CHAPTER 36

Configuring VRF-lite

Virtual Private Networks (VPNs) provide a secure way for customers to share bandwidth over an ISP backbone network. A VPN is a collection of sites sharing a common routing table. A customer site is connected to the service provider network by one or more interfaces, and the service provider associates each interface with a VPN routing table. A VPN routing table is called a VPN routing/forwarding (VRF) table.

With the VRF-lite feature, the Catalyst 4500 series switch supports multiple VPN routing/forwarding instances in customer edge devices. (VRF-lite is also termed multi-VRF CE, or multi-VRF Customer Edge Device). VRF-lite allows a service provider to support two or more VPNs with overlapping IP addresses using one interface.

Note Starting with Cisco IOS Release 12.2(52)SG, the Catalyst 4500 switch supports VRF lite NSF support with routing protocols OSPF/EIGRP/BGP.

This chapter includes these topics:

Note The switch does not use Multiprotocol Label Switching (MPLS) to support VPNs. For information about MPLS VRF, refer to the *Cisco IOS Switching Services Configuration Guide* at:

http://www.cisco.com/en/US/docs/ios/mpls/configuration/guide/mp_vpn_ipv4_ipv6_ps6922_TSD_Products_Configuration_Guide_Chapter.html

Note For complete syntax and usage information for the switch commands used in this chapter, see the *Cisco Catalyst 4500 Series Switch Command Reference* and related publications at this location:

http://www.cisco.com/en/US/products/hw/switches/ps4324/index.html

If the command is not found in the *Cisco Catalyst 4500 Command Reference*, you can locate it in the larger Cisco IOS library. Refer to the *Cisco IOS Command Reference* and related publications at this location:

http://www.cisco.com/en/US/products/ps6350/index.html

About VRF-lite

VRF-lite is a feature that enables a service provider to support two or more VPNs, where IP addresses can be overlapped among the VPNs. VRF-lite 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 VRF. Interfaces in a VRF can be either physical, such as Ethernet ports, or logical, such as VLAN SVIs, but a Layer 3 interface cannot belong to more than one VRF at any time.

Note VRF-lite interfaces must be Layer 3 interfaces.

VRF-lite includes these devices:

- Customer edge (CE) devices provide customer access to the service provider network over a data link to one or more provider edge routers. The CE device advertises the site's local routes to the provider edge router and learns the remote VPN routes from it. A Catalyst 4500 series switch can be a CE.
- Provider edge (PE) routers exchange routing information with CE devices by using static routing or a routing protocol such as BGP, RIPv1, or RIPv2.

  The PE is only required to maintain VPN routes for those VPNs to which it is directly attached, eliminating the need for the PE to maintain all of the service provider VPN routes. Each PE router maintains a VRF for each of its directly connected sites. Multiple interfaces on a PE router can be associated with a single VRF if all of these sites participate in the same VPN. Each VPN is mapped to a specified VRF. After learning local VPN routes from CEs, a PE router exchanges VPN routing information with other PE routers by using internal BGP (iBPG).
- Provider routers (or core routers) are any routers in the service provider network that do not attach to CE devices.

With VRF-lite, multiple customers can share one CE, and only one physical link is used between the CE and the PE. The shared CE maintains separate VRF tables for each customer and switches or routes packets for each customer based on its own routing table. VRF-lite extends limited PE functionality to a CE device, giving it the ability to maintain separate VRF tables to extend the privacy and security of a VPN to the branch office.

Figure 36-1 shows a configuration where each Catalyst 4500 series switch acts as multiple virtual CEs. Because VRF-lite is a Layer 3 feature, each interface in a VRF must be a Layer 3 interface.

Figure 36-1 Catalyst 4500 Series Switches Acting as Multiple Virtual CEs

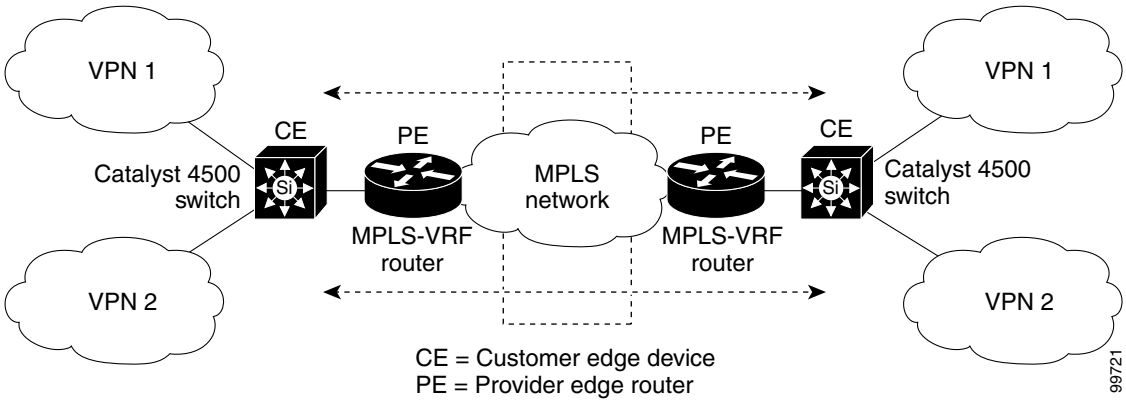


Figure 36-1 illustrates the packet-forwarding process in a VRF-lite CE-enabled network.

- When the CE receives a packet from a VPN, it looks up the routing table based on the input interface. When a route is found, the CE forwards the packet to the PE.
- When the ingress PE receives a packet from the CE, it performs a VRF lookup. When a route is found, the router adds a corresponding MPLS label to the packet and sends it to the MPLS network.
- When an egress PE receives a packet from the network, it strips the label and uses the label to identify the correct VPN routing table. The egress PE then performs the normal route lookup. When a route is found, it forwards the packet to the correct adjacency.
- When a CE receives a packet from an egress PE, it uses the input interface to look up the correct VPN routing table. If a route is found, the CE forwards the packet within the VPN.

To configure VRF, create a VRF table and specify the Layer 3 interface associated with the VRF. You then configure the routing protocols in the VPN and between the CE and the PE. BGP is the preferred routing protocol used to distribute VPN routing information across the providers' backbone. The VRF-lite network has three major components:

- VPN route target communities—Lists all other members of a VPN community. You need to configure VPN route targets for each VPN community member.
- Multiprotocol BGP peering of VPN community PE routers—Propagates VRF reachability information to all members of a VPN community. You need to configure BGP peering in all PE routers within a VPN community.
- VPN forwarding—Transports all traffic between all VPN community members across a VPN service-provider network.

Default VRF-lite Configuration

Table 36-1 shows the default VRF configuration.

Table 36-1 Default VRF Configuration

Feature	Default Setting
VRF	Disabled. No VRFs are defined.
Maps	No import maps, export maps, or route maps are defined.

Table 36-1 Default VRF Configuration (continued)

Feature	Default Setting
VRF maximum routes	None.
Forwarding table	The default for an interface is the global routing table.

VRF-lite Configuration Guidelines

Consider these points when configuring VRF in your network:

- A switch with VRF-lite is shared by multiple customers, and all customers have their own routing tables.
- Because customers use different VRF tables, you can reuse the same IP addresses. Overlapped IP addresses are allowed in different VPNs.
- VRF-lite lets multiple customers share the same physical link between the PE and the CE. Trunk ports with multiple VLANs separate packets among customers. All customers have their own VLANs.
- VRF-lite does not support all MPLS-VRF functionality: label exchange, LDP adjacency, or labeled packets.
- For the PE router, there is no difference between using VRF-lite or using multiple CEs. In Figure 36-1, multiple virtual Layer 3 interfaces are connected to the VRF-lite device.
- The Catalyst 4500 series switch supports configuring VRF by using physical ports, VLAN SVIs, or a combination of both. You can connect SVIs through an access port or a trunk port.
- A customer can use multiple VLANs as long because they do not overlap with those of other customers. A customer's VLANs are mapped to a specific routing table ID that is used to identify the appropriate routing tables stored on the switch.
- The Layer 3 TCAM resource is shared between all VRFs. To ensure that any one VRF has sufficient CAM space, use the **maximum routes** command.
- A Catalyst 4500 series switch using VRF can support one global network and up to 64 VRFs. The total number of routes supported is limited by the size of the TCAM.
- You can use most routing protocols (BGP, OSPF, EIGRP, RIP and static routing) between the CE and the PE. However, we recommend using external BGP (EBGP) for these reasons:
  - BGP does not require multiple algorithms to communicate with multiple CEs.
  - BGP is designed for passing routing information between systems run by different administrations.
  - BGP makes it easy to pass attributes of the routes to the CE.
- VRF-lite does not support IGRP and ISIS.
- VRF-lite does not affect the packet switching rate.
- Starting with Cisco IOS Release 12.2(50)SG, Multicast and VRF can be configured together on a Layer 3 interface.
- The Catalyst 4500 series switch supports all the PIM protocols (PIM-SM, PIM-DM, PIM-SSM, PIM BiDIR).

- Multicast VRF is supported on Supervisor Engine 6-E, Supervisor 6L-E, Catalyst 4900M, and Catalyst 4948E.
- The **capability vrf-lite** subcommand under **router ospf** should be used when configuring OSPF as the routing protocol between the PE and the CE.

Configuring VRFs

To configure one or more VRFs, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# ip routing`	Enables IP routing.
Step 3	`Switch(config)# ip vrf` *vrf-name*	Names the VRF and enters VRF configuration mode.
Step 4	`Switch(config-vrf)# rd` *route-distinguisher*	Creates a VRF table by specifying a route distinguisher. Enter either an AS number and an arbitrary number (xxx:y) or an IP address and arbitrary number (A.B.C.D:y).
Step 5	`Switch(config-vrf)# route-target {export | import | both}` *route-target-ext-community*	Creates a list of import, export, or import and export route target communities for the specified VRF. Enter either an AS system number and an arbitrary number (xxx:y) or an IP address and an arbitrary number (A.B.C.D:y). **Note** This command is effective only if BGP is running.
Step 6	`Switch(config-vrf)# import map` *route-map*	(Optional) Associates a route map with the VRF.
Step 7	`Switch(config-vrf)# interface` *interface-id*	Enters interface configuration mode and specify the Layer 3 interface to be associated with the VRF. The interface can be a routed port or SVI.
Step 8	`Switch(config-if)# ip vrf forwarding` *vrf-name*	Associates the VRF with the Layer 3 interface.
Step 9	`Switch(config-if)# end`	Returns to privileged EXEC mode.
Step 10	`Switch# show ip vrf [brief | detail | interfaces] [vrf-name]`	Verifies the configuration. Displays information about the configured VRFs.
Step 11	`Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Note For complete syntax and usage information for the following commands, see the switch command reference for this release and see the *Cisco IOS Switching Services Command Reference* at: http://www.cisco.com/en/US/docs/ios/ipswitch/command/reference/isw_book.html

Use the **no ip vrf** *vrf-name* global configuration command to delete a VRF and to remove all interfaces from it. Use the **no ip vrf forwarding** interface configuration command to remove an interface from the VRF.

Configuring VRF-Aware Services

IP services can be configured on global interfaces and within the global routing instance. IP services are enhanced to run on multiple routing instances; they are VRF-aware. Any configured VRF in the system can be specified for a VRF-aware service.

VRF-aware services are implemented in platform-independent modules. VRF provides multiple routing instances in Cisco IOS. Each platform has its own limit on the number of VRFs it supports.

VRF-aware services have the following characteristics:

- The user can ping a host in a user-specified VRF.
- ARP entries are learned in separate VRFs. The user can display Address Resolution Protocol (ARP) entries for specific VRFs.

These services are VRF-aware:

- ARP
- Ping
- Simple Network Management Protocol (SNMP)
- Unicast Reverse Path Forwarding (uRPF)
- Syslog
- Traceroute
- FTP and TFTP
- Telnet and SSH
- NTP

Configuring the User Interface for ARP

To configure VRF-aware services for ARP, perform this task:

Command	Purpose
`Switch# show ip arp vrf vrf-name`	Displays the ARP table (static and dynamic entries) in the specified VRF.
`Switch(config)# arp vrf vrf-name ip-address mac-address ARPA`	Creates a static ARP entry in the specified VRF.

Configuring the User Interface for PING

To perform a VRF-aware ping, perform this task:

Command	Purpose
`Switch# ping vrf vrf-name ip-host`	Pings an IP host or address in the specified VRF.

Configuring the User Interface for SNMP

To configure VRF-aware services for SNMP, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# snmp-server trap authentication vrf`	Enables SNMP traps for packets on a VRF.
Step 3	`Switch(config)# snmp-server engineID remote` *host* `vrf` *vpn-instance engine-id string*	Configures a name for the remote SNMP engine on a switch.
Step 4	`Switch(config)# snmp-server host` *host* `vrf` *vpn-instance* `traps` *community*	Specifies the recipient of an SNMP trap operation and specifies the VRF table to be used for sending SNMP traps.
Step 5	`Switch(config)# snmp-server host` *host* `vrf` *vpn-instance* `informs` *community*	Specifies the recipient of an SNMP inform operation and specifies the VRF table to be used for sending SNMP informs.
Step 6	`Switch(config)# snmp-server user` *user group* `remote` *host* `vrf` *vpn-instance security model*	Adds a user to an SNMP group for a remote host on a VRF for SNMP access.
Step 7	`Switch(config)# end`	Returns to privileged EXEC mode.

Configuring the User Interface for uRPF

You can configure uRPF on an interface assigned to a VRF. Source lookup is performed in the VRF table.

To configure VRF-aware services for uRPF, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# interface` *interface-id*	Enters interface configuration mode and specifies the Layer 3 interface to configure.
Step 3	`Switch(config-if)# no switchport`	Removes the interface from Layer 2 configuration mode if it is a physical interface.
Step 4	`Switch(config-if)# ip vrf forwarding` *vrf-name*	Configures VRF on the interface.
Step 5	`Switch(config-if-vrf)# ip address` *ip-address subnet-mask*	Enters the IP address for the interface.
Step 6	`Switch(config-if-vrf)# ip verify unicast source reachable-via rx allow-default`	Enables uRPF on the interface.
Step 7	`Switch(config-if-vrf)# end`	Returns to privileged EXEC mode.

Configuring the User Interface for Syslog

To configure VRF-aware services for syslog, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# logging on`	Enables or temporarily disables logging of storage router event message.
Step 3	`Switch(config)# logging host ip-address vrf vrf-name`	Specifies the host address of the syslog server where logging messages are to be sent.
Step 4	`Switch(config)# logging buffered logging buffered size debugging`	Logs messages to an internal buffer.
Step 5	`Switch(config)# logging trap debugging`	Limits the logging messages sent to the syslog server.
Step 6	`Switch(config)# logging facility facility`	Sends system logging messages to a logging facility.
Step 7	`Switch(config)# end`	Returns to privileged EXEC mode.

Configuring the User Interface for Traceroute

To configure VRF-aware services for traceroute, perform this task:

Command	Purpose
`traceroute vrf vrf-name ipaddress`	Specifies the name of a VPN VRF in which to find the destination address.

Configuring the User Interface for FTP and TFTP

You must configure some FTP and TFTP CLIs in order for FTP and TFTP to be VRF-aware. For example, if you want to use a VRF table that is attached to an interface (for example, E1/0), you need to configure the **ip [t]ftp source-interface E1/0** command to inform [t]ftp to use a specific routing table. In this example, the VRF table is used to look up the destination IP address. These changes are backward-compatible and do not affect existing behavior. You can use the source-interface CLI to send packets out a particular interface even if no VRF is configured on that interface.

To specify the source IP address for FTP connections, use the **ip ftp source-interface** show mode command. To use the address of the interface where the connection is made, use the **no** form of this command.

To configure the user interface for FTP and TFTP, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.

	Command	Purpose
Step 2	`Switch(config)# ip ftp source-interface interface-type interface-number`	Specifies the source IP address for FTP connections.
Step 3	`Switch(config)# end`	Returns to privileged EXEC mode.

To specify the IP address of an interface as the source address for TFTP connections, use the **ip tftp source-interface** show mode command. To return to the default, use the **no** form of this command.

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# ip tftp source-interface interface-type interface-number`	Specifies the source IP address for TFTP connections.
Step 3	`Switch(config)# end`	Returns to privileged EXEC mode.

Configuring the User Interface for Telnet and SSH

To configure VRF-aware for using Telnet and SSH, perform this task:

Command	Purpose
`Switch# telnet ip-address/vrf vrf-name`	Connects through Telnet to an IP host or address in the specified VRF.
`Switch# ssh -l username -vrf vrf-name ip-host`	Connects through SSH to an IP host or address in the specified VRF.

Configuring the User Interface for NTP

To configure VRF-aware for NTP, perform this task:

Command	Purpose
`Switch# ntp server vrf vrf-name ip-host`	Configure the NTP server in the specified VRF.
`Switch# ntp peer vrf vrf-name ip-host`	Configure the NTP peer in the specified VRF.

Configuring Per-VRF for TACACS+ Servers

The per-VRF for TACACS+ servers feature allows you to configure per-virtual route forwarding (per-VRF) authentication, authorization, and accounting (AAA) on TACACS+ servers.

Before configuring per-VRF on a TACACS+ server, you must have configured AAA and a server group. You can create the VRF routing table (shown in Steps 3 and 4) and configure the interface (Steps 6, 7, and 8). The actual configuration of per-VRF on a TACACS+ server is done in Steps 10 through 13.

	Command or Action	Purpose
Step 1	`Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	`Switch# configure terminal`	Enters global configuration mode.
Step 3	`Switch(config)# ip vrf vrf-name`	Configures a VRF table and enters VRF configuration mode.
Step 4	`Switch (config-vrf)# rd route-distinguisher`	Creates routing and forwarding tables for a VRF instance.
Step 5	`Switch (config-vrf)# exit`	Exits VRF configuration mode.
Step 6	`Switch (config)# interface interface-name`	Configures an interface and enters interface configuration mode.
Step 7	`Switch (config-if)# ip vrf forwarding vrf-name`	Configures a VRF for the interface.
Step 8	`Switch (config-if)# ip address ip-address mask [secondary]`	Sets a primary or secondary IP address for an interface.
Step 9	`Switch (config-if)# exit`	Exits interface configuration mode.

Step 10	`aaa group server tacacs+ group-name`
	Example:
	`Switch (config)# aaa group server tacacs+ tacacs1`
		Groups different TACACS+ server hosts into distinct lists and distinct methods and enters server-group configuration mode.

Step 11	`server-private {ip-address | name} [nat] [single-connection] [port port-number] [timeout seconds] [key [0 | 7] string]`
	Example:
	`Switch (config-sg-tacacs+)# server-private 10.1.1.1 port 19 key cisco`
		Configures the IP address of the private TACACS+ server for the group server.

Step 12	`Switch (config-sg-tacacs+)# ip vrf forwarding vrf-name`	Configures the VRF reference of a AAA TACACS+ server group.
Step 13	`Switch (config-sg-tacacs+)# ip tacacs source-interface subinterface-name`	Uses the IP address of a specified interface for all outgoing TACACS+ packets.
Step 14	`Switch (config-sg-tacacs)# exit`	Exits server-group configuration mode.

The following example lists all the steps to configure per-VRF TACACS+:

```
Switch> enable
Switch# configure terminal
Switch (config)# ip vrf cisco
Switch (config-vrf)# rd 100:1
Switch (config-vrf)# exit
Switch (config)# interface Loopback0
Switch (config-if)# ip vrf forwarding cisco
Switch (config-if)# ip address 10.0.0.2 255.0.0.0
Switch (config-if)# exit
Switch (config-sg-tacacs+)# ip vrf forwarding cisco
Switch (config-sg-tacacs+)# ip tacacs source-interface Loopback0
Switch (config-sg-tacacs)# exit
```

For more information about configuring per-VRF for TACACS+ server, see the *Cisco IOS Per VRF for TACACS + Server, Release 12.3(7)T.*

Configuring Multicast VRFs

To configure multicast within a VRF table, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# ip routing`	Enables IP routing.
Step 3	`Switch(config)# ip vrf` *vrf-name*	Names the VRF and enters VRF configuration mode.
Step 4	`Switch(config-vrf)# ip multicast-routing vrf` *vrf-name*	(Optional) Enables global multicast routing for VRF table.
Step 5	`Switch(config-vrf)# rd` *route-distinguisher*	Creates a VRF table by specifying a route distinguisher. Enter either an AS number and an arbitrary number (xxx:y) or an IP address and arbitrary number (A.B.C.D:y).
Step 6	`Switch(config-vrf)# route-target {export | import | both}` *route-target-ext-community*	Creates a list of import, export, or import and export route target communities for the specified VRF. Enter either an AS system number and an arbitrary number (xxx:y) or an IP address and an arbitrary number (A.B.C.D:y). The *route-target-ext-community* value should be the same as the *route-distinguisher* value entered in Step 4.
Step 7	`Switch(config-vrf)# import map` *route-map*	(Optional) Associates a route map with the VRF.
Step 8	`Switch(config-vrf)# interface` *interface-id*	Enters interface configuration mode and specifies the Layer 3 interface to be associated with the VRF. The interface can be a routed port or a SVI.
Step 9	`Switch(config-if)# ip vrf forwarding` *vrf-name*	Associates the VRF with the Layer 3 interface.
Step 10	`Switch(config-if)# ip address` *ip-address* `mask`	Configures IP address for the Layer 3 interface.
Step 11	`Switch(config-if)# ip pim [sparse-dense mode | dense-mode | sparse-mode]`	Enables PIM on the VRF-associated Layer 3 interface.
Step 12	`Switch(config-if)# end`	Returns to privileged EXEC mode.
Step 13	`Switch# show ip vrf [brief | detail | interfaces] [`*vrf-name*`]`	Verifies the configuration. Display information about the configured VRFs.
Step 14	`Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

For more information about configuring a multicast within a Multi-VRF CE, see the *Cisco IOS IP Multicast Configuration Guide, Release 12.4*.

Use the **no ip vrf** *vrf-name* global configuration command to delete a VRF and to remove all interfaces from it. Use the **no ip vrf forwarding** interface configuration command to remove an interface from the VRF.

Configuring a VPN Routing Session

Routing within the VPN can be configured with any supported routing protocol (RIP, OSPF, or BGP) or with static routing. The configuration shown here is for OSPF, but the process is the same for other protocols.

To configure OSPF in the VPN, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# router ospf process-id vrf vrf-name`	Enables OSPF routing, specifies a VPN forwarding table, and enters router configuration mode.
Step 3	`Switch(config-router)# log-adjacency-changes`	(Optional) Logs changes in the adjacency state (the default state).
Step 4	`Switch(config-router)# redistribute bgp autonomous-system-number subnets`	Sets the switch to redistribute information from the BGP network to the OSPF network.
Step 5	`Switch(config-router)# network network-number area area-id`	Defines a network address and mask on which OSPF runs and the area ID for that network address.
Step 6	`Switch(config-router)# end`	Returns to privileged EXEC mode.
Step 7	`Switch# show ip ospf process-id`	Verifies the configuration of the OSPF network.
Step 8	`Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Use the **no router ospf** *process-id* **vrf** *vrf-name* global configuration command to disassociate the VPN forwarding table from the OSPF routing process.

Configuring BGP PE to CE Routing Sessions

To configure a BGP PE to CE routing session, perform this task:

	Command	Purpose
Step 1	`Switch# configure terminal`	Enters global configuration mode.
Step 2	`Switch(config)# router bgp autonomous-system-number`	Configures the BGP routing process with the AS number passed to other BGP routers and enters router configuration mode.
Step 3	`Switch(config-router)# network network-number mask network-mask`	Specifies a network and mask to announce using BGP.
Step 4	`Switch(config-router)# redistribute ospf process-id match internal`	Sets the switch to redistribute OSPF internal routes.
Step 5	`Switch(config-router)# network network-number area area-id`	Defines a network address and mask on which OSPF runs and the area ID for that network address.
Step 6	`Switch(config-router-af)# address-family ipv4 vrf vrf-name`	Defines BGP parameters for PE to CE routing sessions and enters VRF address-family mode.
Step 7	`Switch(config-router-af)# neighbor address remote-as as-number`	Defines a BGP session between PE and CE routers.

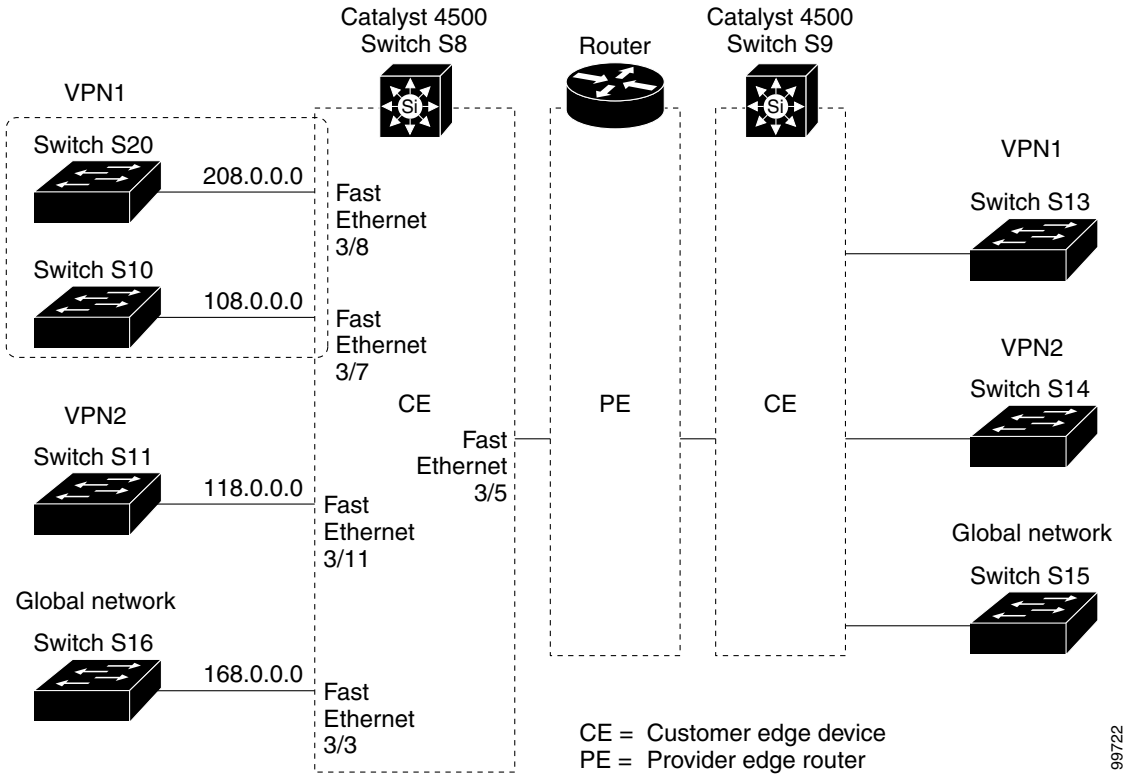
	Command	Purpose
Step 8	`Switch(config-router-af)# neighbor` *address* `activate`	Activates the advertisement of the IPv4 address family.
Step 9	`Switch(config-router-af)# end`	Returns to privileged EXEC mode.
Step 10	`Switch# show ip bgp [ipv4] [neighbors]`	Verifies BGP configuration.
Step 11	`Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Use the **no router bgp** *autonomous-system-number* global configuration command to delete the BGP routing process. Use the command with keywords to delete routing characteristics.

VRF-lite Configuration Example

Figure 36-2 is a simplified example of the physical connections in a network similar to that in Figure 36-1. OSPF is the protocol used in VPN1, VPN2, and the global network. BGP is used in the CE to PE connections. The example commands show how to configure the CE switch S8 and include the VRF configuration for switches S20 and S11 and the PE router commands related to traffic with switch S8. Commands for configuring the other switches are not included but would be similar.

Figure 36-2 VRF-lite Configuration Example



Configuring Switch S8

On switch S8, enable routing and configure VRF.

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# ip routing
Switch(config)# ip vrf v11
Switch(config-vrf)# rd 800:1
Switch(config-vrf)# route-target export 800:1
Switch(config-vrf)# route-target import 800:1
Switch(config-vrf)# exit
Switch(config)# ip vrf v12
Switch(config-vrf)# rd 800:2
Switch(config-vrf)# route-target export 800:2
Switch(config-vrf)# route-target import 800:2
Switch(config-vrf)# exit
```

Configure the loopback and physical interfaces on switch S8. Fast Ethernet interface 3/5 is a trunk connection to the PE. Interfaces 3/7 and 3/11 connect to VPNs:

```
Switch(config)# interface loopback1
Switch(config-if)# ip vrf forwarding v11
Switch(config-if)# ip address 8.8.1.8 255.255.255.0
Switch(config-if)# exit

Switch(config)# interface loopback2
Switch(config-if)# ip vrf forwarding v12
Switch(config-if)# ip address 8.8.2.8 255.255.255.0
Switch(config-if)# exit

Switch(config)# interface FastEthernet3/5
Switch(config-if)# switchport trunk encapsulation dot1q
Switch(config-if)# switchport mode trunk
Switch(config-if)# no ip address
Switch(config-if)# exit

Switch(config)# interface FastEthernet3/8
Switch(config-if)# switchport access vlan 208
Switch(config-if)# no ip address
Switch(config-if)# exit

Switch(config)# interface FastEthernet3/11
Switch(config-if)# switchport trunk encapsulation dot1q
Switch(config-if)# switchport mode trunk
Switch(config-if)# no ip address
Switch(config-if)# exit
```

Configure the VLANs used on switch S8. VLAN 10 is used by VRF 11 between the CE and the PE. VLAN 20 is used by VRF 12 between the CE and the PE. VLANs 118 and 208 are used for VRF for the VPNs that include switch S11 and switch S20, respectively:

```
Switch(config)# interface Vlan10
Switch(config-if)# ip vrf forwarding v11
Switch(config-if)# ip address 38.0.0.8 255.255.255.0
Switch(config-if)# exit
```

```
Switch(config)# interface Vlan20
Switch(config-if)# ip vrf forwarding v12
Switch(config-if)# ip address 83.0.0.8 255.255.255.0
Switch(config-if)# exit

Switch(config)# interface Vlan118
Switch(config-if)# ip vrf forwarding v12
Switch(config-if)# ip address 118.0.0.8 255.255.255.0
Switch(config-if)# exit

Switch(config)# interface Vlan208
Switch(config-if)# ip vrf forwarding v11
Switch(config-if)# ip address 208.0.0.8 255.255.255.0
Switch(config-if)# exit
```

Configure OSPF routing in VPN1 and VPN2:

```
Switch(config)# router ospf 1 vrf vl1
Switch(config-router)# redistribute bgp 800 subnets
Switch(config-router)# network 208.0.0.0 0.0.0.255 area 0
Switch(config-router)# exit
Switch(config)# router ospf 2 vrf vl2
Switch(config-router)# redistribute bgp 800 subnets
Switch(config-router)# network 118.0.0.0 0.0.0.255 area 0
Switch(config-router)# exit
```

Configure BGP for CE to PE routing:

```
Switch(config)# router bgp 800
Switch(config-router)# address-family ipv4 vrf vl2
Switch(config-router-af)# redistribute ospf 2 match internal
Switch(config-router-af)# neighbor 83.0.0.3 remote-as 100
Switch(config-router-af)# neighbor 83.0.0.3 activate
Switch(config-router-af)# network 8.8.2.0 mask 255.255.255.0
Switch(config-router-af)# exit

Switch(config-router)# address-family ipv4 vrf vl1
Switch(config-router-af)# redistribute ospf 1 match internal
Switch(config-router-af)# neighbor 38.0.0.3 remote-as 100
Switch(config-router-af)# neighbor 38.0.0.3 activate
Switch(config-router-af)# network 8.8.1.0 mask 255.255.255.0
Switch(config-router-af)# end
```

Configuring Switch S20

Configure S20 to connect to CE:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# ip routing
Switch(config)# interface Fast Ethernet 0/7
Switch(config-if)# no switchport
Switch(config-if)# ip address 208.0.0.20 255.255.255.0
Switch(config-if)# exit

Switch(config)# router ospf 101
Switch(config-router)# network 208.0.0.0 0.0.0.255 area 0
Switch(config-router)# end
```

Configuring Switch S11

Configure S11 to connect to CE:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# ip routing
Switch(config)# interface Gigabit Ethernet 0/3
Switch(config-if)# switchport trunk encapsulation dot1q
Switch(config-if)# switchport mode trunk
Switch(config-if)# no ip address
Switch(config-if)# exit

Switch(config)# interface Vlan118
Switch(config-if)# ip address 118.0.0.11 255.255.255.0
Switch(config-if)# exit

Switch(config)# router ospf 101
Switch(config-router)# network 118.0.0.0 0.0.0.255 area 0
Switch(config-router)# end
```

Configuring the PE Switch S3

On switch S3 (the router), these commands configure only the connections to switch S8:

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# ip vrf v1
Router(config-vrf)# rd 100:1
Router(config-vrf)# route-target export 100:1
Router(config-vrf)# route-target import 100:1
Router(config-vrf)# exit

Router(config)# ip vrf v2
Router(config-vrf)# rd 100:2
Router(config-vrf)# route-target export 100:2
Router(config-vrf)# route-target import 100:2
Router(config-vrf)# exit

Router(config)# ip cef
Router(config)# interface Loopback1
Router(config-if)# ip vrf forwarding v1
Router(config-if)# ip address 3.3.1.3 255.255.255.0
Router(config-if)# exit

Router(config)# interface Loopback2
Router(config-if)# ip vrf forwarding v2
Router(config-if)# ip address 3.3.2.3 255.255.255.0
Router(config-if)# exit

Router(config)# interface Fast Ethernet3/0.10
Router(config-if)# encapsulation dot1q 10
Router(config-if)# ip vrf forwarding v1
Router(config-if)# ip address 38.0.0.3 255.255.255.0
Router(config-if)# exit

Router(config)# interface Fast Ethernet3/0.20
Router(config-if)# encapsulation dot1q 20
Router(config-if)# ip vrf forwarding v2
Router(config-if)# ip address 83.0.0.3 255.255.255.0
Router(config-if)# exit
```

```
Router(config)# router bgp 100
Router(config-router)# address-family ipv4 vrf v2
Router(config-router-af)# neighbor 83.0.0.8 remote-as 800
Router(config-router-af)# neighbor 83.0.0.8 activate
Router(config-router-af)# network 3.3.2.0 mask 255.255.255.0
Router(config-router-af)# exit
Router(config-router)# address-family ipv4 vrf v1
Router(config-router-af)# neighbor 83.0.0.8 remote-as 800
Router(config-router-af)# neighbor 83.0.0.8 activate
Router(config-router-af)# network 3.3.1.0 mask 255.255.255.0
Router(config-router-af)# end
```

Displaying VRF-lite Status

To display information about VRF-lite configuration and status, perform one of the following tasks:

Command	Purpose
Switch# **show ip protocols vrf** *vrf-name*	Displays routing protocol information associated with a VRF.
Switch# **show ip route vrf** *vrf-name* [**connected**] [*protocol* [*as-number*]] [**list**] [**mobile**] [**odr**] [**profile**] [**static**] [**summary**][**supernets-only**]	Displays IP routing table information associated with a VRF.
Switch# **show ip vrf** [**brief** | **detail** | **interfaces**] [*vrf-name*]	Displays information about the defined VRF instances.
Switch# **show ip mroute vrf** *instance-name a.b.c.d* | **active** | **bidriectional**| **count** | **dense**| **interface** | **proxy** | **pruned** | **sparse** | **ssm** | **static** | **summary**	Displays information about the defined VRF instances.

This example shows how to display multicast route table information within a VRF instance:

```
Switch# show ip mroute vrf mcast2 234.34.10.18
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group
       V - RD & Vector, v - Vector
Outgoing interface flags: H - Hardware switched, A - Assert winner
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 234.34.10.18), 13:39:21/00:02:58, RP 1.1.1.1, flags: BC
  Bidir-Upstream: Vlan134, RPF nbr 172.16.34.1
  Outgoing interface list:
    Vlan45, Forward/Sparse-Dense, 00:00:02/00:02:57, H
    Vlan134, Bidir-Upstream/Sparse-Dense, 13:35:54/00:00:00, H
```

Note For more information about the information in the displays, refer to the *Cisco IOS Switching Services Command Reference* at:

http://www.cisco.com/en/US/docs/ios/ipswitch/command/reference/isw_book.html