Lab - Implement VRF-Lite

# Topology



# Addressing Table

| Device | Interface | IPv4 Address | IPv6 Address | IPv6 Link-Local |
| --- | --- | --- | --- | --- |
| R1 | G0/0/0 | 10.1.2.1/24 | 2001:db8:acad:1012::1/64 | fe80::1:1 |
| R1 | G0/0/1.5 | 10.1.2.1/24 | 2001:db8:acad:1012::1/64 | fe80::1:2 |
| R1 | G0/0/1.8 | 10.1.3.1/24 | 2001:db8:acad:1013::1/64 | fe80::1:4 |
| R1 | S0/1/0 | 10.1.3.1/25 | 2001:db8:acad:1013::1/64 | fe80::1:2 |
| R2 | G0/0/0 | 10.2.3.2/24 | 2001:db8:acad:1023::2/64 | fe80::2:1 |
| R2 | Loopback0 | 192.168.2.1/24 | 2001:db8:acad:2000::1/64 | fe80::2:2 |
| R3 | S0/1/0 | 10.1.3.3/25 | 2001:db8:acad:1013::3/64 | fe80::3:1 |
| R3 | Loopback0 | 192.168.3.1/27 | 2001:db8:acad:3000::1/64 | fe80::3:2 |
| D1 | G1/0/5 | 10.1.2.2/24 | 2001:db8:acad:1012::2/64 | fe80::d1:1 |
| D1 | VLAN 11 | 192.168.2.1/24 | 2001:db8:acad:2000::2/64 | fe80::d1:2 |
| D2 | G1/0/5 | 10.1.3.2/24 | 2001:db8:acad:1013::2/64 | fe80::d2:1 |
| D2 | VLAN 11 | 192.168.3.1/24 | 2001:db8:acad:3000::1/64 | fe80::d2:2 |

# Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify VRF and Interface Addressing

Part 3: Configure and Verify Static Routing for Reachability Inside Each VRF

# Background / Scenario

By default, all interfaces on a router are included in the global routing table. Service providers must be able to virtualize the router, thus creating multiple, virtual routing tables. Virtual Routing and Forwarding (VRF) can do just that. VRF-Lite is VRF without the MPLS component.

In this lab, you will work on R1, playing the part of a service provider router, as it supports two customers who have the same addressing scheme configured. Your task is to deploy VRF-Lite and static routing so that the customers have full reachability within their network.

**Note**: This lab is an exercise in developing, deploying, and verifying VRF-Lite, and does not reflect networking best practices.

**Note**: The routers and switches used with CCNP hands-on labs are Cisco 4221 and Cisco 3650, both with Cisco IOS XE Release 16.9.4 (universalk9 image), and Cisco 2960+ with IOS release 15.2 (lanbase image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and the output produced might vary from what is shown in the labs

**Note**: Ensure that the routers and switches have been erased and have no startup configurations. If you are unsure contact your instructor.

**Note**: The PCs used in this lab do not require addressing. They are needed to bring interface VLAN 11 up.

# Required Resources

* 3 Routers (Cisco 4221 with Cisco IOS XE Release 16.9.4 universal image or comparable)
* 2 Switches (Cisco 3650 with Cisco IOS XE release 16.9.4 universal image or comparable)
* 1 Switch (Cisco 2960+ with Cisco IOS release 15.2 lanbase image or comparable)
* 2 PCs (Windows with a terminal emulation program, such as Tera Term)
* Console cables to configure the Cisco IOS devices via the console ports
* Ethernet and serial cables as shown in the topology

## Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on all devices.

### Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

### Configure basic settings for each device.

* + - 1. Console into each device, enter global configuration mode, and apply the basic settings. A command list for each device using the following startup configurations.

Open configuration window

Router R1

enable

configure terminal

hostname R1

no ip domain lookup

ipv6 unicast-routing

banner motd # R1, Implement VRF-Lite #

line con 0

 exec-timeout 0 0

 logging synchronous

 exit

line vty 0 4

 privilege level 15

 password cisco123

 exec-timeout 0 0

 logging synchronous

 login

 exit

Router R2

enable

configure terminal

hostname R2

no ip domain lookup

ipv6 unicast-routing

banner motd # R2, Implement VRF-Lite #

line con 0

 exec-timeout 0 0

 logging synchronous

 exit

line vty 0 4

 privilege level 15

 password cisco123

 exec-timeout 0 0

 logging synchronous

 login

 exit

interface g0/0/0

 ip address 10.1.2.2 255.255.255.0

 ipv6 address fe80::2:1 link-local

 ipv6 address 2001:db8:acad:1012::2/64

 no shutdown

 exit

interface loopback 0

 ip address 192.168.2.1 255.255.255.0

 ipv6 address fe80::2:2 link-local

 ipv6 address 2001:db8:acad:2000::1/64

 no shutdown

 exit

ip route 0.0.0.0 0.0.0.0 g0/0/0 10.1.2.1

ipv6 route ::/0 g0/0/0 2001:db8:acad:1012::1

Router R3

enable

configure terminal

hostname R3

no ip domain lookup

ipv6 unicast-routing

banner motd # R3, Implement VRF-Lite #

line con 0

 exec-timeout 0 0

 logging synchronous

 exit

line vty 0 4

 privilege level 15

 password cisco123

 exec-timeout 0 0

 logging synchronous

 login

 exit

interface s0/1/0

 ip address 10.1.3.2 255.255.255.0

 ipv6 address fe80::3:1 link-local

 ipv6 address 2001:db8:acad:1013::2/64

 no shutdown

 exit

interface loopback 0

 ip address 192.168.3.1 255.255.255.0

 ipv6 address fe80::3:2 link-local

 ipv6 address 2001:db8:acad:3000::1/64

 no shutdown

 exit

ip route 0.0.0.0 0.0.0.0 s0/1/0 10.1.3.1

ipv6 route ::/0 s0/1/0 2001:db8:acad:1013::1

Switch D1

enable

configure terminal

hostname D1

no ip domain lookup

ip routing

ipv6 unicast-routing

banner motd # D1, Implement VRF-Lite #

line con 0

 exec-timeout 0 0

 logging synchronous

 exit

line vty 0 4

 privilege level 15

 password cisco123

 exec-timeout 0 0

 logging synchronous

 login

 exit

interface range g1/0/1-24, g1/1/1-4, g0/0

 shutdown

 exit

interface g1/0/5

 no switchport

 ip address 10.1.2.2 255.255.255.0

 ipv6 address fe80::d1:1 link-local

 ipv6 address 2001:db8:acad:1012::2/64

 no shutdown

 exit

vlan 11

 name LOCAL\_VLAN

 exit

interface vlan 11

 ip address 192.168.2.1 255.255.255.0

 ipv6 address fe80::d1:2 link-local

 ipv6 address 2001:db8:acad:2000::1/64

 no shutdown

 exit

interface g1/0/23

 switchport mode access

 switchport access vlan 11

 no shutdown

 exit

ip route 0.0.0.0 0.0.0.0 g1/0/5 10.1.2.1

ipv6 route ::/0 g1/0/5 2001:db8:acad:1012::1

Switch D2

enable

configure terminal

hostname D2

no ip domain lookup

ip routing

ipv6 unicast-routing

banner motd # D2, Implement VRF-Lite #

line con 0

 exec-timeout 0 0

 logging synchronous

 exit

line vty 0 4

 privilege level 15

 password cisco123

 exec-timeout 0 0

 logging synchronous

 login

 exit

interface range g1/0/1-24, g1/1/1-4, g0/0

 shutdown

 exit

interface g1/0/5

 no switchport

 ip address 10.1.3.2 255.255.255.0

 ipv6 address fe80::d2:1 link-local

 ipv6 address 2001:db8:acad:1013::2/64

 no shutdown

 exit

vlan 11

 name LOCAL\_VLAN

 exit

interface vlan 11

 ip address 192.168.3.1 255.255.255.0

 ipv6 address fe80::d2:2 link-local

 ipv6 address 2001:db8:acad:3000::1/64

 no shutdown

 exit

interface g1/0/23

 switchport mode access

 switchport access vlan 11

 no shutdown

 exit

ip route 0.0.0.0 0.0.0.0 g1/0/5 10.1.3.1

ipv6 route ::/0 g1/0/5 2001:db8:acad:1013::1

Switch A1

enable

configure terminal

hostname A1

no ip domain lookup

banner motd # A1, Implement VRF-Lite #

line con 0

 exec-timeout 0 0

 logging synchronous

 exit

line vty 0 4

 privilege level 15

 password cisco123

 exec-timeout 0 0

 logging synchronous

 login

 exit

interface range f0/1-24, g0/1-2

 shutdown

 exit

vlan 5

 name D1

 exit

vlan 8

 name D2

 exit

interface f0/11

 switchport mode trunk

 switchport nonegotiate

 no shutdown

 exit

interface f0/1

 switchport mode access

 switchport access vlan 5

 no shutdown

 exit

interface f0/3

 switchport mode access

 switchport access vlan 8

 no shutdown

* + - 1. Set the clock on each router to UTC time.
			2. Save the running configuration to startup-config.

Close configuration window

## Configure and Verify VRF and Interface Addressing

In Part 2, you will configure and verify VRF-Lite on R1. The other devices, R2, R3, D1, D2, and A1 require no additional configuration. Once again, the configuration being used here is not meant to represent best practice, but to assess your ability to complete the required configurations.

### On R1, create the required VRFs.

* + - 1. Create the Customer\_A and Customer\_B VRFs, and initialize them for both IPv4 and IPv6. The VRF names are case sensitive.

Open configuration window

R1(config)# **vrf definition Customer\_A**

R1(config-vrf)# **address-family ipv4**

R1(config-vrf-af)# **address-family ipv6**

R1(config-vrf-af)# **exit**

R1(config-vrf)# **vrf definition Customer\_B**

R1(config-vrf)# **address-family ipv4**

R1(config-vrf-af)# **address-family ipv6**

R1(config-vrf-af)# **exit**

* + - 1. Configure interfaces G0/0/0 and S0/1/0 for the Customer\_A network.

R1(config)# **interface g0/0/0**

R1(config-if)# **vrf forwarding Customer\_A**

R1(config-if)# **ip address 10.1.2.1 255.255.255.0**

R1(config-if)# **ipv6 address fe80::1:1 link-local**

R1(config-if)# **ipv6 address 2001:db8:acad:1012::1/64**

R1(config-if)# **no shutdown**

R1(config-if)# **exit**

R1(config)# **interface s0/1/0**

R1(config-if)# **vrf forwarding Customer\_A**

R1(config-if)# **ip address 10.1.3.1 255.255.255.0**

R1(config-if)# **ipv6 address fe80::1:4 link-local**

R1(config-if)# **ipv6 address 2001:db8:acad:1013::1/64**

R1(config-if)# **no shutdown**

R1(config-if)# **exit**

* + - 1. Configure R1 interface G0/0/1 to support the Customer\_B networks. G0/0/1 will be performing inter-VLAN routing between VLANs 5 and 8.

R1(config)# **interface g0/0/1**

R1(config-if)# **no shutdown**

R1(config-if)# **exit**

R1(config)# **interface g0/0/1.5**

R1(config-subif)# **encapsulation dot1q 5**

R1(config-subif)# **vrf forwarding Customer\_B**

R1(config-subif)# **ip address 10.1.2.1 255.255.255.0**

R1(config-subif)# **ipv6 address fe80::1:2 link-local**

R1(config-subif)# **ipv6 address 2001:db8:acad:1012::1/64**

R1(config-subif)# **exit**

R1(config)# **interface g0/0/1.8**

R1(config-subif)# **encapsulation dot1q 8**

R1(config-subif)# **vrf forwarding Customer\_B**

R1(config-subif)# **ip address 10.1.3.1 255.255.255.0**

R1(config-subif)# **ipv6 address fe80::1:3 link-local**

R1(config-subif)# **ipv6 address 2001:db8:acad:1013::1/64**

R1(config-subif)# **end**

### Verify the VRF-Lite configuration.

* + - 1. Verify the interface assignments using the **show ip vrf interfaces** command.

R1# **show ip vrf interfaces**

Interface IP-Address VRF Protocol

Gi0/0/0 10.1.2.1 Customer\_A up

Se0/1/0 10.1.3.1 Customer\_A up

Gi0/0/1.5 10.1.2.1 Customer\_B up

Gi0/0/1.8 10.1.3.1 Customer\_B up

* + - 1. Verify the VRF routing tables with the **show ip route vrf** *vrf\_name* and **show ipv6 route vrf** *vrf\_name* command.

R1# **show ip route vrf Customer\_A | begin Gateway**

Gateway of last resort is not set

 10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks

C 10.1.2.0/24 is directly connected, GigabitEthernet0/0/0

L 10.1.2.1/32 is directly connected, GigabitEthernet0/0/0

C 10.1.3.0/24 is directly connected, Serial0/1/0

L 10.1.3.1/32 is directly connected, Serial0/1/0

R1# **show ipv6 route vrf Customer\_B**

IPv6 Routing Table - Customer\_B - 5 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

<output omitted>

 a - Application

C 2001:DB8:ACAD:1012::/64 [0/0]

 via GigabitEthernet0/0/1.5, directly connected

L 2001:DB8:ACAD:1012::1/128 [0/0]

 via GigabitEthernet0/0/1.5, receive

C 2001:DB8:ACAD:1013::/64 [0/0]

 via GigabitEthernet0/0/1.8, directly connected

L 2001:DB8:ACAD:1013::1/128 [0/0]

 via GigabitEthernet0/0/1.8, receive

L FF00::/8 [0/0]

 via Null0, receive

* + - 1. Verify next-hop reachability within each vrf with the **ping vrf** *vrf\_name* **address** command.

R1# **ping vrf Customer\_A 10.1.2.2**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.2.2, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms

R1# **ping vrf Customer\_A 2001:db8:acad:1012::2**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:1012::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/10 ms

R1# **ping vrf Customer\_A 10.1.3.2**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.3.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms

R1# **ping vrf Customer\_A 2001:db8:acad:1013::2**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:1013::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms

## Configure and Verify Static Routing for Reachability Inside Each VRF

In Part 3, you will configure static routing so that all networks are reachable within their respective VRFs. At the end of this part, R1 should be able to successfully source a ping from interface loopback0 to R3 interface loopback0, and D1 should be able to successfully source a ping from interface VLAN 11 to D2 interface VLAN 11. Once again, the way these networks are being implemented is not meant to represent best practice, but to assess your ability to complete the required configurations.

### Verify that distant networks are not reachable within each VRF.

In this step, you will check to make sure that distant networks are not reachable from R1 within each VRF.

* + - 1. On R1, issue the commands **ping vrf Customer\_A 192.168.2.1** and **ping vrf Customer\_A 192.168.3.1**. Neither should succeed.

Open configuration window

R1# **ping vrf Customer\_A 192.168.2.1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/5)

R1# **ping vrf Customer\_A 192.168.3.1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/5)

* + - 1. On R1, issue the commands **ping vrf Customer\_A 2001:db8:acad:2000::1** and **ping vrf Customer\_A 2001:db8:acad:3000::1**. Neither should succeed.

R1# **ping vrf Customer\_A 2001:db8:acad:2000::1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:2000::1, timeout is 2 seconds:

% No valid route for destination

Success rate is 0 percent (0/1)

R1# **ping vrf Customer\_A 2001:db8:acad:3000::1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3000::1, timeout is 2 seconds:

% No valid route for destination

Success rate is 0 percent (0/1)

* + - 1. On R1, issue the commands **ping vrf Customer\_B 192.168.2.1** and **ping vrf Customer\_B 192.168.3.1**. Neither should succeed.

R1# **ping vrf Customer\_B 192.168.2.1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/5)

R1# **ping vrf Customer\_B 192.168.3.1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/5)

* + - 1. On R1, issue the commands **ping vrf Customer\_B 2001:db8:acad:2000::1** and **ping vrf Customer\_B 2001:db8:acad:3000::1**. Neither should succeed.

R1# **ping vrf Customer\_B 2001:db8:acad:2000::1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:2000::1, timeout is 2 seconds:

% No valid route for destination

Success rate is 0 percent (0/1)

R1# **ping vrf Customer\_B 2001:db8:acad:3000::1**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3000::1, timeout is 2 seconds:

% No valid route for destination

Success rate is 0 percent (0/1)

### Configure static routing at R1 for each VRF.

In this step, you will configure R1 so that it can reach distant networks in each VRF. The neighbor systems (D1, D2, R2, and R3) have static routes already configured, so as soon as you correctly install these static routes, there will be full reachability within each VRF.

* + - 1. On R1, create static routes for the distant networks in the Customer\_A VRF using the **ip route vrf** *vrf\_name destination\_network next-hop* command.

R1(config)# **ip route vrf Customer\_A 192.168.2.0 255.255.255.0 g0/0/0 10.1.2.2**

R1(config)# **ip route vrf Customer\_A 192.168.3.0 255.255.255.0 s0/1/0 10.1.3.2**

R1(config)# **ipv6 route vrf Customer\_A 2001:db8:acad:2000::/64 g0/0/0 2001:db8:acad:1012::2**

R1(config)# **ipv6 route vrf Customer\_A 2001:db8:acad:3000::/64 s0/1/0 2001:db8:acad:1013::2**

* + - 1. Use the example above to correctly configure fully specified static routes for the Customer\_B network.

### Verify full reachability within each VRF.

* + - 1. On R2, ping the IPv4 and IPv6 addresses of R3 interface Loopback0 using a source address of R2 interface Loopback0. All pings should be successful.

R2# **ping 192.168.3.1 source loopback0**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.2.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms

R2# **ping 2001:db8:acad:3000::1 source loopback0**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3000::1, timeout is 2 seconds:

Packet sent with a source address of 2001:DB8:ACAD:2000::1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/2 ms

* + - 1. On D1, ping the IPv4 and IPv6 addresses of D2 interface VLAN 11 using a source address of D1 interface VLAN 11. All pings should be successful.

D1# **ping 192.168.3.1 source vlan11**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.2.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/4/9 ms

D1# **ping 2001:db8:acad:3000::1 source vlan11**

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3000::1, timeout is 2 seconds:

Packet sent with a source address of 2001:DB8:ACAD:2000::1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 0/5/17 ms

Close configuration window

# Router Interface Summary Table

| Router Model | Ethernet Interface #1 | Ethernet Interface #2 | Serial Interface #1 | Serial Interface #2 |
| --- | --- | --- | --- | --- |
| 1800 | Fast Ethernet 0/0 (F0/0) | Fast Ethernet 0/1 (F0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 1900 | Gigabit Ethernet 0/0 (G0/0) | Gigabit Ethernet 0/1 (G0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 2801 | Fast Ethernet 0/0 (F0/0) | Fast Ethernet 0/1 (F0/1) | Serial 0/1/0 (S0/1/0) | Serial 0/1/1 (S0/1/1) |
| 2811 | Fast Ethernet 0/0 (F0/0) | Fast Ethernet 0/1 (F0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 2900 | Gigabit Ethernet 0/0 (G0/0) | Gigabit Ethernet 0/1 (G0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 4221 | Gigabit Ethernet 0/0/0 (G0/0/0) | Gigabit Ethernet 0/0/1 (G0/0/1) | Serial 0/1/0 (S0/1/0) | Serial 0/1/1 (S0/1/1) |
| 4300 | Gigabit Ethernet 0/0/0 (G0/0/0) | Gigabit Ethernet 0/0/1 (G0/0/1) | Serial 0/1/0 (S0/1/0) | Serial 0/1/1 (S0/1/1) |

**Note**: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

End of document