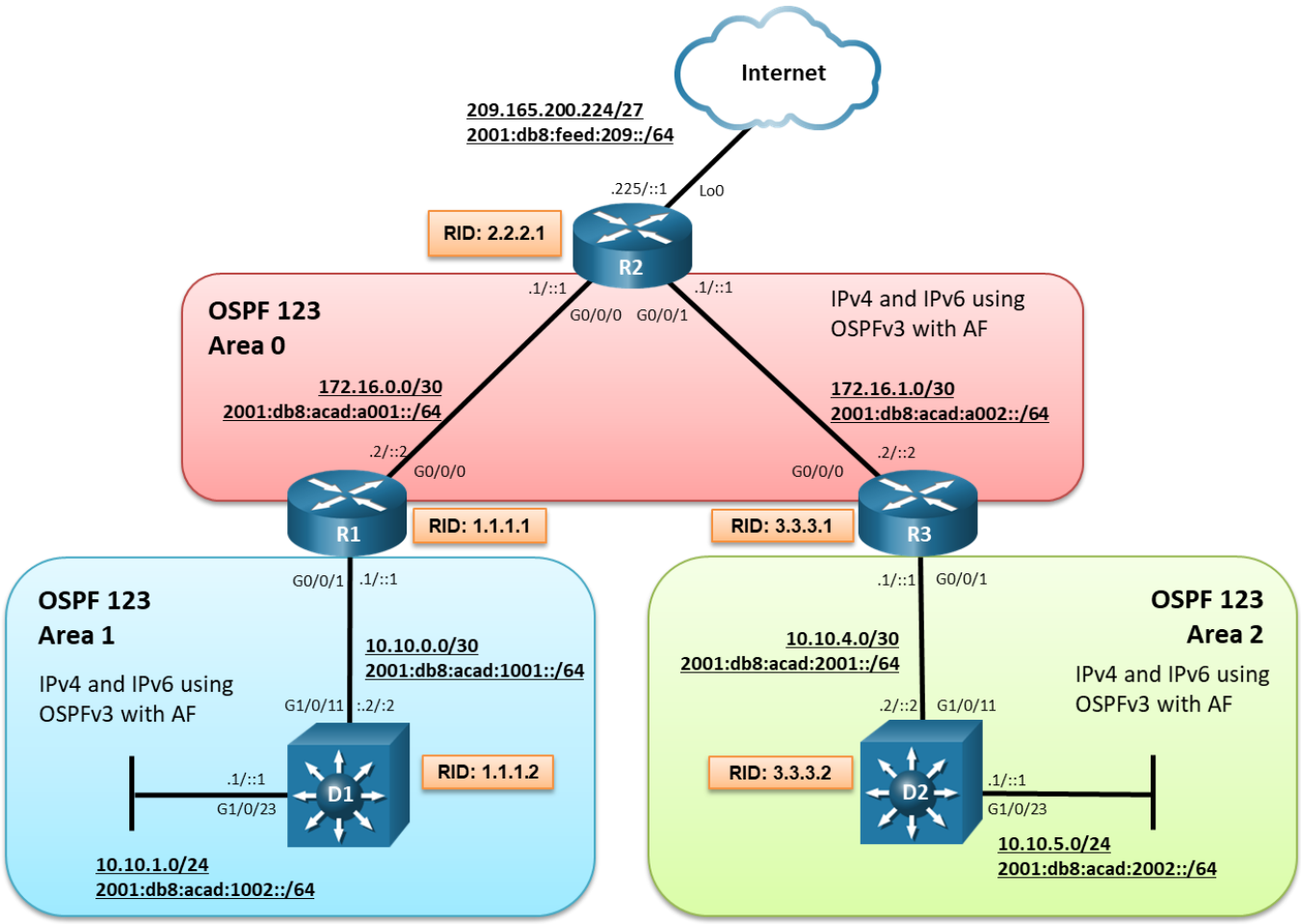
Lab - Implement Multiarea OSPFv3

Topology



Addressing Table

Device	Interface	IPv4 Address	IPv6 Address	IPv6 Link-Local
R1	G0/0/0	172.16.0.2/30	2001:db8:acad:a001::2/64	fe80::1:2
	G0/0/1	10.10.0.1/30	2001:db8:acad:1001::1/64	fe80::1:1
R2	Lo0	209.165.200.225/27	2001:db8:feed:209::1/64	fe80::2:3
	G0/0/0	172.16.0.1/30	2001:db8:acad:a001::1/64	fe80::2:1
	G0/0/1	172.16.1.1/30	2001:db8:acad:a002::1/64	fe80::2:2
R3	G0/0/0	172.16.1.2/30	2001:db8:acad:a002::2/64	fe80::3:2
	G0/0/1	10.10.4.1/30	2001:db8:acad:2001::1/64	fe80::3:1

Device	Interface	IPv4 Address	IPv6 Address	IPv6 Link-Local
D1	G1/0/11	10.10.0.2/30	2001:db8:acad:1001::2/64	fe80::d1:2
	G1/0/23	10.10.1.0/24	2001:db8:acad:1002::1/64	fe80::d1:1
D2	G1/0/11	10.10.4.2/30	2001:db8:acad:2001::2/64	fe80::d2:2
	G1/0/23	10.10.5.1/24	2001:db8:acad:2002::1/64	fe80::d2:1

Objectives

Part 1: Build the Topology and Configure Basic Device Settings and IP Addressing

Part 2: Configure Traditional OSPFv3 for IPv6 on D1

Part 3: Configure OSPFv3 for Address Families (AF) IPv4 and AF IPv6

Part 4: Verify OSPFv3 AF

Part 5: Tune OSPFv3 AF

Background / Scenario

In this lab, you will configure the network with multiarea OSPFv3 routing using the AF feature for both IPv4 and IPv6 in OSPF areas 0, 1 and 2. This lab was specifically designed to use three routers and two Layer 3 switches that support OSPFv3 using AF.

It should be noted that OSPFv3 runs on top of IPv6 and uses IPv6 link local addresses for OSPFv3 control packets. Therefore, it is required that IPv6 be enabled on an OSPFv3 link, although the link may not be participating in any IPv6 AFs. Additionally, OSPFv3 AF for IPv4 unicast is not backwards compatible with OSPFv2.

Note: The routers used with CCNP hands-on labs are Cisco 4221 with Cisco IOS XE Release 16.9.4 (universalk9 image). Other routers 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: The switches used with CCNP hands-on labs are Cisco Catalyst 3650s with Cisco IOS XE Release 16.9.4 (universalk9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and 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.

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)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Instructions

Part 1: Build the Network and Configure Basic Device Settings and Interface Addressing

In Part 1, you will set up the network topology and configure basic settings and interface addressing on routers and switches.

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 router.

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

Router R1

```
hostname R1
no ip domain lookup
line con 0
 logging sync
 exec-time 0 0
 exit
interface g0/0/0
 ip add 172.16.0.2 255.255.255.252
 ipv6 add 2001:db8:acad:a001::2/64
 ipv6 add fe80::1:2 link-local
 no shut
 exit
interface GigabitEthernet0/0/1
 ipv6 add 2001:db8:acad:1001::1/64
 ipv6 add fe80::1:1 link-local
 no shut
 exit
```

Router R2

```
hostname R2
no ip domain lookup
line con 0
 logging sync
 exec-time 0 0
 exit
interface g0/0/0
 ip add 172.16.0.1 255.255.255.252
 ipv6 add 2001:db8:acad:a001::1/64
 ipv6 add fe80::2:1 link-local
 no shut
 exit
```

```
interface GigabitEthernet0/0/1
 ip address 172.16.1.1 255.255.255.252
 ipv6 add 2001:db8:acad:a002::1/64
 ipv6 add fe80::2:2 link-local
 no shut
 exit
int lo0
 ip add 209.165.200.225 255.255.255.224
 ipv6 add 2001:db8:feed:209::1/64
 ipv6 add fe80::2:3 link-local
 exit
```

Router R3

```
hostname R3
no ip domain lookup
line con 0
 logging sync
 exec-time 0 0
 exit
interface g0/0/0
 ip add 172.16.1.2 255.255.255.252
 ipv6 add 2001:db8:acad:a002::2/64
 ipv6 add fe80::3:2 link-local
 no shut
 exit
interface GigabitEthernet0/0/1
 ip address 10.10.4.1 255.255.255.252
 ipv6 add 2001:db8:acad:2001::1/64
 ipv6 add fe80::3:1 link-local
 no shut
 exit
```

Switch D1

```
hostname D1
no ip domain lookup
line con 0
 exec-timeout 0 0
 logging synchronous
 exit
interface g1/0/11
 no switchport
 ipv6 add 2001:db8:acad:1001::2/64
 ipv6 add fe80::d1:2 link-local
 no shutdown
 exit
interface g1/0/23
```

```
 no switchport
 ipv6 add 2001:db8:acad:1002::1/64
 ipv6 add fe80::d1:1 link-local
 no shutdown
 exit
```

Switch D2

```
host D2
no ip domain lookup
line con 0
 logging sync
 exec-time 0 0
 exit
interface gi1/0/11
 no switchport
 ip address 10.10.4.2 255.255.255.252
 ipv6 add 2001:db8:acad:2001::2/64
 ipv6 add fe80::d2:2 link-local
 no shut
 exit
interface gi1/0/23
 no switchport
 ip address 10.10.5.1 255.255.255.0
 ipv6 add 2001:db8:acad:2002::1/64
 ipv6 add fe80::d2:1 link-local
 no shut
 exit
```

b. Save the running configuration to startup-config.

Part 2: Configure Traditional OSPFv3 for IPv6 on D1

Step 1: Configure traditional OSPFv3 on D1.

Traditional OSPFv3 implements OSPF routing for IPv6. In this part of the lab, you will configure traditional OSPFv3 for routing IPv6 on D1, which is in the IPv6-only area.

a. OSPFv3 messages are sourced from the router's IPv6 link-local address. Earlier in this lab, IPv6 GUA and link-local addresses were statically configured on each router's interface. The link-local addresses were statically configured to make these addresses more recognizable than being automatically created using EUI-64. Issue the **show ipv6 interface brief** command to verify the GUA and link-local addresses on the router's interfaces.

```
D1# show ipv6 interface brief
<output omitted>
GigabitEthernet1/0/11  [up/up]
    FE80::D1:2
    2001:DB8:ACAD:1001::2
<output omitted>
GigabitEthernet1/0/23  [up/up]
    FE80::D1:1
```

```
    2001:DB8:ACAD:1002::1
<output omitted>
```

b. IPv6 routing is disabled by default. Enable IPv6 routing using the **ipv6 unicast-routing** command in global configuration mode.

```
D1(config)# ipv6 unicast-routing
```

c. Most Cisco IOS versions have IPv6 CEF enabled by default when IPv6 routing is enabled. Use the **show ipv6 cef** command to verify whether IPv6 CEF is enabled. If you need to enable IPv6 CEF, use the **ipv6 cef** command. If IPv6 CEF is disabled you will see the an IOS message similar to "%IPv6 CEF not running".

```
D1# show ipv6 cef
::/0
  no route
::/127
  discard
2001:DB8:ACAD:1001::/64
  attached to GigabitEthernet1/0/11
2001:DB8:ACAD:1001::2/128
  receive for GigabitEthernet1/0/11
2001:DB8:ACAD:1002::/64
  attached to GigabitEthernet1/0/23
2001:DB8:ACAD:1002::1/128
  receive for GigabitEthernet1/0/23
FE80::/10
  receive for Null0
FF00::/8
  multicast
FF02::/16
  receive
```

d. Configure the OSPFv3 process on D1. Similar to OSPFv2, the process ID does not have to match other routers to form neighbor adjacencies, although that is considered best practice. Configure the 32-bit OSPFv3 router ID on each router. Enable OSPFv3 directly on the interfaces using the interface **ipv6 ospf** *pid* **area** *area* command**.**

```
D1(config)# ipv6 unicast-routing
D1(config)# ipv6 router ospf 123
D1(config-rtr)# router-id 1.1.1.2
D1(config-rtr)# exit
D1(config)# interface g1/0/11
D1(config-if)# ipv6 ospf 123 area 1
D1(config-if)# exit
D1(config)# interface g1/0/23
D1(config-if)# ipv6 ospf 123 area 1
D1(config-if)# exit
```

e. The **show ipv6 ospf** command can be used to verify the OSPF router ID. If the OSPFv3 router ID is uses a 32-bit value other than the one specified by the **router-id** command, you can reset the router ID by using the **clear ipv6 ospf** *pid* **process** command and re-verify using the command **show ipv6 ospf**.

```
D1# show ipv6 ospf
 Routing Process "ospfv3 123" with ID 1.1.1.2
```

```
Supports NSSA (compatible with RFC 3101)
Supports Database Exchange Summary List Optimization (RFC 5243)
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
Router is not originating router-LSAs with maximum metric
Initial SPF schedule delay 50 msecs
Minimum hold time between two consecutive SPFs 200 msecs
Maximum wait time between two consecutive SPFs 5000 msecs
Initial LSA throttle delay 50 msecs
Minimum hold time for LSA throttle 200 msecs
Maximum wait time for LSA throttle 5000 msecs
Minimum LSA arrival 100 msecs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
Retransmission limit dc 24 non-dc 24
EXCHANGE/LOADING adjacency limit: initial 300, process maximum 300
Number of external LSA 0. Checksum Sum 0x000000
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Graceful restart helper support enabled
Reference bandwidth unit is 100 mbps
RFC1583 compatibility enabled
   Area 1
       Number of interfaces in this area is 2
       SPF algorithm executed 5 times
       Number of LSA 12. Checksum Sum 0x0486C1
       Number of DCbitless LSA 0
       Number of indication LSA 0
       Number of DoNotAge LSA 0
       Flood list length 0
```

f. The **show ipv6 protocols** command can be used to verify general OSPFv3 information such as areas and enabled interfaces.

```
D1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 123"
  Router ID 1.1.1.2
  Number of areas: 1 normal, 0 stub, 0 nssa
  Interfaces (Area 1):
    GigabitEthernet1/0/23
    GigabitEthernet1/0/11
  Redistribution:
    None
```

Part 3: Configure OSPFv3 for AF IPv4 and AF IPv6

OSPFv3 with the address family (AF) unifies OSPF configuration for both IPv4 and IPv6. Each OSPFv3 AF is a single process, so you may have two processes per interface, but only one process per AF. OSPFv3 messages are sent over IPv6 which requires that IPv6 routing is enabled and that the interface has a link-local IPv6 address. This is the requirement even if only the IPv4 AF is configured.

In this section you will configure OSPFv3 with AF for the IPv4 and IPv6 address families on R1, R2, R3, D1 and D2.

Step 1: Configure OSPFv3 with AF on R1.

a. After enabling IPv6 unicast routing, configure OSPFv3 with AF on R1 using the **router ospfv3** *pid* command. Use the **?** to see the address families available.

```
R1(config)# ipv6 unicast-routing
R1(config)# router ospfv3 123
R1(config-router)# address-family ?
  ipv4  Address family
  ipv6  Address family
```

b. Next, specify the AF for IPv4 and use the **?** to see the available options.

```
R1(config-router)# address-family ipv4 ?
  unicast  Address Family modifier
  vrf      Specify parameters for a VPN Routing/Forwarding instance
  <cr>
```

c. Enter the AF for IPv4 unicast using the command **address-family ipv4 unicast**. Use the **?** to examine the options in AF configuration mode. Some of the more common configuration commands are highlighted. Use the **router-id** command to configure the router ID for the IPv4 AF.

```
R1(config-router)# address-family ipv4 unicast
R1(config-router-af)# ?
Router Address Family configuration commands:
  adjacency               Control adjacency formation
  area                    OSPF area parameters
  authentication          Authentication parameters
  auto-cost               Calculate OSPF interface cost according to bandwidth
  auto-cost-determination Calculate OSPF interface cost according to bandwidth
  bfd                     BFD configuration commands
  compatible              Compatibility list
  default                 Set a command to its defaults
  default-information     Control distribution of default information
  default-metric          Set metric of redistributed routes
  discard-route           Enable or disable discard-route installation
  distance                Define an administrative distance
  distribute-list         Filter networks in routing updates
  event-log               Event Logging
  exit-address-family     Exit from Address Family configuration mode
  graceful-restart        Graceful-restart options
  help                    Description of the interactive help system
  ignore                  Do not complain about specific event
  interface-id            Source of the interface ID
  limit                   Limit a specific OSPF feature
  local-rib-criteria      Enable or disable usage of local RIB as route
                          criteria
  log-adjacency-changes   Log changes in adjacency state
  manet                   Specify MANET OSPF parameters
  max-lsa                 Maximum number of non self-generated LSAs to accept
```

```
  max-metric                Set maximum metric
  maximum-paths             Forward packets over multiple paths
  mpls                      MPLS Traffic Engineering configs
  no                        Negate a command or set its defaults
  passive-interface         Suppress routing updates on an interface
  prefix-suppression        Enable prefix suppression
  process-min-time          Percentage of quantum to be used before releasing
                            CPU
  queue-depth               Hello/Router process queue depth
  redistribute              Redistribute information from another routing
                            protocol
  router-id                 router-id for this OSPF process
  shutdown                  Shutdown the router process
  snmp                      Modify snmp parameters
  statistics                Enable or disable OSPF statistics options
  summary-address           Configure IP address summaries
  summary-prefix            Configure IP address summaries
  timers                    Adjust routing timers
R1(config-router-af)#
R1(config-router-af)# router-id 1.1.1.1
```

d. Exit the IPv4 AF configuration mode and enter the AF IPv6 configuration mode. The **exit-address-family** (or a shorter version of **exit**) command is used exit address family configuration mode. Issue the **address-family ipv6 unicast** command to enter the IPv6 AF. For the IPv6 AF, use the **router-id** command to configure the router ID. It isn't necessary to configure a different router ID for IPv6 AF but it is a valid option. The **exit** command is used to return to global configuration mode.

```
R1(config-router-af)# exit-address-family
R1(config-router)# address-family ipv6 unicast
R1(config-router-af)# router-id 1.1.1.1
R1(config-router-af)# exit-address-family
R1(config-router)# exit
```

e. OSPFv3 is enabled directly on the interfaces for both IPv4 and IPv6 AFs using the **ospfv3** *pid* [**ipv4** | **ipv6**] **area** *area-id* interface command. Use this command to enable OSPFv3 on both of R1's interfaces.

```
R1(config)# interface g0/0/0
R1(config-if)# ospfv3 123 ipv4 area 0
R1(config-if)# ospfv3 123 ipv6 area 0
R1(config-if)# exit
R1(config)# interface g0/0/1
R1(config-if)# ospfv3 123 ipv4 area 1
R1(config-if)# ospfv3 123 ipv6 area 1
```

Step 2: Configure OSPFv3 with AF IPv4 and AF IPv6 on R2.

Enable IPv6 unicast routing and configure the OSPFv3 with AF for both IPv4 and IPv6 on R2, similar to the configuration for R1.

```
R2(config)# ipv6 unicast-routing

R2(config)# router ospfv3 123
```

```
R2(config-router)# address-family ipv4 unicast
R2(config-router-af)# router-id 2.2.2.1
R2(config-router-af)# exit-address-family
R2(config-router)# address-family ipv6 unicast
R2(config-router-af)# router-id 2.2.2.1
R2(config-router-af)# exit-address-family
R2(config-router)# exit

R2(config)# interface g0/0/0
R2(config-if)# ospfv3 123 ipv4 area 0
R2(config-if)# ospfv3 123 ipv6 area 0
R2(config-if)# exit
R2(config)# interface g0/0/1
R2(config-if)# ospfv3 123 ipv4 area 0
R2(config-if)# ospfv3 123 ipv6 area 0
```

Step 3: Configure OSPFv3 with IPv4 AF and IPv6 AF on R3.

Enable IPv6 unicast routing and configure the OSPFv3 with AF for both IPv4 and IPv6 on R3, similar to the configurations for R1 and R2. On R3, set the router ID for both IPv4 AF and IPv6 AF with a single command as shown.

```
R3(config)# ipv6 unicast-routing

R3(config)# router ospfv3 123
R3(config-router)# router-id 3.3.3.1
R3(config-router)# address-family ipv4 unicast
R3(config-router-af)# exit-address-family
R3(config-router)# address-family ipv6 unicast
R3(config-router-af)# exit-address-family
R3(config-router)# exit

R3(config)# interface g0/0/0
R3(config-if)# ospfv3 123 ipv4 area 0
R3(config-if)# ospfv3 123 ipv6 area 0
R3(config-if)# exit
R3(config)# interface g0/0/1
R3(config-if)# ospfv3 123 ipv4 area 2
R3(config-if)# ospfv3 123 ipv6 area 2
```

Step 4: Configure OSPFv3 with AF on D2.

a. Enter the following command to enable routing for IPv4. (This may not be required on depending on model and IOS.)

```
D2(config)# ip routing
```

b. Enter the following command to enable routing for IPv6. (This may not be required on depending on model and IOS.)

```
D2(config)# ipv6 unicast-routing
```

Note: By default, the 3650 supports IPv6 interface configuration.

c. Configure the OSPFv3 with AF for both IPv4 and IPv6 on D2, similar to the configurations for R1, R2 and R3.

```
D2(config)# router ospfv3 123
D2(config-router)# address-family ipv4 unicast
D2(config-router-af)# router-id 3.3.3.2
D2(config-router-af)# exit-address-family
D2(config-router)# address-family ipv6 unicast
D2(config-router-af)# router-id 3.3.3.2
D2(config-router-af)# exit-address-family
D2(config-router)# exit

D2(config)# interface g1/0/11
D2(config-if)# ospfv3 123 ipv4 area 2
D2(config-if)# ospfv3 123 ipv6 area 2
D2(config-if)# exit
D2(config)# interface g 1/0/23
D2(config-if)# ospfv3 123 ipv4 area 2
D2(config-if)# ospfv3 123 ipv6 area 2
```

Part 4: Verify OSPFv3

The commands to verify traditional OSPFv3 and OSPFv3 with AF may differ. This is because OSPFv3 with AF commands include information for both IPv4 and IPv6 address families, whereas traditional OSPFv3 is for IPv6 only.

Step 1: Verifying neighbor adjacencies.

a. Use the **show ipv6 ospf neighbor** command on D1 to display OSPFv3 neighbors. This is a command used for routers configured with traditional OSPFv3. The equivalent command for OSPFv2 would be **show ip ospf neighbor**.

```
D1# show ipv6 ospf neighbor

            OSPFv3 Router with ID (1.1.1.2) (Process ID 123)

Neighbor ID     Pri   State           Dead Time   Interface ID   Interface
1.1.1.1           1   FULL/DR         00:00:39    6              GigabitEthernet1/0/11
```

b. This same command on a router running OSPFv3 with AF would generate similar output. For example, on R1 issue the same **show ipv6 ospf neighbor** command. Notice the output is only OSPFv3 for the IPv6 AF.

```
R1# show ipv6 ospf neighbor

            OSPFv3 Router with ID (1.1.1.1) (Process ID 123)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
2.2.2.1           1   FULL/BDR        00:00:31    5               GigabitEthernet0/0/0
1.1.1.2           1   FULL/BDR        00:00:38    471             GigabitEthernet0/0/1
```

c. Now, issue the **show ospfv3 neighbor** command on R1. This is a command used for routers configured for OSPFv3 with AF. Notice the output includes neighbors for both IPv4 and IPv6 address families.

```
R1# show ospfv3 neighbor

          OSPFv3 123 address-family ipv4 (router-id 1.1.1.1)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
2.2.2.1           1   FULL/BDR        00:00:38    5               GigabitEthernet0/0/0

          OSPFv3 123 address-family ipv6 (router-id 1.1.1.1)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
2.2.2.1           1   FULL/BDR        00:00:32    5               GigabitEthernet0/0/0
1.1.1.2           1   FULL/BDR        00:00:30    471             GigabitEthernet0/0/1
```

Traditional OSPFv3 commands are similar to those for OSPFv2, except **ipv6** is used as an argument instead of **ip**, for example **show ip ospf neighbor** and **show ipv6 ospf neighbor**. OSPFv3 with AF uses the argument ospfv3 which includes both OSPF for IPv4 and IPv6 AFs. For example, **show ospfv3 neighbor**.

Traditional OSPFv3 commands can be used when a router is configured for OSPFv3 with AF, but the OSPFv3 AF router will only show OSPF for IPv6 AF information. OSPFv3 with AF commands cannot be used on routers configured with traditional OSPFv3.

To summarize the **show** command arguments:

- OSPFv2: Use **show ip ospf** (IPv4 only)
- Traditional OSPFv3: Use **show ipv6 ospf** (IPv6 only)
- OSPFv3 with AF: Use **show ospfv3** (IPv4 and IPv6 AF) or **show ipv6 ospf** (IPv6 only)

Why does the **show ipv6 ospf neighbor** command only display OSPFv3 neighbors in the IPv6 AF?

Step 2: Examining the IP routing tables.

a. Use the **show ipv6 route ospf** command on D1 to display OSPFv3 routing entries in the IPv6 routing table.

```
D1# show ipv6 route ospf
IPv6 Routing Table - default - 9 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, H - NHRP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
       EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination
       NDr - Redirect, RL - RPL, O - OSPF Intra, OI - OSPF Inter
       OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1
       ON2 - OSPF NSSA ext 2, la - LISP alt, lr - LISP site-registrations
       ld - LISP dyn-eid, lA - LISP away, le - LISP extranet-policy
OI  2001:DB8:ACAD:2001::/64 [110/4]
     via FE80::1:1, GigabitEthernet1/0/11
OI  2001:DB8:ACAD:2002::/64 [110/5]
     via FE80::1:1, GigabitEthernet1/0/11
```

```
OI   2001:DB8:ACAD:A001::/64 [110/2]
      via FE80::1:1, GigabitEthernet1/0/11
OI   2001:DB8:ACAD:A002::/64 [110/3]
      via FE80::1:1, GigabitEthernet1/0/11
```

Display the routes using the **show ip route ospf**. Why are there no routes displayed using this command?

b. Understanding the difference between commands associated with OSPFv2 and OSPFv3 can seem challenging at times. The **show ip route ospfv3** command is used to view OSPFv3 routes in the IPv4 routing table. The **show ipv6 route ospf** command is used to view OSPFv3 routes in the IPv6 routing table. The **show ipv6 route ospf** command is the same command used with traditional OSPFv3 for IPv6.

```
R1# show ip route ospf

R1# show ip route ospfv3
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 4 subnets, 3 masks
O IA     10.10.4.0/30 [110/3] via 172.16.0.1, 00:17:34, GigabitEthernet0/0/0
O IA     10.10.5.0/24 [110/4] via 172.16.0.1, 00:17:34, GigabitEthernet0/0/0
      172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
O        172.16.1.0/30 [110/2] via 172.16.0.1, 00:17:34, GigabitEthernet0/0/0

R1# show ipv6 route ospfv3
                      ^
% Invalid input detected at '^' marker.

R1# show ipv6 route ospf
IPv6 Routing Table - default - 9 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, H - NHRP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
       EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination
       NDr - Redirect, RL - RPL, O - OSPF Intra, OI - OSPF Inter
       OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1
       ON2 - OSPF NSSA ext 2, a - Application
O   2001:DB8:ACAD:1002::/64 [110/2]
     via FE80::D1:2, GigabitEthernet0/0/1
```

```
OI  2001:DB8:ACAD:2001::/64 [110/3]
     via FE80::2:1, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:2002::/64 [110/4]
     via FE80::2:1, GigabitEthernet0/0/0
O   2001:DB8:ACAD:A002::/64 [110/2]
     via FE80::2:1, GigabitEthernet0/0/0
```

Why doesn't the **show ip route ospf** command display any routes on R1?

Step 3: Examining the OSPF LSDB.

a. D1 is running traditional OSPFv3. The **show ipv6 ospf database** command is used to display a summary of the OSPFv3 LSDB.

```
D1# show ipv6 ospf database

            OSPFv3 Router with ID (1.1.1.2) (Process ID 123)

                Router Link States (Area 1)

ADV Router       Age         Seq#        Fragment ID  Link count  Bits
 1.1.1.1         1096        0x80000009  0            1           B
 1.1.1.2         1110        0x80000005  0            1           None

                Net Link States (Area 1)

ADV Router       Age         Seq#        Link ID    Rtr count
 1.1.1.1         1152        0x80000001  6          2

                Inter Area Prefix Link States (Area 1)

ADV Router       Age         Seq#        Prefix
 1.1.1.1         1096        0x80000003  2001:DB8:ACAD:A001::/64
 1.1.1.1         1096        0x80000003  2001:DB8:ACAD:A002::/64
 1.1.1.1         833         0x80000005  2001:DB8:ACAD:2001::/64
 1.1.1.1         1497        0x80000002  2001:DB8:ACAD:2002::/64

                Link (Type-8) Link States (Area 1)

ADV Router       Age         Seq#        Link ID    Interface
 1.1.1.2         1150        0x80000001  39         Gi1/0/23
 1.1.1.1         1096        0x80000006  6          Gi1/0/11
 1.1.1.2         1151        0x80000001  38         Gi1/0/11

                Intra Area Prefix Link States (Area 1)

ADV Router       Age         Seq#        Link ID    Ref-lstype  Ref-LSID
 1.1.1.1         1152        0x80000001  6144       0x2002      6
```

```
 1.1.1.2         1150        0x80000003  0          0x2001      0
```

b. R1 is running OSPFv3 with AF. The **show ospfv3 database** command is used to display a summary of the OSPFv3 LSDB for both the IPv4 and IPv6 AFs.

```
R1# show ospfv3 database

          OSPFv3 123 address-family ipv4 (router-id 1.1.1.1)

               Router Link States (Area 0)

ADV Router       Age         Seq#        Fragment ID  Link count  Bits
 1.1.1.1         532         0x80000005  0            1           None
 2.2.2.1         508         0x80000008  0            2           None
 3.3.3.1         507         0x80000006  0            1           B

               Net Link States (Area 0)

ADV Router       Age         Seq#        Link ID    Rtr count
 2.2.2.1         539         0x80000001  5          2
 3.3.3.1         512         0x80000001  5          2

               Inter Area Prefix Link States (Area 0)

ADV Router       Age         Seq#        Prefix
 3.3.3.1         553         0x80000001  10.10.4.0/30
 3.3.3.1         513         0x80000001  10.10.5.0/24

               Link (Type-8) Link States (Area 0)

ADV Router       Age         Seq#        Link ID    Interface
 1.1.1.1         579         0x80000001  5          Gi0/0/0
 2.2.2.1         579         0x80000001  5          Gi0/0/0

               Intra Area Prefix Link States (Area 0)

ADV Router       Age         Seq#        Link ID    Ref-lstype  Ref-LSID
 2.2.2.1         539         0x80000001  5120       0x2002      5
 3.3.3.1         512         0x80000001  5120       0x2002      5

               Router Link States (Area 1)

ADV Router       Age         Seq#        Fragment ID  Link count  Bits
 1.1.1.1         602         0x80000001  0            0           None

          OSPFv3 123 address-family ipv6 (router-id 1.1.1.1)

               Router Link States (Area 0)

ADV Router       Age         Seq#        Fragment ID  Link count  Bits
 1.1.1.1         530         0x80000005  0            1           B
```

```
 2.2.2.1         508         0x80000009  0            2           None
 3.3.3.1         508         0x80000006  0            1           B

                Net Link States (Area 0)

ADV Router       Age         Seq#        Link ID    Rtr count
 2.2.2.1         539         0x80000001  5          2
 3.3.3.1         511         0x80000001  5          2

                Inter Area Prefix Link States (Area 0)

ADV Router       Age         Seq#        Prefix
 1.1.1.1         579         0x80000001  2001:DB8:ACAD:1001::/64
 1.1.1.1         559         0x80000001  2001:DB8:ACAD:1002::/64
 3.3.3.1         551         0x80000001  2001:DB8:ACAD:2001::/64
 3.3.3.1         512         0x80000001  2001:DB8:ACAD:2002::/64

                Link (Type-8) Link States (Area 0)

ADV Router       Age         Seq#        Link ID    Interface
 1.1.1.1         578         0x80000002  5          Gi0/0/0
 2.2.2.1         578         0x80000002  5          Gi0/0/0

                Intra Area Prefix Link States (Area 0)

ADV Router       Age         Seq#        Link ID    Ref-lstype  Ref-LSID
 2.2.2.1         539         0x80000001  5120       0x2002      5
 3.3.3.1         511         0x80000001  5120       0x2002      5

                Router Link States (Area 1)

ADV Router       Age         Seq#        Fragment ID  Link count  Bits
 1.1.1.1         553         0x80000006  0            1           B
 1.1.1.2         552         0x80000025  0            1           None

                Net Link States (Area 1)

ADV Router       Age         Seq#        Link ID    Rtr count
 1.1.1.2         560         0x80000001  38         2

                Inter Area Prefix Link States (Area 1)

ADV Router       Age         Seq#        Prefix
 1.1.1.1         578         0x80000001  2001:DB8:ACAD:A001::/64
 1.1.1.1         538         0x80000001  2001:DB8:ACAD:A002::/64
 1.1.1.1         506         0x80000001  2001:DB8:ACAD:2002::/64
 1.1.1.1         506         0x80000001  2001:DB8:ACAD:2001::/64

                Link (Type-8) Link States (Area 1)
```

```
ADV Router       Age         Seq#        Link ID    Interface
 1.1.1.1         559         0x8000000C  6          Gi0/0/1
 1.1.1.2         598         0x80000002  38         Gi0/0/1

                Intra Area Prefix Link States (Area 1)

ADV Router       Age         Seq#        Link ID    Ref-lstype  Ref-LSID
 1.1.1.2         481         0x80000016  0          0x2001      0
 1.1.1.2         560         0x80000001  38912      0x2002      38
```

What would the **show ipv6 route database** command display on R1, if anything?

Part 5: Tune OSPFv3

Step 1: Configuring a passive interface.

a. To configure a passive interface in traditional OSPFv3, use the **passive-interface** command in OSPFv3 router mode.

```
D1(config)# ipv6 router ospf 123
D1(config-rtr)# passive-interface g1/0/23
```

b. To configure a passive interface in OSPFv3 with AF, you can use the **passive-interface** command in OSPFv3 router mode to configure the passive interface for both IPv4 and IPv6 AFs.

```
D2(config)# router ospfv3 123
D2(config-router)# passive-interface g1/0/23
```

c. As an alternative, you can use the **passive-interface** command within AF configuration mode to configure the passive interface for a specific AFs.

```
D2(config-router)# no passive-interface g1/0/23
D2(config-router)# address-family ipv4 unicast
D2(config-router-af)# passive-interface g1/0/23
D2(config-router-af)# exit-address-family
D2(config-router)# address-family ipv6 unicast
D2(config-router-af)# passive-interface g1/0/23
D2(config-router-af)# exit-address-family
```

Step 2: Configuring summarization.

a. The **area** *area* **range** *ipv6-summary-address* command is used to summarize prefixes from one are into another. The *area* is the area from which the prefixes are summarized.

```
R1(config)# router ospfv3 123
R1(config-router)# address-family ipv6 unicast
R1(config-router-af)# area 1 range 2001:db8:acad:1000::/52

R3(config)# router ospfv3 123
R3(config-router)# address-family ipv6 unicast
R3(config-router-af)# area 2 range 2001:db8:acad:2000::/52
```

b. Notice that R2 is now receiving the summarized prefixes.

```
R2# show ipv6 route ospf
<output omitted>
OI   2001:DB8:ACAD:1000::/52 [110/3]
     via FE80::1:2, GigabitEthernet0/0/0
OI   2001:DB8:ACAD:2000::/52 [110/3]
     via FE80::3:2, GigabitEthernet0/0/1
```

Why is prefix summarization considered desirable? How does it stabilize routing?

Step 3: Modifying the network type.

a. OSPFv3 supports the same network types as OSPFv2. Notice that the Ethernet interfaces between R2 and R1, and R2 and R3, elect a DR and a BDR. This is because Ethernet is a multiaccess network. However, these are point-to-point links and there is no need for a DR or BDR.

```
R2# show ospfv3 interface brief
Interface     PID   Area            AF         Cost  State Nbrs F/C
Gi0/0/1       123   0               ipv4       1     BDR   1/1
Gi0/0/0       123   0               ipv4       1     DR    1/1
Gi0/0/1       123   0               ipv6       1     BDR   1/1
Gi0/0/0       123   0               ipv6       1     DR    1/1
```

b. These connections can be changed to point-to-point using the **ospfv3 network point-to-point** interface command. This command needs to be configured one both sides of the point to point interface.

```
R2(config)# interface g0/0/1
R2(config-if)# ospfv3 network point-to-point
R2(config-if)# exit
R2(config)# interface g0/0/0
R2(config-if)# ospfv3 network point-to-point

R1(config)# interface g0/0/0
R1(config-if)# ospfv3 network point-to-point

R3(config)# interface g0/0/0
R3(config-if)# ospfv3 network point-to-point
```

c. Notice that the links have now change to P2P.

```
R2# show ospfv3 interface brief
Interface     PID   Area            AF         Cost  State Nbrs F/C
Gi0/0/1       123   0               ipv4       1     P2P   1/1
Gi0/0/0       123   0               ipv4       1     P2P   1/1
Gi0/0/1       123   0               ipv6       1     P2P   1/1
Gi0/0/0       123   0               ipv6       1     P2P   1/1
```

What is the effect on the state of the interface when changing a broadcast network to point-to-point?

Step 4: Advertising a default route.

a. Similar to OSPFv2, an ASBR in OSPFv3 advertises using the **default-information** command. Configure a static default route for IPv4 and IPv6 on R2.

Note: Without a default route in the routing table, OSPF would require the **default-information originate always** command to advertise a default route.

```
R2(config)# ipv6 route ::/0 lo0
R2(config)# ip route 0.0.0.0 0.0.0.0 lo0

R2(config)# router ospfv3 123
R2(config-router)# address-family ipv6 unicast
R2(config-router-af)# default-information originate
R2(config-router-af)# exit
R2(config-router)# address-family ipv4 unicast
R2(config-router-af)# default-information originate
R2(config-router-af)# exit
```

b. Verify D1 is receiving an IPv6 default route via OSPFv3.

```
D1# show ipv6 route ospf
<output omitted>
OE2 ::/0 [110/1], tag 123
     via FE80::1:1, GigabitEthernet1/0/11
OI  2001:DB8:ACAD:2000::/52 [110/5]
     via FE80::1:1, GigabitEthernet1/0/11
OI  2001:DB8:ACAD:A001::/64 [110/2]
     via FE80::1:1, GigabitEthernet1/0/11
OI  2001:DB8:ACAD:A002::/64 [110/3]
     via FE80::1:1, GigabitEthernet1/0/11
```

c. Verify D2 is receiving an IPv4 default route via OSPFv3.

```
D2# show ip route ospfv3
<output omitted>
Gateway of last resort is 10.10.4.1 to network 0.0.0.0

O*E2  0.0.0.0/0 [110/1] via 10.10.4.1, 00:01:13, GigabitEthernet1/0/11
      172.16.0.0/30 is subnetted, 2 subnets
O IA     172.16.0.0 [110/3] via 10.10.4.1, 00:02:55, GigabitEthernet1/0/11
O IA     172.16.1.0 [110/2] via 10.10.4.1, 00:20:22, GigabitEthernet1/0/11
```

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.