

Multiarea OSPFv2 and OSPFv3

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**Purpose**

The purpose of this lab is to configure multi-area OSPFv3 on 6 routers, so they can find the best routing path between the source and the destination router. Students will learn to OSPF commands such as **ipv6 router ospf** process-id and **ipv6 ospf** process-id area area-number.

**Background Information on lab concepts**

OSPF or “Open Shortest Port First” is a routing protocol which helps routers find the best routing path between the source and the destination router. It is a link-state routing protocol, which means it exchanges Link State Advertisement (LSA) messages with other neighboring routers that also have OSPF configured.

OSPF has seven states while building neighborship with other routers, which are Down State, Attempt/Init state, two ways state, exstart state, exchange state, loading state, and full state.

In Down State, OSPF learns about the local interfaces that are configured with OSPF. Routers also prepare themselves for the neighborship process and choose a RID (Router ID), which is a unique identifier in an OSPF network.

In the Attempt/Init state, the neighborship building process starts. A router will send a unicast hello packet to so other routers in the network can learn about it as an OSPF router. The router who receives this packet will then send an acknowledgement that it received a valid hello packet. This will put them in a two-way state which designates that the receiving router has received and accepted the neighborship request, establishing communication between the two routers.

In the Exstart state, routers who choose to build adjacency/neighborship will form a master/slave relationship. In each neighborship, the router who has the higher RID will become the master and the one with the lower RID will become the slave. This relationship is built between the two interfaces that need to exchange routing information and will help determine which router will start the exchange process. The master will always start the exchange, while the slave will always receive.

In the exchange state, OSPF routers will exchange database descriptor packets (DBD). Database descriptors contain link-state advertisement (LSA) headers that contain the contents of the link-state database (LSDB). The LSDB can be seen as a collection of all LSAs received by a router. The contents of the DBD are then compared with its own LSDB to check if changes or more updated link-state information is available from its neighbor.

In the Loading state, the actual exchange of link-state information occurs. Based on the DBD packets provided by neighbors, routers send link-state request packets (LSR), which are a list of all the LSAs that router doesn’t have in its own LSDB. Next, the neighbor provides the requested link-state information in link-state update packets (LSU). Link-state updates basically act as an envelope containing all the LSAs requested in the LSR. All OSPF packets are acknowledged with link-state acknowledge packets (LSACK), which make link-state advertisement flooding reliable, by confirming the information sent was received.

The final state OSPF goes through is Full state, which is the normal operating state of OSPF, indicating that everything is functioning the way it should. In this state, all the router and network LSAs have been exchanged, and all routers’ databases are in sync.

A multiarea OSPF network is created when you divide a large area into smaller areas. The simplest topologies use just a backbone area and a standart area. The reason we use multiarea OSPF over single-area OSPF is because if we have a large network, like one with 100 routers for example, we can run into some problems. First, the LSDB will be huge, with every router containing a copy of the same LSDB, with information about every router and link within the entire network. Secondly, the routing table will be filled as well. Since they will have a route to each subnet, every time a packet comes in the router will have to search through hundreds and possibly thousands of routes before finding the right one. Both can impact the disk space and processing power of the router. Lastly, there will be updates happening everywhere in the network. Every time a link or router is changed, updates will be flooded throughout the entire network. Routers will also have to rerun the SPF algorithm every time an update is sent. Using multiarea OSPF, we can reduce the size of our link state database and summarize our routing table. It will also limit update messages to a single area, rather than the whole network.

A multiarea OSPF network is implemented in a two-layer area hierarchy. The backbone (transit) area, and the regular (nonbackbone) area. The backbone area, commonly known as area 0, interconnects with other OSPF area types. The regular area connects users and resources, and all traffic coming from other areas must cross a transit area. There are also four different types of OSPF routers. The Internal router, the Backbone router, the Area Border Router (ABR) and the Autonomous System Boundary Router (ASBR). The internal router is a router that has all its interfaces in the same area, a backbone router is a router in the backbone area, the Area Border Router is a router that has interfaces attached to multiple areas, and the ASBR is a router that has at least one interface attached to an external internetwork. A single router can be classified as more than one router type.

**Lab Summary**

In this lab, I used six 4321 Cisco Routers, four copper-straight through cables, and one fiber optic cable. To connect the four of the routers, I used copper straight through cables. One router had to be connected with a fiber-optic cable, because I didn’t have enough routers on my rack. I connected two copper-straight through cables to each router, except the two routers on the ends, which only had one. One cable went in the GigabitEthernet 0/0/0 interface and the other went in the GigabitEthernet 0/0/1 interface. After that, I assigned the interfaces of each router an IP address and configured loopback addresses on the routers. Then, I configured virtual links between my end routers and their respective neighboring routers so I could configure ipv6 with ospf. Next, I configured OSPFv3 on the routers. Finally, I pinged my routers with each other to verify connectivity and did other commands like show ip route and show ipv6 route to ensure that OSPFv3 was working.

**Lab Commands**

Router(config)**#ipv6 unicast-routing**

This command globally enables IPv6.

Router(config)**#ipv6 router opsf** process-id / **router opsf** process-id

This command is used to enable OSPFv3/OSPFv2 and enter router configuration mode. The process-id is set by the network administrator and is a set value from 1 to 65,535. In this lab, I used a value of 1 for my process-id. It is best to use the same process-id for all OSPF routers.

Router(config)**#ipv6 ospf** process-id area area-number

This command adds an interface to an OSPFv3 area.

Router**#show ipv6/ip ospf int**

This command lists routing protocols on the router, number of areas, router ID and networks.

Router**#show ipv6/ip ospf neighbor**

This command allows you to see the neighboring routers that also have OSPF enabled. It tells you the Neighbor ID, priority, state, dead time, address, and interface of the neighboring routers.

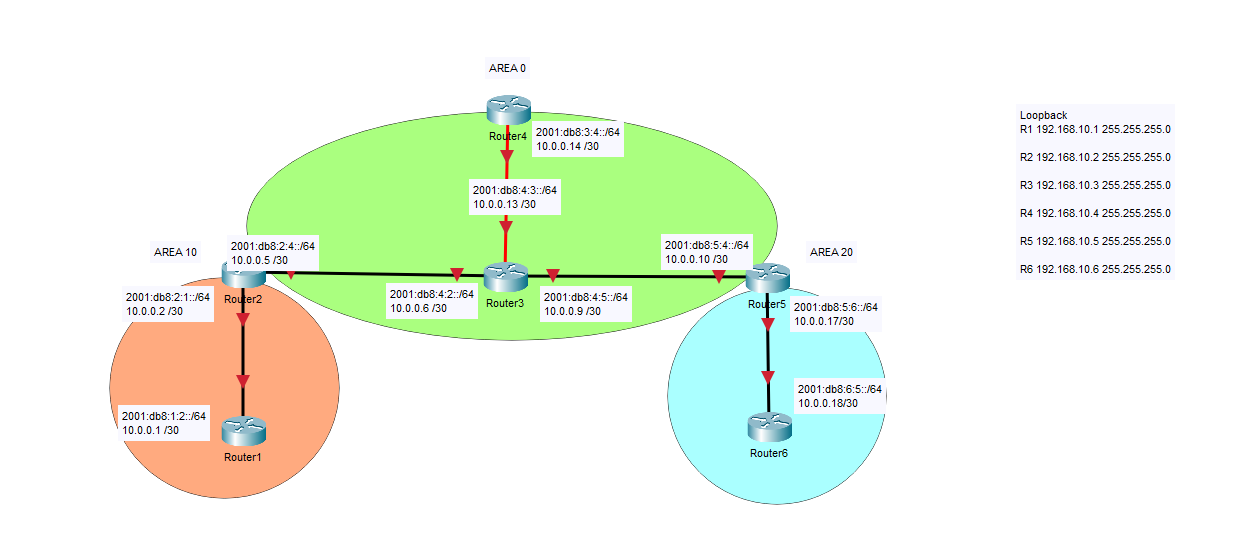
Router**#show ipv6/ip route ospf**

This command lists all OSPF routes on that router.

Router**#show ipv6/ip ospf database**

This command lists the contents of the OSPFv3/OSPFv2 LSDB.

**Network Diagram with IP's**



|  |  |  |  |
| --- | --- | --- | --- |
| **Device** | **Interface** | **IP Address** | **IPv6 Address** |
| R1 | G0/0/0 | 10.1.0.1 /24 | 10:1::1/64 |
| R2 | G0/0/0 | 10.1.0.2 /24 | 10:1::2/64 |
| G0/0/1 | 10.2.0.1 /24 | 10:2::1/64 |
| R3 | G0/0/0 | 10.3.0.1 /24 | 10:3::1/64 |
| G0/0/1 | 10.2.0.2 /24 | 10:2::2/64 |
| R4 | G0/0/1 | 10.3.0.2 /24 | 10:3::2/64 |
| R5 | G0/0/0 | 10.4.0.2 /24 | 10:4::2/64 |
| G0/0/1 | 10.5.0.2 /24 | 10:5::2/64 |
| R6 | G0/0/1 | 10.5.0.1 /24 | 10:5::1/64 |

**Configurations**

**Router 1**

**show run**

R1#show run

Building configuration...

Current configuration : 1767 bytes

!

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 FDO214811ZM

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface Loopback0

ip address 192.168.1.1 255.255.255.0

ipv6 address 10::1:1/64

ipv6 ospf 1 area 10

!

interface GigabitEthernet0/0/0

ip address 10.1.0.1 255.255.255.0

negotiation auto

ipv6 address 10:1::1/64

ipv6 ospf 1 area 10

!

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 GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

negotiation auto

!

interface Vlan1

no ip address

shutdown

!

router ospf 1

router-id 1.1.1.1

area 10 virtual-link 2.2.2.2

network 10.1.0.0 0.0.0.255 area 10

network 192.168.1.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

!

ipv6 router ospf 1

router-id 1.1.1.1

!

control-plane

!

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

end

**show ip route**

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

C 10.1.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.1.0.1/32 is directly connected, GigabitEthernet0/0/0

O 10.2.0.0/24 [110/2] via 10.1.0.2, 02:02:50, GigabitEthernet0/0/0

O 10.3.0.0/24 [110/3] via 10.1.0.2, 02:02:50, GigabitEthernet0/0/0

O 10.4.0.0/24 [110/3] via 10.1.0.2, 02:02:40, GigabitEthernet0/0/0

O IA 10.5.0.0/24 [110/4] via 10.1.0.2, 00:07:13, GigabitEthernet0/0/0

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

192.168.2.0/32 is subnetted, 1 subnets

O 192.168.2.1 [110/2] via 10.1.0.2, 02:02:50, GigabitEthernet0/0/0

192.168.3.0/32 is subnetted, 1 subnets

O 192.168.3.1 [110/3] via 10.1.0.2, 02:02:50, GigabitEthernet0/0/0

192.168.4.0/32 is subnetted, 1 subnets

O 192.168.4.1 [110/4] via 10.1.0.2, 02:02:50, GigabitEthernet0/0/0

192.168.5.0/32 is subnetted, 1 subnets

O 192.168.5.1 [110/4] via 10.1.0.2, 02:02:30, GigabitEthernet0/0/0

**show ipv6 route**

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 10::/64 [0/0]

via Loopback0, directly connected

L 10::1:1/128 [0/0]

via Loopback0, receive

OI 10::2:1/128 [110/1]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10::3:1/128 [110/2]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10::4:1/128 [110/3]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10::5:1/128 [110/3]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10::6:1/128 [110/4]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

C 10:1::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 10:1::1/128 [0/0]

via GigabitEthernet0/0/0, receive

OI 10:2::/64 [110/2]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10:3::/64 [110/3]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10:4::/64 [110/3]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

OI 10:5::/64 [110/4]

via FE80::B6A8:B9FF:FE47:9470, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

**Router 2**

**show run**

R2#show run

Building configuration...

Current configuration : 1857 bytes

!

! Last configuration change at 16:30:56 UTC Wed Sep 22 2021

!

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

!

hostname R2

!

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 FDO214414TX

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface Loopback0

ip address 192.168.2.1 255.255.255.0

ipv6 address 10::2:1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/0

ip address 10.1.0.2 255.255.255.0

negotiation auto

ipv6 address 10:1::2/64

ipv6 ospf 1 area 10

!

interface GigabitEthernet0/0/1

ip address 10.2.0.1 255.255.255.0

negotiation auto

ipv6 address 10:2::1/64

ipv6 ospf 1 area 0

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

negotiation auto

!

interface Vlan1

no ip address

shutdown

!

router ospf 1

router-id 2.2.2.2

area 10 virtual-link 1.1.1.1

network 10.1.0.0 0.0.0.255 area 10

network 10.2.0.0 0.0.0.255 area 0

network 192.168.2.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

!

ipv6 router ospf 1

router-id 2.2.2.2

!

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**show ip route**

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

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

C 10.1.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.1.0.2/32 is directly connected, GigabitEthernet0/0/0

C 10.2.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.2.0.1/32 is directly connected, GigabitEthernet0/0/1

O 10.3.0.0/24 [110/2] via 10.2.0.2, 02:01:27, GigabitEthernet0/0/1

O 10.4.0.0/24 [110/2] via 10.2.0.2, 02:01:13, GigabitEthernet0/0/1

O IA 10.5.0.0/24 [110/3] via 10.2.0.2, 00:05:47, GigabitEthernet0/0/1

192.168.1.0/32 is subnetted, 1 subnets

O 192.168.1.1 [110/2] via 10.1.0.1, 02:01:27, GigabitEthernet0/0/0

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, Loopback0

L 192.168.2.1/32 is directly connected, Loopback0

192.168.3.0/32 is subnetted, 1 subnets

O 192.168.3.1 [110/2] via 10.2.0.2, 02:01:37, GigabitEthernet0/0/1

192.168.4.0/32 is subnetted, 1 subnets

O 192.168.4.1 [110/3] via 10.2.0.2, 02:01:27, GigabitEthernet0/0/1

192.168.5.0/32 is subnetted, 1 subnets

O 192.168.5.1 [110/3] via 10.2.0.2, 02:01:03, GigabitEthernet0/0/1

**show ipv6 route**

R2#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

C 10::/64 [0/0]

via Loopback0, directly connected

O 10::1:1/128 [110/1]

via FE80::267E:12FF:FE55:5720, GigabitEthernet0/0/0

L 10::2:1/128 [0/0]

via Loopback0, receive

O 10::3:1/128 [110/1]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

O 10::4:1/128 [110/2]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

O 10::5:1/128 [110/2]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

OI 10::6:1/128 [110/3]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

C 10:1::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 10:1::2/128 [0/0]

via GigabitEthernet0/0/0, receive

C 10:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 10:2::1/128 [0/0]

via GigabitEthernet0/0/1, receive

O 10:3::/64 [110/2]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

O 10:4::/64 [110/2]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

OI 10:5::/64 [110/3]

via FE80::227:90FF:FED4:F31, GigabitEthernet0/0/1

L FF00::/8 [0/0]

via Null0, receive

**Router 3**

**show run**

R3#show run

Building configuration...

Current configuration : 1915 bytes

!

! Last configuration change at 16:31:42 UTC Wed Sep 22 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 FDO214328EH

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface Loopback0

ip address 192.168.3.1 255.255.255.0

ipv6 address 10::3:1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/0

ip address 10.3.0.1 255.255.255.0

negotiation auto

ipv6 address 10:3::1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/1

ip address 10.2.0.2 255.255.255.0

negotiation auto

ipv6 address 10:2::2/64

ipv6 ospf 1 area 0

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface GigabitEthernet0/2/0

ip address 10.4.0.1 255.255.255.0

negotiation auto

ipv6 address 10:4::1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

ip address dhcp

negotiation auto

!

interface Vlan1

no ip address

shutdown

!

router ospf 1

router-id 3.3.3.3

network 10.2.0.0 0.0.0.255 area 0

network 10.3.0.0 0.0.0.255 area 0

network 10.4.0.0 0.0.0.255 area 0

network 192.168.3.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

!

ipv6 router ospf 1

router-id 3.3.3.3

!

control-plane

!

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

end

**show ip route**

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

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

O IA 10.1.0.0/24 [110/2] via 10.2.0.1, 02:00:51, GigabitEthernet0/0/1

C 10.2.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.2.0.2/32 is directly connected, GigabitEthernet0/0/1

C 10.3.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.3.0.1/32 is directly connected, GigabitEthernet0/0/0

C 10.4.0.0/24 is directly connected, GigabitEthernet0/2/0

L 10.4.0.1/32 is directly connected, GigabitEthernet0/2/0

O IA 10.5.0.0/24 [110/2] via 10.4.0.2, 00:05:01, GigabitEthernet0/2/0

192.168.1.0/32 is subnetted, 1 subnets

O 192.168.1.1 [110/3] via 10.2.0.1, 02:00:41, GigabitEthernet0/0/1

192.168.2.0/32 is subnetted, 1 subnets

O 192.168.2.1 [110/2] via 10.2.0.1, 02:00:51, GigabitEthernet0/0/1

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.3.0/24 is directly connected, Loopback0

L 192.168.3.1/32 is directly connected, Loopback0

192.168.4.0/32 is subnetted, 1 subnets

O 192.168.4.1 [110/2] via 10.3.0.2, 02:00:41, GigabitEthernet0/0/0

192.168.5.0/32 is subnetted, 1 subnets

O 192.168.5.1 [110/2] via 10.4.0.2, 02:00:27, GigabitEthernet0/2/0

**show ipv6 route**

R3#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 10::/64 [0/0]

via Loopback0, directly connected

OI 10::1:1/128 [110/2]

via FE80::B6A8:B9FF:FE47:9471, GigabitEthernet0/0/1

O 10::2:1/128 [110/1]

via FE80::B6A8:B9FF:FE47:9471, GigabitEthernet0/0/1

L 10::3:1/128 [0/0]

via Loopback0, receive

O 10::4:1/128 [110/1]

via FE80::2C1:B1FF:FED5:5331, GigabitEthernet0/0/0

O 10::5:1/128 [110/1]

via FE80::B6A8:B9FF:FE01:B5A0, GigabitEthernet0/2/0

OI 10::6:1/128 [110/2]

via FE80::B6A8:B9FF:FE01:B5A0, GigabitEthernet0/2/0

OI 10:1::/64 [110/2]

via FE80::B6A8:B9FF:FE47:9471, GigabitEthernet0/0/1

C 10:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 10:2::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 10:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 10:3::1/128 [0/0]

via GigabitEthernet0/0/0, receive

C 10:4::/64 [0/0]

via GigabitEthernet0/2/0, directly connected

L 10:4::1/128 [0/0]

via GigabitEthernet0/2/0, receive

OI 10:5::/64 [110/2]

via FE80::B6A8:B9FF:FE01:B5A0, GigabitEthernet0/2/0

L FF00::/8 [0/0]

via Null0, receive

**Router 4**

**show run**

R4#show run

Building configuration...

Current configuration : 1640 bytes

!

! Last configuration change at 16:16:24 UTC Wed Sep 22 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 FDO210907U3

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface Loopback0

ip address 192.168.4.1 255.255.255.0

ipv6 address 10::4:1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/0/1

ip address 10.3.0.2 255.255.255.0

negotiation auto

ipv6 address 10:3::2/64

ipv6 ospf 1 area 0

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface Service-Engine0/2/0

no ip address

shutdown

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

ip address dhcp

negotiation auto

!

interface Vlan1

no ip address

shutdown

!

router ospf 1

router-id 4.4.4.4

network 10.3.0.0 0.0.0.255 area 0

network 192.168.4.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

!

ipv6 router ospf 1

router-id 4.4.4.4

!

control-plane

!

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

end

**show route**

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O IA 10.1.0.0/24 [110/3] via 10.3.0.1, 02:00:20, GigabitEthernet0/0/1

O 10.2.0.0/24 [110/2] via 10.3.0.1, 02:00:20, GigabitEthernet0/0/1

C 10.3.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.3.0.2/32 is directly connected, GigabitEthernet0/0/1

O 10.4.0.0/24 [110/2] via 10.3.0.1, 01:59:58, GigabitEthernet0/0/1

O IA 10.5.0.0/24 [110/3] via 10.3.0.1, 00:04:32, GigabitEthernet0/0/1

192.168.1.0/32 is subnetted, 1 subnets

O 192.168.1.1 [110/4] via 10.3.0.1, 02:00:10, GigabitEthernet0/0/1

192.168.2.0/32 is subnetted, 1 subnets

O 192.168.2.1 [110/3] via 10.3.0.1, 02:00:20, GigabitEthernet0/0/1

192.168.3.0/32 is subnetted, 1 subnets

O 192.168.3.1 [110/2] via 10.3.0.1, 02:00:20, GigabitEthernet0/0/1

192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.4.0/24 is directly connected, Loopback0

L 192.168.4.1/32 is directly connected, Loopback0

192.168.5.0/32 is subnetted, 1 subnets

O 192.168.5.1 [110/3] via 10.3.0.1, 01:59:48, GigabitEthernet0/0/1

**show ipv6 route**

R4#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 10::/64 [0/0]

via Loopback0, directly connected

OI 10::1:1/128 [110/3]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

O 10::2:1/128 [110/2]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

O 10::3:1/128 [110/1]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

L 10::4:1/128 [0/0]

via Loopback0, receive

O 10::5:1/128 [110/2]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

OI 10::6:1/128 [110/3]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

OI 10:1::/64 [110/3]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

O 10:2::/64 [110/2]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

C 10:3::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 10:3::2/128 [0/0]

via GigabitEthernet0/0/1, receive

O 10:4::/64 [110/2]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

OI 10:5::/64 [110/3]

via FE80::227:90FF:FED4:F30, GigabitEthernet0/0/1

L FF00::/8 [0/0]

via Null0, receive

**Router 5**

**show run**

R5#show run

Building configuration...

Current configuration : 1782 bytes

!

! Last configuration change at 16:29:01 UTC Wed Sep 22 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

!

no ip domain lookup

!

ipv6 unicast-routing

!

subscriber templating

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO214421CH

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface Loopback0

ip address 192.168.5.1 255.255.255.0

ipv6 address 10::5:1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/0

ip address 10.4.0.2 255.255.255.0

negotiation auto

ipv6 address 10:4::2/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/1

ip address 10.5.0.2 255.255.255.0

negotiation auto

ipv6 address 10:5::2/64

ipv6 ospf 1 area 20

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface Service-Engine0/2/0

no ip address

shutdown

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

ip address dhcp

negotiation auto

!

interface Vlan1

no ip address

shutdown

!

router ospf 1

router-id 5.5.5.5

area 20 virtual-link 6.6.6.6

network 10.4.0.0 0.0.0.255 area 0

network 10.5.0.0 0.0.0.255 area 20

network 192.168.5.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

!

ipv6 router ospf 1

router-id 5.5.5.5

!

control-plane

!

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

end

**show route**

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

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

O IA 10.1.0.0/24 [110/3] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

O 10.2.0.0/24 [110/2] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

O 10.3.0.0/24 [110/2] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

C 10.4.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.4.0.2/32 is directly connected, GigabitEthernet0/0/0

C 10.5.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.5.0.2/32 is directly connected, GigabitEthernet0/0/1

192.168.1.0/32 is subnetted, 1 subnets

O 192.168.1.1 [110/4] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

192.168.2.0/32 is subnetted, 1 subnets

O 192.168.2.1 [110/3] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

192.168.3.0/32 is subnetted, 1 subnets

O 192.168.3.1 [110/2] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

192.168.4.0/32 is subnetted, 1 subnets

O 192.168.4.1 [110/3] via 10.4.0.1, 00:02:15, GigabitEthernet0/0/0

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.5.0/24 is directly connected, Loopback0

L 192.168.5.1/32 is directly connected, Loopback0

**show ipv6 route**

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

C 10::/64 [0/0]

via Loopback0, directly connected

OI 10::1:1/128 [110/3]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

O 10::2:1/128 [110/2]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

O 10::3:1/128 [110/1]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

O 10::4:1/128 [110/2]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

L 10::5:1/128 [0/0]

via Loopback0, receive

O 10::6:1/128 [110/1]

via FE80::B6A8:B9FF:FE47:96B1, GigabitEthernet0/0/1

OI 10:1::/64 [110/3]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

O 10:2::/64 [110/2]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

O 10:3::/64 [110/2]

via FE80::227:90FF:FED4:F40, GigabitEthernet0/0/0

C 10:4::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 10:4::2/128 [0/0]

via GigabitEthernet0/0/0, receive

C 10:5::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 10:5::2/128 [0/0]

via GigabitEthernet0/0/1, receive

L FF00::/8 [0/0]

via Null0, receive

**Router 6**

**show run**

R6#show run

Building configuration...

Current configuration : 1589 bytes

!

! Last configuration change at 14:46:05 UTC Thu Sep 23 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

!

no ip domain lookup

!

ipv6 unicast-routing

!

subscriber templating

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO214414VU

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface Loopback0

ip address 192.168.6.1 255.255.255.0

ipv6 address 10::6:1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/0/1

ip address 10.5.0.1 255.255.255.0

negotiation auto

ipv6 address 10:5::1/64

ipv6 ospf 1 area 20

!

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

!

router ospf 1

router-id 6.6.6.6

area 20 virtual-link 5.5.5.5

network 10.5.0.0 0.0.0.255 area 20

network 192.168.6.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

!

ipv6 router ospf 1

router-id 6.6.6.6

!

control-plane

!

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

end

**show route**

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O IA 10.1.0.0/24 [110/4] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

O IA 10.2.0.0/24 [110/3] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

O IA 10.3.0.0/24 [110/3] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

O IA 10.4.0.0/24 [110/2] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

C 10.5.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.5.0.1/32 is directly connected, GigabitEthernet0/0/1

192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

O IA 192.168.1.1/32 [110/5] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

L 192.168.1.6/32 is directly connected, Loopback0

192.168.2.0/32 is subnetted, 1 subnets

O IA 192.168.2.1 [110/4] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

192.168.3.0/32 is subnetted, 1 subnets

O IA 192.168.3.1 [110/3] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

192.168.4.0/32 is subnetted, 1 subnets

O IA 192.168.4.1 [110/4] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

192.168.5.0/32 is subnetted, 1 subnets

O IA 192.168.5.1 [110/2] via 10.5.0.2, 00:00:18, GigabitEthernet0/0/1

**show ipv6 route**

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

C 10::/64 [0/0]

via Loopback0, directly connected

OI 10::1:1/128 [110/4]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10::2:1/128 [110/3]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10::3:1/128 [110/2]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10::4:1/128 [110/3]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10::5:1/128 [110/1]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

L 10::6:1/128 [0/0]

via Loopback0, receive

OI 10:1::/64 [110/4]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10:2::/64 [110/3]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10:3::/64 [110/3]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

OI 10:4::/64 [110/2]

via FE80::B6A8:B9FF:FE01:B5A1, GigabitEthernet0/0/1

C 10:5::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 10:5::1/128 [0/0]

via GigabitEthernet0/0/1, receive

L FF00::/8 [0/0]

via Null0, receive

**Problems**

A problem I faced was that we didn’t have enough routers for our topology on one rack. To solve this problem, I had to put a fiber-optic cable going from the rack with most of my routers, to another rack with some other routers that I would be using. Another problem I had was achieving adjacency with my internal routers (routers 1 and 6). After I finished configuring everything, I did a show ip route and a show ipv6 route. When I did the show ip route everything on the network had adjacency, but when I did a show ipv6 route, only router 2-5 had adjacency. To figure out why my two internal/end routers weren’t becoming neighbors with the other routers, I looked at the configurations for them. After looking a few times, I realized that my virtual-links were not in the right area. I configured both of my virtual-links in area 0 instead of area 10 for router 1, and area 20 for router 6. This was a problem because I needed the virtual-links in areas 10 and 20, not area 0. After changing the areas to 10 on router 1 and 20 on router 6, I did the show ipv6 route command, and I had neighbor adjacency between all 6 routers.

**Conclusion**

OSPF is a routing protocol that allows routers to share the network information to find the best routing path, with the use of LSA’s. Multiarea OSPF allows you to run OSPF on large networks without overwhelming routers with a huge routing table and topology database. While going through the OSPF process, routers go through 7 steps to achieve neighborship/adjacency. To configure this, you need to use OSPF specific commands such as **ipv6 router ospf** process-id, **ipv6 ospf** process-id area area-number, and **network** ip-address wildcard-mask **area** area-id. There are also some OSPF specific show commands that are helpful to verify OSPF is working correctly after configuring it. These include show **ip/ipv6 ospf route** and show **ip/ipv6 ospf neighbor.** I was able a configure a multiarea OSPF network on 6 Cisco 4321 routers. Although having some problems achieving adjacency between routers, I was able to troubleshoot them to get OSPF to work. Through this lab, I learned how to configure a multiarea OSPF network, in both ipv4 and ipv6, as well as develop a deeper understanding of everything needed to make it work.

**Teacher Signoff Page of Lab Completed**

**Evan Choi has completed this OSPFv3 Lab**

**November 5, 2021**

