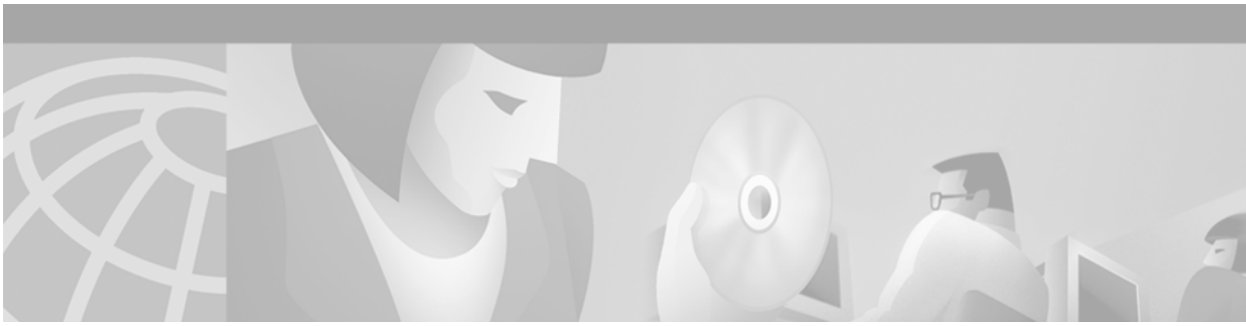


Cisco uBR7200 Series MPLS VPN Cable Enhancements

This feature module describes the Cisco uBR7200 series universal broadband router cable multiprotocol label switching virtual private network (MPLS VPN) and cable interface bundling features. It explains how to create a VPN using MPLS protocol, cable subinterfaces, and interface bundles. VPNs can be created in many ways using different protocols.

This feature module includes the following sections:

Feature Overview

Using MPLS VPN technology, service providers can create scalable and efficient private networks using a shared hybrid fiber coaxial (HFC) network and Internet protocol (IP) infrastructure.

The cable MPLS VPN network consists of:

- The multiple service operator (MSO) or cable company that owns the physical infrastructure and builds VPNs for the Internet service providers (ISPs) to move traffic over the cable and IP backbone.
- ISPs that use the HFC network and IP infrastructure to supply Internet service to cable customers.

Each ISP moves traffic to and from a subscriber's PC, through the MSO's physical network infrastructure, to the ISP's network. MPLS VPNs, created in Layer 3, provide privacy and security by constraining the distribution of a VPN’s routes only to the routers that belong to its network. Thus, each ISP's VPN is insulated from other ISPs that use the same MSO infrastructure.

An MPLS VPN assigns a unique VPN Routing/Forwarding (VRF) instance to each VPN. A VRF instance consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine the contents of the forwarding table.

Each PE router maintains one or more VRF tables. It looks up a packet's IP destination address in the appropriate VRF table, only if the packet arrived directly through an interface associated with that table.

MPLS VPNs use a combination of BGP and IP address resolution to ensure security. See *Configuring Multiprotocol Label Switching.*

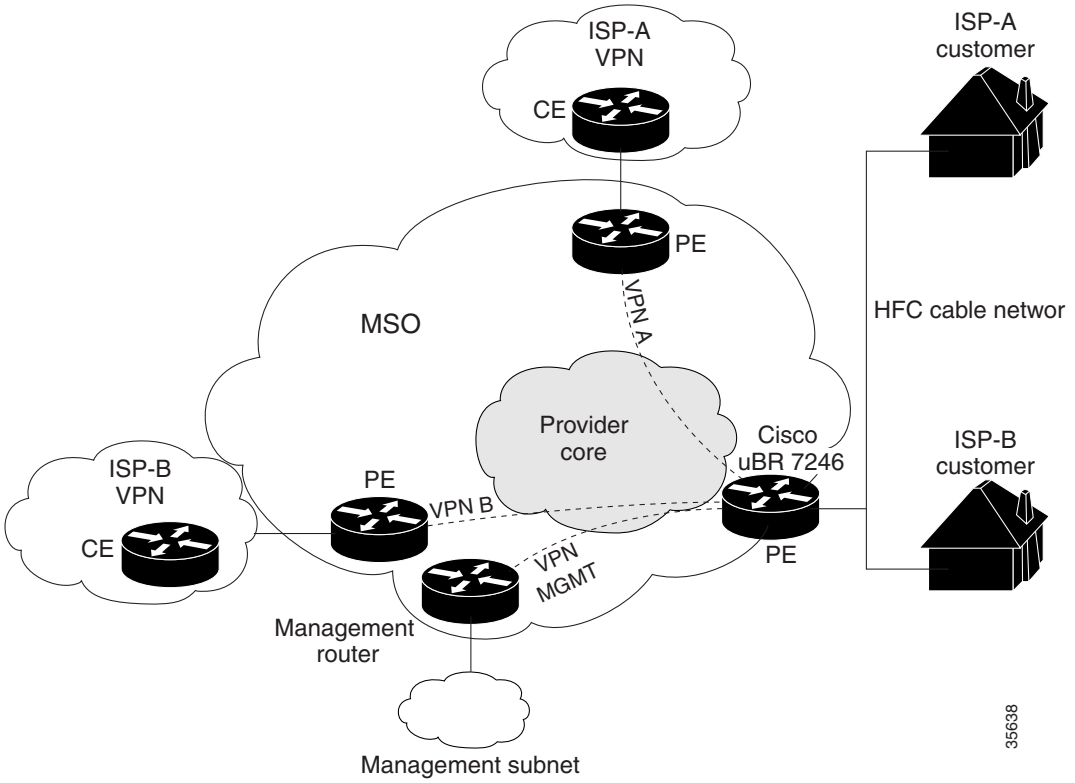
Figure 1 shows a cable MPLS VPN network. The routers in the network are:

- Provider (P) router—Routers in the core of the provider network. P routers run MPLS switching, and do not attach VPN labels (MPLS label in each route assigned by the PE router) to routed packets. VPN labels are used to direct data packets to the correct egress router.
- Provider Edge (PE) router— Router that attaches the VPN label to incoming packets based on the interface or subinterface on which they are received. A PE router attaches directly to a CE router. In the MPLS-VPN approach, each Cisco uBR7200 series router acts as a PE router.
- Customer (C) router—Router in the ISP or enterprise network.
- Customer Edge (CE) router—Edge router on the ISP's network that connects to the PE router on the MSO's network. A CE router must interface with a PE router.

The MPLS network has a unique VPN that exclusively manages the MSOs devices called the management VPN. It contains servers and devices that other VPNs can access. The management VPN connects the Cisco uBR7200 series router to a PE router, which connects to management servers such as Cisco Network Registrar (CNR) and Time of Day (ToD) servers. A PE router connects to management servers and is a part of the management VPN. Regardless of the ISP they belong to, the management servers serve the Dynamic Host Configuration Protocol (DHCP), DNS (Domain Name System), and TOD requests coming from PCs or cable modems.

Note When configuring MPLS VPNs, you must configure the first subinterface created as a part of the management VPN. See Creating VRFs for each VPN, page 9.

Figure 1 MPLS VPN Network



Cable VPN configuration involves an:

- MSO domain that requires a direct peering link to each enterprise network (ISP), provisioning servers for residential and commercial subscribers, and dynamic DNS for commercial users. The MSO manages cable interface IP addressing, Data-over-Cable Service Interface Specifications (DOCSIS) provisioning, CM hostnames, routing modifications, privilege levels, and usernames and passwords.
- ISP or enterprise domain that includes the DHCP server for subscriber or telecommuter host devices, enterprise gateway within the MSO address space, and static routes back to the telecommuter subnets.

Note Cisco recommends that the MSO assign all addresses to the end user devices and gateway interfaces. The MSO can also use split management to let the ISP configure tunnels and security.

In an MPLS VPN configuration, the MSO must configure the following:

- CMTS (Cisco uBR7200 series)
- P routers
- PE routers
- CE routers
- One VPN per ISP DOCSIS servers for all cable modem customers. The MSO must attach DOCSIS servers to the management VPN, and make them visible.

The MSO must configure Cisco uBR7200 series routers that serve the ISP, and remote PE routers connecting to the ISP, as PE routers in the VPN.

The MSO must determine the primary IP address range, which is the MSO's range for all cable modems belonging to the ISP subscribers.

The ISP must determine the secondary IP address range, which is the ISP's range for its subscriber PCs.

To reduce security breaches and differentiate DHCP requests from cable modems in VPNs or under specific ISP management, MSOs can use the **cable helper-address** command in Cisco IOS software. See “cable helper-address” section on page 26. The MSO can specify the host IP address to be accessible only in the ISP’s VPN. This lets the ISP use its DHCP server to allocate IP addresses. Cable modem IP address must be accessible from the management VPN.

The MPLS VPN approach of creating VPNs for individual ISPs or customers requires subinterfaces to be configured on the cable interface or the cable interface bundle. Each ISP requires one subinterface. The subinterfaces are tied to the VPN Routing/Forwarding (VRF) tables for their respective ISPs. The first subinterface must be created on the cable interface bound to the management VPN.

To route a reply from the CNR back to the cable modem, the PE router that connects to the CNR must import the routes of the ISP VPN into the management VPN. Similarly, to forward management requests (such as DHCP renewal to CNR) to the cable modems, the ISP VPN must export and import the appropriate management VPN routes.

Cisco uBR7200 series software supports the definition of logical network layer interfaces over a physical cable interface or a bundle of cable interfaces. You can create subinterfaces on either a physical cable interface or a bundle of cable interfaces. Subinterfaces let service providers share one IP subnet across multiple cable interfaces grouped into a cable interface bundle.

You can group all of the cable interfaces on a Cisco uBR7200 series router into a single bundle so that only one subnet is required for each router. When you group cable interfaces, no separate IP subnet or each individual cable interface is required. This grouping avoids the performance, memory, and security problems in using a bridging solution to manage subnets, especially for a large number of subscribers.

Subinterfaces allow traffic to be differentiated on a single physical interface, and assigned to multiple VPNs. You can configure multiple subinterfaces, and associate an MPLS VPN with each subinterface. You can split a single physical interface (the cable plant) into multiple subinterfaces, where each subinterface is associated with a specific VPN. Each ISP requires access on a physical interface and is given its own subinterface. Create a management subinterface to support cable modem initialization from an ISP.

Using each subinterface associated with a specific VPN (and therefore, ISP) subscribers connect to a logical subinterface, which reflects the ISP that provides their subscribed services. When properly configured, subscriber traffic enters the appropriate subinterface and VPN.

The CMTS MSO administrator can:

- Define subinterfaces on a cable physical interface and assign Layer 3 configurations to each subinterface.

  or

- Bundle a group of physical interfaces, define subinterfaces on the bundle master, and give each subinterface a Layer 3 configuration.

Benefits

- MPLS VPNs give cable MSOs and ISPs a manageable way of supporting multiple access to a cable plant. Service providers can create scalable and efficient VPNs across the core of their networks. MPLS VPNs provide systems support scalability in cable transport infrastructure and management.
- Each ISP can support Internet access services from a subscriber's PC through an MSO's physical cable plant to their networks.
- MPLS VPNs allow MSOs to deliver value-added services through an ISP, and thus, deliver connectivity to a wider set of potential customers. MSOs can partner with ISPs to deliver multiple services from multiple ISPs and add value within the MSO's own network using VPN technology.
- Subscribers can select combinations of services from various service providers.
- The Cisco IOS MPLS VPN cable feature sets build on CMTS DOCSIS 1.0 and DOCSIS 1.0 extensions to ensure services are reliably and optimally delivered over the cable plant. MPLS VPN provides systems support domain selection, authentication per subscriber, selection of QoS, policy-based routing, and ability to reach behind the cable modem to subscriber end devices for QoS and billing while preventing session spoofing.
- MPLS VPN technology ensures both secure access across the shared cable infrastructure and service integrity.
- Cable interface bundling eliminates the need for an IP subnet on each cable interface. Instead, an IP subnet is only required for each cable interface bundle. All cable interfaces in a Cisco uBR7200 series router can be added to a single bundle.

Restrictions

- Each subinterface on the CMTS requires an address range from the ISP and from the MSO. These two ranges must not overlap and must be extensible to support an increased number of subscribers for scalability. Cisco IOS Release 12.1(2)EC and 12.1(2)T does not support overlapping addresses for the MPLS VPN subinterface.

Note This document does not address allocation and management of MSO and ISP IP addresses. See *Configuring Multiprotocol Label Switching* for this information.

- Cisco IOS Release 12.1(2) T supports the **cable source-verify dhcp** command, but Cisco IOS Release 12.1(2)EC does not support it. The **cable source-verify dhcp** command enables Dynamic Host Control Protocol (DHCP) servers to verify IP addresses of upstream traffic, and prevent MSO customers from using unauthorized, spoofed, or stolen IP addresses.
- When using only MPLS VPNs, create subinterfaces on the bundle master, assign it an IP address, and provide VRF configuration for each ISP. When you create subinterfaces and configure only MPLS VPNs, the cable interface bundling feature is independent of the MPLS VPN.

- When using cable interface bundling:
  - Define one of the interfaces in the bundle as the bundle's master interface.
  - Specify all generic IP networking information (such as IP address, routing protocols, and switching modes) on the bundle master interface. Do not specify generic IP networking information on bundle slave interfaces. If you attempt to add an interface to a bundle as a nonmaster interface and an IP address is assigned to this interface, the command will fail. You must remove the IP address configuration before you can add the interface to a bundle.
  - An interface that has a subinterface(s) defined over it is not allowed to be a part of the bundle.
  - Specify generic (not downstream or upstream related) cable interface configurations, such as source-verify or ARP handling, on the master interface. Do not specify generic configuration on nonmaster interfaces.
  - If you configure an interface as a part of a bundle and it is not the master interface, all generic cable configuration for this interface is removed. The master interface configuration will then apply to all interfaces in the bundle.
- Cable interface bundling is only supported on cable interfaces. Cisco IOS software provides cable interfaces with Cisco uBR-MC11, Cisco uBR-MC12, Cisco uBR-MC14, and Cisco uBR-MC16 cable modem cards.
- Interface bundles can only be configured using the command line interface (including the CLI-based HTML configuration).

Related Documents

For additional information on the Cisco uBR7200 series and MPLS VPN, see:

- *Cisco uBR7200 Series Universal Broadband Router Software Configuration Guide*
- *Cisco uBR7200 Series Universal Broadband Router Hardware Installation Guide*
- *Cisco uBR7200 Series Software Release Notes and Features*
- *Cisco uBR7200 Series Configuration Notes*
- *Cisco Network Registrar for the Cisco uBR7200 Series Universal Broadband Routers*
- *Regulatory Compliance and Safety Information for the Cisco uBR7200 Series Universal Broadband Router*
- *Configuring Multiprotocol Label Switching*
- *MPLS Label Switching on Cisco Routers*
- *Cisco IOS Release 12.1 Documents*

Supported Platforms

- Cisco uBR7223
- Cisco uBR7246
- Cisco uBR7246 VXR

Supported Standards, MIBs, and RFCs

Standards

DOCSIS 1.0.

MIBs

- CISCO-DOCS-REMOTE-QUERY.my

No new or modified MIB objects are supported by the cable interface bundling feature.

For descriptions of supported MIBs and how to use MIBs, see the Cisco MIB web site on CCO at http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml.

RFCs

- RFC 1163, *A Border Gateway Protocol*
- RFC 1164, *Application of the Border Gateway Protocol in the Internet*
- RFC 2283, *Multiprotocol Extensions for BGP-4*
- RFC 2547, *BGP/MPLS VPNs*
- RFC 2233, *DOCSIS OSSI Objects Support*
- RFC 2669, *Cable Device MIB*
- RFC 2665, *DOCSIS Ethernet MIB Objects Support*

Prerequisites

Before configuring IP-based VPNs on Cisco uBR7200 series, complete the following tasks:

- Ensure your network supports reliable broadband data transmission. Your plant must be swept, balanced, and certified based on National Television Standards Committee (NTSC) or appropriate international cable plant recommendations. Ensure your plant meets all DOCSIS or European Data-over-Cable Service Interface Specifications (EuroDOCSIS) downstream and upstream RF requirements.
- Ensure your Cisco uBR7200 series universal broadband router is installed following instructions in the *Cisco uBR7200 Series Universal Broadband Router Hardware Installation Guide* and the *Regulatory Compliance and Safety Information for the Cisco uBR7200 Series Universal Broadband Router.*
- Ensure your Cisco uBR7200 series universal broadband router is configured for basic operations following instructions in the *Cisco uBR7200 Series Universal Broadband Router Software Configuration Guide*. The chassis must contain at least one port adapter to provide backbone connectivity and one Cisco cable modem card to serve as the RF cable TV interface.

Others

- Ensure all other required headend or distribution hub routing and network interface equipment is installed, configured, and operational based on the services to support. This includes all routers, servers (DHCP, TFTP, and ToD), network management systems, and other configuration or billing systems and backbone and other equipment to support VPN.

- Ensure DHCP and DOCSIS configuration files have been created and pushed to appropriate servers such that each cable modem, when initialized, can transmit a DHCP request, receive an IP address, obtain TFTP and ToD server addresses, and download a DOCSIS configuration file. Configure each subinterface to connect to the ISP's VPN.
- Ensure DOCSIS servers are attached and made visible on the management VPN.
- Be familiar with your channel plan to assign appropriate frequencies. Outline your strategies for setting up bundling or VPN solution sets if applicable to your headend or distribution hub. Obtain passwords, IP addresses, subnet masks, and device names as appropriate.
- Create subinterfaces on a physical cable interface or on a bundle of cable interfaces. Configure each subinterface to connect to the ISP network.

The MPLS VPN configuration steps assume the following:

- IP addressing has already been determined and there are assigned ranges in the MSO and ISP network for specific subinterfaces.
- The MSO is using CNR and has configured it (using the **cable helper-address** command) to serve appropriate IP addresses to cable modems based on the cable modem MAC address. The CMTS forwards DHCP requests to the CNR based on the **cable helper-address** settings. The CNR server determines the IP address to assign the cable modem using the client-classes feature, which let the CNR assign specific parameters to devices based on MAC addresses. See "cable helper-address" section on page 26 and "ip dhcp relay information option" section on page 27.
- ISP CE routers are configured (using the **cable helper-address** command) to appropriately route relevant IP address ranges into the VPN.
- P and PE routers are already running Cisco Express Forwarding (CEF).
- MPLS is configured on the outbound VPN using the **tag switching ip** command in interface configuration mode.

Configuration Tasks

To configure MPLS VPNs on Cisco uBR7200 series, perform the following steps:

- Configuring the Cisco uBR7200 series CMTS and PE routers:
  - Creating VRFs for each VPN, page 9
  - Defining Subinterfaces on a Physical Cable Interface and Assigning VRFs, page 10

    or
  - Configuring Cable Interface Bundles, page 11 and Configuring Subinterfaces and MPLS VPNs on a Bundle Master, page 12
- Configuring MPLS in the P Routers in the Provider Core, page 12

Creating VRFs for each VPN

To create VRFs for each VPN, perform the following steps beginning in the router configuration mode.

Note Since only the CMTS has logical subinterfaces, assignments of VRFs on the other PE devices will be to specific physical interfaces.

	Command	Purpose
Step 1	`Router(config)# ip vrf mgmt-vpn`	Enters VRF configuration mode `(config-vrf)#` and maps a VRF table to the VPN (specified by *mgmt-vpn*). The management VPN is the first VPN configured.
Step 2	`Router(config-vrf)# rd mgmt-rd`	Creates a routing and forwarding table by assigning a route distinguisher to the management VPN.
Step 3	`Router(config-vrf)# route-target {export| import| both} mgmt-rd`	Exports and/or imports all routes for the management VPNs route distinguisher. This determines which routes will be shared within VRFs.
Step 4	`Router(config-vrf)# route-target import isp1-vpn-rd`	Imports all routes for the VPNs (*isp1-vpn)* route distinguisher.
Step 5	`Router(config-vrf)# route-target import isp2-vpn-rd`	Imports all routes for the VPNs (*isp2-vpn)* route distinguisher.
Step 6	`Router(config-vrf)# ip vrf isp1-vpn`	Creates a routing and forwarding table by assigning a route distinguisher to *isp1-vpn*.
Step 7	`Router(config-vrf)# rd mgmt-rd`	Creates a routing and forwarding table by assigning a route distinguisher (*mgmt-rd)* to the management VPN (*mgmt-vpn*).
Step 8	`Router(config-vrf)# route-target export isp1-vpn-rd`	Exports all routes for the VPNs (*isp1-vpn)* route distinguisher.
Step 9	`Router(config-vrf)# route-target import isp1-vpn-rd`	Imports all routes for the VPNs (*isp1-vpn)* route distinguisher.

	Command	Purpose
Step 10	`Router(config-vrf)# route-target import mgmt-vpn-rd`	Exports all routes for the VPNs (*mgmt-vpn)* route distinguisher.
Step 11	`Router(config-vrf)# ip vrf isp2-vpn`	Creates a routing and forwarding table by assigning a route distinguisher to *isp2-vpn*.
Step 12	`Router(config-vrf)# route-target export isp2-vpn-rd`	Exports all routes for the VPNs (*isp2-vpn)* route distinguisher.
Step 13	`Router(config-vrf)# route-target import isp2-vpn-rd`	Imports all routes for the VPNs (*isp2-vpn)* route distinguisher.
Step 14	`Router(config-vrf)# route-target import mgmt-vpn-rd`	Imports all routes for the VPNs (*mgmt-vpn)* route distinguisher.

Defining Subinterfaces on a Physical Cable Interface and Assigning VRFs

To create a logical cable subinterface, perform the following steps beginning in the global configuration mode. Create one subinterface for each VPN (one per ISP). The first subinterface created must be configured as part of the management VPN (with the lowest subinterface number). Create VRFs using the procedure, "Creating VRFs for each VPN" section on page 9, and apply them to the subinterface.

	Command	Purpose
Step 1	`Router# configure terminal`	Enters configuration mode.
Step 2	`Router(config)# interface cable slot/port`	Enters cable interface configuration mode. *slot* = slot number in chassis (slot numbers begin with a 0) *port* = port number on cable modem card slot (port numbers begin with a 0)
Step 3	`Router(config-if)# interface cable slot/port.n`	Defines the first (management) subinterface with the lowest subinterface number. Valid range for n is 1 to 255.
Step 4	`Router(config-subif)# description string`	Identifies the subinterface as the management subinterface.
Step 5	`Router(config-subif)# ip vrf forwarding mgmt-vpn`	Assigns the subinterface to the management VPN (the MPLS VPN used by the MSO to supply service to customers).
Step 6	`Router(config-subif)# ip address ipaddress mask`	Assigns the subinterface an IP address and a subnet mask.
Step 7	`Router(config-subif)# cable helper-address ip-address cable-modem`	Forwards DHCP requests from cable modems to the IP address listed.
Step 8	`Router(config-subif)# cable helper-address ip-address host`	Forwards DHCP requests from hosts to the IP address listed.
Step 9	`Router(config-if)# interface cable slot/port.n`	Defines an additional subinterface for the ISP (such as isp1). Valid range for n is 1 to 255.

	Command	Purpose
Step 10	`Router(config-subif)# description string`	Identifies the subinterface (such as subinterface for *isp1-vpn).*
Step 11	`Router(config-subif)# ip vrf forwarding isp1-vpn`	Assigns the subinterface to *isp1-vpn* VPN.
Step 12	`Router(config-subif)# ip address ipaddress mask`	Assigns the subinterface an IP address and a subnet mask.
Step 13	`Router(config-subif)# cable helper-address ip-address cable-modem`	Forwards DHCP requests from cable modems to the IP address listed.
Step 14	`Router(config-subif)# cable helper-address ip-address host`	Forwards DHCP requests from hosts to the IP address listed.
Step 15	`Router(config-if)# interface cable slot/port.n`	Defines an additional subinterface for the ISP (such as isp2). Valid range for n is 1 to 255.
Step 16	`Router(config-subif)# description string`	Identifies the subinterface (such as subinterface for *isp2-vpn).*
Step 17	`Router(config-subif)# ip vrf forwarding isp2-vpn`	Assigns the subinterface to *isp2-vpn* VPN.
Step 18	`Router(config-subif)# ip address ipaddress mask`	Assigns the subinterface an IP address and a subnet mask.
Step 19	`Router(config-subif)# cable helper-address ip-address cable-modem`	Forwards DHCP requests from cable modems to the IP address listed.
Step 20	`Router(config-subif)# cable helper-address ip-address host`	Forwards DHCP requests from hosts to the IP address listed.
Step 21	`Router(config)# copy running-config startup-config`	Returns to configuration mode, and stores the configuration or changes to your startup configuration in NVRAM. **Note** Use this command to save the configuration settings that you created in the Cisco uBR7200 series universal broadband router using the configuration mode, the setup facility, and AutoInstall. If you fail to do this, your configuration will be lost the next time you reload the router.
Step 22	`Router(config)# exit`	Returns to configuration mode.

Configuring Cable Interface Bundles

To assign a cable interface to a bundle, perform the following steps beginning in the interface configuration mode.

	Command	Purpose
Step 1	`Router(config)# interface cable slot/port`	Enters the cable interface configuration mode. *slot* = slot number in chassis (slot numbers begin with 0) *port* = port number on cable modem card slot (port numbers begin with 0) IP addresses are not assigned to this interface. They are assigned to the logical subinterfaces created within this interface.
Step 2	`Router(config-if)# cable bundle bundle-number master`	Defines the interface as the bundle's master interface. Valid range for *bundle-number* is 1 to 255.
Step 3	`Router(config)# interface cable slot/port`	Enters the cable interface configuration mode for another cable interface. *slot* = slot number in chassis (slot numbers begin with 0) *port* = port number on cable modem card slot (port numbers begin with 0) IP addresses are not assigned to this interface. They are assigned to the logical subinterfaces created within this interface.
Step 4	`Router(config-if)# cable bundle bundle-number`	Adds the interface to the bundle specified by *bundle-number*. Valid range for *bundle-number* is 1 to 255.

Configuring Subinterfaces and MPLS VPNs on a Bundle Master

To configure subinterfaces on a bundle master and assign each subinterface a Layer 3 configuration:

Configure cable interface bundles using the procedure, "Configuring Cable Interface Bundles" section on page 11.

Define subinterfaces on the bundle's master interface and assign a Layer 3 configuration to each subinterface using the procedure, "Defining Subinterfaces on a Physical Cable Interface and Assigning VRFs" section on page 10. Create one subinterface for each customer VPN (one per ISP).

Configuring MPLS in the P Routers in the Provider Core

To configure MPLS in the P routers in the provider core, perform the following steps.

	Command	Purpose
Step 1	`Router# configure terminal`	Enters configuration mode.
Step 2	`Router(config)#ip cef`	Enables Cisco Express Forwarding (CEF) operation. For information about CEF configuration and command syntax, see Cisco Express Forwarding Overview and Configuring Cisco Express Forwarding.
Step 3	`Router(config)#interface FastEthernet slot/port`	Enters FastEthernet interface configuration mode.
Step 4	`Router(config-if)#ip address ip-address mask`	Defines the primary IP address range for the interface.
Step 5	`Router(config-if)#mpls ip`	Enables the interface to be forwarded to an MPLS packet.
Step 6	`Router(config-if)#mpls label-protocol ldp`	Enables Label Distribution Protocol (LDP) on the interface. For information about LDP and MPLS, see Configuring Multiprotocol Label Switching.
Step 7	`Router(config)#copy running-config startup-config`	Stores the configuration or changes to your startup configuration in NVRAM. **Note** Use this command to save the configuration settings that you created in the Cisco uBR7200 series universal broadband router using the configuration mode, the setup facility, and AutoInstall. If you fail to do this, your configuration will be lost the next time you reload the router.
Step 8	`Router(config)# exit`	Returns to the configuration mode.

Verifying the MPLS VPN Configuration

Use the following commands to verify MPLS VPN operations on PE routers. For more MPLS VPN verification commands, see Configuring Multiprotocol Label Switching.

	Command	Purpose
Step 1	`Router#`**`show ip vrf`**	Displays the set of VRFs and interfaces.
Step 2	`Router#`**`show ip route vrf`**	Displays the IP routing table for a VRF.
Step 3	`Router#`**`show ip protocols vrf`**	Displays the routing protocol information for a VRF.
Step 4	`Router(config) #`**`show cable bundle`** *`n forwarding-table`*	Displays the forwarding table for the specified interface.

Configuration Examples

This section provides the following configuration examples:

Subinterface Configuration Example

The following example shows how to define a subinterface on the cable3/0.

```
interface cable3/0
! No IP address
! MAC level configuration only


! first subinterface
interface cable3/0.1
description Management Subinterface
ip address 10.255.1.1 255.255.255.0
cable helper-address 10.151.129.2

! second subinterface
interface cable3/0.2
ip address 10.279.4.2 255.255.255.0
cable helper-address 10.151.129.2

! third subinterface
interface cable3/0.3
ip address 10.254.5.2 255.255.255.0
cable helper-address 10.151.129.2
```

Cable Interface Bundling Example

The following example shows how to bundle a group of physical interfaces.

`int c3/0` and `int c4/0` are bundled.

```
int c3/0
ip address 209.165.200.225 255.255.255.0
ip address 209.165.201.1 255.255.255.0 secondary
cable helper-address 10.5.1.5
! MAC level configuration
cable bundle 1 master
int c4/0
! No IP address
! MAC layer configuration only
cable bundle 1
```

Subinterface Definition on Bundle Master Example

The following example shows how to define subinterfaces on a bundle master and define Layer 3 configurations for each subinterface.

int c3/0 and int c4/0 are bundled.

```
int c3/0
! No IP address
! MAC level configuration only
cable bundle 1 master

int c4/0
! No IP address
! MAC layer configuration
cable bundle 1

! first subinterface
int c3/0.1
ip address 10.22.64.0 255.255.255.0
cable helper-address 10.4.1.2

! second subinterface
int c3/0.2
ip address 10.12.39.0 255.255.255.0
cable helper-address 10.4.1.2

! third subinterface
int c3/0.3
ip address 10.96.3.0 255.255.255.0
cable helper-address 10.4.1.2
```

Cable Interface Bundle Master Configuration Example

The following examples show how to configure cable interface bundles:

```
Displaying the contents of the bundle
Router(config-if)#cable bundle ?
  <1-255>  Bundle number
Router(config-if)#cable bundle 25 ?
  master  Bundle master
  <cr>
Router(config-if)#cable bundle 25 master ?
  <cr>
Router(config-if)#cable bundle 25 master
Router(config-if)#
07:28:17: %UBR7200-5-UPDOWN: Interface Cable3/0 Port U0, changed state to down
07:28:18: %UBR7200-5-UPDOWN: Interface Cable3/0 Port U0, changed state to up
```

PE Router Configuration Example

```
!
! Identifies the version of Cisco IOS software installed.
version 12.0

! Defines the hostname of the Cisco uBR7246
hostname region-1-ubr
!
! Describes where the system is getting the software image it is running. In
! this configuration example, the system is loading a Cisco uBR7246 image named
! AdamSpecial from slot 0.
boot system flash slot0:ubr7200-p-mz.AdamSpecial
!
! Creates the enable secret password.
enable secret xxxx
enable password xxxx
!
! Sets QoS per modem for the cable plant.
no cable qos permission create
no cable qos permission update
cable qos permission modems
!
! Allows the system to use a full range of IP addresses, including subnet zero, for
! interface addresses and routing updates.
ip subnet-zero
!
! Enables Cisco Express Forwarding.
ip cef
!
! Configures a Cisco IOS Dynamic Host Configuration Protocol (DHCP) server to insert the
! DHCP relay agent information option in forwarded BOOTREQUEST messages.
ip dhcp relay information option
!
! Enters the virtual routing forwarding (VRF) configuration mode and maps a VRF table to
! the virtual private network (VPN) called MGMT-VPN. The VRF table contains the set of
! routes that points to or gives routes to the CNR device, which provisions the cable
! modem devices. Each VRF table defines a path through the MPLS cloud.
ip vrf MGMT-VPN
```

```
!
! Creates the route distinguisher and creates the routing and forwarding table of the
! router itself.
 rd 100:1
!
! Creates a list of import and/or export route target communities for the VPN.
 route-target export 100:2
 route-target export 100:3
!
! Maps a VRF table to the VPN called ISP1-VPN.
ip vrf ISP1-VPN
!
! Creates the route distinguisher and creates the routing and forwarding table of the
! router itself.
 rd 100:2
!
! Creates a list of import and/or export route target communities for the VPN.
 route-target import 100:1
!
! Maps a VRF table to the VPN called ISP2-VPN.
ip vrf ISP2-VPN
!
! Creates the route distinguisher and creates the routing and forwarding table of the
! router itself.
 rd 100:3
!
! Creates a list of import and/or export route target communities for the VPN.
 route-target import 100:1
!
! Maps a VRF table to the VPN called MSO-isp. Note: MSO-isp could be considered ISP-3; in
! this case, the MSO is competing with other ISPs for other ISP services.
ip vrf MSO-isp
!
! Creates the route distinguisher and creates the routing and forwarding table of the
! router itself.
 rd 100:4
!
! Creates a list of import and/or export route target communities for the VPN.
  route-target import 100:1
!
! Builds a loopback interface to be used with MPLS and BGP; creating a loopback interface
! eliminates unnecessary updates (caused by physical interfaces going up and down) from
! flooding the network.
interface Loopback0
 ip address 10.0.0.0 255.255.255.0
 no ip directed-broadcast
!
! Assigns an IP address to this Fast Ethernet interface. MPLS tag-switching must be
! enabled on this interface.
interface FastEthernet0/0
 description Connection to MSO core.
 ip address 10.0.0.0 255.255.255.0
 no ip directed-broadcast
 full-duplex
 tag-switching ip
!
! Enters cable interface configuration mode and configures the physical aspects of the
! 3/0 cable interface. Please note that no IP addresses are assigned to this interface;
! they will be assigned instead to the logical subinterfaces. All other commands for
! this cable interface should be configured to meet the specific needs of your cable RF
! plant and cable network.
interface Cable3/0
 no ip address
 ip directed-broadcast
```

```
 no ip mroute-cache
 load-interval 30
 no keepalive
 cable downstream annex B
 cable downstream modulation 64qam
 cable downstream interleave-depth 32
 cable downstream frequency 855000000
 cable upstream 0 frequency 30000000
 cable upstream 0 power-level 0
 no cable upstream 0 shutdown
 cable upstream 1 shutdown
 cable upstream 2 shutdown
 cable upstream 3 shutdown
 cable upstream 4 shutdown
 cable upstream 5 shutdown
!
! Configures the physical aspects of the 3/0.1 cable subinterface. If cable modems have
! not been assigned IP addresses, they will automatically come on-line using the settings
! for subinterface X.1.
interface Cable3/0.1
 description Cable Administration Network
!
! Associates this interface with the VRF and MPLS VPNs that connect to the MSO cable
! network registrar (CNR). The CNR provides cable modems with IP addresses and other
! initialization parameters.
 ip vrf forwarding MSO
!
! Defines a range of IP addresses and masks to be assigned to cable modems not yet
associated with an ISP.
 ip address 10.0.0.0 255.255.255.0
!
! Disables the translation of directed broadcasts to physical broadcasts.
 no ip directed-broadcast
!
! Defines the DHCP server for cable modems whether they are associated with an ISP or
! with the MSO acting as ISP.
 cable helper-address 10.4.1.2 cable-modem
!
! Defines the DHCP server for PCs that are not yet associated with an ISP.
 cable helper-address 10.4.1.2 host
!
! Disables cable proxy Address Resolution Protocol (ARP) and IP multicast echo on this
! cable interface.
 no cable proxy-arp
 no cable ip-multicast-echo
!
! Configures the physical aspects of the 3/0.2 cable subinterface.
interface Cable3/0.2
 description MSO as ISP Network
!
! Assigns this subinterface to the MPLS VPN used by the MSO to supply service to
! customers—in this case, MSO-isp.
 ip vrf forwarding MSO-isp
!
! Defines a range of IP addresses and masks to be assigned to cable modems associated
! with the MSO as ISP network.
 ip address 10.1.0.0 255.255.255.0 secondary
!
! Defines a range of IP addresses and masks to be assigned to host devices associated
! with the MSO as ISP network.
 ip address 10.1.0.0 255.255.255.0
!
! Disables the translation of directed broadcasts to physical broadcasts.
 no ip directed-broadcast
```

```
!
! Defines the DHCP server for cable modems whether they are associated with an ISP or
! with the MSO acting as ISP.
 cable helper-address 10.4.1.2 cable-modem
!
! Defines the DHCP server for PC host devices.
 cable helper-address 10.4.1.2 host
!
! Disables cable proxy Address Resolution Protocol (ARP) and IP multicast echo on this
! cable interface.
 no cable proxy-arp
 no cable ip-multicast-echo
!
! Configures the physical aspects of the 3/0.3 cable subinterface
interface Cable3/0.3
 description ISP1's Network
!
! Makes this subinterface a member of the MPLS VPN.
 ip vrf forwarding isp1
!
! Defines a range of IP addresses and masks to be assigned to cable modems associated
! with the MSO as ISP network.
 ip address 10.1.1.1 255.255.255.0 secondary
!
! Defines a range of IP addresses and masks to be assigned to host devices associated
! with the MSO as ISP network.
 ip address 10.0.1.1 255.255.255.0
!
! Disables the translation of directed broadcasts to physical broadcasts.
 no ip directed-broadcast
!
! Disables cable proxy Address Resolution Protocol (ARP) and IP multicast echo on this
! cable interface.
 no cable proxy-arp
 no cable ip-multicast-echo
!
! Defines the DHCP server for cable modems whether they are associated with an ISP or
! with the MSO acting as ISP.
 cable helper-address 10.4.1.2 cable-modem
!
! Defines the DHCP server for PC host devices.
 cable helper-address 10.4.1.2 host
!
! Configures the physical aspects of the 3/0.4 cable subinterface
interface Cable3/0.4
 description ISP2's Network
!
! Makes this subinterface a member of the MPLS VPN.
 ip vrf forwarding isp2
!
! Defines a range of IP addresses and masks to be assigned to cable modems associated
! with the MSO as ISP network.
 ip address 10.1.2.1 255.255.255.0 secondary
!
! Defines a range of IP addresses and masks to be assigned to host devices associated
! with the MSO as ISP network.
 ip address 10.0.1.1 255.255.255.0
!
! Disables the translation of directed broadcasts to physical broadcasts.
 no ip directed-broadcast
!
! Disables cable proxy Address Resolution Protocol (ARP) and IP multicast echo on this
! cable interface.
 no cable proxy-arp
```

```
 no cable ip-multicast-echo
!
!
 cable dhcp-giaddr policy
!
!! Defines the DHCP server for cable modems whether they are associated with an ISP or
! with the MSO acting as ISP.
 cable helper-address 10.4.1.2 cable-modem
!
! Defines the DHCP server for PC host devices.
 cable helper-address 10.4.1.2 host
!
!
end
```

P Router Configuration Example

```
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R7460-7206-02
!
enable password xxxx
!
ip subnet-zero
ip cef
ip host brios 223.255.254.253
!
interface Loopback0
 ip address 10.2.1.3 255.255.255.0
 no ip directed-broadcast
!
interface Loopback1
 no ip address
 no ip directed-broadcast
 no ip mroute-cache
!
interface FastEthernet0/0
 ip address 1.7.108.2 255.255.255.0
 no ip directed-broadcast
 no ip mroute-cache
 shutdown
 full-duplex
 no cdp enable
!
interface Ethernet1/0
 ip address 10.0.1.2 255.255.255.0
 no ip directed-broadcast
 no ip route-cache cef
 no ip mroute-cache
 tag-switching ip
 no cdp enable
!
interface Ethernet1/1
 ip address 10.0.1.17 255.255.255.0
 no ip directed-broadcast
 no ip route-cache cef
 no ip mroute-cache
 tag-switching ip
 no cdp enable
!
interface Ethernet1/2
 ip address 10.0.2.2 255.255.255.0
 no ip directed-broadcast
 no ip route-cache cef
 no ip mroute-cache
 tag-switching ip
 no cdp enable
!
interface Ethernet1/3
 ip address 10.0.3.2 255.255.255.0
 no ip directed-broadcast
```

```
 no ip route-cache cef
 no ip mroute-cache
 tag-switching ip
 no cdp enable
!
interface Ethernet1/4
 ip address 10.0.4.2 255.255.255.0
 no ip directed-broadcast
 no ip route-cache cef
 no ip mroute-cache
 tag-switching ip
 no cdp enable
!
interface Ethernet1/5
 no ip address
 no ip directed-broadcast
 no ip route-cache cef
 shutdown
 no cdp enable
!
interface Ethernet1/6
 no ip address
 no ip directed-broadcast
 no ip route-cache cef
 shutdown
 no cdp enable
!
interface Ethernet1/7
 no ip address
 no ip directed-broadcast
 no ip route-cache cef
 shutdown
 no cdp enable
!
router ospf 222
 network 10.0.1.0 255.255.255.0 area 0
 network 10.0.2.0 255.255.255.0 area 0
 network 10.0.3.0 255.255.255.0 area 0
 network 10.0.4.0 255.255.255.0 area 0
 network 20.2.1.3 255.255.255.0 area 0
!
ip classless
no ip http server
!
!
map-list test-b
no cdp run
!
tftp-server slot0:master/120/c7200-p-mz.120-1.4
!
line con 0
 exec-timeout 0 0
 password xxxx
 login
 transport input none
line aux 0
line vty 0 4
 password xxxx
 login
!
no scheduler max-task-time
end
```

Command Reference

This section documents the following new commands. All other commands used with this feature are documented in the Cisco IOS Release 12.1 command reference publications.

- **cable bundle**
- **cable helper-address**
- **ip dhcp relay information option**
- **show cable bundle**

cable bundle

To configure a cable interface to belong to an interface bundle, use the **cable bundle** interface configuration command. To delete a cable interface bundle definition, use the **no** form of this command.

cable bundle *n* [**master**]

no cable bundle *n* [**master**]

Syntax Description

n	Specifies the bundle identifier. Valid range is from 1 to 255.
master	(Optional) Defines the specified interface as the master.

Defaults

No default behavior or values.

Command Modes

Interface configuration

Command History

Release	Modification
12.0(7)XR	This command was introduced.

Usage Guidelines

You can configure up to four interface bundles. In each bundle, specify one interface as the master interface by using the optional **master** keyword.

Configure only an IP address on the master interface. If an IP address is configured and the interface is not specified as the master interface, any attempt to add an interface to a bundle is rejected.

Specify all generic IP networking information (such as IP address, routing protocols, and switching modes) on the bundle master interface. Do not specify generic IP networking information on bundle slave interfaces.

If you attempt to add an interface to a bundle as nonmaster interface and an IP address is assigned to this interface, the command will fail. You must remove the IP address configuration before you can add the interface to a bundle.

If you have configured an IP address on a bundled interface and the interface is not the master interface, a warning message appears.

Specify generic (not downstream or upstream related) cable interface configurations, such as source-verify or ARP (Address Resolution Protocol) handling, on the master interface. Do not specify generic configuration on nonmaster interfaces.

If you configure an interface as a part of a bundle and it is not the master interface, all generic cable configuration for this interface is removed. The master interface configuration will then apply to all interfaces in the bundle.

If you shut down or remove the master interface in a bundle, no data packets are sent to any of the interfaces in this bundle. Packets are still physically received from nonmaster interfaces which have not been shut down, but those packets will be discarded. This means that modems connected to those interfaces will not be disconnected immediately, but modems going online will not be able to obtain an IP address, download their configuration file, or renew their IP address assignment if the DHCP lease expires.

If you shut down a slave interface, only this shut down interface is affected.

Examples

See the following example to configure interface 25 to be the master interface:

```
Router(config-if)# cable bundle 25 master
Router(config-if)#
07:28:17: %UBR7200-5-UPDOWN: Interface Cable3/0 Port U0, changed state to down
07:28:18: %UBR7200-5-UPDOWN: Interface Cable3/0 Port U0, changed state to up
```

The following example shows the error message that appears if you try to configure an interface with an IP address that is not the master interface:

```
Router(config-if)# cable bundle 5
Please remove ip address config first then reenter this command
```

Related Commands

Command	Description
show cable bundle	Displays the forwarding table for the specified interface bundle.

cable helper-address

To specify a destination address for User Datagram Protocol (UDP) broadcast (DHCP) packets, use the **cable helper-address** interface configuration command. Use the **no** form of this command to disable this feature.

cable helper-address *ipaddress* {**cable-modem | host**}

no cable helper-address *ipaddress* {**cable-modem | host**}

Syntax Description

ipaddress	The IP address of a DHCP server. Based on whether you add the **host** or **cable-modem** flag at the end of the **cable helper-address** command, it is the IP address of the MSOs CNR server or the ISPs DHCP server.
cable-modem	Specifies that only cable modem UDP broadcasts are forwarded
host	Specifies that only host UDP broadcasts are forwarded.

Defaults

None.

Command Modes

Interface configuration

Command History

Release	Modification
11.3 NA	This command was introduced.

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 NA. If you specify a secondary interface address, the giaddr field in the DHCP requests will be sent to the primary address for DHCP requests received from cable modems, and to the secondary IP address for DHCP requests received from hosts.

Examples

The following example forwards UDP broadcasts from cable modems to the DHCP server at 172.23.66.44:

```
Router(config-if)# cable helper-address 172.23.66.44 cable-modem
```

The following example forwards UDP broadcasts from hosts to the DHCP server at 172.23.66.44:

```
Router(config-if)# cable helper-address 172.23.66.44 host
```

ip dhcp relay information option

To enable the system to insert the cable modem MAC address into a DHCP packet received from a cable modem or host and forward the packet to a DHCP server, use the **ip dhcp relay information option** in global configuration mode. To disable MAC address insertion, use the **no** form of this command.

ip dhcp relay information option

no ip dhcp relay information option

Syntax Description

This command has no keywords or arguments.

Defaults

no ip dhcp relay info option

Command Modes

Global configuration

Command History

Release	Modification
11.3NA	This command was introduced.
12.0	In previous releases, routers running Cisco IOS Release 11.3NA used the **cable relay-agent option** command in the cable interface configuration mode. Cisco uBR7200 series routers running Cisco IOS Release 12.0 use the **ip dhcp relay information option** command in the global configuration mode.
12.0SC	This command was modified to configure the **cable relay agent option** using **ip dhcp relay information option**.

Usage Guidelines

This functionality enables a DHCP server to identify the user (cable modem) sending the request and initiate appropriate action based on this information. To insert DHCP relay-agent option fields, use the cable **ip dhcp relay information option** in global configuration mode.

In Cisco uBR7200 series running Cisco IOS Release 12.0 use the global configuration command **ip dhcp relay information option** to insert DHCP relay-agent option fields. Previously, routers running Cisco IOS Release 11.3NA used the **cable relay-agent-option** command.

Cisco IOS Release 12.0SC was built off Cisco IOS Release 11.3NA with additional features such as interface bundling. If you use Cisco Release IOS Release 12.0.7XR2 for concatenation, you should be able to configure the cable relay agent option using the **ip dhcp relay information option** command.

Examples

The following example enables the insertion of DHCP relay agent information into DHCP packets:

```
interface cable 6/0
cable ip dhcp relay information option
```

show cable bundle

To display the forwarding table for the specified interface, use the **show cable bundle** privileged EXEC command.

show cable bundle *n forwarding-table*

Syntax Description

n	Specifies the bundle identifier. Valid range is from 1 to 255.
forwarding-table	Displays the forwarding table for the specified interface.

Defaults

No default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(7)XR	This command was introduced.

Examples

```
Router# show cable bundle 25 forwarding-table
MAC address         Interface
0050.7366.17ab      Cable3/0
0050.7366.1803      Cable3/0
0050.7366.1801      Cable3/0
```

The fields in the show cable bundle display are:

- MAC address—Media Access Control ID for each interface in the bundle.
- Interface—The cable interface slot and port number.

Related Commands

Command	Description
cable bundle	Creates an interface bundle.

Glossary

C Network—Customer (enterprise or ISP) networks

C Router—Customer router, a router in the C network

CMTS—Cable Modem Termination System.

CPE—Customer Premises Equipment

CE router—Customer Edge Router. An edge router in the C network, defined as a C router which attaches directly to a PE router.

CEF—Cisco Express Forwarding.

HFC—Hybrid Fiber Coaxial.

HG—Home Gateway. A device owned and managed by a customer (enterprise network or ISP) to provide the Layer 2 Tunneling Protocol Network Server (LNS) function to remote access users.

IG—Internet Gateway. PE router connecting the MPLS backbone to the public Internet.

label—A short fixed-length label that tells switching nodes how to forward data (packets or cells).

LDP—Label Distribution Protocol. The Internet Engineering Task Force (IETF) equivalent of Tag Distribution Protocol (TDP) that switches labeled packets according to precomputed switching tables.

LSR—Label Switching Router. A Layer 3 router that forwards a packet based on the value of a label encapsulated in the packet.

MPLS—Multiprotocol Label Switching.

NAT—Network Address Translation.

P network—Provider's MPLS-capable core network.

P router—Provider router, a router in the P network. P routers perform MPLS label switching.

PE router—Provider Edge router, an edge router in the provider network.

Subinterface—A logical network layer interface over a physical interface or a bundle of physical interfaces.

TDP—Tag Distribution Protocol. The protocol used to distribute label bindings to LSRs.

VRF—Virtual Private Network Routing/Forwarding table. A Routing table instance which is populated with VPN routes.