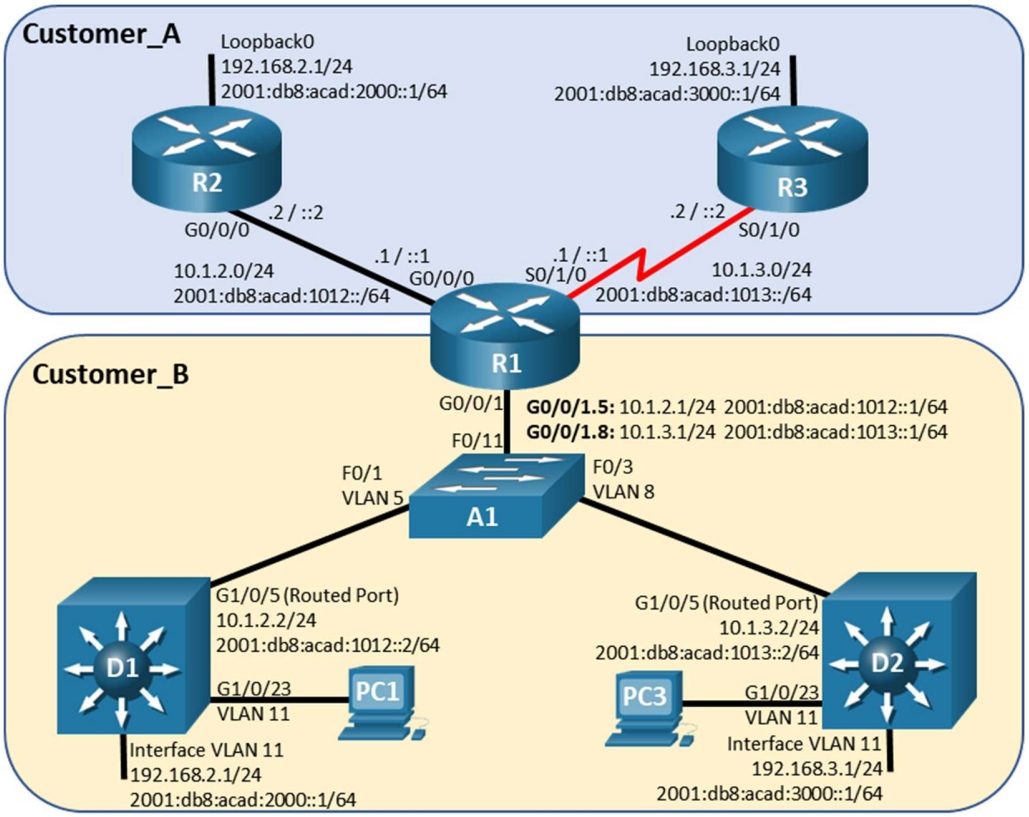
Lab - Implement VRF-Lite

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
	G0/0/1.5	10.1.2.1/24	2001:db8:acad:1012::1/64	fe80::1:2
	G0/0/1.8	10.1.3.1/24	2001:db8:acad:1013::1/64	fe80::1:4
	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
	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
	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

Device	Interface	IPv4 Address	IPv6 Address	IPv6 Link-Local
	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
	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

Part 1: 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.

Step 1: Cable the network as shown in the topology.

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

Step 2: Configure basic settings for each device.

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

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
```

b. Set the clock on each router to UTC time.

c. Save the running configuration to startup-config.

Part 2: 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.

Step 1: On R1, create the required VRFs.

a. Create the Customer_A and Customer_B VRFs, and initialize them for both IPv4 and IPv6. The VRF names are case sensitive.

```
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
```

b. 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
```

c. 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
```

Step 2: Verify the VRF-Lite configuration.

a. 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
```

b. 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
```

c. 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
```

Part 3: 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.

Step 1: 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.

a. 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.

```
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)
```

b. 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)
```

c. 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)
```

d. 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)
```

Step 2: 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.

a. 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
```

b. Use the example above to correctly configure fully specified static routes for the Customer_B network.

Step 3: Verify full reachability within each VRF.

a. 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
```

b. 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
```

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)

Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
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.