include:

- CSC-PE1 Configuration Example, page 46
- CSC-PE2 Configuration Example, page 47

CSC-PE1 Configuration Example

The following example shows how to configure a CSC-PE1 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
 no atm enable-ilmi-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
```

CSC-PE2 Configuration Example

The following example shows how to configure a CSC-PE2 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 ee.ee.ee.ee 255.255.255.255
!
interface Ethernet5/0
 ip vrf forwarding vpn1
 ip address ss.0.0.2 255.0.0.0
 no ip directed-broadcast
 no ip route-cache distributed
 clock source internal
!
interface ATM2/1/0
 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 ATM2/1/0.1 mpls
 ip unnumbered Loopback0
```

```
 no ip directed-broadcast
 no atm enable-ilmi-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 Ethernet5/0
 passive-interface ATM3/0/0
 network ee.ee.ee.ee 0.0.0.0 area 100
!
router bgp 100
 no bgp default ipv4-unicast
 bgp log-neighbor-changes
 timers bgp 10 30
 neighbor dd.dd.dd.dd remote-as 100
 neighbor dd.dd.dd.dd update-source Loopback0
!
address-family vpnv4                              !VPNv4 session with CSC-PE1.
 neighbor dd.dd.dd.dd activate
 neighbor dd.dd.dd.dd send-community extended
 bgp dampening 30
 exit-address-family
!
 address-family ipv4 vrf vpn1
 neighbor ss.0.0.1 remote-as 200
 neighbor ss.0.0.1 activate
 neighbor ss.0.0.1 as-override
 neighbor ss.0.0.1 advertisement-interval 5
 neighbor ss.0.0.1 send-label
 no auto-summary
 no synchronization
 bgp dampening 30
 exit-address-family
```

Configuring EBGP Link with send-label Option for Carrier Supporting Carrier on CSC-CE Routers Examples

CSC-CE router configuration examples in this section include:

- CSC-CE1 Configuration Example, page 48
- CSC-CE2 Configuration Example, page 49

CSC-CE1 Configuration Example

The following example shows how to configure a CSC-CE1 router:

```
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 mroute-cache
 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
```

CSC-CE2 Configuration Example

This example shows how to configure a CSC-CE2 router:

```
ip cef
!
mpls label protocol ldp
!
interface Loopback0
 ip address gg.gg.gg.gg 255.255.255.255
!
interface Ethernet2/2
 ip address ss.0.0.2 255.0.0.0
 no ip directed-broadcast
 no ip mroute-cache
 mpls label protocol ldp
  mpls ip
!
interface ATM3/1/0.1 point2point
 ip address yy.0.0.1 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no ip mroute-cache
!
router ospf 200
 log-adjacency-changes
 auto-cost reference-bandwidth 1000
 redistribute connected subnets                  !Exchange routes
 redistribute bgp 200 metric 3 subnets           !learned from PE2.
```

```
 passive-interface ATM3/1/0.1
 network gg.gg.gg.gg 0.0.0.0 area 200
 network ss.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 yy.0.0.2 remote-as 100
 neighbor yy.0.0.2 update-source ATM3/1/0.1
 no auto-summary
!
 address-family ipv4
 redistribute connected
 redistribute ospf 200 metric 4 match internal
 neighbor yy.0.0.2 activate
 neighbor yy.0.0.2 send-label
 no auto-summary
 no synchronization
 bgp dampening 30
 exit-address-family
```

Verifying Labels in the CSC-PE Routers Examples

Commands that verify labels and their output on the CSC-PE router included in this section are as follows:

- CSC-PE1 Router Verification Examples, page 50
- CSC-PE2 Router Verification Examples, page 53

CSC-PE1 Router Verification Examples

Verify that the BGP session is up and running between the CSC-PE1 router and the CSC-CE1 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 dd.dd.dd.dd, 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
ee.ee.ee.ee     4   100    7685    7686       52    0    0 21:17:04        6
pp.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 PE1 router is in the routing table of the CSC-PE1 router:

```
Router# show ip route vrf vpn2 bb.bb.bb.bb

Routing entry for bb.bb.bb.bb/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 PE2 router is in the routing table of the CSC-PE1 router:

```
Router# show ip route vrf vpn2 hh.hh.hh.hh

Routing entry for hh.hh.hh.hh/32
  Known via "bgp 100", distance 200, metric 4
  Tag 200, type internal
  Last update from ee.ee.ee.ee 21:27:39 ago
  Routing Descriptor Blocks:
  * ee.ee.ee.ee (Default-IP-Routing-Table), from ee.ee.ee.ee, 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

   Network          Next Hop      In label/Out label
Route Distinguisher: 100:1 (vpn1)
   cc.cc.cc.cc/32   pp.0.0.2        22/imp-null
   bb.bb.bb.bb/32   pp.0.0.2        27/20
   hh.hh.hh.hh/32   ee.ee.ee.ee     34/35
   gg.gg.gg.gg/32   ee.ee.ee.ee     30/30
   nn.0.0.0         pp.0.0.2        23/imp-null
   ss.0.0.0         ee.ee.ee.ee     33/34
   pp.0.0.0         pp.0.0.2        25/aggregate(vpn1)
```

Verify that the prefix of the PE router in the local customer carrier MPLS VPN service provider (PE1) is in the CEF table:

```
Router# show ip cef vrf vpn2 bb.bb.bb.bb
bb.bb.bb.bb/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 bb.bb.bb.bb detail

bb.bb.bb.bb/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 local customer carrier MPLS VPN service provider (PE1) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table vrf vpn2 bb.bb.bb.bb

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
27     20          bb.bb.bb.bb/32[V] 958048     Et3/1      pp.0.0.2

Router# show mpls forwarding-table vrf vpn2 bb.bb.bb.bb detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
27     20          bb.bb.bb.bb/32[V] 958125     Et3/1      pp.0.0.2
        MAC/Encaps=14/18, MTU=1500, Tag Stack{20}
        00B04A74A05400B0C26E10558847 00014000
        VPN route: vpn1
        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 prefix of the PE router in the remote customer carrier MPLS VPN service provider (PE2) is in the CEF table:

```
Router# show ip cef vrf vpn2 hh.hh.hh.hh

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}

Router# show ip cef vrf vpn2 hh.hh.hh.hh 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 (PE2 router) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table vrf vpn2 hh.hh.hh.hh

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


Router# show mpls forwarding-table vrf vpn2 hh.hh.hh.hh detail

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
        MAC/Encaps=14/18, MTU=1500, Tag Stack{35}
        00B0C26E447000B0C26E10A88847 00023000
        VPN route: vpn1
        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
```

CSC-PE2 Router Verification Examples

Verify that the BGP session is up and running between the CSC-PE2 router and the CSC-CE2 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

BGP router identifier ee.ee.ee.ee, local AS number 100
BGP table version is 51, main routing table version 51
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, 31/18 paths, scan interval 5 secs


Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
dd.dd.dd.dd     4   100    7901    7900       51    0    0 21:52:59        7
ss.0.0.2        4   200    7871    7880       51    0    0 21:50:15        6
```

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
GigabitEthernet4/0     Yes (ldp)      No       Yes


VRF vpn1:
Ethernet5/0            No             No       Yes
```

Verify that the prefix of the PE1 router is in the routing table of the CSC-PE2 router:

```
Router# show ip route vrf vpn2 bb.bb.bb.bb.bb

Routing entry for bb.bb.bb.bb/32
  Known via "bgp 100", distance 200, metric 4
  Tag 200, type internal
  Last update from dd.dd.dd.dd 21:53:30 ago
```

```
  Routing Descriptor Blocks:
  * dd.dd.dd.dd (Default-IP-Routing-Table), from dd.dd.dd.dd, 21:53:30 ago
      Route metric is 4, traffic share count is 1
      AS Hops 1, BGP network version 0
```

Verify that the prefix of the PE2 router is in the routing table of the CSC-PE2 router:

```
Router# show ip route vrf vpn2 hh.hh.hh.hh

Routing entry for hh.hh.hh.hh/32
  Known via "bgp 100", distance 20, metric 4
  Tag 200, type external
  Last update from ss.0.0.2 21:53:12 ago
  Routing Descriptor Blocks:
  * ss.0.0.2, from ss.0.0.2, 21:53:12 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 routing table, and that the prefixes have appropriate labels:

```
Router# show ip bgp vpnv4 vrf vpn2 labels

   Network          Next Hop      In label/Out label
Route Distinguisher: 100:1 (vpn1)
   cc.cc.cc.cc/32   dd.dd.dd.dd     27/22
   bb.bb.bb.bb/32   dd.dd.dd.dd     26/27
   hh.hh.hh.hh/32   ss.0.0.2        35/31
   gg.gg.gg.gg/32   ss.0.0.2        30/imp-null
   nn.0.0.0         dd.dd.dd.dd     24/23
   ss.0.0.0         ss.0.0.2        34/aggregate(vpn1)
   pp.0.0.0         dd.dd.dd.dd     21/25
```

Verify that the prefix of the PE router in the remote customer carrier MPLS VPN service provider (PE1) is in the CEF table:

```
Router# show ip cef vrf vpn2 bb.bb.bb.bb

bb.bb.bb.bb/32, version 15, cached adjacency rr.0.0.1
0 packets, 0 bytes
  tag information set
    local tag: 26
    fast tag rewrite with Gi4/0, rr.0.0.1, tags imposed {27}
  via dd.dd.dd.dd, 0 dependencies, recursive
    next hop rr.0.0.1, GigabitEthernet4/0 via dd.dd.dd.dd/32
    valid cached adjacency
    tag rewrite with Gi4/0, rr.0.0.1, tags imposed {27}


Router# show ip cef vrf vpn2 bb.bb.bb.bb detail

bb.bb.bb.bb/32, version 15, cached adjacency rr.0.0.1
0 packets, 0 bytes
  tag information set
    local tag: 26
    fast tag rewrite with Gi4/0, rr.0.0.1, tags imposed {27}
  via dd.dd.dd.dd, 0 dependencies, recursive
    next hop rr.0.0.1, GigabitEthernet4/0 via dd.dd.dd.dd/32
    valid cached adjacency
    tag rewrite with Gi4/0, rr.0.0.1, tags imposed {27}
```

Verify that the prefix of the PE router in the remote customer carrier MPLS VPN service provider (PE1) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table vrf vpn2 bb.bb.bb.bb

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
26     27          bb.bb.bb.bb/32[V] 967450     Gi4/0      rr.0.0.1


Router# show mpls forwarding-table vrf vpn2 bb.bb.bb.bb detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
26     27          bb.bb.bb.bb/32[V] 967510     Gi4/0      rr.0.0.1
        MAC/Encaps=14/18, MTU=1500, Tag Stack{27}
        00B0C26E10A800B0C26E44708847 0001B000
        VPN route: vpn1
        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
72k-131-9#
```

Verify that the prefix of the PE router in the local customer carrier MPLS VPN service provider (PE2) is in the CEF table:

```
Router# show ip cef vrf vpn2 hh.hh.hh.hh

hh.hh.hh.hh/32, version 33, cached adjacency ss.0.0.2
0 packets, 0 bytes
  tag information set
    local tag: 35
    fast tag rewrite with Et5/0, ss.0.0.2, tags imposed {31}
  via ss.0.0.2, 0 dependencies, recursive
    next hop ss.0.0.2, Ethernet5/0 via ss.0.0.2/32
    valid cached adjacency
    tag rewrite with Et5/0, ss.0.0.2, tags imposed {31}

Router# show ip cef vrf vpn2 hh.hh.hh.hh detail

hh.hh.hh.hh/32, version 33, cached adjacency ss.0.0.2
0 packets, 0 bytes
  tag information set
    local tag: 35
    fast tag rewrite with Et5/0, ss.0.0.2, tags imposed {31}
  via ss.0.0.2, 0 dependencies, recursive
    next hop ss.0.0.2, Ethernet5/0 via ss.0.0.2/32
    valid cached adjacency
    tag rewrite with Et5/0, ss.0.0.2, tags imposed {31}
```

Verify that the prefix of the PE router in the local customer carrier MPLS VPN service provider (PE2) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table vrf <CSC-PE-vrf-name> hh.hh.hh.hh

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
35     31          hh.hh.hh.hh/32[V] 2023332    Et5/0      ss.0.0.2


Router# show mpls forwarding-table vrf <CSC-PE-vrf-name> hh.hh.hh.hh detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
35     31          hh.hh.hh.hh/32[V] 2023469    Et5/0      ss.0.0.2
```

```
        MAC/Encaps=14/18, MTU=1500, Tag Stack{31}
        0030A363380300B0C26E448C8847 0001F000
        VPN route: vpn1
        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
```

Verifying Labels in the CSC-CE Routers Examples

Commands that verify labels and their output on the CSC-PE router included in this section are as follows:

- CSC-CE1 Router Verification Examples, page 56
- CSC-CE2 Router Verification Examples, page 58

CSC-CE1 Router Verification Examples

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 (PE1) is in the routing table:

```
Router# show ip route bb.bb.bb.bb

Routing entry for bb.bb.bb.bb/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.bb.bb.bb, 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 (PE2) is in the routing table:

```
Router# show ip route hh.hh.hh.hh

Routing entry for hh.hh.hh.hh/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 (PE1) is in the MPLS LDP bindings:

```
Router# show mpls ldp bindings bb.bb.bb.bb 255.255.255.255

  tib entry: bb.bb.bb.bb/32, rev 20
        local binding:  tag: 20
        remote binding: tsr: bb.bb.bb.bb:0, tag: imp-null
```

Verify that the prefix of the local PE router (PE1) is in the CEF table:

```
Router# show ip cef bb.bb.bb.bb

bb.bb.bb.bb/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 (PE1) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table bb.bb.bb.bb

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 bb.bb.bb.bb 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 (PE2) is in the CEF table:

```
Router# show ip cef hh.hh.hh.hh

hh.hh.hh.hh/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 (PE2) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table hh.hh.hh.hh

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    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 hh.hh.hh.hh detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    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
```

CSC-CE2 Router Verification Examples

Verify that the BGP session is up and running:

```
Router# show ip bgp summary

BGP router identifier gg.gg.gg.gg, local AS number 200
BGP table version is 31, main routing table version 31
13 network entries and 13 paths using 1885 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. 0 history paths, 0 dampened paths
BGP activity 17/4 prefixes, 20/7 paths, scan interval 60 secs


Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
ss.0.0.1        4   100    7962    7953       31    0    0 22:03:55        6
```

Verify that the loopback address of the local PE router (PE2) is in the routing table:

```
Router# show ip route hh.hh.hh.hh

Routing entry for hh.hh.hh.hh/32
  Known via "ospf 200", distance 110, metric 7, type intra area
  Redistributing via bgp 200
  Advertised by bgp 200 metric 4 match internal
  Last update from 19.19.19.19 on ATM3/1/0.1, 01:37:02 ago
  Routing Descriptor Blocks:
  * hh.hh.hh.hh, from hh.hh.hh.hh, 01:37:02 ago, via ATM3/1/0.1
      Route metric is 7, traffic share count is 1
```

Verify that the loopback address of the remote PE router (PE1) is in the routing table:

```
Router# show ip route bb.bb.bb.bb

Routing entry for bb.bb.bb.bb/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 ss.0.0.1 22:04:44 ago
  Routing Descriptor Blocks:
  * ss.0.0.1, from ss.0.0.1, 22:04:44 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 (PE2) is in the MPLS LDP bindings:

```
Router# show mpls ldp bindings hh.hh.hh.hh 255.255.255.255

  tib entry: hh.hh.hh.hh/32, rev 37
        local binding:  tag: 31

Router# show mpls ldp bindings hh.hh.hh.hh 255.255.255.255 detail

  tib entry: hh.hh.hh.hh/32, rev 37
        local binding:  tag: 31
```

Verify that the prefix of the local PE (PE2) is in the CEF table:

```
Router# show ip cef hh.hh.hh.hh

hh.hh.hh.hh/32, version 31, cached adjacency to ATM3/1/0.1
0 packets, 0 bytes
  tag information set
    local tag: 31
    fast tag rewrite with AT3/1/0.1, point2point, tags imposed {2/33(vcd=2)}
  via hh.hh.hh.hh, ATM3/1/0.1, 0 dependencies
    next hop hh.hh.hh.hh, ATM3/1/0.1
    unresolved
    valid cached adjacency
    tag rewrite with AT3/1/0.1, point2point, tags imposed {2/33(vcd=2)}

Router# show ip cef hh.hh.hh.hh detail

hh.hh.hh.hh/32, version 31, cached adjacency to ATM3/1/0.1
0 packets, 0 bytes
  tag information set
    local tag: 31
    fast tag rewrite with AT3/1/0.1, point2point, tags imposed {2/33(vcd=2)}
  via hh.hh.hh.hh, ATM3/1/0.1, 0 dependencies
    next hop hh.hh.hh.hh, ATM3/1/0.1
    unresolved
    valid cached adjacency
    tag rewrite with AT3/1/0.1, point2point, tags imposed {2/33(vcd=2)}
```

Verify that the prefix of the local PE router (PE2) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table hh.hh.hh.hh

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
31     2/33        hh.hh.hh.hh/32    1908083    AT3/1/0.1  point2point


Router# show mpls forwarding-table hh.hh.hh.hh detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
31     2/33        hh.hh.hh.hh/32    1908200    AT3/1/0.1  point2point
        MAC/Encaps=4/8, MTU=4470, Tag Stack{2/33(vcd=2)}
        00028847 00002000
        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   ss.0.0.1         18/27
bb.bb.bb.bb/32   ss.0.0.1         19/26
hh.hh.hh.hh/32   hh.hh.hh.hh      31/exp-null
gg.gg.gg.gg/32   0.0.0.0          imp-null/exp-null
nn.0.0.0         ss.0.0.1         22/24
ss.0.0.0         0.0.0.0          imp-null/exp-null
ss.0.0.1/32      0.0.0.0          16/exp-null
pp.0.0.0         ss.0.0.1         26/21
```

Verify that the prefix of the remote PE router (PE1) is in the CEF table:

```
Router# show ip cef bb.bb.bb.bb

bb.bb.bb.bb/32, version 18, cached adjacency ss.0.0.1
0 packets, 0 bytes
  tag information set
    local tag: 19
    fast tag rewrite with Et0/0/3, ss.0.0.1, tags imposed {26}
  via ss.0.0.1, 0 dependencies, recursive
    next hop ss.0.0.1, Ethernet0/0/3 via ss.0.0.1/32
    valid cached adjacency
    tag rewrite with Et0/0/3, ss.0.0.1, tags imposed {26}


Router# show ip cef bb.bb.bb.bb detail

bb.bb.bb.bb/32, version 18, cached adjacency ss.0.0.1
0 packets, 0 bytes
  tag information set
    local tag: 19
    fast tag rewrite with Et0/0/3, ss.0.0.1, tags imposed {26}
  via ss.0.0.1, 0 dependencies, recursive
    next hop ss.0.0.1, Ethernet0/0/3 via ss.0.0.1/32
    valid cached adjacency
    tag rewrite with Et0/0/3, ss.0.0.1, tags imposed {26}
```

Verify that the prefix of the remote PE router (PE1) is in the MPLS forwarding table:

```
Router# show mpls forwarding-table bb.bb.bb.bb

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
19     26          bb.bb.bb.bb/32    965401     Et0/0/3    ss.0.0.1


Router# show mpls forwarding-table bb.bb.bb.bb detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
19     26          bb.bb.bb.bb/32    965478     Et0/0/3    ss.0.0.1
        MAC/Encaps=14/18, MTU=1500, Tag Stack{26}
        00B0C26E448C0030A36338038847 0001A000
        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 Route Maps on the CSC-PE Routers Example

The following example creates two route maps, which are named:

- IN for incoming routes
- OUT for outgoing routes

The route maps specify the following:

- If an IP address in an incoming BGP update message matches an IP address in access list 99, the route is added to the BGP table.
- If an IP address in an outbound BGP update message matches an IP address in access list 88, the router distributes that route.

The route maps are applied to the CSC-PE router with the address qq.0.0.1.

```
address-family ipv4 vrf vpn2
 neighbor qq.0.0.1 remote-as 200
 neighbor qq.0.0.1 activate
 neighbor qq.0.0.1 as-override
 neighbor qq.0.0.1 advertisement-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
!
access-list 88 permit rr.rr.rr.rr
access-list 88 permit ss.ss.ss.ss
access-list 88 permit tt.tt.tt.tt
access-list 99 permit uu.uu.uu.uu
access-list 99 permit vv.vv.vv.vv
access-list 99 permit ww.ww.ww.ww
!
route-map IN permit 1
 match ip address 99
!
route-map OUT permit 1
 match ip address 88
 set mpls-label
!
```

Configuring and Verifying the Customer Carrier Network Examples

Customer carrier configuration and verification examples in this section include:

- Verifying IP Connectivity in the Customer Carrier Example, page 61
- Configuring a Customer Carrier Core Router as a Route Reflector Example, page 62

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 jj.jj.jj.jj

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 jj.jj.jj.jj

Type escape sequence to abort.
Tracing the route to jj.jj.jj.jj

  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 8 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 aa.aa.aa.aa

Type escape sequence to abort.
Tracing the route to aa.aa.aa.aa


  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 and Verifying the Customer Site for Hierarchical VPNs Examples

This section contains the following configuration and verification examples for the customer site:

- Configuring Provider Edge Routers for Hierarchical VPNs Examples, page 63
- Verifying Labels in Each Provider Edge Router for Hierarchical VPNs Examples, page 65
- Configuring Customer Edge Routers for Hierarchical VPNs Examples, page 68
- Verifying IP Connectivity in the Customer Site Examples, page 69

Configuring Provider Edge Routers for Hierarchical VPNs Examples

Provider Edge (PE) router configuration examples in this section include:

- PE1 Router Configuration Example, page 63
- PE2 Router Configuration Example, page 64

PE1 Router Configuration Example

This example shows how to configure a PE1 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
 neighbor hh.hh.hh.hh remote-as 200
 neighbor hh.hh.hh.hh update-source Loopback0
!
```

```
address-family vpnv4                                !VPNv4 session with PE2.
 neighbor hh.hh.hh.hh activate
 neighbor hh.hh.hh.hh send-community extended
 bgp dampening 30
 exit-address-family
!
 address-family ipv4 vrf vpn2
 neighbor mm.0.0.1 remote-as 300
 neighbor mm.0.0.1 activate
 neighbor mm.0.0.1 as-override
 neighbor mm.0.0.1 advertisement-interval 5
no auto-summary
 no synchronization
 bgp dampening 30
 exit-address-family
```

PE2 Router Configuration Example

This example shows how to configure a PE2 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 hh.hh.hh.hh 255.255.255.255
!
interface Ethernet3/6
 ip vrf forwarding vpn2
 ip address tt.0.0.2 255.0.0.0
!
interface ATM5/0.1 point2point
 ip address qq.0.0.1 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no ip mroute-cache
 mpls label protocol ldp
 mpls ip
!
router bgp 200
 no bgp default ipv4-unicast
 bgp log-neighbor-changes
 timers bgp 10 30
 neighbor bb.bb.bb.bb remote-as 200
 neighbor bb.bb.bb.bb update-source Loopback0
!
address-family vpnv4                          !VPNv4 session with PE1.
 neighbor bb.bb.bb.bb activate
 neighbor bb.bb.bb.bb send-community extended
 bgp dampening 30
 exit-address-family
!
 address-family ipv4 vrf vpn2
 neighbor tt.0.0.1 remote-as 300
 neighbor tt.0.0.1 activate
 neighbor tt.0.0.1 as-override
 neighbor tt.0.0.1 advertisement-interval 5
 no auto-summary
```

```
 no synchronization
 bgp dampening 30
 exit-address-family
```

Verifying Labels in Each Provider Edge Router for Hierarchical VPNs Examples

Provider edge (PE) router label verification examples in this section include the following:

- PE1 Router Label Verification Examples, page 65
- PE2 Router Label Verification Examples, page 66

PE1 Router Label Verification Examples

Verify that the loopback address of the local CE router (CE1) is in the routing table of the PE1 router:

```
Router# show ip route vrf vpn2 aa.aa.aa.aa

Routing entry for aa.aa.aa.aa/32
  Known via "bgp 200", distance 20, metric 0
  Tag 300, type external
  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 (CE1) is in the MPLS forwarding table, and that the prefix is untagged:

```
Router# show mpls forwarding-table vrf vpn2 aa.aa.aa.aa

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 (PE2) is in the Cisco Express Forwarding (CEF) table:

```
Router# show ip cef hh.hh.hh.hh

hh.hh.hh.hh/32, version 31, cached adjacency nn.0.0.2
0 packets, 0 bytes
  tag information set
    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 (CE2) is in the routing table:

```
Router# show ip route vrf vpn2 jj.jj.jj.jj

Routing entry for jj.jj.jj.jj/32
  Known via "bgp 200", distance 200, metric 0
  Tag 300, type internal
  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 (CE2) is in the MPLS forwarding table, and that an outgoing interface exists:

```
Router# show mpls forwarding-table vrf vpn2 jj.jj.jj.jj

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    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 (CE2) is in the CEF table:

```
Router# show ip cef vrf vpn2 jj.jj.jj.jj

jj.jj.jj.jj/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 (PE1) is in the CEF table:

```
Router# show ip cef bb.bb.bb.bb

bb.bb.bb.bb/32, version 9, connected, receive
  tag information set
    local tag: implicit-null
```

PE2 Router Label Verification Examples

Verify that the loopback address of the local CE router (CE2) is in the routing table of the PE2 router:

```
Router# show ip route vrf vpn2 jj.jj.jj.jj

Routing entry for jj.jj.jj.jj/32
  Known via "bgp 200", distance 20, metric 0
  Tag 300, type external
  Last update from tt.0.0.2 22:11:06 ago
  Routing Descriptor Blocks:
  * tt.0.0.2, from tt.0.0.2, 22:11:06 ago
      Route metric is 0, traffic share count is 1
      AS Hops 1, BGP network version 0
```

Verify that the prefix of the local CE router (CE2) is in the MPLS forwarding table, and is untagged:

```
Router# show mpls forwarding-table vrf vpn2 jj.jj.jj.jj

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
32     Untagged    jj.jj.jj.jj/32[V] 0          Et3/6      tt.0.0.2
```

```
Router# show mpls forwarding-table vrf vpn2 jj.jj.jj.jj detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
32     Untagged    jj.jj.jj.jj/32[V] 0          Et3/6      tt.0.0.2
        MAC/Encaps=0/0, MTU=1504, Tag Stack{}
        VPN route: vpn2
        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 prefix of the remote PE router (PE1) is in the CEF table:

```
Router# show ip cef bb.bb.bb.bb

bb.bb.bb.bb/32, version 19, cached adjacency to ATM5/0.1
0 packets, 0 bytes
  tag information set
    local tag: 20
    fast tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6)}
  via gg.gg.gg.gg, ATM5/0.1, 2 dependencies
    next hop gg.gg.gg.gg, ATM5/0.1
    unresolved
    valid cached adjacency
    tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6)}


Router# show ip cef bb.bb.bb.bb detail

bb.bb.bb.bb/32, version 19, cached adjacency to ATM5/0.1
0 packets, 0 bytes
  tag information set
    local tag: 20
    fast tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6)}
  via gg.gg.gg.gg, ATM5/0.1, 2 dependencies
    next hop gg.gg.gg.gg, ATM5/0.1
    unresolved
    valid cached adjacency
    tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6)}
```

Verify that the loopback address of the remote CE router (CE1) is in the routing table:

```
Router# show ip route vrf vpn2 aa.aa.aa.aa

Routing entry for aa.aa.aa.aa/32
  Known via "bgp 200", distance 200, metric 0
  Tag 300, type internal
  Last update from bb.bb.bb.bb 01:43:34 ago
  Routing Descriptor Blocks:
  * bb.bb.bb.bb (Default-IP-Routing-Table), from bb.bb.bb.bb, 01:43:34 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 (CE1) is in the MPLS forwarding table, and that it has an outgoing interface:

```
Router# show mpls forwarding-table vrf vpn2 aa.aa.aa.aa

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
None   2/35        aa.aa.aa.aa/32    0          AT5/0.1    point2point
```

```
Router# show mpls forwarding-table vrf vpn2 aa.aa.aa.aa detail

Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
None   2/35        aa.aa.aa.aa/32    0          AT5/0.1    point2point
        MAC/Encaps=4/12, MTU=4466, Tag Stack{2/35(vcd=6) 23}
        00068847 0000600000017000
        No output feature configured
```

Verify that the prefix of the remote CE router (CE1) is in the CEF table:

```
Router# show ip cef vrf vpn2 aa.aa.aa.aa

aa.aa.aa.aa/32, version 10, cached adjacency to ATM5/0.1
0 packets, 0 bytes
  tag information set
    local tag: VPN route head
    fast tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6) 23}
  via bb.bb.bb.bb, 0 dependencies, recursive
    next hop gg.gg.gg.gg, ATM5/0.1 via bb.bb.bb.bb/32
    valid cached adjacency
    tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6) 23}

Router# show ip cef vrf vpn2 aa.aa.aa.aa detail

aa.aa.aa.aa/32, version 10, cached adjacency to ATM5/0.1
0 packets, 0 bytes
  tag information set
    local tag: VPN route head
    fast tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6) 23}
  via bb.bb.bb.bb, 0 dependencies, recursive
    next hop gg.gg.gg.gg, ATM5/0.1 via bb.bb.bb.bb/32
    valid cached adjacency
    tag rewrite with AT5/0.1, point2point, tags imposed {2/35(vcd=6) 23}
```

Verify that the prefix of the local PE router (PE2) is in the CEF table:

```
Router# show ip cef hh.hh.hh.hh

hh.hh.hh.hh/32, version 9, connected, receive
  tag information set
    local tag: implicit-null

Router# show ip cef hh.hh.hh.hh detail

hh.hh.hh.hh/32, version 9, connected, receive
  tag information set
    local tag: implicit-null
```

Configuring Customer Edge Routers for Hierarchical VPNs Examples

Customer edge (CE) router configuration examples in this section include:

- CE1 Configuration Example, page 69
- CE2 Configuration Example, page 69

CE1 Configuration Example

The following example shows how to configure a CE1 router:

```
ip cef
interface Loopback0
ip address aa.aa.aa.aa 255.255.255.255
!
interface Ethernet3/3
 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
```

CE2 Configuration Example

The following example shows how to configure a CE2 router:

```
ip cef
!
interface Loopback0
 ip address jj.jj.jj.jj 255.255.255.255
!
interface Ethernet3/6
 ip address tt.0.0.1 255.0.0.0
!
router bgp 300
 no synchronization
 bgp log-neighbor-changes
 timers bgp 10 30                              !Redistributing static routes into BGP
 redistribute connected                        !to send to PE2.
 redistribute ospf 300 match internal external 1 external 2
 neighbor tt.0.0.2 remote-as 200
 neighbor tt.0.0.2 advertisement-interval 5
 no auto-summary
```

Verifying IP Connectivity in the Customer Site Examples

Customer edge (CE) router verification examples in this section include:

- CE1 Router Verification Example, page 69
- CE2 Router Verification Example, page 70

CE1 Router Verification Example

Verify that the loopback address of the remote CE router (CE2), learned from the PE router, is in the routing table of the CE1 router:

```
Router# show ip route jj.jj.jj.jj

Routing entry for jj.jj.jj.jj/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
      Route metric is 0, traffic share count is 1
      AS Hops 2
```

CE2 Router Verification Example

Verify that the loopback address of the remote CE router (CE1), learned from the PE router, is in the routing table of the CE2 router:

```
Router# show ip route aa.aa.aa.aa

Routing entry for aa.aa.aa.aa/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 tt.0.0.1 22:16:46 ago
  Routing Descriptor Blocks:
  * tt.0.0.1, from tt.0.0.1, 22:16:46 ago
      Route metric is 0, traffic share count is 1
      AS Hops 2
```

Additional References

For additional information related to MPLS VPN—Carrier Supporting Carrier—IPv4 BGP Label Distribution, refer to the following references:

- Related Documents, page 71
- Standards, page 72
- MIBs, page 72
- RFCs, page 73
- Technical Assistance, page 73

Related Documents

Related Topic	Document Title
MPLS configuration tasks	"Configuring Multiprotocol Label Switching" chapter in the *Cisco IOS Switching Services Configuration Guide*, Release 12.2
MPLS VPN configuration tasks	*MPLS Virtual Private Networks (VPNs)*
Enhanced MPLS VPN traffic management configuration tasks	*MPLS Virtual Private Network Enhancements*
Basic MPLS VPN Carrier Supporting Carrier configuration tasks	*MPLS VPN Carrier Supporting Carrier*
BGP configuration tasks	"Configuring BGP chapter" in the *Cisco IOS IP Configuration Guide*, Release 12.2
An explanation of how BGP works and how you can use it to participate in routing with other networks that run BGP	*Using the Border Gateway Protocol for Interdomain Routing*
An explanation of the purpose of the BGP and the BGP route selection process, and how to use BGP attributes in route selection	"Border Gateway Protocol" chapter in the Internetworking Technology Overview
Commands to configure and monitor BGP	"Border Gateway Protocol" chapter in the *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols*, Release 12.2
MPLS LDP configuration tasks	*MPLS Label Distribution Protocol (LDP)*
OSPF configuration tasks	"Configuring OSFP" chapter in the " *Cisco IOS IP Configuration Guide, Release 12.2, IP Routing Protocols*
IS-IS configuration tasks	"Configuring Integrated IS-IS chapter" in the *Cisco IOS IP Configuration Guide, Release 12.2, IP Routing Protocol*
Extended **ping** and extended **traceroute** commands	*Using the Extended **ping** and Extended **traceroute** Commands*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs[1]	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To obtain lists of supported MIBs by platform and Cisco IOS release, and to download MIB modules, go to the Cisco MIB website on Cisco.com at the following URL: http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

1. Not all supported MIBs are listed.

To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:

http://tools.cisco.com/ITDIT/MIBS/servlet/index

If Cisco MIB Locator does not support the MIB information that you need, you can also obtain a list of supported MIBs and download MIBs from the Cisco MIBs page at the following URL:

http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

To access Cisco MIB Locator, you must have an account on Cisco.com. If you have forgotten or lost your account information, send a blank e-mail to cco-locksmith@cisco.com. An automatic check will verify that your e-mail address is registered with Cisco.com. If the check is successful, account details with a new random password will be e-mailed to you. Qualified users can establish an account on Cisco.com by following the directions found at this URL:

http://www.cisco.com/register

RFCs

RFCs[1]	Title
RFC 1164	*Application of the Border Gateway Protocol in the Internet*
RFC 1171	*A Border Gateway Protocol 4*
RFC 1700	*Assigned Numbers*
RFC 1966	*BGP Route Reflection: An Alternative to Full Mesh IBGP*
RFC 2283	*Multiprotocol Extensions for BGP-4*
RFC 2547	*BGP/MPLS VPNs*
RFC 2842	*Capabilities Advertisement with BGP-4*
RFC 2858	*Multiprotocol Extensions for BGP-4*
RFC 3107	*Carrying Label Information in BGP-4*

1. Not all supported RFCs are listed.

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, tools, and lots more. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/public/support/tac/home.shtml

Command Reference

This section documents new or modified commands. All other commands used with this feature are documented in the Cisco IOS Release 12.2 command reference publications.

New Commands

- **match mpls-label**
- **neighbor send-label**
- **set mpls-label**
- **show ip bgp labels**

Modified Commands

- **debug ip bgp**
- **show ip bgp**
- **show ip bgp neighbors**
- **show ip bgp vpnv4**
- **show route-map**

debug ip bgp

To display information related to processing of the Border Gateway Protocol (BGP), use the **debug ip bgp** command in privileged EXEC mode. To disable the display of BGP information, use the **no** form of this command.

debug ip bgp [*A.B.C.D.* | **dampening** | **events** | **in** | **keepalives** | **out** | **updates** | **vpnv4** | **mpls**]

no debug ip bgp [*A.B.C.D.* | **dampening** | **events** | **in** | **keepalives** | **out** | **updates** | **vpnv4** | **mpls**]

Syntax Description

A.B.C.D.	(Optional) Displays the BGP neighbor IP address.
dampening	(Optional) Displays BGP dampening.
events	(Optional) Displays BGP events.
in	(Optional) Displays BGP inbound information.
keepalives	(Optional) Displays BGP keepalives.
out	(Optional) Displays BGP outbound information.
updates	(Optional) Displays BGP updates.
vpnv4	(Optional) Displays VPNv4 NLRI information.
mpls	(Optional) Displays the MPLS information.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(5)T	This command was introduced.
12.0(21)ST	This command was integrated into Cisco IOS 12.0(21)ST. The **mpls** keyword was added.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into the Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Examples

The following example displays the output from this command:

```
Router# debug ip bgp vpnv4

03:47:14:vpn:bgp_vpnv4_bnetinit:100:2:58.0.0.0/8
03:47:14:vpn:bnettable add:100:2:58.0.0.0 / 8
03:47:14:vpn:bestpath_hook route_tag_change for vpn2:58.0.0.0/255.0.0.0(ok)
03:47:14:vpn:bgp_vpnv4_bnetinit:100:2:57.0.0.0/8
03:47:14:vpn:bnettable add:100:2:57.0.0.0 / 8
03:47:14:vpn:bestpath_hook route_tag_change for vpn2:57.0.0.0/255.0.0.0(ok)
03:47:14:vpn:bgp_vpnv4_bnetinit:100:2:14.0.0.0/8
03:47:14:vpn:bnettable add:100:2:14.0.0.0 / 8
03:47:14:vpn:bestpath_hook route_tag_chacle ip bgp *nge for vpn2:14.0.0.0/255.0.0.0(ok)
```

match mpls-label

To redistribute routes that include Multiprotocol Label Switching (MPLS) labels if the routes meet the conditions specified in the route map, use the **match mpls-label** command in route map configuration mode. To disable this function, use the **no** form of this command.

match mpls-label

no match mpls-label

Syntax Description

This command has no arguments or keywords.

Defaults

This command has no default behavior or values.

Command Modes

Route map configuration

Command History

Release	Modification
12.0(21)ST	This command was introduced.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Usage Guidelines

A route map that includes this command can be used in the following instances:

- With the **neighbor route-map in** command to manage inbound route maps in BGP
- With the **redistribute bgp** command to redistribute route maps in an IGP

Use the **route-map** global configuration command, and the **match** and **set** route map configuration commands, to define the conditions for redistributing routes from one routing protocol into another. Each **route-map** command has a list of **match** and **set** commands associated with it. The **match** commands specify the match criteria—the conditions under which redistribution is allowed for the current **route-map** command. The **set** commands specify the set actions—the particular redistribution actions to perform if the criteria enforced by the **match** commands are met. The **no route-map** command deletes the route map.

The **match route-map** configuration command has multiple formats. The **match** commands can be given in any order, and all **match** commands must “pass” to cause the route to be redistributed according to the set actions given with the **set** commands. The **no** forms of the **match** commands remove the specified match criteria.

When you are passing routes through a route map, a route map can have several parts. Any route that does not match at least one match clause relating to a **route-map** command will be ignored; that is, the route will not be advertised for outbound route maps and will not be accepted for inbound route maps. If you want to modify only some data, you must configure a second route map section with an explicit match specified.

Examples

The following example creates a route map that redistributes routes if the following conditions are met:

- The IP address of the route matches an IP address in ACL 2.
- The route includes an MPLS label.

```
Router(config-router)# route-map incoming permit 10

Router(config-route-map)# match ip address 2

Router(config-route-map)# match mpls-label
```

Related Commands

Command	Description
match ip address	Distributes any routes that have a destination network number address that is permitted by a standard or extended access list.
route-map (IP)	Defines the conditions for redistributing routes from one routing protocol into another, or enables policy routing.
set mpls-label	Enables a route to be distributed with an MPLS label if the route matches the conditions specified in the route map.

neighbor send-label

To enable a Border Gateway Protocol (BGP) router to send Multiprotocol Label Switching (MPLS) labels with BGP routes to a neighboring BGP router, use the **neighbor send-label** command in router configuration mode. To disable the BGP router from sending MPLS labels with BGP routes, use the **no** form of this command.

neighbor {*ip-address*} **send-label**

no neighbor {*ip-address*} **send-label**

Syntax Description

ip-address	IP address of the neighboring router.

Defaults

By default, BGP routers distribute only BGP routes.

Command Modes

Router configuration

Command History

Release	Modification
12.0(21)ST	This command was introduced.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Usage Guidelines

This command enables a router to use BGP to distribute MPLS labels along with the IPv4 routes to a peer router. You must issue this command on both the local router and the neighboring router.

This command has the following restrictions:

- If a BGP session is running when you issue the **neighbor send-label** command, the command does not take effect until the BGP session is restarted.
- You can use this command only with IPv4 addresses.

Examples

The following example enables a router called BGP 1 to send MPLS labels with BGP routes to the neighboring router, whose IP address is 192.168.0.0:

```
Router(config)# router bgp1

Router(config-router)# neighbor 192.168.0.0 send-label
```

Related Commands

Command	Description
neighbor activate	Enables the exchange of information with a neighboring router.

set mpls-label

To enable a route to be distributed with a Multiprotocol Label Switching (MPLS) label if the route matches the conditions specified in the route map, use the **set mpls-label** command in route map configuration mode. To disable this function, use the **no** form of this command.

set mpls-label

no set mpls-label

Syntax Description

This command has no arguments or keywords.

Defaults

This command has no default behavior or values.

Command Modes

Route map configuration

Command History

Release	Modification
12.0(21)ST	This command was introduced.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Usage Guidelines

This command can be used only with the **neighbor route-map out** command to manage outbound route maps for a Border Gateway Protocol (BGP) session.

Use the **route-map** global configuration command with **match** and **set route-map** configuration commands to define the conditions for redistributing routes from one routing protocol into another. Each **route-map** command has a list of **match** and **set** commands associated with it. The **match** commands specify the match criteria—the conditions under which redistribution is allowed for the current **route-map** command. The **set** commands specify the set actions—the particular redistribution actions to perform if the criteria enforced by the **match** commands are met. The **no route-map** command deletes the route map.

Examples

The following example creates a route map that enables the route to be distributed with a label if the IP address of the route matches an IP address in ACL 1.

```
Router(config-router)# route-map incoming permit 10

Router(config-route-map)# match ip address 1

Router(config-route-map)# set mpls-label
```

Related Commands

Command	Description
match ip address	Distributes any routes that have a destination network number address that is permitted by a standard or extended access list.
match mpls-label	Redistributes routes that contain MPLS labels and match the conditions specified in the route map.
route-map (IP)	Defines the conditions for redistributing routes from one routing protocol into another, or enables policy routing.

show ip bgp

To display entries in the Border Gateway Protocol (BGP) routing table, use the **show ip bgp** command in privileged EXEC mode.

show ip bgp [*network*] [*network-mask*] [**longer-prefixes**]

Syntax Description

network	(Optional) Network number, entered to display a particular network in the BGP routing table.
network-mask	(Optional) Displays all BGP routes matching the address and mask pair.
longer-prefixes	(Optional) Displays the route and more specific routes.

Command Modes

Privileged EXEC

Command History

Release	Modification
10.0	This command was introduced.
12.0	The display of prefix advertisement statistics was added.
12.0(6)T	This command was integrated into Cisco IOS Release 12.0(6)T. The display of a message indicating support for route refresh capability was added.
12.0(21)ST	This command was updated to show the number of MPLS labels that arrive at and depart from the prefix and integrated into the Cisco IOS Release 12.0(21)ST.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Examples

The following is sample output from the **show ip bgp** command in privileged EXEC mode:

```
Router# show ip bgp

BGP table version is 5, local router ID is 10.0.33.34
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 1.0.0.0          0.0.0.0                  0         32768 ?
*  2.0.0.0          10.0.33.35              10             0 35 ?
*>                  0.0.0.0                  0         32768 ?
*  10.0.0.0         10.0.33.35              10             0 35 ?
*>                  0.0.0.0                  0         32768 ?
*> 192.168.0.0/16   10.0.33.35              10             0 35 ?
```

Table 3 describes the significant fields shown in the display.

Table 3 show ip bgp Field Descriptions

Field	Description
BGP table version	Internal version number of the table. This number increments when the table changes.
local router ID	IP address of the router.
Status codes	Status of the table entry. The status is displayed at the beginning of each line in the table. It can be one of the following values: s—The table entry is suppressed. d—The table entry is dampened and will not be advertised to BGP neighbors. h—The table entry does not contain the best path based on historical information. *—The table entry is valid. >—The table entry is the best entry to use for that network. i—The table entry was learned via an IBGP session.
Origin codes	Origin of the entry. The origin code is placed at the end of each line in the table. It can be one of the following values: i—Entry originated from Interior Gateway Protocol (IGP) and was advertised with a **network** router configuration command. e—Entry originated from Exterior Gateway Protocol (EGP). ?—Origin of the path is not clear. Usually, this is a router that is redistributed into BGP from an IGP.
Network	IP address of a network entity.
Next Hop	IP address of the next system that is used when forwarding a packet to the destination network. An entry of 0.0.0.0 indicates that the router has some non-BGP routes to this network.
Metric	If shown, the value of the inter-autonomous system metric.
LocPrf	Local preference value as set with the **set local-preference route-map** configuration command. The default value is 100.
Weight	Weight of the route as set via autonomous system filters.
Path	Autonomous system paths to the destination network. There can be one entry in this field for each autonomous system in the path.

The following is sample output from the **show ip bgp** command in privileged EXEC mode when you specify the **longer-prefixes** keyword:

```
Router# show ip bgp 198.92.0.0 255.255.0.0 longer-prefixes
BGP table version is 1738, local router ID is 198.92.72.24
Status codes: s suppressed, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
*> 198.92.0.0       198.92.72.30        8896         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.1.0       198.92.72.30        8796         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.11.0      198.92.72.30       42482         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.14.0      198.92.72.30        8796         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.15.0      198.92.72.30        8696         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.16.0      198.92.72.30        1400         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.17.0      198.92.72.30        1400         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.18.0      198.92.72.30        8876         32768 ?
*                   198.92.72.30                         0 109 108 ?
*> 198.92.19.0      198.92.72.30        8876         32768 ?
*                   198.92.72.30                         0 109 108 ?
```

The following is sample output from the **show ip bgp** command in privileged EXEC mode, showing information for prefix ww.0.0.0:

```
Router# show ip bgp ww.0.0.0

BGP routing table entry for ww.0.0.0/8, version 628
Paths: (1 available, best #1)
Advertised to peer-groups:
 ebgp
Advertised to non peer-group peers:
 171.69.232.162
109 65000 297 701 80
 171.69.233.56 from 171.69.233.56 (172.19.185.32)
  Origin incomplete, localpref 100, valid, external, best, ref 2
MPLS labels in/out 24/22
```

Note If a prefix has not been advertised to any peer, the display shows "Not advertised to any peer."

Related Commands

Command	Description
clear ip bgp	Resets a BGP connection or session.
neighbor soft-reconfiguration	Configures the Cisco IOS software to start storing updates.

show ip bgp labels

To display information about Multiprotocol Label Switching (MPLS) labels from the External Border Gateway Protocol (EBGP) route table, use the **show ip bgp labels** command in privileged EXEC mode.

show ip bgp labels

Syntax Description

This command has no arguments or keywords.

Defaults

This command has no default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(21)ST	This command was introduced.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Usage Guidelines

Use this command to display EBGP labels associated with a carrier supporting carrier customer edge (CSC-CE) router.

This command displays labels for BGP routes in the default table only. To display labels in the VRF tables, use the **show ip bgp vpnv4** {**all** | **vrf** *vrf-name*} command with the optional **labels** keyword.

Examples

The following example shows output for a CSC-CE router using BGP as a label distribution protocol:

```
Router# show ip bgp labels

Network           Next Hop          In Label/Out Label
3.3.0.0/16        0.0.0.0           imp-null/exp-null
15.15.15.15/32    15.15.15.15       18/exp-null
16.16.16.16/32    0.0.0.0           imp-null/exp-null
17.17.17.17/32    34.0.0.1          20/exp-null
18.18.18.18/32    43.0.0.1          24/31
18.18.18.18/32    38.0.0.1          24/33
19.19.19.19/32    43.0.0.1          25/32
19.19.19.19/32    38.0.0.1          25/34
20.20.20.20/32    43.0.0.1          21/30
20.20.20.20/32    38.0.0.1          21/32
33.0.0.0          15.15.15.15       19/exp-null
34.0.0.0          0.0.0.0           imp-null/exp-null
35.0.0.0          43.0.0.1          22/29
35.0.0.0          38.0.0.1          22/31
```

```
38.0.0.0         0.0.0.0          imp-null/exp-null
38.0.0.1/32      38.0.0.1         17/29
38.0.0.1/32      0.0.0.0          17/exp-null
40.0.0.0         38.0.0.1         26/35
40.0.0.0         43.0.0.1         26/34
42.0.0.0         43.0.0.1         23/28
42.0.0.0         38.0.0.1         23/30
43.0.0.0         0.0.0.0          imp-null/exp-null
43.0.0.1/32      0.0.0.0          16/exp-null
```

Table 4 describes the significant fields shown in the display.

Table 4 show ip bgp labels Field Descriptions

Field	Description
Network	Displays the network address from the EGBP table.
Next Hop	Specifies the EBGP next hop address.
In Label	Displays the label (if any) assigned by this router.
Out Label	Displays the label assigned by the BGP next hop router.

Related Commands

Command	Description
show ip bgp vpnv4	Displays VPN address information from the BGP table.

show ip bgp neighbors

To display information about the TCP/IP and Border Gateway Protocol (BGP) connections to neighbors, use the **show ip bgp neighbors** command in privileged EXEC mode.

show ip bgp neighbors [*neighbor-address*] [**received-routes** | **routes** | **advertised-routes** | {**paths** *regexp*} | **dampened-routes**] [**received prefix-filter**]

Syntax Description

neighbor-address	(Optional) Address of the neighbor whose routes you have learned from. If you omit this argument, all neighbors are displayed.
received-routes	(Optional) Displays all received routes (both accepted and rejected) from the specified neighbor.
routes	(Optional) Displays all routes that are received and accepted. This is a subset of the output from the **received-routes** keyword.
advertised-routes	(Optional) Displays all the routes the router has advertised to the neighbor.
paths *regexp*	(Optional) Regular expression that is used to match the paths received.
dampened-routes	(Optional) Displays the dampened routes to the neighbor at the IP address specified.
received prefix-filter	(Optional) Displays the configured prefix list for the specified IP address.

Command Modes

Privileged EXEC

Command History

Release	Modification
10.0	This command was introduced.
11.2	The **received-routes** keyword was added.
12.0(21)ST	This command was updated to display MPLS label information and integrated into Cisco IOS Release 12.0(21)ST.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Examples

The following example shows output from the **show ip bgp neighbors** command in privileged EXEC mode when Multiprotocol Label Switching (MPLS) labels are being sent and received:

```
Router# show ip bgp neighbors 172.16.232.178

BGP neighbor is 172.16.232.178,  remote AS 35, external link
  BGP version 4, remote router ID 192.168.3.3
  BGP state = Established, up for 1w1d
  Last read 00:00:53, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    MPLS Label capability:  advertised and received
    Address family IPv4 Unicast: advertised and received
```

```
    Address family IPv4 Multicast: advertised and received
  Received 12519 messages, 0 notifications, 0 in queue
  Sent 12523 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds

For address family: IPv4 Unicast
  BGP table version 5, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor
Inbound path policy configured
  Outbound path policy configured
  Route map for incoming advertisements is uni-in
  Route map for outgoing advertisements is uni-out
  Sending Prefix & Label
  3 accepted prefixes consume 108 bytes
  Prefix advertised 6, suppressed 0, withdrawn 0

 For address family: IPv4 Multicast
  BGP table version 5, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Inbound path policy configured
  Outbound path policy configured
  Route map for incoming advertisements is mul-in
  Route map for outgoing advertisements is mul-out
  3 accepted prefixes consume 108 bytes
  Prefix advertised 6, suppressed 0, withdrawn 0

  Connections established 2; dropped 1
  Last reset 1w1d, due to Peer closed the session
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.232.178, Local port: 179
Foreign host: 172.16.232.179, Foreign port: 11002

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x2CF49CF8):
Timer          Starts    Wakeups            Next
Retrans         12518          0             0x0
TimeWait            0          0             0x0
AckHold         12514      12281             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss:  273358651  snduna:  273596614  sndnxt:  273596614     sndwnd:  15434
irs:  190480283  rcvnxt:  190718186  rcvwnd:      15491  delrcvwnd:    893

SRTT: 300 ms, RTTO: 607 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 0 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 24889 (out of order: 0), with data: 12515, total data bytes: 237921
Sent: 24963 (retransmit: 0), with data: 12518, total data bytes: 237981
```

Table 5 describes the significant fields shown in the display.

Table 5 show ip bgp neighbors Field Descriptions

Field	Description
BGP neighbor	IP address of the BGP neighbor and its autonomous system number. If the neighbor is in the same autonomous system as the router, then the link between them is internal; otherwise, it is considered external.
remote AS	Autonomous system of the neighbor.
external link	Indicates that this peer is an EBGP peer.
BGP version	BGP version being used to communicate with the remote router; the router ID (an IP address) of the neighbor is also specified.
remote router ID	IP address of the neighbor.
BGP state	Internal state of this BGP connection.
up for	Amount of time, in seconds, that the underlying TCP connection has been in existence.
Last read	Time that BGP last read a message from this neighbor.
hold time	Maximum amount of time that can elapse between messages from the peer.
keepalive interval	Time period, in seconds, between sending keepalive packets, which help ensure that the TCP connection is up.
Neighbor capabilities	BGP capabilities advertised and received from this neighbor.
MPLS Label capability	Indicates that MPLS labels are both sent and received by the EBGP peer.
Address family IPv4 Unicast:	IP Version 4 unicast-specific properties of this neighbor.
Address family IPv4 Multicast:	IP Version 4 multicast-specific properties of this neighbor.
Received	Number of total BGP messages received from this peer, including keepalives.
notifications	Number of error messages received from the peer.
Sent	Total number of BGP messages that have been sent to this peer, including keepalives.
notifications	Number of error messages the router has sent to this peer.
Route refresh request:	Number of route refresh requests sent and received from this neighbor.
advertisement runs	Value of minimum advertisement interval.
For address family:	Address family to which the following fields refer.
BGP table version	Indicates that the neighbor has been updated with this version of the primary BGP routing table.
neighbor version	Number used by the software to track the prefixes that have been sent and those that must be sent to this neighbor.
Community attribute	Appears if the **neighbor send-community** command is configured for this neighbor.
Inbound path policy	Indicates if an inbound policy is configured.
Outbound path policy	Indicates if an outbound policy is configured.

Table 5 show ip bgp neighbors Field Descriptions (continued)

Field	Description
uni-in	Name of inbound route map for the unicast address family.
uni-out	Name of outbound route map for the unicast address family.
mul-in	Name of inbound route map for the multicast address family.
mul-out	Name of outbound route map for the multicast address family.
Sending Prefix & Label	Indicates that the EBGP peer sends MPLS labels with its routes.
accepted prefixes	Number of prefixes accepted.
Prefix advertised	Number of prefixes advertised.
suppressed	Number of prefixes suppressed.
withdrawn	Number of prefixes withdrawn.
Connections established	Number of times the router has established a TCP connection and the two peers have agreed to speak BGP with each other.
dropped	Number of times that a good connection has failed or been taken down.
Last reset	Elapsed time since this peering session was last reset.
Connection state	State of BGP peer.
unread input bytes	Number of bytes of packets still to be processed.
Local host, Local port	Peering address of local router, plus port.
Foreign host, Foreign port	Peering address of the neighbor.
Event Timers	Table displays the number of starts and wakeups for each timer.
iss	Initial send sequence number.
snduna	Last send sequence number the local host sent but has not received an acknowledgment for.
sndnxt	Sequence number the local host will send next.
sndwnd	TCP window size of the remote host.
irs	Initial receive sequence number.
rcvnxt	Last receive sequence number the local host has acknowledged.
rcvwnd	TCP window size of the local host.
delrcvwnd	Delayed receive window—data the local host has read from the connection, but has not yet subtracted from the receive window the host has advertised to the remote host. The value in this field gradually increases until it is larger than a full-sized packet, at which point it is applied to the rcvwnd field.
SRTT	A calculated smoothed round-trip timeout.
RTTO	Round-trip timeout.
RTV	Variance of the round-trip time.
KRTT	New round-trip timeout (using the Karn algorithm). This field separately tracks the round-trip time of packets that have been re-sent.
minRTT	Smallest recorded round-trip timeout (hard wire value used for calculation).

Table 5 show ip bgp neighbors Field Descriptions (continued)

Field	Description
maxRTT	Largest recorded round-trip timeout.
ACK hold	Time the local host will delay an acknowledgment in order to piggyback data on it.
Flags	IP precedence of the BGP packets.
Datagrams: Rcvd	Number of update packets received from a neighbor.
with data	Number of update packets received with data.
total data bytes	Total bytes of data.
Sent	Number of update packets sent.
with data	Number of update packets with data sent.
total data bytes	Total number of data bytes.

The following is sample output from the **show ip bgp neighbors** command with the **advertised-routes** keyword:

```
Router# show ip bgp neighbors 172.16.232.178 advertised-routes

BGP table version is 27, local router ID is 172.16.232.181
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
*>i110.0.0.0        172.16.232.179         0    100      0 ?
*> 200.2.2.0        0.0.0.0                0         32768 i
```

The following is sample output from the **show ip bgp neighbors** command with the **routes** keyword:

```
Router# show ip bgp neighbors 172.16.232.178 routes

BGP table version is 27, local router ID is 172.16.232.181
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
*> 10.0.0.0         172.16.232.178        40             0 10 ?
*> gg.0.0.0         172.16.232.178        40             0 10 ?
```

Table 6 describes the significant fields shown in the displays.

Table 6 show ip bgp neighbors advertised-routes and routes Field Descriptions

Field	Description
BGP table version	Internal version number of the table. This number increments when the table changes.
local router ID	IP address of the router.
Status codes	Status of the table entry. The status is displayed at the beginning of each line in the table. It can be one of the following values: s—The table entry is suppressed. d—The table entry is dampened and will not be advertised to BGP neighbors. h—The table entry does not contain the best path based on historical information. *—The table entry is valid. >—The table entry is the best entry to use for that network. i—The table entry was learned via an internal BGP (iBGP) session.
Origin codes	Origin of the entry. The origin code is placed at the end of each line in the table. It can be one of the following values: i—Entry originated from Interior Gateway Protocol (IGP) and was advertised with a **network** router configuration command. e—Entry originated from Exterior Gateway Protocol (EGP). ?—Origin of the path is not clear. Usually, this is a router that is redistributed into BGP from an IGP.
Network	IP address of a network entity.
Next Hop	IP address of the next system that is used when forwarding a packet to the destination network. An entry of 0.0.0.0 indicates that the router has some non-BGP routes to this network.
Metric	If shown, this is the value of the inter-autonomous system metric. This field is frequently not used.
LocPrf	Local preference value as set with the **set local-preference route-map** configuration command. The default value is 100.
Weight	Weight of the route as set via autonomous system filters.
Path	Autonomous system paths to the destination network. There can be one entry in this field for each autonomous system in the path.

The following is sample output from the **show ip bgp neighbors** command with the **paths** keyword in privileged EXEC mode:

```
Router# show ip bgp neighbors 171.69.232.178 paths ^10

Address    Refcount Metric Path
0x60E577B0        2     40 10 ?
```

Table 7 describes the significant fields shown in the display.

Table 7 show ip bgp neighbors paths Field Descriptions

Field	Description
Address	Internal address where the path is stored.
Refcount	Number of routes using that path.
Metric	Multi Exit Discriminator (MED) metric for the path. (The name of this metric for BGP versions 2 and 3 is INTER_AS.)
Path	Autonomous system path for that route, followed by the origin code for that route.

The following is sample output from the **show ip bgp neighbors** command with the **received prefix-filter** keyword in privileged EXEC mode:

```
Router# show ip bgp neighbor 192.168.20.72 received prefix-filter

Address family:IPv4 Unicast
ip prefix-list 192.168.20.72:1 entries
   seq 5 deny 10.0.0.0/8 le 32
```

Table 8 describes the significant fields shown in the display.

Table 8 show ip bgp neighbors received prefix-filter Field Descriptions

Field	Description
Address family:	Configured address family mode.
ip prefix-list	Configured prefix list for the specified neighbor.

show ip bgp vpnv4

To display Virtual Private Network (VPN) address information from the Border Gateway Protocol (BGP) table, use the **show ip bgp vpnv4** command in EXEC mode.

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*]] [**cidr-only**] [**community**] [**community-list**] [**dampened-paths**] [**filter-list**] [**flap-statistics**] [**inconsistent-as**] [**neighbors**] [**paths** [*line*]] [**peer-group**] [**quote-regexp**] [**regexp**] [**summary**] [**labels**]

Syntax Description

all	Displays the complete VPNv4 database.
rd *route-distinguisher*	Displays NLRIs that have a matching route distinguisher.
vrf *vrf-name*	Displays NLRIs associated with the named VRF.
ip-prefix/length	(Optional) The IP prefix address (in dotted decimal format) and the length of the mask (0 to 32).
longer-prefixes	(Optional) Displays the entry, if any, that exactly matches the specified prefix parameter and all entries that match the prefix in a “longest-match” sense. That is, prefixes for which the specified prefix is an initial substring.
output-modifiers	(Optional) For a list of associated keywords and arguments, use context-sensitive help.
network-address	(Optional) The IP address of a network in the BGP routing table.
mask	(Optional) The mask of the network address, in dotted decimal format.
cidr-only	(Optional) Displays only routes that have nonnatural net masks.
community	(Optional) Displays routes matching this community.
community-list	(Optional) Displays routes matching this community list.
dampened-paths	(Optional) Displays paths suppressed on account of dampening (BGP route from peer is up and down).
filter-list	(Optional) Displays routes conforming to the filter list.
flap-statistics	(Optional) Displays flap statistics of routes.
inconsistent-as	(Optional) Displays only routes that have inconsistent autonomous systems of origin.
neighbors	(Optional) Displays details about TCP and BGP neighbor connections.
paths	(Optional) Displays path information.
line	(Optional) A regular expression to match the BGP autonomous system paths.
peer-group	(Optional) Displays information about peer groups.
quote-regexp	(Optional) Displays routes matching the autonomous system path “regular expression.”
regexp	(Optional) Displays routes matching the autonomous system path regular expression.

summary	(Optional) Displays BGP neighbor status.
labels	(Optional) Displays incoming and outgoing BGP labels for each NLRI.

Defaults

This command has no default behavior or values.

Command Modes

EXEC

Command History

Release	Modification
12.0(5)T	This command was introduced.
12.2(2)T	The output of the **show ip bgp vpnv4 all** *ip-prefix* command was enhanced to display attributes including multipaths and a best path to the specified network.
12.0(21)ST	The keyword **tags** was replaced with the keyword **labels** to conform to the MPLS IETF guidelines. This command was integrated into Cisco IOS Release 12.0(21)ST.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Usage Guidelines

Use this command to display VPNv4 information from the BGP database. The **show ip bgp vpnv4 all** command displays all available VPNv4 information. The **show ip bgp vpnv4 summary** command displays BGP neighbor status.

Examples

The following example shows output for all available VPNv4 information in a BGP routing table:

```
Router# show ip bgp vpnv4 all

BGP table version is 18, local router ID is 14.14.14.14
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP,? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 1:101 (default for vrf vpn1)
*>i6.6.6.6/32       223.0.0.21              11    100      0 ?
*> 7.7.7.7/32       150.150.0.2             11         32768 ?
*>i69.69.0.0/30     223.0.0.21               0    100      0 ?
*> 150.150.0.0/24   0.0.0.0                  0         32768 ?
*> 222.0.0.1/32     150.150.0.2             11         32768 ?
*>i222.0.0.3/32     223.0.0.21              11    100      0 ?
*> 222.0.0.10/32    0.0.0.0                  0         32768 ?
*>i222.0.0.30/32    223.0.0.21               0    100      0 ?
```

Table 9 describes the significant fields shown in the display.

Table 9 show ip bgp vpnv4 Field Descriptions

Field	Description
Network	Displays the network address from the BGP table.
Next Hop	Displays the address of the BGP next hop.
Metric	Displays the BGP metric.
LocPrf	Displays the local preference.
Weight	Displays the BGP weight.
Path	Displays the BGP path per route.

The following example shows how to display a table of labels for NLRIs that have a route distinguisher value of 100:1.

```
Router# show ip bgp vpnv4 rd 100:1 labels

Network            Next Hop       In label/Out label
Route Distinguisher: 100:1 (vrf1)
   2.0.0.0          10.20.0.60      34/nolabel
   10.0.0.0         10.20.0.60      35/nolabel
   12.0.0.0         10.20.0.60      26/nolabel
                    10.20.0.60      26/nolabel
   13.0.0.0         10.15.0.15      nolabel/26
```

Table 10 describes the significant fields shown in the display.

Table 10 show ip bgp vpnv4 rd labels Field Descriptions

Field	Description
Network	Displays the network address from the BGP table.
Next Hop	Specifies the BGP next hop address.
In label	Displays the label (if any) assigned by this router.
Out label	Displays the label assigned by the BGP next hop router.

The following example shows VPNv4 routing entries for the VRF named vpn1:

```
Router# show ip bgp vpnv4 vrf vpn1

BGP table version is 18, local router ID is 14.14.14.14
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP,? - incomplete

Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 1:101 (default for vrf vpn1)
*>i6.6.6.6/32       223.0.0.21              11    100       0 ?
*> 7.7.7.7/32       150.150.0.2             11          32768 ?
*>i69.69.0.0/30     223.0.0.21               0    100       0 ?
*> 150.150.0.0/24   0.0.0.0                  0          32768 ?
*> 222.0.0.1/32     150.150.0.2             11          32768 ?
*>i222.0.0.3/32     223.0.0.21              11    100       0 ?
```

Table 11 describes the significant fields shown in the display.

Table 11 show ip bgp vpnv4 vrf Field Descriptions

Field	Description
Network	Displays the network address from the BGP table.
Next Hop	Displays the address of the BGP next hop.
Metric	Displays the BGP metric.
LocPrf	Displays the local preference.
Weight	Displays the BGP weight.
Path	Displays the BGP path per route.

The following example shows attributes for network 10.22.22.0 that includes multipaths and a best path:

```
Router# show ip bgp vpnv4 all 10.22.22.0

BGP routing table entry for 100:1:10.22.22.0/24, version 50
Paths:(6 available, best #1)
Multipath:iBGP
  Advertised to non peer-group peers:
  200.1.12.12
  22
    1.22.7.8 (metric 11) from 1.11.3.4 (100.0.0.8)
      Origin IGP, metric 0, localpref 100, valid, internal, multipath, best
      Extended Community:RT:100:1
      Originator:100.0.0.8, Cluster list:100.1.1.44
  22
    1.22.1.9 (metric 11) from 1.11.1.2 (100.0.0.9)
      Origin IGP, metric 0, localpref 100, valid, internal, multipath
      Extended Community:RT:100:1
      Originator:100.0.0.9, Cluster list:100.1.1.22
  22
    1.22.6.10 (metric 11) from 1.11.6.7 (100.0.0.10)
      Origin IGP, metric 0, localpref 100, valid, internal, multipath
      Extended Community:RT:100:1
      Originator:100.0.0.10, Cluster list:100.0.0.7
  22
    1.22.4.10 (metric 11) from 1.11.4.5 (100.0.0.10)
      Origin IGP, metric 0, localpref 100, valid, internal, multipath
      Extended Community:RT:100:1
      Originator:100.0.0.10, Cluster list:100.0.0.5
  22
    1.22.5.10 (metric 11) from 1.11.5.6 (100.0.0.10)
      Origin IGP, metric 0, localpref 100, valid, internal, multipath
      Extended Community:RT:100:1
      Originator:100.0.0.10, Cluster list:100.0.0.6
```

Table 12 describes the significant fields shown in the display.

Table 12 show ip bgp vpn4 all 10.22.22.0 Field Descriptions

Field	Description
BGP routing table ... version	Internal version number of the table. This number is incremented whenever the table changes.
Paths:	Number of autonomous system paths to the specified network. If multiple paths exist, one of the multipaths is designated the best path.
Multipath:	Indicates the maximum-paths configured (iBGP or eBGP).
Advertised to non peer-group peers: 200.1.12.12 22	IP address of the BGP peers that the specified route is advertised to.
1.22.7.8 (metric 11) from 1.11.3.4 (100.0.0.8)	Indicates the next hop address and the address of the gateway that sent the update.
Origin	Indicates the origin of the entry. It can be one of the following values: IGP—Entry originated from Interior Gateway Protocol (IGP) and was advertised with a **network** router configuration command. incomplete — Entry originated from other than an IGP or Exterior Gateway Protocol (EGP) and was advertised with the **redistribute** router configuration command. EGP — Entry originated from an EGP.
metric	If shown, the value of the interautonomous system metric.
localpref	Local preference value as set with the **set local-preference route-map** configuration command. The default value is 100.
valid	Indicates that the route is usable and has a valid set of attributes.
internal/external	The field is *internal* if the path is learned via iBGP. The field is *external* if the path is learned via eBGP.
multipath	One of multiple paths to the specified network.
best	If multiple paths exist, one of the multipaths is designated the best path and advertised the neighbors.
Extended Community:RT:100:1	Route Target value associated with the specified route.
Originator:	The router ID of the route originating router when route reflector is used.
Cluster list:	The router ID of all the route reflectors that the specified route has passed through.

Related Commands

Command	Description
show ip vrf	Displays the set of defined VRFs and associated interfaces.

show route-map

To display all route maps configured or only the one specified, use the1

show route-map command in EXEC mode.

show route-map [*map-name*]

Syntax Description

map-name	(Optional) Name of a specific route map.

Command Modes

EXEC

Command History

Release	Modification
10.0	This command was introduced.
12.0(21)ST	This command was updated to display information about MPLS labels and integrated into Cisco IOS Release 12.0(21)ST.
12.0(22)S	This command was integrated into Cisco IOS Release 12.0(22)S.
12.0(23)S	This command was integrated into Cisco IOS Release 12.0(23)S.
12.2(13)T	This command was integrated into Cisco IOS Release 12.2(13)T.
12.2(28)SB	This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series router.

Examples

The following is sample output from the **show route-map** command:

```
Router# show route-map

route-map sid, permit, sequence 10
Match clauses:
    tag 1 2
Set clauses:
    metric 5
route-map sid, permit, sequence 20
Match clauses:
    tag 3 4
Set clauses:
    metric 6
Policy routing matches: 0packets; 0 bytes
```

The following example shows MPLS-related route map information:

```
Router# show route-map

route-map OUT, permit, sequence 10
Match clauses:
  ip address (access-lists): 1
Set clauses:
  mpls label
Policy routing matches: 0 packets, 0 bytes
```

```
route-map IN, permit, sequence 10
Match clauses:
  ip address (access-lists): 2
  mpls label
Set clauses:
Policy routing matches: 0 packets, 0 bytes
```

Table 13 describes the fields shown in the display.

Table 13 show route-map Field Descriptions

Field	Description
route-map	Name of the route map.
permit	Indicates that the route is redistributed as controlled by the set actions.
sequence	Number that indicates the position a route map takes in the list of route maps already configured with the same name.
Match clauses:	Match criteria—conditions under which redistribution is allowed for the current route map.
Set clauses:	Set actions—the particular redistribution actions to perform if the criteria enforced by the **match** commands are met.
Policy routing matches:	Displays the number of packets and bytes that have been filtered by policy routing.

Related Commands

Command	Description
redistribute (IP)	Redistributes routes from one routing domain into another routing domain.
route-map (IP)	Defines the conditions for redistributing routes from one routing protocol into another, or enables policy routing.

Glossary

AS—autonomous system. A collection of networks that share the same routing protocol and that are under the same system administration.

BGP—Border Gateway Protocol. The exterior border gateway protocol used to exchange routing information between routers in separate autonomous systems. BGP uses Transmission Control Protocol (TCP). Because TCP is a reliable protocol, BGP does not experience problems with dropped or fragmented data packets.

BGP prefix—A route announcement using the BGP. A prefix is composed of a path of autonomous system numbers, indicating which networks the packet must pass through, and the IP block that is being routed. A BGP prefix would look something like: 701 1239 42 206.24.14.0/24. (The /24 part is referred to as a CIDR mask.) The /24 indicates that there are 24 ones in the netmask for this block starting from the left hand side. A /24 corresponds to the natural mask 255.255.255.0.

CE router—customer edge router. The customer router that connects to the provider edge (PE) router.

EBGP—External Border Gateway Protocol. A BGP session between routers in different autonomous systems (ASs). When a pair of routers in different ASs are more than one IP hop away from each other, an external BGP session between those two routers is called multihop external BGP.

IBGP—Internal Border Gateway Protocol. A BGP session between routers within the same autonomous system.

IGP—Interior Gateway Protocol. Internet protocol used to exchange routing information within an autonomous system. Examples of common Internet IGPs include IGRP, OSPF, and RIP.

LDP—Label Distribution Protocol. A standard protocol between MPLS-enabled routers to negotiate the labels (addresses) used to forward packets.

LER—label edge router. The edge router that performs label imposition and disposition.

LSP—label-switched path. A sequence of hops in which a packet travels from one router to another router by means of label switching mechanisms. A label-switched path can be established dynamically, based on normal routing mechanisms, or through configuration.

LSR—label switch router. An LSR forwards packets in an MPLS network by looking only at the fixed-length label.

MPLS—Multiprotocol Label Switching. A method for forwarding packets (frames) through a network. MPLS enables routers at the edge of a network to apply labels to packets (frames). ATM switches or existing routers in the network core can switch packets according to the labels.

Multihop BGP—A Border Gateway Protocol between two routers in different autonomous systems that are more than one hop away from each other.

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.

P router—provider router. The core router in the service provider network that connects to provider edge (PE) routers. In a packet-switched star topology, a router that is part of the backbone and that serves as the single pipe through which all traffic from peripheral networks must pass on its way to other peripheral networks.

PE router—provider edge router. The label edge router (LER) in the service provider network that connects to the customer edge (CE) router.

POP—point of presence. An access point to the Internet. A POP has a unique IP address. The ISP or online service provider (such as AOL) has one or more POPs on the Internet. ISP users dial into the POP to connect to the Internet. A POP can reside in rented space owned by the telecommunications carrier (such as Sprint) to which the ISP is connected. A POP usually includes routers, digital/analog call aggregators, servers, and frequently frame relay or ATM switches.

RR—route reflector. A router that advertises, or reflects, IBGP learned routes to other IBGP peers without requiring a full network mesh.

VPN—Virtual Private Network. A group of sites that, as a result of a set of administrative policies, can communicate with each other over a shared backbone.

VPNv4 addresses—When multiple VPNs use the same address space, the VPN addresses are made unique by adding a route distinguisher to the front of the address.

VRF table—VPN routing/forwarding table. A VRF table includes the routing information that defines a customer VPN site that is attached to a PE router. A VRF table consists of the following elements:

- An IP routing table
- A derived forwarding table
- A set of interfaces that use the forwarding table
- A set of rules and routing protocols that determine what goes into the forwarding table

Note Refer to the *Internetworking Terms and Acronyms* for terms not included in this glossary.