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Advanced Cisco CCNP Networking

Multi-Area OSPF Configuration

Lab 2

Purpose
The purpose of this lab was to learn how to implement multi-area OSPF.

Background Information on Lab Concepts
OSPF (Open Shortest Path First) is a routing protocol (for IPV4 and IPV6) used to distribute traffic in a network. Notably, OSPF is a link-state protocol. This means OSPF has full awareness of the topology of its network by sending position requests (or LSA's) to each router on the network. It essentially has a picture of all the devices in the area, allowing it to find the shortest path to route traffic. The method OSPF uses to find the shortest path between links is called Dijkstra's Algorithm. Dijkstra's Algorithm is generally used to find the shortest path between two points, and it is frequently utilized in GPS apps such as Google Maps. To understand how OSPF uses Dijkstra's Algorithm, imagine you are in a large maze and must deliver envelopes to mailboxes scattered throughout the maze. While walking through the maze, you discover a mailbox, and deliver your first envelope. Eventually, after an extended period of time, you find all of the mailboxes and deliver all of your envelopes. When you are given a new set of envelopes to deliver, you enter the maze again, but this time you remember the position of the mailboxes from your last time entering the maze. Since you remember the mailbox positions, you can deliver the envelopes faster. Eventually, after multiple series of delivering the envelopes, you have learned the layout of the mailboxes and maze. Therefore, you can efficiently deliver the envelopes. OSPF works the same way. Instead of delivering envelopes to mailboxes, OSPF delivers packets to routers. Overtime, it learns the topology (or maze) of the network and finds the shortest path between routers using Dijkstra's Algorithm. By having a full picture of the network and knowing the shortest path between routers, OSPF can quickly route traffic. Single area OSPF is commonly used in small networks, while multi-area OSPF is used in larger networks (20-30 routers). The advantage of multi-area OSPF in large networks is decreased CPU usage as a result of a smaller routing table. Using the above analogy, instead of having to remember one large maze with a bunch of mailboxes, you only have to remember the locations of a few mailboxes in one area of the maze.

Lab Summary
We first created a topology and labeled our desired areas for the OSPF configuration. We then subnetted all of the networks required in these areas. After we created a document with the config for each router in the network, we tested our configuration using packet tracer and debugged accordingly. Once the simulated multi-area OSPF configuration functioned perfectly in packet tracer, we moved to setting up the network on the CCNP lab equipment. We connected the routers according to our topology. We found our configuration did not function perfectly on the CCNP lab equipment, so we proceeded to debug. To test our setup, we pinged the loopback interfaces and IP addresses of all the routers from each router. Using this system, we were able to identify the errors and fix them. A modification we made to OSPF was changing the dead interval timer to 80 seconds on each router.

Lab Commands
```
Router> enable
```
Turns on privileged exec mode which allows changes to be made to the router.

```
Router# config t
```
Enters the router config file and allows you to make changes to the router configuration file.

```
Router# copy run start
```
Saves the running-configuration (current config on the router, includes the edits you have made during the session, clears when the router powers off) to the startup-configuration (file that router pulls running-config from on bootup, default config)

```
Router# show ip route
```

Displays information about the various routes that are available to the router, including the protocol by which the route was acquired (OSPF, RIP, EGRIP, static, etc.)

Router# show **ip ospf**
Displays general information about all OSPF instances and roles on the router

Router# show **ip ospf interface**
Displays the OSPF status of all OSPF-enabled interfaces on the router

Router# show **ip route**
Displays information about the various routes that are available to the router, including the protocol by which the route was acquired (OSPF, RIP, EGRIP, static, etc.)

Router# show **ip ospf neighbor**
Displays the OSPF status of routers that are directly connected and OSPF-enabled

Router(config)# **interface** [*interface*] [*id*]
Enables configuration on a specific interface.

Router(config)# **router ospf** [*process id*]
Enables the OSPF routing protocol and enters router configuration mode.
It is good practice for the process ID to be the same, however isn't necessary for OSPF to form adjacencies; process ID is only locally significant. Each OSPF process retains a different routing table, so depending on the configuration, process ID could determine what routes are redistributed. A router can have multiple OSPF processes but will contain a separate OSPF database per process.

Router(config-router)# **network** [*network address*] [*wildcard mask*] area [*area number*]
Activates OSPFv2 for a specific subnet.
This command is typed after you enter router OSPF configuration mode. Routers in a particular area share a complete topological database and have route summaries of external areas.

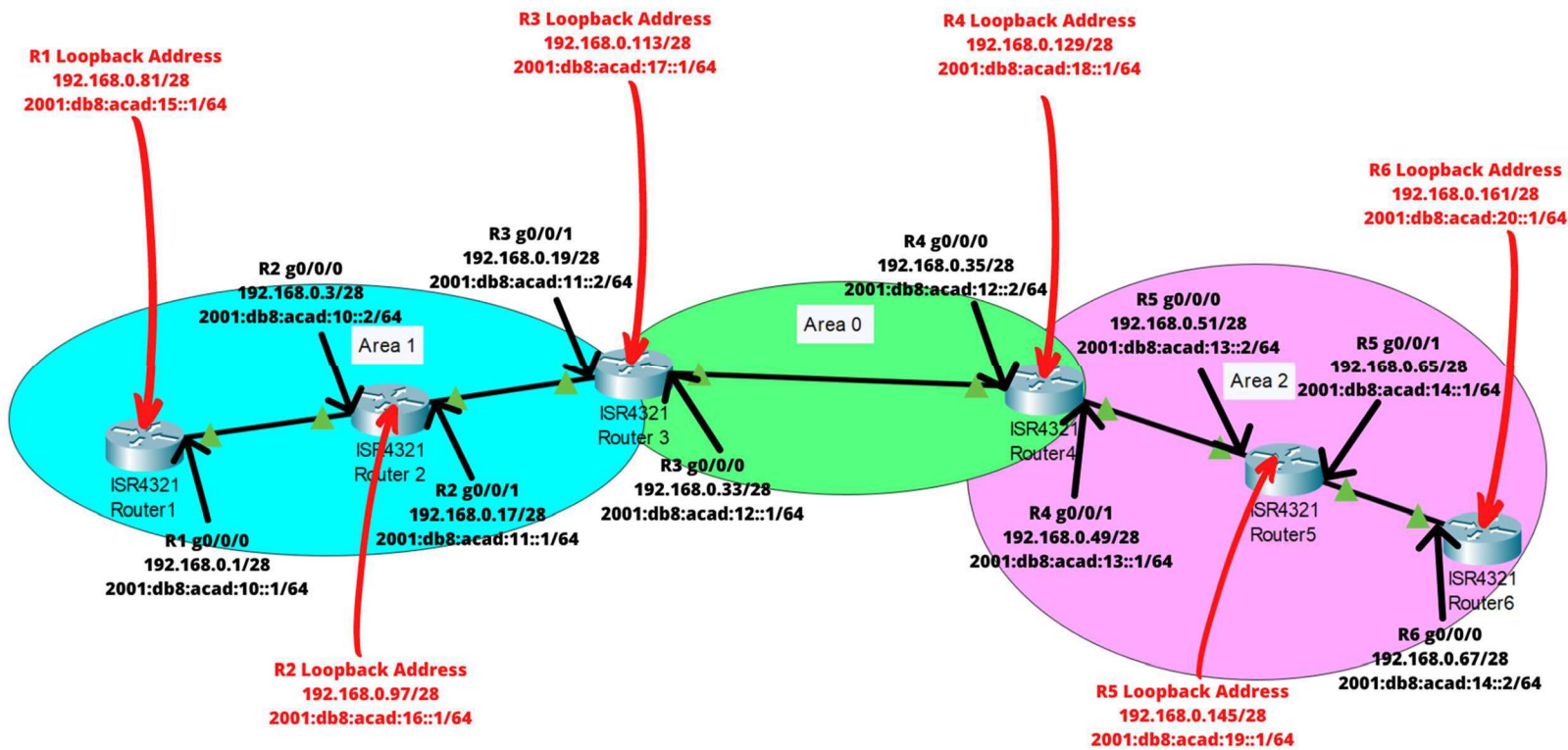Router(config-if)# **ip ospf dead-interval** [*interval time in seconds*]
Modifies the timer valuer for the OSPF dead-interval. If an interface stops sending hello packets, other routers will use this timer to determine when to remove it from the SPF tree.

Router(config-if)# **ipv6 ospf** [*process id*] area [*number*]
Activates OSPFv3 under a specific interface.
This command is typed when in interface configuration mode. It is good practice for the process ID to be the same, however isn't necessary for OSPF to form adjacencies; process ID is only locally significant. Each OSPF process retains a different routing table, so depending on the configuration, process ID could determine what routes are redistributed. A router can have multiple OSPF processes but will contain a separate OSPF database per process. Routers in a particular area share a complete topological database and have route summaries of external areas.

Network Diagram with IP's

R1 Loopback Address
192.168.0.81/28
2001:db8:acad:15::1/64

R3 Loopback Address
192.168.0.113/28
2001:db8:acad:17::1/64

R4 Loopback Address
192.168.0.129/28
2001:db8:acad:18::1/64

R6 Loopback Address
192.168.0.161/28
2001:db8:acad:20::1/64

R3 g0/0/1
192.168.0.19/28
2001:db8:acad:11::2/64

R2 g0/0/0
192.168.0.3/28
2001:db8:acad:10::2/64

R4 g0/0/0
192.168.0.35/28
2001:db8:acad:12::2/64

R5 g0/0/0
192.168.0.51/28
2001:db8:acad:13::2/64

R5 g0/0/1
192.168.0.65/28
2001:db8:acad:14::1/64

Area 0

Area 1

Area 2

ISR4321
Router 3

ISR4321
Router 2

ISR4321
Router4

ISR4321
Router5

ISR4321
Router1

R3 g0/0/0
192.168.0.33/28
2001:db8:acad:12::1/64

R2 g0/0/1
192.168.0.17/28
2001:db8:acad:11::1/64

R4 g0/0/1
192.168.0.49/28
2001:db8:acad:13::1/64

R1 g0/0/0
192.168.0.1/28
2001:db8:acad:10::1/64

ISR4321
Router6

R6 g0/0/0
192.168.0.67/28
2001:db8:acad:14::2/64

R2 Loopback Address
192.168.0.97/28
2001:db8:acad:16::1/64

R5 Loopback Address
192.168.0.145/28
2001:db8:acad:19::1/64

Configurations

Router 1:

```
R1#show run
Building configuration...
Current configuration : 1762 bytes
Last configuration change at 18:27:00
UTC Tue Sep 28 2021
version 15.5
service timestamps debug datetime
msec
service timestamps log datetime msec
no platform punt-keepalive disable-
kernel-core
hostname R1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
address-family ipv4
exit-address-family
address-family ipv6
exit-address-family
no aaa new-model
ipv6 unicast-routing
subscriber templating
```

```
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FDO21482
DXE
spanning-tree extend system-id
redundancy
mode none
vlan internal allocation policy
ascending
interface Loopback0
ip address 192.168.0.81
255.255.255.240
ipv6 address 2001:DB8:ACAD:15::1/64
ipv6 ospf 10 area 1
interface GigabitEthernet0/0/0
ip address 192.168.0.1
255.255.255.240
negotiation auto
ipv6 address 2001:DB8:ACAD:10::1/64
ipv6 ospf 10 area 1
interface GigabitEthernet0/0/1
no ip address
shutdown
```

```
negotiation auto                                no ip address
interface Serial0/1/0                           shutdown
no ip address                                   router ospf 10
shutdown                                        network 192.168.0.0 0.0.0.15 area 1
interface Serial0/1/1                           network 192.168.0.80 0.0.0.15 area 1
no ip address                                   ip forward-protocol nd
shutdown                                        no ip http server
interface GigabitEthernet0/2/0                  no ip http secure-server
no ip address                                   ip tftp source-interface
shutdown                                        GigabitEthernet0
negotiation auto                                ipv6 router ospf 10
interface GigabitEthernet0/2/1                  router-id 1.1.1.1
no ip address                                   control-plane
shutdown                                        line con 0
negotiation auto                                stopbits 1
interface GigabitEthernet0                      line aux 0
vrf forwarding Mgmt-intf                         stopbits 1
no ip address                                   line vty 0 4
shutdown                                        login
negotiation auto                                End
interface Vlan1
R1#show ip route
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


      192.168.0.0/24 is variably subnetted, 13 subnets, 2 masks
C        192.168.0.0/28 is directly connected, GigabitEthernet0/0/0
L        192.168.0.1/32 is directly connected, GigabitEthernet0/0/0
O  192.168.0.16/28
           [110/2] via 192.168.0.3, 00:12:50, GigabitEthernet0/0/0
O IA     192.168.0.32/28
           [110/3] via 192.168.0.3, 00:12:50, GigabitEthernet0/0/0
O IA     192.168.0.48/28
           [110/4] via 192.168.0.3, 00:12:31, GigabitEthernet0/0/0
O IA     192.168.0.64/28
           [110/5] via 192.168.0.3, 00:12:05, GigabitEthernet0/0/0
C        192.168.0.80/28 is directly connected, Loopback0
L        192.168.0.81/32 is directly connected, Loopback0
O        192.168.0.97/32
           [110/2] via 192.168.0.3, 00:13:00, GigabitEthernet0/0/0
O        192.168.0.113/32
           [110/3] via 192.168.0.3, 00:12:50, GigabitEthernet0/0/0
O IA     192.168.0.129/32
           [110/4] via 192.168.0.3, 00:12:31, GigabitEthernet0/0/0
O IA     192.168.0.145/32
           [110/5] via 192.168.0.3, 00:12:05, GigabitEthernet0/0/0
```

```
O IA    192.168.0.161/32
            [110/6] via 192.168.0.3, 00:11:31, GigabitEthernet0/0/0

R1#show ipv6 route
IPv6 Routing Table - default - 14 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, 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
       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
C   2001:DB8:ACAD:10::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L   2001:DB8:ACAD:10::1/128 [0/0]
     via GigabitEthernet0/0/0, receive
O   2001:DB8:ACAD:11::/64 [110/2]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:12::/64 [110/3]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:13::/64 [110/4]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:14::/64 [110/5]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
C   2001:DB8:ACAD:15::/64 [0/0]
     via Loopback0, directly connected
L   2001:DB8:ACAD:15::1/128 [0/0]
     via Loopback0, receive
O   2001:DB8:ACAD:16::1/128 [110/1]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
O   2001:DB8:ACAD:17::1/128 [110/2]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:18::1/128 [110/3]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:19::1/128 [110/4]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:20::1/128 [110/5]
     via FE80::521C:B0FF:FE63:3830, GigabitEthernet0/0/0
L   FF00::/8 [0/0]
     via Null0, receive

R1#show ip ospf neighbor

Neighbor ID      Pri   State            Dead Time    Address          Interface
192.168.0.97      1    FULL/DR          00:00:39     192.168.0.3      GigabitEthernet
0/0/0

R1#show ipv6 ospf neighbor

           OSPFv3 Router with ID (1.1.1.1) (Process ID 10)

Neighbor ID      Pri   State            Dead Time    Interface ID    Interface
2.2.2.2           1    FULL/DR          00:00:39     6               GigabitEthernet
0/0/0
```

```
R1#show ip ospf interface
Loopback0 is up, line protocol is up
  Internet Address 192.168.0.81/28, Area 1, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.81, Network Type LOOPBACK, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
         0           1         no          no           Base
  Loopback interface is treated as a stub Host
GigabitEthernet0/0/0 is up, line protocol is up
  Internet Address 192.168.0.1/28, Area 1, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.81, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
         0           1         no          no           Base
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.0.97, Interface address 192.168.0.3
  Backup Designated router (ID) 192.168.0.81, Interface address 192.168.0.1
  Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:02
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/2/2, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.0.97  (Designated Router)
  Suppress hello for 0 neighbor(s)
R1#show ipv6 ospf interface
Loopback0 is up, line protocol is up
  Link Local Address FE80::521C:B0FF:FE2C:5100, Interface ID 14
  Area 1, Process ID 10, Instance ID 0, Router ID 1.1.1.1
  Network Type LOOPBACK, Cost: 1
  Loopback interface is treated as a stub Host
GigabitEthernet0/0/0 is up, line protocol is up
  Link Local Address FE80::521C:B0FF:FE2C:5100, Interface ID 6
  Area 1, Process ID 10, Instance ID 0, Router ID 1.1.1.1
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 2.2.2.2, local address FE80::521C:B0FF:FE63:3830
  Backup Designated router (ID) 1.1.1.1, local address
FE80::521C:B0FF:FE2C:5100
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
  Graceful restart helper support enabled
  Index 1/2/2, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 2, maximum is 2
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 2.2.2.2  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

Router 2:
```
R2#show run                           Building configuration...
                                      Current configuration : 1986 bytes
```

```
Last configuration change at 18:15:00          no ip address
UTC Tue Sep 28 2021                             shutdown
version 15.5                                    interface Serial0/1/1
service timestamps debug datetime msec         no ip address
service timestamps log datetime msec           shutdown
no platform punt-keepalive disable-            interface GigabitEthernet0/2/0
kernel-core                                     no ip address
hostname R2                                     shutdown
boot-start-marker                               negotiation auto
boot-end-marker                                 interface GigabitEthernet0/2/1
vrf definition Mgmt-intf                        no ip address
address-family ipv4                             shutdown
exit-address-family                             negotiation auto
address-family ipv6                             interface GigabitEthernet0
exit-address-family                             vrf forwarding Mgmt-intf
no aaa new-model                                no ip address
ipv6 unicast-routing                            shutdown
subscriber templating                           negotiation auto
multilink bundle-name authenticated             interface Vlan1
license udi pid ISR4321/K9 sn                   no ip address
FDO21500G1N                                     shutdown
spanning-tree extend system-id                  router ospf 10
redundancy                                      network 192.168.0.0 0.0.0.15 area 1
mode none                                       network 192.168.0.16 0.0.0.15 area 1
vlan internal allocation policy                 network 192.168.0.80 0.0.0.15 area 1
ascending                                       network 192.168.0.96 0.0.0.15 area 1
interface Loopback0                             ip forward-protocol nd
ip address 192.168.0.97 255.255.255.240         no ip http server
ipv6 address 2001:DB8:ACAD:15::1/64             no ip http secure-server
ipv6 address 2001:DB8:ACAD:16::1/64             ip tftp source-interface
ipv6 ospf 10 area 1                             GigabitEthernet0
interface GigabitEthernet0/0/0                  ipv6 router ospf 10
ip address 192.168.0.3 255.255.255.240          router-id 2.2.2.2
negotiation auto                                control-plane
ipv6 address 2001:DB8:ACAD:10::1/64             line con 0
ipv6 address 2001:DB8:ACAD:10::2/64             stopbits 1
ipv6 ospf 10 area 1                             line aux 0
interface GigabitEthernet0/0/1                  stopbits 1
ip address 192.168.0.17 255.255.255.240         line vty 0 4
negotiation auto                                login
ipv6 address 2001:DB8:ACAD:11::1/64             End
ipv6 ospf 10 area 1
interface Serial0/1/0


R2# show ip route
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

      192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks
C        192.168.0.0/28 is directly connected, GigabitEthernet0/0/0
L        192.168.0.3/32 is directly connected, GigabitEthernet0/0/0
C        192.168.0.16/28 is directly connected, GigabitEthernet0/0/1
L        192.168.0.17/32 is directly connected, GigabitEthernet0/0/1
O IA     192.168.0.32/28
            [110/2] via 192.168.0.19, 00:17:40, GigabitEthernet0/0/1
O IA     192.168.0.48/28
            [110/3] via 192.168.0.19, 00:17:21, GigabitEthernet0/0/1
O IA     192.168.0.64/28
            [110/4] via 192.168.0.19, 00:16:55, GigabitEthernet0/0/1
O        192.168.0.81/32
            [110/2] via 192.168.0.1, 00:17:50, GigabitEthernet0/0/0
C        192.168.0.96/28 is directly connected, Loopback0
L        192.168.0.97/32 is directly connected, Loopback0
O        192.168.0.113/32
            [110/2] via 192.168.0.19, 00:17:40, GigabitEthernet0/0/1
O IA     192.168.0.129/32
            [110/3] via 192.168.0.19, 00:17:21, GigabitEthernet0/0/1
O IA     192.168.0.145/32
            [110/4] via 192.168.0.19, 00:16:55, GigabitEthernet0/0/1
O IA     192.168.0.161/32
            [110/5] via 192.168.0.19, 00:16:21, GigabitEthernet0/0/1


R2# show ipv6 route
IPv6 Routing Table - default - 16 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, 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
       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
C   2001:DB8:ACAD:10::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L   2001:DB8:ACAD:10::2/128 [0/0]
     via GigabitEthernet0/0/0, receive
C   2001:DB8:ACAD:11::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
L   2001:DB8:ACAD:11::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
OI  2001:DB8:ACAD:12::/64 [110/2]
     via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
OI  2001:DB8:ACAD:13::/64 [110/3]
     via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
OI  2001:DB8:ACAD:14::/64 [110/4]
     via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
C   2001:DB8:ACAD:15::/64 [0/0]
     via Loopback0, directly connected
L   2001:DB8:ACAD:15::1/128 [0/0]
     via Loopback0, receive
C   2001:DB8:ACAD:16::/64 [0/0]
     via Loopback0, directly connected
L   2001:DB8:ACAD:16::1/128 [0/0]
```

```
       via Loopback0, receive
O    2001:DB8:ACAD:17::1/128 [110/1]
       via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
OI   2001:DB8:ACAD:18::1/128 [110/2]
       via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
OI   2001:DB8:ACAD:19::1/128 [110/3]
       via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
OI   2001:DB8:ACAD:20::1/128 [110/4]
       via FE80::B6A8:B9FF:FE47:9231, GigabitEthernet0/0/1
L    FF00::/8 [0/0]
       via Null0, receive


R2#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time   Address         Interface
192.168.0.113     1    FULL/DR         00:00:37    192.168.0.19
GigabitEthernet0/0/1
192.168.0.81      1    FULL/BDR        00:00:32    192.168.0.1
GigabitEthernet0/0/0

R2#show ipv6 ospf neighbor

          OSPFv3 Router with ID (2.2.2.2) (Process ID 10)

Neighbor ID      Pri   State           Dead Time   Interface ID    Interface
3.3.3.3           1    FULL/DR         00:00:38    7
GigabitEthernet0/0/1
1.1.1.1           1    FULL/BDR        00:00:30    6
GigabitEthernet0/0/0

R2#show ip ospf
Routing Process "ospf 10" with ID 192.168.0.97
Start time: 00:01:48.289, Time elapsed: 00:19:20.646
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
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 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
EXCHANGE/LOADING adjacency limit: initial 300, process maximum 300
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
```

```
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
    Area 1
        Number of interfaces in this area is 3 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:18:04.707 ago
        SPF algorithm executed 5 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x0637D5
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0


R2#show ipv6 ospf
Routing Process "ospfv3 10" with ID 2.2.2.2
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 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 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 3
        SPF algorithm executed 3 times
        Number of LSA 20. Checksum Sum 0x0A8BF2
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0


R2#show ip ospf interface
Loopback0 is up, line protocol is up
  Internet Address 192.168.0.97/28, Area 1, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.97, Network Type LOOPBACK, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no             Base
```

```
    Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
   Internet Address 192.168.0.17/28, Area 1, Attached via Network Statement
   Process ID 10, Router ID 192.168.0.97, Network Type BROADCAST, Cost: 1
   Topology-MTID    Cost     Disabled     Shutdown      Topology Name
         0            1         no           no             Base
   Transmit Delay is 1 sec, State BDR, Priority 1
   Designated Router (ID) 192.168.0.113, Interface address 192.168.0.19
   Backup Designated router (ID) 192.168.0.97, Interface address 192.168.0.17
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
     oob-resync timeout 40
     Hello due in 00:00:00
   Supports Link-local Signaling (LLS)
   Cisco NSF helper support enabled
   IETF NSF helper support enabled
   Index 1/3/3, flood queue length 0
   Next 0x0(0)/0x0(0)/0x0(0)
   Last flood scan length is 1, maximum is 1
   Last flood scan time is 0 msec, maximum is 0 msec
   Neighbor Count is 1, Adjacent neighbor count is 1
     Adjacent with neighbor 192.168.0.113  (Designated Router)
   Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/0 is up, line protocol is up
   Internet Address 192.168.0.3/28, Area 1, Attached via Network Statement
   Process ID 10, Router ID 192.168.0.97, Network Type BROADCAST, Cost: 1
   Topology-MTID    Cost     Disabled     Shutdown      Topology Name
         0            1         no           no             Base
   Transmit Delay is 1 sec, State DR, Priority 1
   Designated Router (ID) 192.168.0.97, Interface address 192.168.0.3
   Backup Designated router (ID) 192.168.0.81, Interface address 192.168.0.1
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
     oob-resync timeout 40
     Hello due in 00:00:06
   Supports Link-local Signaling (LLS)
   Cisco NSF helper support enabled
   IETF NSF helper support enabled
   Index 1/2/2, flood queue length 0
   Next 0x0(0)/0x0(0)/0x0(0)
   Last flood scan length is 1, maximum is 2
   Last flood scan time is 0 msec, maximum is 1 msec
   Neighbor Count is 1, Adjacent neighbor count is 1
     Adjacent with neighbor 192.168.0.81  (Backup Designated Router)
   Suppress hello for 0 neighbor(s)
R2#show ipv6 ospf interface
Loopback0 is up, line protocol is up
   Link Local Address FE80::521C:B0FF:FE63:3830, Interface ID 14
   Area 1, Process ID 10, Instance ID 0, Router ID 2.2.2.2
   Network Type LOOPBACK, Cost: 1
   Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
   Link Local Address FE80::521C:B0FF:FE63:3831, Interface ID 7
   Area 1, Process ID 10, Instance ID 0, Router ID 2.2.2.2
   Network Type BROADCAST, Cost: 1
   Transmit Delay is 1 sec, State BDR, Priority 1
   Designated Router (ID) 3.3.3.3, local address FE80::B6A8:B9FF:FE47:9231
```

```
  Backup Designated router (ID) 2.2.2.2, local address FE80::521C:B0FF:FE63:3831
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
  Graceful restart helper support enabled
  Index 1/3/3, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 2, maximum is 2
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 3.3.3.3  (Designated Router)
  Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/0 is up, line protocol is up
  Link Local Address FE80::521C:B0FF:FE63:3830, Interface ID 6
  Area 1, Process ID 10, Instance ID 0, Router ID 2.2.2.2
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.2, local address FE80::521C:B0FF:FE63:3830
  Backup Designated router (ID) 1.1.1.1, local address FE80::521C:B0FF:FE2C:5100
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Graceful restart helper support enabled
  Index 1/2/2, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 6
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 1.1.1.1  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
```

Router 3:

```
R3#show run
Building configuration...
Current configuration : 1763 bytes
Last configuration change at 18:25:51
UTC Tue Sep 28 2021
version 15.5
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-
kernel-core
hostname R3
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
address-family ipv4
exit-address-family
address-family ipv6
exit-address-family
no aaa new-model
ipv6 unicast-routing
subscriber templating
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn
FDO21441WDF
spanning-tree extend system-id

redundancy
mode none
vlan internal allocation policy
ascending
interface Loopback0
ip address 192.168.0.113 255.255.255.240
ipv6 address 2001:DB8:ACAD:17::1/64
ipv6 ospf 10 area 1
interface GigabitEthernet0/0/0
ip address 192.168.0.33 255.255.255.240
negotiation auto
ipv6 address 2001:DB8:ACAD:12::1/64
ipv6 ospf 10 area 0
interface GigabitEthernet0/0/1
ip address 192.168.0.19 255.255.255.240
negotiation auto
ipv6 address 2001:DB8:ACAD:11::2/64
ipv6 ospf 10 area 1
interface Serial0/1/0
no ip address
shutdown
interface Serial0/1/1
no ip address
shutdown
interface GigabitEthernet0
vrf forwarding Mgmt-intf
no ip address
```

```
shutdown                                ip tftp source-interface
negotiation auto                        GigabitEthernet0
interface Vlan1                         ipv6 router ospf 10
no ip address                           router-id 3.3.3.3
shutdown                                control-plane
router ospf 10                          line con 0
network 192.168.0.0 0.0.0.15 area 1     stopbits 1
network 192.168.0.16 0.0.0.15 area 1    line aux 0
network 192.168.0.32 0.0.0.15 area 0    stopbits 1
network 192.168.0.112 0.0.0.15 area 1   line vty 0 4
ip forward-protocol nd                  login
no ip http server                       end
no ip http secure-server
```

```
  R3#show ip route
  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

      192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks
O        192.168.0.0/28
            [110/2] via 192.168.0.17, 00:19:22, GigabitEthernet0/0/1
C        192.168.0.16/28 is directly connected, GigabitEthernet0/0/1
L        192.168.0.19/32 is directly connected, GigabitEthernet0/0/1
C        192.168.0.32/28 is directly connected, GigabitEthernet0/0/0
L        192.168.0.33/32 is directly connected, GigabitEthernet0/0/0
O IA     192.168.0.48/28
            [110/2] via 192.168.0.35, 00:18:58, GigabitEthernet0/0/0
O IA     192.168.0.64/28
            [110/3] via 192.168.0.35, 00:18:32, GigabitEthernet0/0/0
O        192.168.0.81/32
            [110/3] via 192.168.0.17, 00:19:22, GigabitEthernet0/0/1
O        192.168.0.97/32
            [110/2] via 192.168.0.17, 00:19:22, GigabitEthernet0/0/1
C        192.168.0.112/28 is directly connected, Loopback0
L        192.168.0.113/32 is directly connected, Loopback0
O IA     192.168.0.129/32
            [110/2] via 192.168.0.35, 00:18:58, GigabitEthernet0/0/0
O IA     192.168.0.145/32
            [110/3] via 192.168.0.35, 00:18:32, GigabitEthernet0/0/0
O IA     192.168.0.161/32
            [110/4] via 192.168.0.35, 00:17:58, GigabitEthernet0/0/0


  R3#show ipv6 route
  IPv6 Routing Table - default - 15 entries
  Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
         B - BGP, R - RIP, 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
         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:10::/64 [110/2]
      via FE80::521C:B0FF:FE63:3831, GigabitEthernet0/0/1
C    2001:DB8:ACAD:11::/64 [0/0]
      via GigabitEthernet0/0/1, directly connected
L    2001:DB8:ACAD:11::2/128 [0/0]
      via GigabitEthernet0/0/1, receive
C    2001:DB8:ACAD:12::/64 [0/0]
      via GigabitEthernet0/0/0, directly connected
L    2001:DB8:ACAD:12::1/128 [0/0]
      via GigabitEthernet0/0/0, receive
OI   2001:DB8:ACAD:13::/64 [110/2]
      via FE80::CE8E:71FF:FE1E:22E0, GigabitEthernet0/0/0
OI   2001:DB8:ACAD:14::/64 [110/3]
      via FE80::CE8E:71FF:FE1E:22E0, GigabitEthernet0/0/0
O    2001:DB8:ACAD:15::1/128 [110/1]
      via FE80::521C:B0FF:FE63:3831, GigabitEthernet0/0/1
O    2001:DB8:ACAD:16::1/128 [110/1]
      via FE80::521C:B0FF:FE63:3831, GigabitEthernet0/0/1
C    2001:DB8:ACAD:17::/64 [0/0]
      via Loopback0, directly connected
L    2001:DB8:ACAD:17::1/128 [0/0]
      via Loopback0, receive
OI   2001:DB8:ACAD:18::1/128 [110/1]
      via FE80::CE8E:71FF:FE1E:22E0, GigabitEthernet0/0/0
OI   2001:DB8:ACAD:19::1/128 [110/2]
      via FE80::CE8E:71FF:FE1E:22E0, GigabitEthernet0/0/0
OI   2001:DB8:ACAD:20::1/128 [110/3]
      via FE80::CE8E:71FF:FE1E:22E0, GigabitEthernet0/0/0
L    FF00::/8 [0/0]
      via Null0, receive


R3#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.0.129    1    FULL/DR         00:00:39    192.168.0.35
GigabitEthernet0/0/0
192.168.0.97     1    FULL/BDR        00:00:39    192.168.0.17
GigabitEthernet0/0/1
R3#show ipv6 ospf neighbor

          OSPFv3 Router with ID (3.3.3.3) (Process ID 10)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
4.4.4.4          1    FULL/DR         00:00:38    6
GigabitEthernet0/0/0
2.2.2.2          1    FULL/BDR        00:00:34    7
GigabitEthernet0/0/1


R3#show ip ospf interface
GigabitEthernet0/0/0 is up, line protocol is up
```

```
    Internet Address 192.168.0.33/28, Area 0, Attached via Network Statement
    Process ID 10, Router ID 192.168.0.113, Network Type BROADCAST, Cost: 1
    Topology-MTID    Cost    Disabled    Shutdown      Topology Name
         0            1         no          no             Base
    Transmit Delay is 1 sec, State BDR, Priority 1
    Designated Router (ID) 192.168.0.129, Interface address 192.168.0.35
    Backup Designated router (ID) 192.168.0.113, Interface address 192.168.0.33
    Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
      oob-resync timeout 40
      Hello due in 00:00:00
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    Index 1/1/3, flood queue length 0
    Next 0x0(0)/0x0(0)/0x0(0)
    Last flood scan length is 1, maximum is 1
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 1, Adjacent neighbor count is 1
      Adjacent with neighbor 192.168.0.129  (Designated Router)
    Suppress hello for 0 neighbor(s)
Loopback0 is up, line protocol is up
    Internet Address 192.168.0.113/28, Area 1, Attached via Network Statement
    Process ID 10, Router ID 192.168.0.113, Network Type LOOPBACK, Cost: 1
    Topology-MTID    Cost    Disabled    Shutdown      Topology Name
         0            1         no          no             Base
    Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
    Internet Address 192.168.0.19/28, Area 1, Attached via Network Statement
    Process ID 10, Router ID 192.168.0.113, Network Type BROADCAST, Cost: 1
    Topology-MTID    Cost    Disabled    Shutdown      Topology Name
         0            1         no          no             Base
    Transmit Delay is 1 sec, State DR, Priority 1
    Designated Router (ID) 192.168.0.113, Interface address 192.168.0.19
    Backup Designated router (ID) 192.168.0.97, Interface address 192.168.0.17
    Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
      oob-resync timeout 40
      Hello due in 00:00:03
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    Index 1/2/2, flood queue length 0
    Next 0x0(0)/0x0(0)/0x0(0)
    Last flood scan length is 1, maximum is 3
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 1, Adjacent neighbor count is 1
      Adjacent with neighbor 192.168.0.97  (Backup Designated Router)
    Suppress hello for 0 neighbor(s)

R3#show ipv6 ospf interface
GigabitEthernet0/0/0 is up, line protocol is up
    Link Local Address FE80::B6A8:B9FF:FE47:9230, Interface ID 6
    Area 0, Process ID 10, Instance ID 0, Router ID 3.3.3.3
    Network Type BROADCAST, Cost: 1
    Transmit Delay is 1 sec, State BDR, Priority 1
```

```
   Designated Router (ID) 4.4.4.4, local address FE80::CE8E:71FF:FE1E:22E0
   Backup Designated router (ID) 3.3.3.3, local address FE80::B6A8:B9FF:FE47:9230
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
     Hello due in 00:00:00
   Graceful restart helper support enabled
   Index 1/1/2, flood queue length 0
   Next 0x0(0)/0x0(0)/0x0(0)
   Last flood scan length is 2, maximum is 2
   Last flood scan time is 0 msec, maximum is 0 msec
   Neighbor Count is 1, Adjacent neighbor count is 1
     Adjacent with neighbor 4.4.4.4  (Designated Router)
   Suppress hello for 0 neighbor(s)
 Loopback0 is up, line protocol is up
   Link Local Address FE80::B6A8:B9FF:FE47:9230, Interface ID 12
   Area 1, Process ID 10, Instance ID 0, Router ID 3.3.3.3
   Network Type LOOPBACK, Cost: 1
   Loopback interface is treated as a stub Host
 GigabitEthernet0/0/1 is up, line protocol is up
   Link Local Address FE80::B6A8:B9FF:FE47:9231, Interface ID 7
   Area 1, Process ID 10, Instance ID 0, Router ID 3.3.3.3
   Network Type BROADCAST, Cost: 1
   Transmit Delay is 1 sec, State DR, Priority 1
   Designated Router (ID) 3.3.3.3, local address FE80::B6A8:B9FF:FE47:9231
   Backup Designated router (ID) 2.2.2.2, local address FE80::521C:B0FF:FE63:3831
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
     Hello due in 00:00:01
   Graceful restart helper support enabled
   Index 1/2/3, flood queue length 0
   Next 0x0(0)/0x0(0)/0x0(0)
   Last flood scan length is 1, maximum is 6
   Last flood scan time is 0 msec, maximum is 0 msec
   Neighbor Count is 1, Adjacent neighbor count is 1
     Adjacent with neighbor 2.2.2.2  (Backup Designated Router)
   Suppress hello for 0 neighbor(s)
```

Router 4:

```
R4#show run
Building configuration...
Current configuration : 1726 bytes
 Last configuration change at 18:19:09
UTC Tue Sep 28 2021
version 15.5
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-
kernel-core
hostname R4
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
address-family ipv4
exit-address-family
address-family ipv6
exit-address-family
no aaa new-model
ipv6 unicast-routing
subscriber templating
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn
FDO215009QY
spanning-tree extend system-id
redundancy
mode none
vlan internal allocation policy
ascending
interface Loopback0
ip address 192.168.0.129 255.255.255.240
ipv6 address 2001:DB8:ACAD:18::1/64
ipv6 ospf 10 area 2
interface GigabitEthernet0/0/0
ip address 192.168.0.35 255.255.255.240
negotiation auto
ipv6 address 2001:DB8:ACAD:12::2/64
```

```
ipv6 ospf 10 area 0                          router ospf 10
interface GigabitEthernet0/0/1               network 192.168.0.32 0.0.0.15 area 0
ip address 192.168.0.49 255.255.255.240      network 192.168.0.48 0.0.0.15 area 2
negotiation auto                             network 192.168.0.128 0.0.0.15 area 2
ipv6 address 2001:DB8:ACAD:13::1/64          ip forward-protocol nd
ipv6 ospf 10 area 2                          no ip http server
interface Serial0/1/0                        no ip http secure-server
no ip address                                ip tftp source-interface
shutdown                                     GigabitEthernet0
interface Serial0/1/1                        ipv6 router ospf 10
no ip address                                router-id 4.4.4.4
shutdown                                     control-plane
interface GigabitEthernet0                   line con 0
vrf forwarding Mgmt-intf                      stopbits 1
no ip address                                line aux 0
shutdown                                     stopbits 1
negotiation auto                             line vty 0 4
interface Vlan1                              login
no ip address                                end
shutdown
```

```
  R4#show ip route
  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

      192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks
  O IA     192.168.0.0/28
              [110/3] via 192.168.0.33, 00:21:13, GigabitEthernet0/0/0
  O IA     192.168.0.16/28
              [110/2] via 192.168.0.33, 00:21:13, GigabitEthernet0/0/0
  C        192.168.0.32/28 is directly connected, GigabitEthernet0/0/0
  L        192.168.0.35/32 is directly connected, GigabitEthernet0/0/0
  C        192.168.0.48/28 is directly connected, GigabitEthernet0/0/1
  L        192.168.0.49/32 is directly connected, GigabitEthernet0/0/1
  O        192.168.0.64/28
              [110/2] via 192.168.0.51, 00:20:22, GigabitEthernet0/0/1
  O IA     192.168.0.81/32
              [110/4] via 192.168.0.33, 00:21:13, GigabitEthernet0/0/0
  O IA     192.168.0.97/32
              [110/3] via 192.168.0.33, 00:21:13, GigabitEthernet0/0/0
  O IA     192.168.0.113/32
              [110/2] via 192.168.0.33, 00:21:13, GigabitEthernet0/0/0
  C        192.168.0.128/28 is directly connected, Loopback0
  L        192.168.0.129/32 is directly connected, Loopback0
  O        192.168.0.145/32
              [110/2] via 192.168.0.51, 00:20:46, GigabitEthernet0/0/1
```

```
O        192.168.0.161/32
          [110/3] via 192.168.0.51, 00:20:12, GigabitEthernet0/0/1

R4#show ipv6 route
IPv6 Routing Table - default - 15 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, 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
       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
OI  2001:DB8:ACAD:10::/64 [110/3]
     via FE80::B6A8:B9FF:FE47:9230, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:11::/64 [110/2]
     via FE80::B6A8:B9FF:FE47:9230, GigabitEthernet0/0/0
C   2001:DB8:ACAD:12::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L   2001:DB8:ACAD:12::2/128 [0/0]
     via GigabitEthernet0/0/0, receive
C   2001:DB8:ACAD:13::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
L   2001:DB8:ACAD:13::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
O   2001:DB8:ACAD:14::/64 [110/2]
     via FE80::B6A8:B9FF:FE47:9350, GigabitEthernet0/0/1
OI  2001:DB8:ACAD:15::1/128 [110/2]
     via FE80::B6A8:B9FF:FE47:9230, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:16::1/128 [110/2]
     via FE80::B6A8:B9FF:FE47:9230, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:17::1/128 [110/1]
     via FE80::B6A8:B9FF:FE47:9230, GigabitEthernet0/0/0
C   2001:DB8:ACAD:18::/64 [0/0]
     via Loopback0, directly connected
L   2001:DB8:ACAD:18::1/128 [0/0]
     via Loopback0, receive
O   2001:DB8:ACAD:19::1/128 [110/1]
     via FE80::B6A8:B9FF:FE47:9350, GigabitEthernet0/0/1
O   2001:DB8:ACAD:20::1/128 [110/2]
     via FE80::B6A8:B9FF:FE47:9350, GigabitEthernet0/0/1
L   FF00::/8 [0/0]
     via Null0, receive

R4#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.0.113    1    FULL/BDR        00:00:39    192.168.0.33
GigabitEthernet0/0/0
192.168.0.145    1    FULL/DR         00:00:32    192.168.0.51
GigabitEthernet0/0/1

R4#show ipv6 ospf neighbor

          OSPFv3 Router with ID (4.4.4.4) (Process ID 10)
```

```
Neighbor ID      Pri   State              Dead Time    Interface ID    Interface
3.3.3.3            1   FULL/BDR           00:00:33     6
GigabitEthernet0/0/0
5.5.5.5            1   FULL/DR            00:00:37     6
GigabitEthernet0/0/1

R4#show ip ospf
Routing Process "ospf 10" with ID 192.168.0.129
Start time: 00:01:38.595, Time elapsed: 00:22:42.504
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
Supports NSSA (compatible with RFC 3101)
Supports Database Exchange Summary List Optimization (RFC 5243)
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
It is an area border router
Router is not originating router-LSAs with maximum metric
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
EXCHANGE/LOADING adjacency limit: initial 300, process maximum 300
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
    Area BACKBONE(0)
        Number of interfaces in this area is 1
        Area has no authentication
        SPF algorithm last executed 00:21:37.390 ago
        SPF algorithm executed 4 times
        Area ranges are
        Number of LSA 13. Checksum Sum 0x05885F
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
    Area 2
        Number of interfaces in this area is 2 (1 loopback)
        Area has no authentication
```

```
        SPF algorithm last executed 00:20:36.966 ago
        SPF algorithm executed 7 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x04A842
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

R4#show ipv6 ospf
Routing Process "ospfv3 10" with ID 4.4.4.4
Supports NSSA (compatible with RFC 3101)
Supports Database Exchange Summary List Optimization (RFC 5243)
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
It is an area border router
Router is not originating router-LSAs with maximum metric
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 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 2. 2 normal 0 stub 0 nssa
Graceful restart helper support enabled
Reference bandwidth unit is 100 mbps
RFC1583 compatibility enabled
    Area BACKBONE(0)
        Number of interfaces in this area is 1
        SPF algorithm executed 4 times
        Number of LSA 16. Checksum Sum 0x09052D
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
    Area 2
        Number of interfaces in this area is 2
        SPF algorithm executed 6 times
        Number of LSA 18. Checksum Sum 0x098A37
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

R4#show ip ospf interface
GigabitEthernet0/0/0 is up, line protocol is up
  Internet Address 192.168.0.35/28, Area 0, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.129, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown       Topology Name
```

```
        0            1         no         no             Base
   Transmit Delay is 1 sec, State DR, Priority 1
   Designated Router (ID) 192.168.0.129, Interface address 192.168.0.35
   Backup Designated router (ID) 192.168.0.113, Interface address 192.168.0.33
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
     oob-resync timeout 40
     Hello due in 00:00:02
   Supports Link-local Signaling (LLS)
   Cisco NSF helper support enabled
   IETF NSF helper support enabled
   Index 1/1/2, flood queue length 0
   Next 0x0(0)/0x0(0)/0x0(0)
   Last flood scan length is 1, maximum is 3
   Last flood scan time is 0 msec, maximum is 0 msec
   Neighbor Count is 1, Adjacent neighbor count is 1
     Adjacent with neighbor 192.168.0.113  (Backup Designated Router)
   Suppress hello for 0 neighbor(s)
Loopback0 is up, line protocol is up
   Internet Address 192.168.0.129/28, Area 2, Attached via Network Statement
   Process ID 10, Router ID 192.168.0.129, Network Type LOOPBACK, Cost: 1
   Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0            1         no         no             Base
   Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
   Internet Address 192.168.0.49/28, Area 2, Attached via Network Statement
   Process ID 10, Router ID 192.168.0.129, Network Type BROADCAST, Cost: 1
   Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0            1         no         no             Base
   Transmit Delay is 1 sec, State BDR, Priority 1
   Designated Router (ID) 192.168.0.145, Interface address 192.168.0.51
   Backup Designated router (ID) 192.168.0.129, Interface address 192.168.0.49
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
     oob-resync timeout 40
     Hello due in 00:00:06
   Supports Link-local Signaling (LLS)
   Cisco NSF helper support enabled
   IETF NSF helper support enabled
   Index 1/2/3, flood queue length 0
   Next 0x0(0)/0x0(0)/0x0(0)
   Last flood scan length is 1, maximum is 1
   Last flood scan time is 0 msec, maximum is 0 msec
   Neighbor Count is 1, Adjacent neighbor count is 1
     Adjacent with neighbor 192.168.0.145  (Designated Router)
   Suppress hello for 0 neighbor(s)

R4#show ipv6 ospf interface
GigabitEthernet0/0/0 is up, line protocol is up
   Link Local Address FE80::CE8E:71FF:FE1E:22E0, Interface ID 6
   Area 0, Process ID 10, Instance ID 0, Router ID 4.4.4.4
   Network Type BROADCAST, Cost: 1
   Transmit Delay is 1 sec, State DR, Priority 1
   Designated Router (ID) 4.4.4.4, local address FE80::CE8E:71FF:FE1E:22E0
   Backup Designated router (ID) 3.3.3.3, local address FE80::B6A8:B9FF:FE47:9230
   Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
```

```
      Hello due in 00:00:00
    Graceful restart helper support enabled
    Index 1/1/2, flood queue length 0
    Next 0x0(0)/0x0(0)/0x0(0)
    Last flood scan length is 1, maximum is 6
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 1, Adjacent neighbor count is 1
      Adjacent with neighbor 3.3.3.3  (Backup Designated Router)
    Suppress hello for 0 neighbor(s)
  Loopback0 is up, line protocol is up
    Link Local Address FE80::CE8E:71FF:FE1E:22E0, Interface ID 12
    Area 2, Process ID 10, Instance ID 0, Router ID 4.4.4.4
    Network Type LOOPBACK, Cost: 1
    Loopback interface is treated as a stub Host
  GigabitEthernet0/0/1 is up, line protocol is up
    Link Local Address FE80::CE8E:71FF:FE1E:22E1, Interface ID 7
    Area 2, Process ID 10, Instance ID 0, Router ID 4.4.4.4
    Network Type BROADCAST, Cost: 1
    Transmit Delay is 1 sec, State BDR, Priority 1
    Designated Router (ID) 5.5.5.5, local address FE80::B6A8:B9FF:FE47:9350
    Backup Designated router (ID) 4.4.4.4, local address FE80::CE8E:71FF:FE1E:22E1
    Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
      Hello due in 00:00:05
    Graceful restart helper support enabled
    Index 1/2/3, flood queue length 0
    Next 0x0(0)/0x0(0)/0x0(0)
    Last flood scan length is 2, maximum is 2
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 1, Adjacent neighbor count is 1
      Adjacent with neighbor 5.5.5.5  (Designated Router)
    Suppress hello for 0 neighbor(s)
```

Router 5:
```
R5#show run
Building configuration...
Current configuration : 1726 bytes
Last configuration change at 18:26:24
UTC Tue Sep 28 2021
version 15.5
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-
kernel-core
hostname R5
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
address-family ipv4
exit-address-family
address-family ipv6
exit-address-family
no aaa new-model
ipv6 unicast-routing
subscriber templating
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn
FDO214420HM
spanning-tree extend system-id
redundancy
mode none
vlan internal allocation policy
ascending
interface Loopback0
ip address 192.168.0.145 255.255.255.240
ipv6 address 2001:DB8:ACAD:19::1/64
ipv6 ospf 10 area 2
interface GigabitEthernet0/0/0
ip address 192.168.0.51 255.255.255.240
negotiation auto
ipv6 address 2001:DB8:ACAD:13::2/64
ipv6 ospf 10 area 2
interface GigabitEthernet0/0/1
ip address 192.168.0.65 255.255.255.240
negotiation auto
ipv6 address 2001:DB8:ACAD:14::1/64
ipv6 ospf 10 area 2
interface Serial0/1/0
no ip address
```

```
shutdown                                       ip forward-protocol nd
interface Serial0/1/1                          no ip http server
no ip address                                  no ip http secure-server
shutdown                                       ip tftp source-interface
interface GigabitEthernet0                     GigabitEthernet0
vrf forwarding Mgmt-intf                        ipv6 router ospf 10
no ip address                                  router-id 5.5.5.5
shutdown                                       control-plane
negotiation auto                               line con 0
interface Vlan1                                stopbits 1
no ip address                                  line aux 0
shutdown                                       stopbits 1
router ospf 10                                 line vty 0 4
network 192.168.0.48 0.0.0.15 area 2           login
network 192.168.0.64 0.0.0.15 area 2           end
network 192.168.0.144 0.0.0.15 area 2


R5#show ip route
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

      192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks
O IA     192.168.0.0/28
            [110/4] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
O IA     192.168.0.16/28
            [110/3] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
O IA     192.168.0.32/28
            [110/2] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
C        192.168.0.48/28 is directly connected, GigabitEthernet0/0/0
L        192.168.0.51/32 is directly connected, GigabitEthernet0/0/0
C        192.168.0.64/28 is directly connected, GigabitEthernet0/0/1
L        192.168.0.65/32 is directly connected, GigabitEthernet0/0/1
O IA     192.168.0.81/32
            [110/5] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
O IA     192.168.0.97/32
            [110/4] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
O IA     192.168.0.113/32
            [110/3] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
O        192.168.0.129/32
            [110/2] via 192.168.0.49, 00:22:34, GigabitEthernet0/0/0
C        192.168.0.144/28 is directly connected, Loopback0
L        192.168.0.145/32 is directly connected, Loopback0
O        192.168.0.161/32
            [110/2] via 192.168.0.67, 00:22:10, GigabitEthernet0/0/1


R5# show ipv6 route
```

```
IPv6 Routing Table - default - 15 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, 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
       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
OI  2001:DB8:ACAD:10::/64 [110/4]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:11::/64 [110/3]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:12::/64 [110/2]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
C   2001:DB8:ACAD:13::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L   2001:DB8:ACAD:13::2/128 [0/0]
     via GigabitEthernet0/0/0, receive
C   2001:DB8:ACAD:14::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
L   2001:DB8:ACAD:14::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
OI  2001:DB8:ACAD:15::1/128 [110/3]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:16::1/128 [110/3]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:17::1/128 [110/2]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
O   2001:DB8:ACAD:18::1/128 [110/1]
     via FE80::CE8E:71FF:FE1E:22E1, GigabitEthernet0/0/0
C   2001:DB8:ACAD:19::/64 [0/0]
     via Loopback0, directly connected
L   2001:DB8:ACAD:19::1/128 [0/0]
     via Loopback0, receive
O   2001:DB8:ACAD:20::1/128 [110/1]
     via FE80::227:90FF:FED5:F800, GigabitEthernet0/0/1
L   FF00::/8 [0/0]
     via Null0, receive

R5#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.0.161     1   FULL/DR         00:00:37    192.168.0.67
GigabitEthernet0/0/1
192.168.0.129     1   FULL/BDR        00:00:33    192.168.0.49
GigabitEthernet0/0/0

R5#show ipv6 ospf neighbor

           OSPFv3 Router with ID (5.5.5.5) (Process ID 10)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
6.6.6.6           1   FULL/DR         00:00:35    6
GigabitEthernet0/0/1
4.4.4.4           1   FULL/BDR        00:00:34    7
GigabitEthernet0/0/0
```

```
R5#show ip ospf
Routing Process "ospf 10" with ID 192.168.0.145
Start time: 00:01:32.891, Time elapsed: 00:23:56.832
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
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 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
EXCHANGE/LOADING adjacency limit: initial 300, process maximum 300
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
    Area 2
        Number of interfaces in this area is 3 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:22:27.146 ago
        SPF algorithm executed 5 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x04A842
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

R5#show ipv6 ospf
Routing Process "ospfv3 10" with ID 5.5.5.5
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 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 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 2
        Number of interfaces in this area is 3
        SPF algorithm executed 3 times
        Number of LSA 20. Checksum Sum 0x09B7EA
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0


R5#show ip ospf interface
Loopback0 is up, line protocol is up
  Internet Address 192.168.0.145/28, Area 2, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.145, Network Type LOOPBACK, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
  Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
  Internet Address 192.168.0.65/28, Area 2, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.145, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.0.161, Interface address 192.168.0.67
  Backup Designated router (ID) 192.168.0.145, Interface address 192.168.0.65
  Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:03
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/3/3, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.0.161  (Designated Router)
  Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/0 is up, line protocol is up
  Internet Address 192.168.0.51/28, Area 2, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.145, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.0.145, Interface address 192.168.0.51
  Backup Designated router (ID) 192.168.0.129, Interface address 192.168.0.49
```

```
     Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
       oob-resync timeout 40
       Hello due in 00:00:06
     Supports Link-local Signaling (LLS)
     Cisco NSF helper support enabled
     IETF NSF helper support enabled
     Index 1/2/2, flood queue length 0
     Next 0x0(0)/0x0(0)/0x0(0)
     Last flood scan length is 2, maximum is 3
     Last flood scan time is 0 msec, maximum is 0 msec
     Neighbor Count is 1, Adjacent neighbor count is 1
       Adjacent with neighbor 192.168.0.129  (Backup Designated Router)
     Suppress hello for 0 neighbor(s)
R5#show ipv6 ospf interface
Loopback0 is up, line protocol is up
     Link Local Address FE80::B6A8:B9FF:FE47:9350, Interface ID 12
     Area 2, Process ID 10, Instance ID 0, Router ID 5.5.5.5
     Network Type LOOPBACK, Cost: 1
     Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
     Link Local Address FE80::B6A8:B9FF:FE47:9351, Interface ID 7
     Area 2, Process ID 10, Instance ID 0, Router ID 5.5.5.5
     Network Type BROADCAST, Cost: 1
     Transmit Delay is 1 sec, State BDR, Priority 1
     Designated Router (ID) 6.6.6.6, local address FE80::227:90FF:FED5:F800
     Backup Designated router (ID) 5.5.5.5, local address FE80::B6A8:B9FF:FE47:9351
     Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
       Hello due in 00:00:02
     Graceful restart helper support enabled
     Index 1/3/3, flood queue length 0
     Next 0x0(0)/0x0(0)/0x0(0)
     Last flood scan length is 2, maximum is 2
     Last flood scan time is 0 msec, maximum is 0 msec
     Neighbor Count is 1, Adjacent neighbor count is 1
       Adjacent with neighbor 6.6.6.6  (Designated Router)
     Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/0 is up, line protocol is up
     Link Local Address FE80::B6A8:B9FF:FE47:9350, Interface ID 6
     Area 2, Process ID 10, Instance ID 0, Router ID 5.5.5.5
     Network Type BROADCAST, Cost: 1
     Transmit Delay is 1 sec, State DR, Priority 1
     Designated Router (ID) 5.5.5.5, local address FE80::B6A8:B9FF:FE47:9350
     Backup Designated router (ID) 4.4.4.4, local address FE80::CE8E:71FF:FE1E:22E1
     Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
       Hello due in 00:00:05
     Graceful restart helper support enabled
     Index 1/2/2, flood queue length 0
     Next 0x0(0)/0x0(0)/0x0(0)
     Last flood scan length is 4, maximum is 6
     Last flood scan time is 0 msec, maximum is 0 msec
     Neighbor Count is 1, Adjacent neighbor count is 1
       Adjacent with neighbor 4.4.4.4  (Backup Designated Router)
     Suppress hello for 0 neighbor(s)
```

Router 6:

```
R6#show run
Building configuration...
Current configuration : 1614 bytes
Last configuration change at 18:23:08
UTC Tue Sep 28 2021
version 15.5
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-
kernel-core
hostname R6
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
address-family ipv4
exit-address-family
address-family ipv6
exit-address-family
no aaa new-model
ipv6 unicast-routing
subscriber templating
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn
FDO214414DZ
spanning-tree extend system-id
redundancy
mode none
vlan internal allocation policy
ascending
interface Loopback0
ip address 192.168.0.161 255.255.255.240
ipv6 address 2001:DB8:ACAD:20::1/64
ipv6 ospf 10 area 2
interface GigabitEthernet0/0/0
ip address 192.168.0.67 255.255.255.240
negotiation auto
```

```
ipv6 address 2001:DB8:ACAD:14::2/64
ipv6 ospf 10 area 2
interface GigabitEthernet0/0/1
no ip address
shutdown
negotiation auto
interface Serial0/1/0
no ip address
shutdown
interface Serial0/1/1
no ip address
shutdown
interface GigabitEthernet0
vrf forwarding Mgmt-intf
no ip address
shutdown
negotiation auto
interface Vlan1
no ip address
shutdown
router ospf 10
network 192.168.0.64 0.0.0.15 area 2
network 192.168.0.160 0.0.0.15 area 2
ip forward-protocol nd
no ip http server
no ip http secure-server
ip tftp source-interface
GigabitEthernet0
ipv6 router ospf 10
router-id 6.6.6.6
control-plane
line con 0
stopbits 1
line aux 0
stopbits 1
line vty 0 4
login
end
```

```
R6#show ip route
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
```

```
        192.168.0.0/24 is variably subnetted, 13 subnets, 2 masks
O IA     192.168.0.0/28
            [110/5] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O IA     192.168.0.16/28
            [110/4] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O IA     192.168.0.32/28
            [110/3] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O        192.168.0.48/28
            [110/2] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
C        192.168.0.64/28 is directly connected, GigabitEthernet0/0/0
L        192.168.0.67/32 is directly connected, GigabitEthernet0/0/0
O IA     192.168.0.81/32
            [110/6] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O IA     192.168.0.97/32
            [110/5] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O IA     192.168.0.113/32
            [110/4] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O        192.168.0.129/32
            [110/3] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
O        192.168.0.145/32
            [110/2] via 192.168.0.65, 00:24:01, GigabitEthernet0/0/0
C        192.168.0.160/28 is directly connected, Loopback0
L        192.168.0.161/32 is directly connected, Loopback0

R6# show ipv6 route
IPv6 Routing Table - default - 14 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, 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
       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
OI  2001:DB8:ACAD:10::/64 [110/5]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:11::/64 [110/4]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:12::/64 [110/3]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
O   2001:DB8:ACAD:13::/64 [110/2]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
C   2001:DB8:ACAD:14::/64 [0/0]
    via GigabitEthernet0/0/0, directly connected
L   2001:DB8:ACAD:14::2/128 [0/0]
    via GigabitEthernet0/0/0, receive
OI  2001:DB8:ACAD:15::1/128 [110/4]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:16::1/128 [110/4]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
OI  2001:DB8:ACAD:17::1/128 [110/3]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
O   2001:DB8:ACAD:18::1/128 [110/2]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
O   2001:DB8:ACAD:19::1/128 [110/1]
    via FE80::B6A8:B9FF:FE47:9351, GigabitEthernet0/0/0
```

```
C    2001:DB8:ACAD:20::/64 [0/0]
     via Loopback0, directly connected
L    2001:DB8:ACAD:20::1/128 [0/0]
     via Loopback0, receive
L    FF00::/8 [0/0]
     via Null0, receive

R6#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time   Address          Interface
192.168.0.145     1    FULL/BDR        00:00:34    192.168.0.65
GigabitEthernet0/0/0
R6#show ipv6 ospf neighbor

             OSPFv3 Router with ID (6.6.6.6) (Process ID 10)

Neighbor ID      Pri   State           Dead Time   Interface ID     Interface
5.5.5.5           1    FULL/BDR        00:00:39    7
GigabitEthernet0/0/0

R6#show ip ospf
Routing Process "ospf 10" with ID 192.168.0.161
Start time: 00:01:35.836, Time elapsed: 00:25:24.951
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
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 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
EXCHANGE/LOADING adjacency limit: initial 300, process maximum 300
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
    Area 2
        Number of interfaces in this area is 2 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:24:19.578 ago
```

```
        SPF algorithm executed 3 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x04A842
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

R6#show ipv6 interface
GigabitEthernet0/0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::227:90FF:FED5:F800
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:14::2, subnet is 2001:DB8:ACAD:14::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::5
    FF02::6
    FF02::1:FF00:2
    FF02::1:FFD5:F800
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
Loopback0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::227:90FF:FED5:F800
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:20::1, subnet is 2001:DB8:ACAD:20::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::5
    FF02::1:FF00:1
    FF02::1:FFD5:F800
  MTU is 1514 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is not supported
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
```

```
    ND RAs are suppressed (periodic)
    Hosts use stateless autoconfig for addresses.


R6#show ip ospf interface
Loopback0 is up, line protocol is up
  Internet Address 192.168.0.161/28, Area 2, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.161, Network Type LOOPBACK, Cost: 1
  Topology-MTID    Cost     Disabled    Shutdown      Topology Name
        0           1        no          no              Base
  Loopback interface is treated as a stub Host
GigabitEthernet0/0/0 is up, line protocol is up
  Internet Address 192.168.0.67/28, Area 2, Attached via Network Statement
  Process ID 10, Router ID 192.168.0.161, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost     Disabled    Shutdown      Topology Name
        0           1        no          no              Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.0.161, Interface address 192.168.0.67
  Backup Designated router (ID) 192.168.0.145, Interface address 192.168.0.65
  Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:00
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/2/2, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 3, maximum is 3
  Last flood scan time is 1 msec, maximum is 1 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.0.145  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
R6#show ipv6 ospf interface
Loopback0 is up, line protocol is up
  Link Local Address FE80::227:90FF:FED5:F800, Interface ID 12
  Area 2, Process ID 10, Instance ID 0, Router ID 6.6.6.6
  Network Type LOOPBACK, Cost: 1
  Loopback interface is treated as a stub Host
GigabitEthernet0/0/0 is up, line protocol is up
  Link Local Address FE80::227:90FF:FED5:F800, Interface ID 6
  Area 2, Process ID 10, Instance ID 0, Router ID 6.6.6.6
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 6.6.6.6, local address FE80::227:90FF:FED5:F800
  Backup Designated router (ID) 5.5.5.5, local address FE80::B6A8:B9FF:FE47:9351
  Timer intervals configured, Hello 10, Dead 80, Wait 80, Retransmit 5
    Hello due in 00:00:02
  Graceful restart helper support enabled
  Index 1/2/2, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 6, maximum is 6
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 5.5.5.5  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
```

```
R1#ping 192.168.0.81
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.81, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 2001:db8:acad:15::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:15::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 192.168.0.97
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.97, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 2001:db8:acad:16::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:16::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 192.168.0.113
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.113, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 2001:db8:acad:17::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:17::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms
R1#ping 192.168.0.129
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 2001:db8:acad:18::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:18::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms
R1#ping 192.168.0.145
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.145, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 2001:db8:acad:19::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:19::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/7 ms
R1#ping 192.168.0.161
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.161, timeout is 2 seconds:
```

```
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1#ping 2001:db8:acad:20::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:20::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms
```

```
R2#ping 192.168.0.81
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.81, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 2001:db8:acad:15::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:15::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 192.168.0.97
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.97, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 2001:db8:acad:16::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:16::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 192.168.0.113
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.113, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 2001:db8:acad:17::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:17::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms
R2#ping 192.168.0.129
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 2001:db8:acad:18::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:18::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

```
R2#ping 192.168.0.145
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.145, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 2001:db8:acad:19::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:19::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 192.168.0.161
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.161, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R2#ping 2001:db8:acad:20::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:20::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Router 3:
```
R3#ping 192.168.0.81
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.81, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 2001:db8:acad:15::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:15::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms
R3#ping 192.168.0.97
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.97, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 2001:db8:acad:16::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:16::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
R3#ping 192.168.0.113
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.113, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 2001:db8:acad:17::1
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:17::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 192.168.0.129
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 2001:db8:acad:18::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:18::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms
R3#ping 192.168.0.145
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.145, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 2001:db8:acad:19::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:19::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 192.168.0.161
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.161, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R3#ping 2001:db8:acad:20::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:20::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Router 4:
```
R4#ping 192.168.0.81
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.81, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 2001:db8:acad:15::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:15::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms
R4#ping 192.168.0.97
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.97, timeout is 2 seconds:
!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 2001:db8:acad:16::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:16::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 192.168.0.113
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.113, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 2001:db8:acad:17::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:17::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 192.168.0.129
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 2001:db8:acad:18::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:18::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 192.168.0.145
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.145, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 2001:db8:acad:19::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:19::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms
R4#ping 192.168.0.161
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.161, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 2001:db8:acad:20::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:20::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Router 5:
```
R5#ping 192.168.0.81
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.81, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 2001:db8:acad:15::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:15::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms
R5#ping 192.168.0.97
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.97, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 2001:db8:acad:16::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:16::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 192.168.0.113
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.113, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 2001:db8:acad:17::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:17::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 192.168.0.129
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 2001:db8:acad:18::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:18::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 192.168.0.145
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.145, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R5#ping 2001:db8:acad:19::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:19::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

```
R5#ping 192.168.0.161
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.161, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
R5#ping 2001:db8:acad:20::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:20::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/11 ms
```

Router 6:

```
 R6#ping 192.168.0.81
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.81, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 3/9/30 ms
R6#ping 2001:db8:acad:15::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:15::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/7 ms
R6#ping 192.168.0.97
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.97, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 2001:db8:acad:16::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:16::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
R6#ping 192.168.0.113
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.113, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 2001:db8:acad:17::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:17::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 192.168.0.129
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 2001:db8:acad:18::1
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:18::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 192.168.0.145
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.145, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 2001:db8:acad:19::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:19::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 192.168.0.161
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.161, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R6#ping 2001:db8:acad:20::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:20::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Problems

As a result of using multi-areas of OSPF, we encountered difficulty in subnetting our network. We asked another student, Lucus, to proofread our subnetting scheme. He highlighted some potential flaws, and we were able to fix those errors along with some additional ones. After re-working our subnetting scheme, we found it function correctly. This lab also did not have strict requirements for how many routers to include in each OSPF area, so we encountered difficulty in choosing how to build our topology.

Conclusions

We completed this lab by creating the topology and configuration virtually in packet tracer, then transferring this to the routers in the CCNP lab. We encountered some problems, but we were assisted by some peers in our lab and overcame these issues. Finally, we verified that our network functioned properly by pinging all the loopback interfaces and other routers in the network. Overall, this lab taught us a valuable networking concept that we can use in many scenarios in the future. Learning how to subnet multi-area OSPF properly with many areas will be a useful tool to know when working with larger networks.

Instructor Signoff