Multi-VRF Support

The Multi-VRF Support feature allows you to configure and maintain more than one instance of a routing and forwarding table within the same customer edge (CE) device.

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Prerequisites for Multi-VRF Support

The network's core and provider edge (PE) devices must be configured for Virtual Private Network (VPN) operation.

Restrictions for Multi-VRF Support

- You can configure the Multi-VRF Support feature only on Layer 3 interfaces.
- The Multi-VRF Support feature is not supported by Interior Gateway Routing Protocol (IGRP) nor Intermediate System to Intermediate System (IS-IS).
- Label distribution for a given VPN routing and forwarding (VRF) instance on a given device can be handled by either Border Gateway Protocol (BGP) or Label Distribution Protocol (LDP), but not by both protocols at the same time.
- Multicast cannot operate on a Layer 3 interface that is configured with the Multi-VRF Support feature.

Information About Multi-VRF Support

How the Multi-VRF Support Feature Works

The Multi-VRF Support feature enables a service provider to support two or more Virtual Private Networks (VPNs), where the IP addresses can overlap several VPNs. The Multi-VRF Support feature uses input interfaces to distinguish routes for different VPNs and forms virtual packet-forwarding tables by associating one or more Layer 3 interfaces with each virtual routing and forwarding (VRF) instance. Interfaces in a VRF can be either physical, such as FastEthernet ports, or logical, such as VLAN bridge domain interfaces (BDIs), but a Layer 3 interface cannot belong to more than one VRF at any one time. The Multi-VRF Support feature allows an operator to support two or more routing domains on a customer edge (CE) device, with each routing domain having its own set of interfaces and its own set of routing and forwarding tables. The Multi-VRF Support feature makes it possible to extend the label switched paths (LSPs) to the CE and into each routing domain that the CE supports.

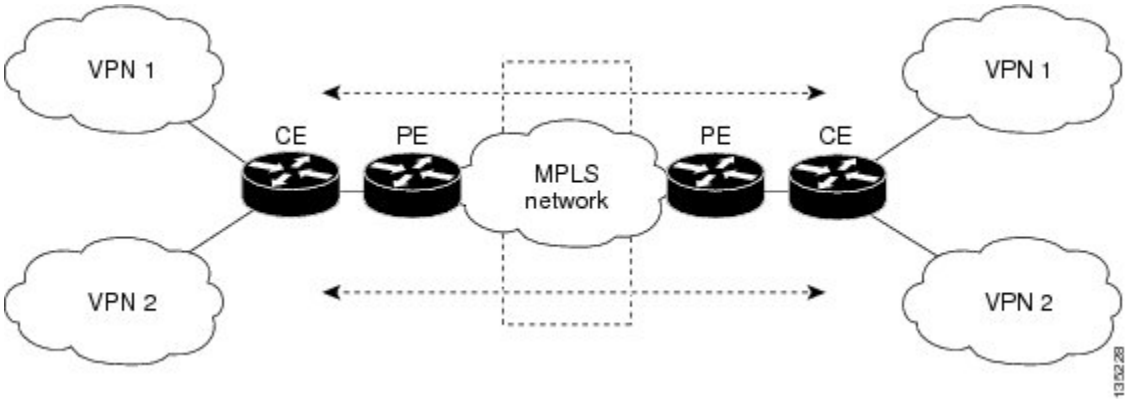
The Multi-VRF Support feature works as follows:

- Each CE device advertises its site's local routes to a provider edge (PE) device and learns the remote VPN routes from that provider edge (PE) device.
- PE devices exchange routing information with CE devices by using static routing or a routing protocol such as the Border Gateway Protocol (BGP), Routing Information Protocol version 1 (RIPv1), or RIPv2.
- PE devices exchange MPLS label information with CE devices through Label Distribution Protocol (LDP) or BGP.
- The PE device needs to maintain VPN routes only for those VPNs to which it is directly attached, eliminating the requirement that the PE maintain all of the service provider's VPN routes. Each PE device maintains a VRF for each of its directly connected sites. Two or more interfaces on a PE device can be associated with a single VRF if all the sites participate in the same VPN. Each VPN is mapped to a specified VRF. After learning local VPN routes from CE devices, the PE device exchanges VPN routing information with other PE devices through internal BGP (iBGP).

With the Multi-VRF Support feature, two or more customers can share one CE device, and only one physical link is used between the CE and the PE devices. The shared CE device maintains separate VRF tables for each customer and routes packets for each customer based on that customer's own routing table. The Multi-VRF Support feature extends limited PE device functionality to a CE device, giving it the ability, through the maintenance of separate VRF tables, to extend the privacy and security of a VPN to the branch office.

The figure below shows a configuration where each CE device acts as if it were two CE devices. Because the Multi-VRF Support feature is a Layer 3 feature, each interface associated with a VRF must be a Layer 3 interface.

Figure 1: Each CE Device Acting as Several Virtual CE Devices



How Packets Are Forwarded in a Network Using the Multi-VRF Support Feature

Following is the packet-forwarding process in an Multi-VRF customer edge (CE)-enabled network, as illustrated in the figure above:

- When the CE receives a packet from a Virtual Private Network (VPN), it looks up the routing table based on the input interface. When a route is found, the CE imposes the Multiprotocol Label Switching (MPLS) label that it received from the provider edge (PE) for that route and forwards the packet to the PE.
- When the ingress PE receives a packet from the CE, it swaps the incoming label with the corresponding label stack and sends the packet to the MPLS network.
- When an egress PE receives a packet from the network, it swaps the VPN label with the label that it had earlier received for the route from the CE, and it forwards the packet to the CE.
- When a CE receives a packet from an egress PE, it uses the incoming label on the packet to forward the packet to the correct VPN.

To configure Multi-VRF, you create a VRF table and then specify the Layer 3 interface associated with that VRF. Next, you configure the routing protocols within the VPN, and between the CE and the PE. The Border Gateway Protocol (BGP) is the preferred routing protocol for distributing VPN routing information across the provider's backbone.

The Multi-VRF network has three major components:

- VPN route target communities: These are lists of all other members of a VPN community. You must configure VPN route targets for each VPN community member.
- Multiprotocol BGP peering of VPN community PE devices: This propagates VRF reachability information to all members of a VPN community. You must configure BGP peering in all PE devices within a VPN community.
- VPN forwarding: This transports all traffic between VPN community members across a VPN service-provider network.

Considerations When Configuring the Multi-VRF Support Feature

- A device with the Multi-VRF Support feature is shared by several customers, and each customer has its own routing table.
- Because each customer uses a different virtual routing and forwarding (VRF) table, the same IP addresses can be reused. Overlapping IP addresses are allowed in different Virtual Private Networks (VPNs).
- The Multi-VRF Support feature lets several customers share the same physical link between the provider edge (PE) and the customer edge (CE) devices. Trunk ports with several VLANs separate packets among the customers. Each customer has its own VLAN.
- For the PE device, there is no difference between using the Multi-VRF Support feature or using several CE devices.
- The Multi-VRF Support feature does not affect the packet-switching rate.

How to Configure Multi-VRF Support

Configuring VRFs

To configure virtual routing and forwarding (VRF) instances, complete the following procedure. Be sure to configure VRFs on both the provider edge (PE) and customer edge (CE) devices.

If a VRF has not been configured, the device has the following default configuration:

- No VRFs have been defined.
- No import maps, export maps, or route maps have been defined.
- No VRF maximum routes exist.
- Only the global routing table exists on the interface.

Note Multi-VRF/MVPN GRE configured layer-3 interface cannot participate in more than one VRF at the same time.

Procedure

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

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**ip routing** **Example:** `Device(config)# ip routing`	Enables IP routing.
Step 4	**ip vrf** *vrf-name* **Example:** `Device(config)# ip vrf v1`	Names the VRF, and enters VRF configuration mode.
Step 5	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 100:1`	Creates a VRF table by specifying a route distinguisher. Enter either an autonomous system number and an arbitrary number (xxx:y), or an IP address and an arbitrary number (A.B.C.D:y).
Step 6	**route-target** {**export** | **import** | **both**} *route-target-ext-community* **Example:** `Device(config-vrf)# route-target export 100:1`	Creates a list of import, export, or import and export route target communities for the specified VRF. Enter either an autonomous system number and an arbitrary number (xxx:y), or an IP address and an arbitrary number (A.B.C.D:y). **Note** This command works only if BGP is running.
Step 7	**import map** *route-map* **Example:** `Device(config-vrf)# import map importmap1`	(Optional) Associates a route map with the VRF.
Step 8	**exit** **Example:** `Device(config-vrf)# exit`	Returns to global configuration mode.
Step 9	**interface** *type slot/subslot/port*[**.***subinterface*] **Example:** `Device(config)# interface GigabitEthernet 0/0/0`	Specifies the Layer 3 interface to be associated with the VRF and enters interface configuration mode. The interface can be a routed port or an BDI.
Step 10	**ip vrf forwarding** *vrf-name* **Example:**	Associates the VRF with the Layer 3 interface.

	Command or Action	Purpose
	`Device(config-if)# ip vrf forwarding v1`	
Step 11	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.
Step 12	**show ip vrf** **Example:** `Device# show ip vrf`	Displays the settings of the VRFs.

Configuring BGP as the Routing Protocol

Most routing protocols can be used between the customer edge (CE) and the provider edge (PE) devices. However, external BGP (eBGP) is recommended, because:

- BGP does not require more than one algorithm to communicate with many CE devices.
- BGP is designed to pass routing information between systems run by different administrations.
- BGP makes it easy to pass route attributes to the CE device.

When BGP is used as the routing protocol, it can also be used to handle the Multiprotocol Label Switching (MPLS) label exchange between the PE and CE devices. By contrast, if Open Shortest Path First (OSPF), Enhanced Interior Gateway Routing Protocol (EIGRP), Routing Information Protocol (RIP), or static routing is used, the Label Distribution Protocol (LDP) must be used to signal labels.

To configure a BGP PE-to-CE routing session, perform the following steps on the CE and on the PE devices.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 100`	Configures the BGP routing process with the autonomous system number passed to other BGP devices, and enters router configuration mode.

	Command or Action	Purpose
Step 4	**network** *ip-address* **mask** *network-mask* **Example:** `Device(config-router)# network 10.0.0.0 mask 255.255.255.0`	Specifies a network and mask to announce using BGP.
Step 5	**redistribute ospf** *process-id* **match internal** **Example:** `Device(config-router)# redistribute ospf 2 match internal`	Sets the device to redistribute OSPF internal routes.
Step 6	**network** *ip-address wildcard-mask* **area** *area-id* **Example:** `Device(config-router)# network 10.0.0.0 255.255.255.0 area 0`	Identifies the network address and mask on which OSPF is running, and the area ID of that network address.
Step 7	**address-family ipv4 vrf** *vrf-name* **Example:** `Device(config-router)# address-family ipv4 vrf v12`	Identifies the name of the virtual routing and forwarding (VRF) instance that will be associated with the next two commands, and enters VRF address-family mode.
Step 8	**neighbor** {*ip-address* | *peer-group-name*} **remote-as** *as-number* **Example:** `Device(config-router-af)# neighbor 10.0.0.3 remote-as 100`	Informs this device's BGP neighbor table of the neighbor's address (or peer group name) and the neighbor's autonomous system number.
Step 9	**neighbor** *address* **activate** **Example:** `Device(config-router-af)# neighbor 10.0.0.3 activate`	Activates the advertisement of the IPv4 address-family neighbors.

Configuring PE-to-CE MPLS Forwarding and Signaling with BGP

If the Border Gateway Protocol (BGP) is used for routing between the provider edge (PE) and the customer edge (CE) devices, configure BGP to signal the labels on the virtual routing and forwarding (VRF) interfaces of both the CE and the PE devices. You must enable signalling globally at the router-configuration level and for each interface:

- At the router-configuration level, to enable Multiprotocol Label Switching (MPLS) label signalling via BGP, use the **neighbor send-label** command).

- At the interface level, to enable MPLS forwarding on the interface used for the PE-to-CE external BGP (eBGP) session, use the **mpls bgp forwarding** command.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 100`	Configures the BGP routing process with the autonomous system number passed to other BGP devices and enters router configuration mode.
Step 4	**address-family ipv4 vrf** *vrf-name* **Example:** `Device(config-router)# address-family ipv4 vrf v12`	Identifies the name of the VRF instance that will be associated with the next two commands and enters address family configuration mode.
Step 5	**neighbor** *address* **send-label** **Example:** `Device(config-router-af)# neighbor 10.0.0.3 send-label`	Enables the device to use BGP to distribute MPLS labels along with the IPv4 routes to the peer devices. If a BGP session is running when you issue this command, the command does not take effect until the BGP session is restarted.
Step 6	**neighbor** *address* **activate** **Example:** `Device(config-router-af)# neighbor 10.0.0.3 activate`	Activates the advertisement of the IPv4 address-family neighbors.
Step 7	**end** **Example:** `Device(config-router-af)# end`	Returns to privileged EXEC mode.
Step 8	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 9	**interface** *type slot/subslot/port*[**.***subinterface*] **Example:** `Device(config)# interface GigabitEthernet 0/0/0`	Enters interface configuration mode for the interface to be used for the BGP session. The interface can be a routed port or an BDI.
Step 10	**mpls bgp forwarding** **Example:** `Device(config-if)# mpls bgp forwarding`	Enables MPLS forwarding on the interface.

Configuring a Routing Protocol Other than BGP

You can use the Routing Information Protocol (RIP), Enhanced Interior Gateway Routing Protocol (EIGRP), Open Shortest Path First (OSPF), or static routing. This configuration uses OSPF, but the process is the same for other protocols.

If you use OSPF as the routing protocol between the provider edge (PE) and the customer edge (CE) devices, issue the **capability vrf-lite** command in router configuration mode.

Note If RIP EIGRP, OSPF or static routing is used, the Label Distribution Protocol (LDP) must be used to signal labels.

The Multi-VRF Support feature is not supported by Interior Gateway Routing Protocol (IGRP) or Intermediate System-to-Intermediate System (IS-IS).

Multicast cannot be configured on the same Layer 3 interface as the Multi-VRF Support feature is configured.

Procedure

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

	Command or Action	Purpose
Step 3	**router ospf** *process-id* [**vrf** *vpn-name*] **Example:** `Device(config)# router ospf 100 vrf v1`	Enables OSPF routing, specifies a virtual routing and forwarding (VRF) table, and enters router configuration mode.
Step 4	**log-adjacency-changes** **Example:** `Device(config-router)# log-adjacency-changes`	(Optional) Logs changes in the adjacency state. This is the default state.
Step 5	**redistribute bgp** *autonomous-system-number* **subnets** **Example:** `Device(config-router)# redistribute bgp 800 subnets`	Sets the device to redistribute information from the Border Gateway Protocol (BGP) network to the OSPF network.
Step 6	**network** *ip-address subnet-mask* **area** *area-id* **Example:** `Device(config-router)# network 10.0.0.0 255.255.255.0 area 0`	Indicates the network address and mask on which OSPF runs, and the area ID of that network address.
Step 7	**end** **Example:** `Device(config-router)# end`	Returns to privileged EXEC mode.
Step 8	**show ip ospf** **Example:** `Device# show ip ospf`	Displays information about the OSPF routing processes.

Configuring PE-to-CE MPLS Forwarding and Signaling with LDP

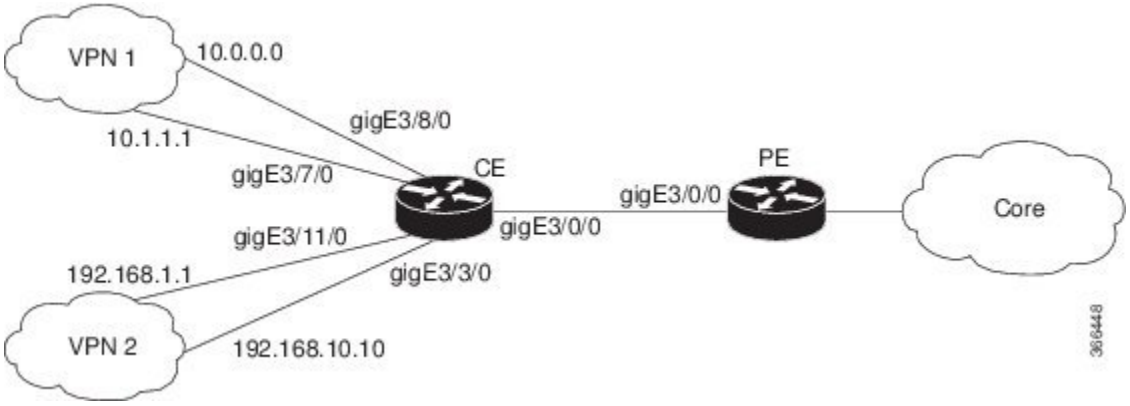
Procedure

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

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**interface** *type slot /subslot/port*[**.***subinterface*] **Example:** `Device(config)# interface GigabitEthernet 0/0/0`	Enters interface configuration mode for the interface associated with the VRF. The interface can be a routed port or an BDI.
Step 4	**mpls ip** **Example:** `Device(config-if)# mpls ip`	Enables MPLS forwarding of IPv4 packets along normally routed paths for this interface.

Configuration Examples for Multi-VRF Support

The figure below is an example of a Multi-VRF topology.



Example: Configuring Multi-VRF Support on the PE Device

The following example shows how to configure a VRF:

```
configure terminal
ip vrf v1
 rd 100:1
 route-target export 100:1
 route-target import 100:1
 exit
ip vrf v2
 rd 100:2
 route-target export 100:2
 route-target import 100:2
 exit
```

The following example shows how to configure on PE device, PE-to-CE connections using BGP for both routing and label exchange:

```
router bgp 100
 address-family ipv4 vrf v2
  neighbor 10.0.0.8 remote-as 800
  neighbor 10.0.0.8 activate
  neighbor 10.0.0.8 send-label
  exit
 address-family ipv4 vrf vl
  neighbor 10.0.0.8 remote-as 800
  neighbor 10.0.0.8 activate
  neighbor 10.0.0.8 send-label
  end
configure terminal
interface GigabitEthernet3/0/0
 service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  bridge-domain 10
 !
 service instance 20 ethernet
  encapsulation dot1q 20
  rewrite ingress tag pop 1 symmetric
  bridge-domain 20

interface BDI10
  ip vrf forwarding v11
  ip address 10.0.0.3 255.255.255.0
  mpls bgp forwarding
  exit
interface BDI20
  ip vrf forwarding v12
  ip address 10.0.0.3 255.255.255.0
  mpls bgp forwarding
  exit
```

The following example shows how to configure on PE device, PE-to-CE connections using OSPF for routing and LDP for label exchange:

```
router ospf 100 vrf v1
 network 10.0.0.0 255.255.255.0 area 0
 exit
router ospf 101 vrf v2
 network 10.0.0.0 255.255.255.0 area 0
 exit
interface GigabitEthernet3/0/0
 service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  bridge-domain 10
 !
 service instance 20 ethernet
  encapsulation dot1q 20
  rewrite ingress tag pop 1 symmetric
  bridge-domain 20

interface BDI10
  ip vrf forwarding v11
  ip address 10.0.0.3 255.255.255.0
  mpls bgp forwarding
  exit
interface BDI20
  ip vrf forwarding v12
  ip address 10.0.0.3 255.255.255.0
```

```
 mpls bgp forwarding
 exit
```

Example: Configuring Multi-VRF Support on the CE Device

The following example shows how to configure VRFs:

```
configure terminal
 ip routing
 ip vrf v11
  rd 800:1
  route-target export 800:1
  route-target import 800:1
  exit
 ip vrf v12
  rd 800:2
  route-target export 800:2
  route-target import 800:2
  exit
```

The following example shows how to configure CE device VPN connections:

```
interface GigabitEthernet 3/8/0
 ip vrf forwarding v11
 ip address 10.0.0.8 255.255.255.0
 exit
interface GigabitEthernet 3/11/0
 ip vrf forwarding v12
 ip address 10.0.0.8 255.255.255.0
 exit
router ospf 1 vrf v11
 network 10.0.0.0 255.255.255.0 area 0
 network 10.0.0.0 255.255.255.0 area 0
 exit
router ospf 2 vrf v12
 network 10.0.0.0 255.255.255.0 area 0
 network 10.0.0.0 255.255.255.0 area 0
 exit
```

Note If BGP is used for routing between the PE and CE devices, the BGP-learned routes from the PE device can be redistributed into OSPF using the commands in the following example.

```
router ospf 1 vrf v11
 redistribute bgp 800 subnets
 exit
router ospf 2 vrf v12
 redistribute bgp 800 subnets
 exit
```

The following example shows how to configure on CE devices, PE-to-CE connections using BGP for both routing and label exchange:

```
router bgp 800
 address-family ipv4 vrf v12
 neighbor 10.0.0.3 remote-as 100
 neighbor 10.0.0.3 activate
```

```
 neighbor 10.0.0.3 send-label
 redistribute ospf 2 match internal
 exit
 address-family ipv4 vrf vl1
 neighbor 10.0.0.3 remote-as 100
 neighbor 10.0.0.3 activate
 neighbor 10.0.0.3 send-label
 redistribute ospf 1 match internal
 end
interface GigabitEthernet3/0/0
 service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  bridge-domain 10
 !
 service instance 20 ethernet
  encapsulation dot1q 20
  rewrite ingress tag pop 1 symmetric
  bridge-domain 20

interface BDI10
  ip vrf forwarding v11
  ip address 10.0.0.8 255.255.255.0
  mpls bgp forwarding
  exit
interface BDI20
  ip vrf forwarding v12
  ip address 10.0.0.8 255.255.255.0
  mpls bgp forwarding
  exit
```

The following example shows how to configure on CE devices, PE-to-CE connections using OSPF for both routing and LDP for label exchange:

```
router ospf 1 vrf v11
 network 10.0.0.0 255.255.255.0 area 0
 exit
router ospf 2 vrf v12
 network 10.0.0.0 255.255.255.0 area 0
 exit
interface GigabitEthernet3/0/0
 service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  bridge-domain 10
 !
 service instance 20 ethernet
  encapsulation dot1q 20
  rewrite ingress tag pop 1 symmetric
  bridge-domain 20

interface BDI10
  ip vrf forwarding v11
  ip address 10.0.0.8 255.255.255.0
  mpls bgp forwarding
  exit
interface BDI20
  ip vrf forwarding v12
  ip address 10.0.0.8 255.255.255.0
  mpls bgp forwarding
  exit
```

Additional References

Related Documents

Related Topic	Document Title
MPLS and MPLS applications commands	Cisco IOS Multiprotocol Label Switching Command Reference
OSPF with Multi-VRF	"OSPF Support for Multi-VRF in CE Routers" module in the OSPF Configuration Guide .

Technical Assistance

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

Feature Information for Multi-VRF Support

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

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

Table 1: Feature Information for Multi-VRF Support

Feature Name	Releases	Feature Information
Multi-VRF Support		The Multi-VRF Support feature allows you to configure and maintain more than one instance of a routing and forwarding table within the same CE device. In Cisco IOS XE Release 3.5S, support was added for the Cisco RSP1 Module. In Cisco IOS XE Release 3.13S, support was added for the Cisco RSP2 Module. In Cisco IOS XE Release 3.16S, support was added for the Cisco RSP3 Module.