CHAPTER 4

IPv6 and 6VPE Support in MPLS VPN

This chapter provides an overview of IPv6 and 6VPE support in MPLS VPN. It contains the following sections:

- Overview of IPv6 and 6VPE, page 4-1
- Comparison of IOS and IOS XR, page 4-3
- ISC and MPLS VPN Updates to Support IPv6 and 6VPE, page 4-7
- IPv6 and 6VPE Features Not Supported in ISC 5.1, page 4-11

Note For information on how MPLS VPN features are implemented and supported in the ISC GUI, see the appropriate sections of this guide, as indicated by the references provided.

Overview of IPv6 and 6VPE

The ISC MPLS VPN management application supports the configuration and management of Cisco's 12000 router running IOS XR for provisioning of IPv6 VPNs and 6VPEs for ISC Layer 3 VPN services. This section provides an overview of IPv6 and 6VPE technologies. For a comparison of IOS and IOS XR, see Comparison of IOS and IOS XR, page 4-3.

Note For a list of IOS XR versions supported in ISC 5.1, see *Release Notes for Cisco IP Solution Center, 5.1.*

Internet Protocol Version 6 (IPv6)

IPv6 is an IP protocol designed to replace IPv4, the Internet protocol that is predominantly deployed and extensively used throughout the world. IPv6 quadruples the number of network address bits from 32 bits (in IPv4) to 128 bits, or approximately 3.4 x 10^{38} addressable nodes. This provides more than enough globally unique IP addresses for every network device on the planet. Cisco Systems has added IPv6 to its Cisco IOS Software. This means that current Cisco Systems-based networks are IPv6-capable, enabling coexistence and parallel operation between IPv4 and IPv6, thereby allowing network managers to configure IPv6 when it is required. While many see IPv6 as a way to build a larger global Internet, it does not eliminate the need to create VPNs for Intranets and other similar applications.

A variety of deployment strategies are available for deploying IPv6 over MPLS backbones. Currently, service providers have two approaches to support IPv6 without making any changes to the current IPv4 MPLS backbones:

- **6PE.** Cisco IOS IPv6 Provider Edge Router (6PE) over MPLS. 6PE lets IPv6 domains communicate with each other over an IPv4 cloud without explicit tunnel setup, requiring only one IPv4 address per IPv6 domain. The 6PE technique allows service providers to provide global IPv6 reachability over IPv4 MPLS. It allows one shared routing table for all other devices.
- **6VPE.** Cisco IPv6 VPN Provider Edge Router (6VPE) over MPLS. This facilitates the RFC 2547bis-like VPN model for IPv6 networks. 6VPE is more like a regular IPv4 MPLS VPN provider edge, with the addition of IPv6 support within Virtual Routing and Forwarding (VRF). It provides logically separate routing table entries for VPN member devices.

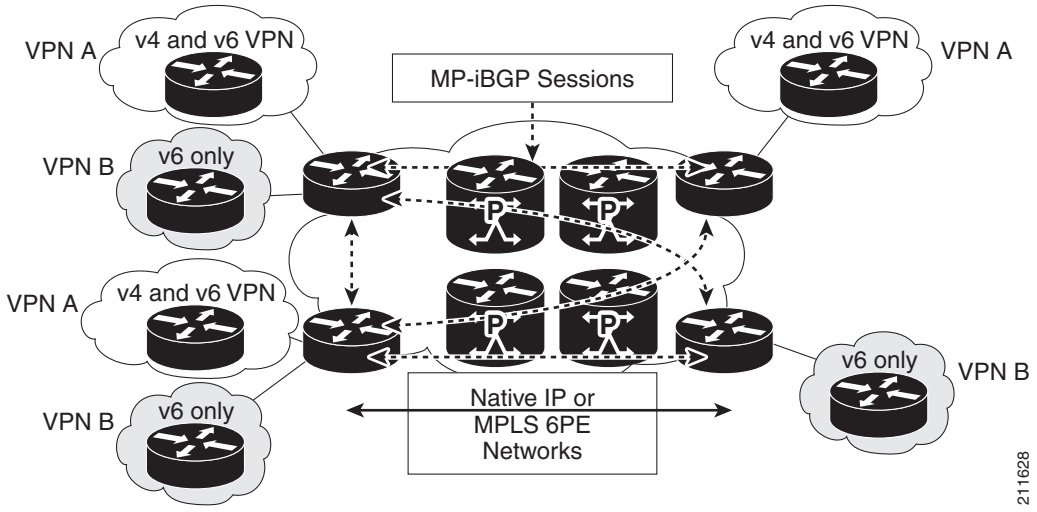
MPLS VPN in ISC 5.1 uses 6VPE to manage Layer 3 VPN services for deployment of IPv6 over a MPLS backbone.

IPv6 VPN Provider Edge Router (6VPE)

Cisco Systems's 6VPE solution smoothly introduces IPv6 VPN service in a scalable way, without any IPv6 addressing restrictions. It does not jeopardize a well-controlled service provider IPv4 backbone or any customer networks. VPN service backbone stability is a key issue for those service providers who have recently stabilized their IPv4 infrastructure. For IPv4 VPN customers, IPv6 VPN service is exactly the same as MPLS VPN for IPv4.

The IPv6 MPLS VPN service model is similar to that of IPv4 MPLS VPNs. Service providers who have already deployed MPLS IPv4 VPN services over an IPv4 backbone can deploy IPv6 MPLS VPN services over the same IPv4 backbone by upgrading the PE router IOS version and dual-stack configuration, without any change on the core routers. IPv4 services can be provided in parallel with IPv6 services. A PE-CE link can be an IPv4 link, an IPv6 link, or a combination of an IPv4 and IPv6 link, as shown in Figure 4-1.

Figure 4-1 6VPE Deployment



IPv6 VPN service is exactly the same as MPLS VPN for IPv4. 6VPE offers the same architectural features as MPLS VPN for IPv4. It offers IPv6 VPN and uses the same components, such as:

- Multiprotocol BGP (MP-BGP) VPN address family
- Route distinguishers
- VPN Routing and Forwarding (VRF) instances
- Site of Origin (SoO)
- Extended community
- MP-BGP

The 6VPE router exchanges either IPv4 or IPv6 routing information through any of the supported routing protocols, and switches IPv4 and IPv6 traffic using the respective fast switching CEF or distributed CEF path over the native IPv4 and IPv6 VRF interfaces. The 6VPE router exchanges reachability information with the other 6VPE routers in the MPLS domain using Multiprotocol BGP, and shares a common IPv4 routing protocol (such as OSPF or IS-IS) with the other P and PE devices in the domain. Separate routing tables are maintained for the IPv4 and IPv6 stacks. A hierarchy of MPLS labels is imposed on an incoming customer IPv6 packet at the edge LSR:

- Outer label (IGP Label) for iBGP next-hop, distributed by LDP.
- Inner label (VPN Label) for the IPv6 prefix, distributed by MP-BGP.

Incoming customer IPv6 packets at the 6VPE VRF interface are transparently forwarded inside the service provider's IPv4 core, based on MPLS labels. This eliminates the need to tunnel IPv6 packets. P routers inside the MPLS core are unaware that they are switching IPv6 labelled packets.

Comparison of IOS and IOS XR

This section provides a comparison between IOS and IOS XR, showing various configuration scenarios. It contains the following sections:

- General Comparison of IOS and IOS XR Device Configlets, page 4-3
- Using OSPF as the PE-CE Routing Protocol, page 4-4
- Using EIGRP as the PE-CE Routing Protocol, page 4-5
- Using Static as the PE-CE Routing Protocol, page 4-5
- Multicast Routing on IOS XR Devices, page 4-6

Note For a list of IOS XR versions supported in ISC 5.1, see *Release Notes for Cisco IP Solution Center, 5.1.*

General Comparison of IOS and IOS XR Device Configlets

This section provides examples of VRF-related and interface-related configlets for IOS an IOS XR.

VRF-Related Configlets

IOS

In IOS, RD and RT configlets have to be specified in IP VRF configuration mode:

```
ip vrf vrfname
 rd ASN:uniqueno
 route-target export ASN:uniqueno
 route-target import ASN:uniqueno
 route-target import ASN:uniqueno
!
```

IOS XR

In IOS XR, RT values are configured in VRF configuration mode and the RD value has to be specified under BGP configuration mode:

```
vrf vrfname
 address-family ipv4 unicast
  import route-target
   ASN:uniqueno
   ASN:uniqueno
  !
  export route-target
   ASN:uniqueno
  !
```

Router BGP mode:

```
vrf vrfname
 rd AS:uniqueno
 address-family ipv4 unicast
  redistribute connected
  redistribute static
```

Interface-Related Configlets

IOS

```
interface interfacename
ip address ipaddress subnetmask
ip vrf forwarding vrfname
```

IOS XR

```
interface interfacename
ipv4 address ipaddress subnetmask
vrf vrfname
```

Using OSPF as the PE-CE Routing Protocol

Note In ISC 5.1, ISC provisions OSPF-based service requests in the same way, irrespective of whether IOS or IOS XR is used.

The following examples highlight differences between IOS and IOS XR when using OSPF as the PE-CE routing protocol.

IOS

- IOS supports the network command:

```
router ospf  processid  vrf vrfname
log-adjacency-changes
redistribute bgp AS subnets
network networkipadress wildcardmask area areanumber
```

- IOS supports only one VRF per OSPF process ID.

IOS XR

- In IOS XR, there is no network command support under the **ospf process id** command. In place of the network command, it uses **interface interfacename**.

```
router ospf processid
  vrf vrfname
  redistribute bgp AS
  area areano
   interface interface interfacename
```

- IOS XR supports multiple VRFs per **ospf process id** command.

```
router ospf process id
 vrf vpnnew
  redistribute bgp AS
  area areano
   interface interface interfacename
   !
 vrf V12:vrfname
  redistribute bgp AS
  area areano
   interface interface interfacename
   !
```

Using EIGRP as the PE-CE Routing Protocol

The following examples highlight differences between IOS and IOS XR when using EIGRP as the PE-CE routing protocol.

IOS

IOS supports multiple EIGRP process IDs per device.

IOS XR

IOS XR supports a single EIGRP process ID per device.

Using Static as the PE-CE Routing Protocol

The following examples highlight differences between IOS and IOS XR when using Static at the PE-CE routing protocol.

IOS

Configlets for creating a static route in IOS.

- When using **nexthopip** for the static route:

```
ip route vrf coke destination network subnetmask nexthopip
```

- When using **outgoing interface** for the static route

```
ip route vrf coke destination network subnetmask outgoing interface
```

IOS XR

Configlets for creating a static route in IOS XR:

- Using **outgoing interface** for the static route:

```
router static
 !
 vrf vrfname
  address-family ipv4 unicast
   destinationnetwork/prefixlength outgoinginterface nexthopip
     !
```

- Using **nexthopip** for the static route:

```
router static
 !
 vrf vrfname
  address-family ipv4 unicast
   destinationnetwork/prefixlength nexthopip
     !
```

Multicast Routing on IOS XR Devices

Note Multicast VRF deployments for IOS XR devices are supported only for IPv4 services. Multicast cannot be enabled on IPv6 services. When multicast is enabled on IPv4+IPv6 service, only IPv4 multicast is enabled on the interface. Currently, multicast on IOS XR is supported only for IOS XR versions 3.5.2, 3.6, and 3.7.0.

This section describes how ISC supports multicast routing for IPv4 on IOS XR devices. There are no changes in the GUI (Create VPN window) to support this feature. To enable support, the IOS multicast commands are mapped to equivalent IOS XR commands. Because there are no XML configurations to support multicast routing on IOS XR devices, ISC supports the XR CLIs to enable multicast routing on IOS XR devices.

The following sections shows an example of the relevant IOS commands and the corresponding IOS XR commands to enable multicast routing.

IOS Commands

The following is a sample IOS configuration:

```
ip vrf V27:MulticastCERC3
rd 100:124
route-target import 100:406
route-target import 100:407
route-target export 100:406
mdt default 226.2.3.4
mdt data 226.5.6.7 0.0.0.15 2000
mdt mtu 2000
ip multicast-routing vrf V27:MulticastCERC3
ip pim vrf V28:VPN13 ssm default
ip pim vrf V27:MulticastCERC3 rp-address 10.20.1.1
ip pim vrf V27:MulticastCERC3 rp-address 10.20.3.1 test2
ip pim vrf V27:MulticastCERC3 rp-address 10.20.2.1 test1 override
```

IOS XR Commands

The following IOS commands are not supported on the IOS XR devices, because the corresponding commands do not exist in IOS XR.

- **ip multicast vrf <vrfName> route-limit**. The reason for not supporting this is that the command to set the route limit per VRF is not available on IOS XR devices.
- **ip pim vrf <vrfName> sparse-dense-mode**. Sparse-dense mode is not supported by IOS XR. Only sparse mode and bidirectional modes are supported.

The following IOS commands are enabled on the IOS XR device by default when the multicast routing is enabled. They cannot be disabled.

- **ip pim vrf <vrfName> sparse-mode**
- **ip pim vrf <vrfName> ssm default**
- **ip pim vrf <vrfName> autorp listener**

ISC and MPLS VPN Updates to Support IPv6 and 6VPE

This section summarizes how ISC and the MPLS VPN management application support IPv6 and 6VPE in ISC 5.1. It contains the following subsections:

- Inventory and Device Management, page 4-7
- MPLS VPN Service Provisioning, page 4-9
- MPLS Reports, page 4-11

See Chapter 2, “Setting Up the ISC Services” for information setting up ISC services mentioned in this section. For additional information on setting up basic ISC services, see the *Cisco IP Solution Center Infrastructure Reference, 5.1.*

Inventory and Device Management

To activate MPLS VPN services, you must configure ISC so it “knows” about the preconfiguration information, such as devices, providers, customers, and so on, that ISC is going to manage. Changes in this release of ISC to support inventory and device management for IPv6 and 6VPE include:

Discovery features for supporting IPv6/6VPE:

- ISC Inventory Manager supports bulk-import of 6VPE devices into the ISC repository.

Collect Config task features for supporting IPv6/6VPE:

- The Collect Config task collects device information and interface information. It has been updated to collect IPv6 addresses of interfaces. When interfaces contain both IPv4 and IPv6 addresses, both will be collected and stored in the ISC repository.
- The Collect Config task retrieves the OS type and the version information. If the device is a Cisco 12000 series router or a Cisco CRS-1 Carrier Routing System and is running IOS XR, the device will be marked as 6VPE supported.

Device configuration features for supporting IPv6/6VPE:

- 6VPE devices with IPv6 addressing can be created and managed in the ISC GUI.
  - A “6VPE” check box has been added to the Create PE Device window to designate an N-PE device as a 6VPE.
  - A new column has been added to the Interface Attributes window to show IPv6 addresses. It is not possible to bulk change the IPv6 addresses by selecting multiple interfaces. The IPv6 Address column is noneditable.
  - The Edit Device Interface window has also been updated to show IPv6 addresses on interfaces. In case of dual-stack interfaces containing both IPv4 and IPv6 addresses, both addresses are displayed.
  - The Create CPE Device window has been updated to display IPv6 addresses on interfaces. In case of dual-stack interfaces containing both IPv4 and IPv6 addresses, both addresses are displayed.
  - You cannot create an IPv6 interface using the existing Create Interface feature. This screen currently lets you create interfaces in the repository only, with the device configuration remaining unchanged. This feature does not support IPv6 addresses. The IPv6 interface creation in the device is supported through the MPLS VPN service deployment.

General features for supporting IPv6/6VPE:

- Windows within the Inventory and Connection Manager GUI have been updated in several areas to support IPv6 addressing for a 6VPE device.
- The ISC GUI provides messages to the user that IPv6 addressing scheme is only applicable to IOS XR devices.

VPN Creation and Configuration

There are no changes in the ISC VPN workflow for IPv6 and 6VPE. However, a new feature called VRF object management was added in ISC 5.0.1. See the next section, VRF Object Support, page 4-8, for more information.

VRF Object Support

Starting in ISC 5.0.1, ISC allows you to specify VPN and VRF information in an independent VRF object, which is subsequently deployed to a PE device and then associated with an MPLS VPN link via an MPLS VPN service request. For details on using this feature, see Chapter 3, “Independent VRF Management.”

Resource Pools

ISC uses resource pools to automatically assign critical parameters like VLAN, VCID, and IP Addresses during the service provisioning. IPv6 address pools are not supported in this release.

MPLS VPN Service Provisioning

ISC MPLS VPN management application supports the provisioning of IPv6 Layer 3 VPNs on an IPv6 Provider Edge router (6VPE), starting with the IOS XR 3.5 release. ISC 5.1 provides the ability to configure the following on the 6VPE:

- IPv6 addressing on 6VPE (optionally, IPv4 or both IPv6+IPv4 addresses)
- Assign a static route to the 6VPE facing interface on a CE device.
- Enable MP-BGP peering with target 6VPE.
- Redistribute connected (if needed).

The following sections describe changes to MPLS VPN service policy definition, service request creation, and service request auditing to support IPv6 and 6VPE in ISC 5.1.

MPLS VPN Service Policies

Changes in this release of ISC to support MPLS VPN service policy creation for IPv6 and 6VPE include:

- The ISC MPLS VPN service policy design has been extended to support the configuration of IPv6 on a 6VPE router for the following policy types:
  - Regular: PE-CE (with unmanaged CE)
- Both Unmanaged CE and No CE scenarios are supported for IPv6.
- The service policies support the following addressing schemes:
  - IPv4
  - IPv6
  - Both IPv4 and IPv6
- The IP Numbering Scheme field in the MPLS Policy Editor - IP Address Scheme window has been updated with option to specify each of the supported address schemes.
- The IPv4 routing and IPv6 routing are independent. The ISC GUI allows you to input the same or different routing protocols for IPv4 and IPv6.
- When setting up the policy, the following PE-CE routing protocols are supported for the IPv6 addressing scheme:
  - Static
  - BGP
  - EIGRP
  - None

- IPv6 validity checks. The following checks will be performed on addresses entered in the IPv6 address fields:
  - The address can be specified eight consecutive blocks of 16-bit each separated by the ":" (colon) character. Each 16-bit block can be specified as 4-digit hexadecimal number. Example: 21DA:00D3:0000:2F3B:02AA:00FF:FE28:9C5A.
  - The leading zeros can be skipped in each hexadecimal block. Here is the modified valid address from the previous example: 21DA:D3:0:2F3B:2AA:FF:FE28:9C5A.
  - Where there are consecutive "0:" blocks, they can be replaced with "::". Example: 21DA:D3:0:0:0:FF:FE28:9C5A can be represented as 21DA:D3::FF:FE28:9C5A.
  - The string "::" cannot appear more than once in the address. Example: 21DA:0000:0000:2F3B:0000:0000:0000:9C5A can be represented as 21DA::2F3B:0000:0000:0000:9C5A or 21DA:0000:0000:2F3B::9C5A, but not as 21DA::2F3B::9C5A.

See Chapter 5, "MPLS VPN Service Policies" for information on defining MPLS VPN service policies.

MPLS VPN Service Requests

Changes for MPLS VPN policy creation to support IPv6 and 6VPE are carried over to the corresponding windows in the service request creation workflow. If the options were set as editable during policy creation, they can be modified when the service request is created.

- The IP Numbering Scheme field in the MPLS Link Attribute Editor - IP Address Scheme window has been updated with options to specify each of the supported address schemes.
- The IPv4 and IPv6 Unnumbered schemes are not supported on IOS XR devices.When you select an IOS XR device and go the to IP Addressing Scheme window, only the following options are displayed:
  - IPv4 Numbered
  - IPV6 Numbered
  - IPV4+IPV6 Numbered
- As part of the regular PE-CE MPLS service, the required VRF will be configured on the PE device. The CE-facing interface will be configured with the IPv6 address and the interface will be assigned to the VRF. The IPv6 address-family configuration in BGP along with the PE-CE routing information will be configured. The PE-CE Routing protocols supported are Static, BGP and EIGRP.
- If the PE Interface is dual-stacked and contains both IPv4 and IPv6 addresses, you can enter the routing information for both IPv4 and IPv6 independently. The GUI provides steps to enter the IPv6 routing information in addition to the existing IPv4 routing information.
- This release supports the scenario of the CE device not present in the service request. This release also supports the Unmanaged CE devices being present in the service request. In the later case, the configlets for service provisioning will be generated but not rolled onto the CE device.
- It is possible to modify a 6VPE service request.
- If the PE device is an IOS XR device, all of the configuration operations will be performed using the IOS XR interface.
- All configlets generated for 6VPE devices are IOS XR configlets and are in XML format. Different versions of IOS XR will generate different XML configlets. However, the configurations will be almost identical, except for changes in the XML schema.

See Chapter 6, "MPLS VPN Service Requests" and subsequent chapters in this guide for information on creating MPLS VPN service requests.

MPLS Service Request Audits

L3 VPN functional audit has been enhanced to support IPv6 VPNs (IPv6 addresses and 6VPE devices). The current capabilities include checking the routes to remote CEs in the VRF route tables on the PE devices. See Auditing Service Requests, page 6-28 for information on auditing service requests.

MPLS Reports

The MPLS VPN reports support has been extended to support IPv6 addresses and 6VPE devices. See Chapter 14, "Generating MPLS Reports" for information on generating MPLS VPN reports for IPv6 and 6VPE.

IPv6 and 6VPE Features Not Supported in ISC 5.1

The following features are not currently supported for IPv6 and/or 6VPEs:

- Discovery of existing IPv6 VPN services on the device.
- Support of IPv6 addressing for IOS-based routers.
- IPv6 addressing as part of a CPE device definition and configuration.
- IPv6 address pools.
- IPv6 multicast address pools.
- The IPv4 and IPv6 Unnumbered address schemes are not supported for IOS XR.
- Grey management VPN support for 6VPE and IOS XR.
- Staging service request deployment to support eBGP route maps on IOS XR devices.
- Support for eBGP Extensions introduced in ISC 5.1 on IOS XR devices. These include BGP maximum path configuration, unique route distinguisher, eBGP advertisement interval, and maximum prefix configuration.
- Managed CE services.
- Multi-VRF CE (MVRFCE) support.
- Multicast VRF for IPv6.
- One-time setup operations on the 6VPE device like enabling IPv6 routing, BGP VPNv6 configuration.
- RIP and OSPF as the PE-CE routing protocol.
- Tunnel interface. An IPv6 address cannot be specified as the Tunnel Source Address value.
- Template Manager support for IPv6 features.