CCNP ROUTING AND SWITCHING

Configuring Multi-Area OSPF

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Purpose:

The purpose of this lab is to configure mutliarea OSPF on six routers, with the routers split between three areas. Students will learn how to configure multiarea OSPF and OSPFv3 on routers as well as modifying hello and dead timers.

Background

Multiarea OSPF has several advantages over single-area OSPF. Using multiarea OSPF reduces processing and memory overhead, reduced link-state overhead and frequency of SPF calculations and smaller routing tables.

Multiarea OSPF has two different layers, the backbone area and the regular area. Multiarea divides a large OSPF area into several smaller areas. Routers are spread throughout different areas which all connect back to the backbone.The backbone or transit area (area 0) is an OSPF area that specalizes in the efficient movement of IP packets. The regular or nonbackbone area connects users with resources. Traffic from other areas must cross the backbone.

There are four different types of OSPF routers in multiarea OSPF. Internal routers, backbone routers, ABRs and ASBRs. Internal routers are routers that have all interfaces in the same area. A backbone router is a router in the backbone area of 0. An Area Border Router (ABR) is a router that has interfaces attached to multiple areas. In my toplogy, Router 2 is an ABR as it has its Gig 0/0/0 and 0/0/1 in areas that are not the backbone. An Autonomous System Boundary Router (ASBR) is a router that serves as a gateway to routers outside the OSPF domain and those operating with different protocols (IGRP, EIGRP, RIP, BGP, Static). ASBRs can import and translate routes from different protocols into OSPF using redistribution.

OSPFv3 allows the use of IPv6 addresses and routes in OSPF and is an expandison of OSPFv2. Configuring OSPFv3 has several differences to how OSPFv2 is configured. IPv6 unicast routing must be enabled and interfaces used must have IPv6 configured. Hello and dead intervals can be configured with shorter times than the default 10 and 30 seconds. While this will result in faster convergence and less delays in rerouting if a link goes down, more packets will be exchanged in regular network operation.

Lab Summary

When configuring multiarea OSPFv2 and v3 I set up six 4321 Cisco Routers with two routers installed with a NIM-2T WAN Interface Card for serial connection. I used copper crossover cables to connect the Gig 0/0/0 and 0/0/1 interfaces on routers in area 1 and 2 to each other and to area 0. R1 and R2 in area 0 used a serial DCE connection. Routers used the IPv4 network of 10.0.0.0 with a /30 subnet from 10.0.0.0-10.0.0.19. They also used the IPv6 network of 2001:db8:acad:0::1/64. Loopback addresses are used in the place of LANs. Loopbacks have IPv4 addresses in the 192.168.0.0/16 network and are subnetted into /30s. They use IPv6 addresses in the 2001:db8:acad:0::1/64 network. I also configured OSPFv2 and OSPFv3 on all five routers using the commands listed below and set all loopback interfaces as passive-interfaces to ensure network security and efficiency. I also placed R1 and R2 in the backbone area of Area 0, R3 and R4 in Area 1 and R5 and R6 in Area 2. I also changed the hello and dead intervals in the interfaces connected to R2's G0/0/0 and G0/0/1 to hello of 1 second and dead of 3 seconds instead of the normal 10 seconds and 30 seconds. Finally I pinged all addresses in the network to ensure all routes and multiarea OSPF was working.

Lab Commands

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

Definition: This command enables IPv6 routing globally on a router.

```
Router(config)#ipv6 ospf process-id area area_number
```

Definition: This commands enables ospfv3 on an interface and assigns it an area.

```
Router(config)#ipv6 router ospf process-id
```

Definition: This command enables OSPFv3 on a router. The process-id is a value between 1 and 65,535 and is locally significant but its best practice to use the same ID on all OSPF routers. I used the ID of 1 for my network.

```
Router(config)#ip ospf hello-interval seconds
```

Definition: This command specifies the interval in seconds between OSPF hello packets.

```
Router(config)#ip ospf dead-interval second
```

Definition: This command specifies the interval in seconds between OSPF dead packets.

```
Router#show ipv6 ospf interface
```

Definition: This command lists information's about the OSPFv3 process running on the router including OSPFv3 router ID, area IDs, and the number of interfaces.

```
Router#show ipv6 route
```

Definition: This command displays the current state of the routing table. This includes static, dynamically assigned or learned routes.

```
Router#show ipv6 ospf neighbor
```

Definition: This command shows neighboring OSPFv3 routers. The router-id, priority, state, hello and dead timers, ip address and interfaces of the neighbors are also shown.

```
Router#clear ip/ipv6 ospf process
```

Defintion: This command resets the OSPF process on all OSPFv2/v3 routers. This is usually used to reset the router ID or change the ospf priority.

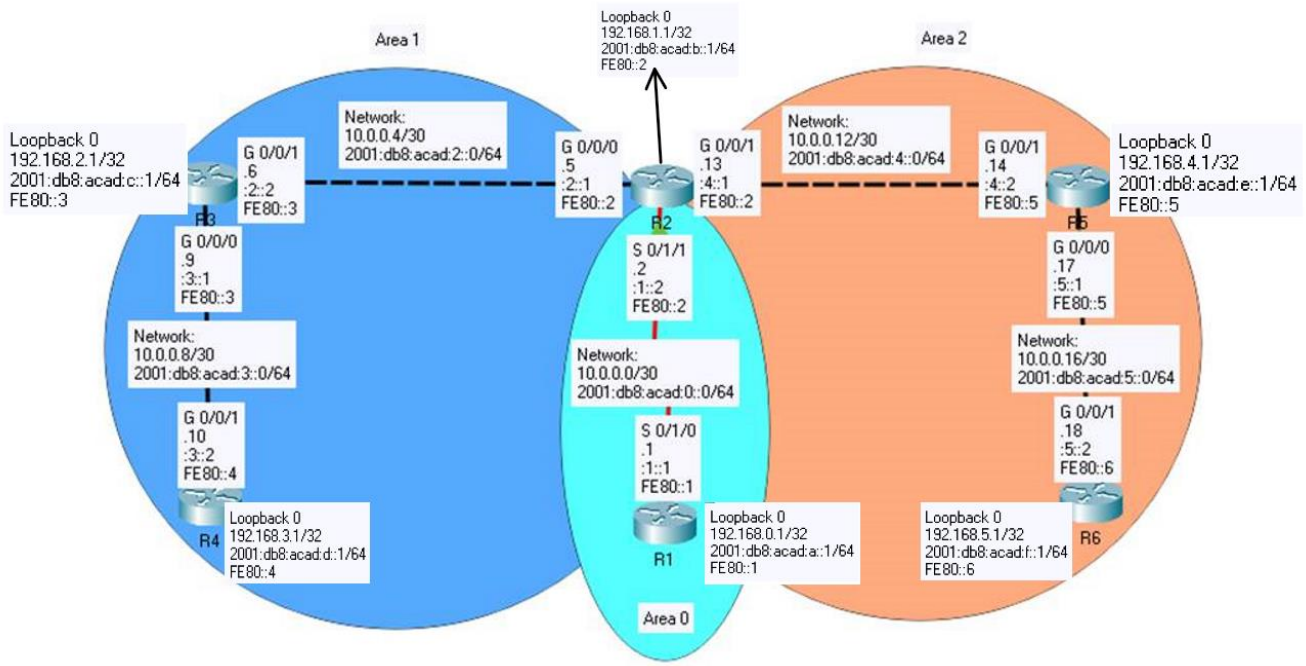
```
Router#show ip/ipv6 protocols
```

Definition: This command is a quick way to verify OSPFv2/v3 configuration information. This information includes the OSPFv2/v3 process IDs, OSPFv2/v3 interfaces, neighbor routers, administrative distance and areas.

```
Router#show ip/v6 ospf border-router
```

Definition: This command displays the OSPF routes to Area Border Routers (ABRs) and Autonomous System Boundary Routers (ASBRs).

Diagram of Network Toplogy



Device	Interface	IP Address	IPv6 Address	Area	Link-Local Addresses
R1	S 0/1/0	10.0.0.1/30	2001:db8:acad:1::1/64	0	fe80::1
	Loopback 0	192.168.0.1/32	2001:db8:acad:a::1/64	0	fe80::1
R2	S 0/1/1	10.0.0.2/30	2001:db8:acad:1::2/64	0	fe80::2
	G 0/0/0	10.0.0.5/30	2001:db8:acad:2::1/64	1	fe80::2
	G 0/0/1	10.0.0.13/30	2001:db8:acad:4::1/64	2	fe80::2
	Loopback 0	192.168.1.1/32	2001:db8:acad:b::1/64	0	fe80::2
R3	G 0/0/0	10.0.0.9/30	2001:db8:acad:3::1/64	1	fe80::3
	G 0/0/1	10.0.0.6/30	2001:db8:acad:2::2/64	1	fe80::3
	Loopback 0	192.168.2.1/32	2001:db8:acad:c::1/64	1	fe80::3

R4	G 0/0/1	10.0.0.10/30	2001:db8:acad:3::2/64	1	fe80::4
	Loopback 0	192.168.3.1/32	2001:db8:acad:d::1/64	1	fe80::4
R5	G 0/0/0	10.0.0.17/30	2001:db8:acad:5::1/64	2	fe80::5
	G 0/0/1	10.0.0.14/30	2001:db8:acad:4::2/64	2	fe80::5
	Loopback 0	192.168.4.1/32	2001:db8:acad:e::1/64	2	fe80::5
R6	G 0/0/1	10.0.0.18/32	2001:db8:acad:5::2/64	2	fe80::6
	Loopback 0	192.168.5.1/32	2001:db8:acad:f::1/64	2	fe80::6

Pings to Routers and Loopbacks for IPv4

```
R1#ping 10.0.0.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/75/132 ms

R1#ping 10.0.0.6

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/64/97 ms

R1#ping 10.0.0.10

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.10, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/29/68 ms

R1#ping 10.0.0.14

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.14, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/51/92 ms

R1#ping 10.0.0.18

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.18, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/29/70 ms

R1#ping 192.168.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 67/83/103 ms

R1#ping 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/48/89 ms

R1#ping 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/25/59 ms

R1#ping 192.168.4.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.4.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 11/53/95 ms

R1#ping 192.168.5.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.5.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/22/69 ms
```

```
R1#ping 2001:db8:acad:1::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:1::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/72/118 ms

R1#ping 2001:db8:acad:2::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:2::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 31/66/93 ms

R1#ping 2001:db8:acad:3::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:3::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/26/66 ms

R1#ping 2001:db8:acad:4::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:4::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/21/68 ms

R1#ping 2001:db8:acad:5::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:5::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/22/65 ms

R1#ping 2001:db8:acad:a::1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:a::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 27/37/55 ms

R1#ping 2001:db8:acad:b::1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:b::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/49/130 ms

R1#ping 2001:db8:acad:c::1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:c::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/36/64 ms

R1#ping 2001:db8:acad:d::1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:d::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/14/63 ms

R1#ping 2001:db8:acad:e::1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:e::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/53/94 ms
```

Router 1 Config:

show run:

```
R1#show run
Building configuration...
```

```
Current configuration : 1268 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R1
!
no ip cef
ipv6 unicast-routing
!
no ipv6 cef
!
spanning-tree mode pvst
!
interface Loopback0
ip address 192.168.0.1 255.255.255.255
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
ipv6 ospf 1 area 0
!
interface GigabitEthernet0/0/0
no ip address
duplex auto
speed auto
shutdown
!
interface GigabitEthernet0/0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/1/0
ip address 10.0.0.1 255.255.255.252
ip ospf hello-interval 1
ip ospf dead-interval 3
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:1::1/64
ipv6 ospf 1 area 0
!
interface Serial0/1/1
no ip address
clock rate 2000000
shutdown
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 1.1.1.1
log-adjacency-changes
passive-interface Loopback0
network 10.0.0.0 0.0.0.3 area 0
network 192.168.0.1 0.0.0.0 area 0
!
ipv6 router ospf 1
router-id 1.1.1.1
log-adjacency-changes
passive-interface Loopback0
!
ip classless
!
ip flow-export version 9
!
no cdp run
!
line con 0
!
line aux 0
!
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, E - EGP
i - IS-IS, 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

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C 10.0.0.0/30 is directly connected, Serial0/1/0
L 10.0.0.1/32 is directly connected, Serial0/1/0
O IA 10.0.0.4/30 [110/65] via 10.0.0.2, 00:07:40, Serial0/1/0
O IA 10.0.0.8/30 [110/66] via 10.0.0.2, 00:02:51, Serial0/1/0
O IA 10.0.0.12/30 [110/65] via 10.0.0.2, 00:07:40, Serial0/1/0
O IA 10.0.0.16/30 [110/66] via 10.0.0.2, 00:03:22, Serial0/1/0
192.168.0.0/32 is subnetted, 1 subnets
C 192.168.0.1/32 is directly connected, Loopback0
192.168.1.0/32 is subnetted, 1 subnets
O 192.168.1.1/32 [110/65] via 10.0.0.2, 00:07:40, Serial0/1/0
192.168.2.0/32 is subnetted, 1 subnets
O IA 192.168.2.1/32 [110/66] via 10.0.0.2, 00:02:51, Serial0/1/0
192.168.3.0/32 is subnetted, 1 subnets
O IA 192.168.3.1/32 [110/67] via 10.0.0.2, 00:02:51, Serial0/1/0
192.168.4.0/32 is subnetted, 1 subnets
O IA 192.168.4.1/32 [110/66] via 10.0.0.2, 00:03:22, Serial0/1/0
192.168.5.0/32 is subnetted, 1 subnets
O IA 192.168.5.1/32 [110/67] via 10.0.0.2, 00:03:22, Serial0/1/0
```

show ipv6 route:

```
R1#show ipv6 route
IPv6 Routing Table - 14 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route, M - MIPv6
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
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
D - EIGRP, EX - EIGRP external
C 2001:DB8:ACAD:1::/64 [0/0]
via Serial0/1/0, directly connected
L 2001:DB8:ACAD:1::1/128 [0/0]
via Serial0/1/0, receive
OI 2001:DB8:ACAD:2::/64 [110/65]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:3::/64 [110/66]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:4::/64 [110/65]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:5::/64 [110/66]
via FE80::2, Serial0/1/0
C 2001:DB8:ACAD:A::/64 [0/0]
via Loopback0, directly connected
L 2001:DB8:ACAD:A::1/128 [0/0]
via Loopback0, receive
O 2001:DB8:ACAD:B::1/128 [110/64]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:C::1/128 [110/65]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:D::1/128 [110/66]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:E::1/128 [110/65]
via FE80::2, Serial0/1/0
OI 2001:DB8:ACAD:F::1/128 [110/66]
via FE80::2, Serial0/1/0
L FF00::/8 [0/0]
via Null0, receive
```

show ip ospf interface:

```
R1#show ip ospf interface

Loopback0 is up, line protocol is up
Internet address is 192.168.0.1/32, Area 0
Process ID 10, Router ID 1.1.1.1, Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
Serial0/1/0 is up, line protocol is up
```

```
Internet address is 10.0.0.1/30, Area 0
Process ID 10, Router ID 1.1.1.1, Network Type POINT-TO-POINT, Cost: 64
Transmit Delay is 1 sec, State POINT-TO-POINT,
Timer intervals configured, Hello 1, Dead 3, Wait 3, Retransmit 5
Hello due in 00:00:00
Index 2/2, flood queue length 0
Next 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 2.2.2.2
Suppress hello for 0 neighbor(s)
```

show ipv6 ospf interface:

```
R1#show ipv6 ospf interface
Loopback0 is up, line protocol is up
Link Local Address FE80::1, Interface ID 5
Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
Serial0/1/0 is up, line protocol is up
Link Local Address FE80::1, Interface ID 3
Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
Network Type POINT-TO-POINT, Cost: 64
Transmit Delay is 1 sec, State POINT-TO-POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:06
Index 2/2, flood queue length 0
Next 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 2.2.2.2
Suppress hello for 0 neighbor(s)
```

show ip ospf neighbor:

```
R1#show ip ospf neighbor


Neighbor ID Pri State Dead Time Address Interface
2.2.2.2 0 FULL/ - 00:00:02 10.0.0.2 Serial0/1/0
```

show ip protocol:

```
R1#show ip protocol

Routing Protocol is "ospf 10"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 1.1.1.1
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
10.0.0.0 0.0.0.3 area 0
192.168.0.1 0.0.0.0 area 0
Passive Interface(s):
Loopback0
Routing Information Sources:
Gateway Distance Last Update
1.1.1.1 110 00:09:31
2.2.2.2 110 00:09:31
Distance: (default is 110)
```

show ipv6 protocol:

```
R1#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Interfaces (Area 0)
Loopback0
Serial0/1/0
Redistribution:
None
```

show ip ospf border-router:

```
R1#show ip ospf border-router
OSPF Process 10 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [64] via 10.0.0.2, Serial0/1/0, ABR, Area 0, SPF 64
```

show ipv6 ospf border-router:

```
R1#show ipv6 ospf border-router
```

```
OSPFv3 Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [64] via FE80::2, Serial0/1/0, ABR, Area 0, SPF 2
```

Router 2 Config:

show run:

```
R2# show run
Building configuration...

Current configuration : 1660 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R2
!
no ip cef
ipv6 unicast-routing
!
no ipv6 cef
!
spanning-tree mode pvst
!
interface Loopback0
ip address 192.168.1.1 255.255.255.255
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:B::1/64
ipv6 ospf 1 area 0
!
interface GigabitEthernet0/0/0
ip address 10.0.0.5 255.255.255.252
ip ospf hello-interval 1
ip ospf dead-interval 3
duplex auto
speed auto
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:2::1/64
ipv6 ospf 1 area 1
!
interface GigabitEthernet0/0/1
ip address 10.0.0.13 255.255.255.252
ip ospf hello-interval 1
ip ospf dead-interval 3
duplex auto
speed auto
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:4::1/64
ipv6 ospf 1 area 2
!
interface Serial0/1/0
no ip address
clock rate 2000000
shutdown
!
interface Serial0/1/1
ip address 10.0.0.2 255.255.255.252
ip ospf hello-interval 1
ip ospf dead-interval 3
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:1::2/64
ipv6 ospf 1 area 0
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 2.2.2.2
log-adjacency-changes
passive-interface Loopback0
network 10.0.0.4 0.0.0.3 area 1
network 10.0.0.0 0.0.0.3 area 0
network 192.168.1.1 0.0.0.0 area 0
```

```
network 10.0.0.12 0.0.0.3 area 2
!
ipv6 router ospf 1
router-id 2.2.2.2
log-adjacency-changes
passive-interface Loopback0
!
ip classless
!
ip flow-export version 9
!
no cdp run
!
line con 0
!
line aux 0
!
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, E - EGP
i - IS-IS, 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

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
C 10.0.0.0/30 is directly connected, Serial0/1/1
L 10.0.0.2/32 is directly connected, Serial0/1/1
C 10.0.0.4/30 is directly connected, GigabitEthernet0/0/0
L 10.0.0.5/32 is directly connected, GigabitEthernet0/0/0
O 10.0.0.8/30 [110/2] via 10.0.0.6, 4294967273:4294967247:4294967295, GigabitEthernet0/0/0
C 10.0.0.12/30 is directly connected, GigabitEthernet0/0/1
L 10.0.0.13/32 is directly connected, GigabitEthernet0/0/1
O 10.0.0.16/30 [110/2] via 10.0.0.14, 4294967273:4294967248:4294967265, GigabitEthernet0/0/1
192.168.0.0/32 is subnetted, 1 subnets
O 192.168.0.1/32 [110/65] via 10.0.0.1, 4294967273:4294967252:4294967275, Serial0/1/1
192.168.1.0/32 is subnetted, 1 subnets
C 192.168.1.1/32 is directly connected, Loopback0
192.168.2.0/32 is subnetted, 1 subnets
O 192.168.2.1/32 [110/2] via 10.0.0.6, 4294967273:4294967247:4294967295, GigabitEthernet0/0/0
192.168.3.0/32 is subnetted, 1 subnets
O 192.168.3.1/32 [110/3] via 10.0.0.6, 4294967273:4294967247:4294967295, GigabitEthernet0/0/0
192.168.4.0/32 is subnetted, 1 subnets
O 192.168.4.1/32 [110/2] via 10.0.0.14, 4294967273:4294967248:4294967265, GigabitEthernet0/0/1
192.168.5.0/32 is subnetted, 1 subnets
O 192.168.5.1/32 [110/3] via 10.0.0.14, 4294967273:4294967248:4294967265, GigabitEthernet0/0/1
```

show ipv6 route:

```
R2#show ipv6 route
IPv6 Routing Table - 16 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route, M - MIPv6
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
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
D - EIGRP, EX - EIGRP external
C 2001:DB8:ACAD:1::/64 [0/0]
via Serial0/1/1, directly connected
L 2001:DB8:ACAD:1::2/128 [0/0]
via Serial0/1/1, receive
C 2001:DB8:ACAD:2::/64 [0/0]
via GigabitEthernet0/0/0, directly connected
L 2001:DB8:ACAD:2::1/128 [0/0]
via GigabitEthernet0/0/0, receive
O 2001:DB8:ACAD:3::/64 [110/2]
via FE80::3, GigabitEthernet0/0/0
C 2001:DB8:ACAD:4::/64 [0/0]
via GigabitEthernet0/0/1, directly connected
L 2001:DB8:ACAD:4::1/128 [0/0]
```

```
via GigabitEthernet0/0/1, receive
O 2001:DB8:ACAD:5::/64 [110/2]
via FE80::5, GigabitEthernet0/0/1
O 2001:DB8:ACAD:A::1/128 [110/64]
via FE80::1, Serial0/1/1
C 2001:DB8:ACAD:B::/64 [0/0]
via Loopback0, directly connected
L 2001:DB8:ACAD:B::1/128 [0/0]
via Loopback0, receive
O 2001:DB8:ACAD:C::1/128 [110/1]
via FE80::3, GigabitEthernet0/0/0
O 2001:DB8:ACAD:D::1/128 [110/2]
via FE80::3, GigabitEthernet0/0/0
O 2001:DB8:ACAD:E::1/128 [110/1]
via FE80::5, GigabitEthernet0/0/1
O 2001:DB8:ACAD:F::1/128 [110/2]
via FE80::5, GigabitEthernet0/0/1
L FF00::/8 [0/0]
via Null0, receive
```

show ip ospf interface:

```
R2#show ip ospf interface

GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 10.0.0.5/30, Area 1
Process ID 10, 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, Interface address 10.0.0.6
Backup Designated Router (ID) 2.2.2.2, Interface address 10.0.0.5
Timer intervals configured, Hello 1, Dead 3, Wait 3, Retransmit 5
Hello due in 00:00:00
Index 1/1, flood queue length 0
Next 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 3.3.3.3 (Designated Router)
Suppress hello for 0 neighbor(s)
Loopback0 is up, line protocol is up
Internet address is 192.168.1.1/32, Area 0
Process ID 10, Router ID 2.2.2.2, Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
Serial0/1/1 is up, line protocol is up
Internet address is 10.0.0.2/30, Area 0
Process ID 10, Router ID 2.2.2.2, Network Type POINT-TO-POINT, Cost: 64
Transmit Delay is 1 sec, State POINT-TO-POINT,
Timer intervals configured, Hello 1, Dead 3, Wait 3, Retransmit 5
Hello due in 00:00:00
Index 3/3, flood queue length 0
Next 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 1.1.1.1
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/1 is up, line protocol is up
Internet address is 10.0.0.13/30, Area 2
Process ID 10, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 5.5.5.5, Interface address 10.0.0.14
Backup Designated Router (ID) 2.2.2.2, Interface address 10.0.0.13
Timer intervals configured, Hello 1, Dead 3, Wait 3, Retransmit 5
Hello due in 00:00:00
Index 4/4, flood queue length 0
Next 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 5.5.5.5 (Designated Router)
Suppress hello for 0 neighbor(s)
```

show ipv6 ospf interface:

```
R2#show ipv6 ospf interface
Loopback0 is up, line protocol is up
Link Local Address FE80::2, Interface ID 5
Area 0, Process ID 1, Instance ID 0, Router ID 2.2.2.2
Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
```

```
Serial0/1/1 is up, line protocol is up
Link Local Address FE80::2, Interface ID 4
Area 0, Process ID 1, Instance ID 0, Router ID 2.2.2.2
Network Type POINT-TO-POINT, Cost: 64
Transmit Delay is 1 sec, State POINT-TO-POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:09
Index 2/2, flood queue length 0
Next 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 1.1.1.1
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/0 is up, line protocol is up
Link Local Address FE80::2, Interface ID 1
Area 1, Process ID 1, 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::2
Backup Designated Router (ID) 2.2.2.2, local address FE80::2
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:09
Index 3/3, flood queue length 0
Next 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 3.3.3.3 (Designated Router)
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/1 is up, line protocol is up
Link Local Address FE80::2, Interface ID 2
Area 2, Process ID 1, 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) 5.5.5.5, local address FE80::2
Backup Designated Router (ID) 2.2.2.2, local address FE80::2
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:00
Index 4/4, flood queue length 0
Next 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 5.5.5.5 (Designated Router)
Suppress hello for 0 neighbor(s)
```

show ip ospf neighbor:

```
R2#show ip ospf neighbor


Neighbor ID Pri State Dead Time Address Interface
3.3.3.3 1 FULL/DR 00:00:02 10.0.0.6 GigabitEthernet0/0/0
1.1.1.1 0 FULL/ - 00:00:02 10.0.0.1 Serial0/1/1
5.5.5.5 1 FULL/DR 00:00:02 10.0.0.14 GigabitEthernet0/0/1
```

show ip protocol:

```
R2#show ip protocol

Routing Protocol is "ospf 10"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 2.2.2.2
Number of areas in this router is 3. 3 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
10.0.0.4 0.0.0.3 area 1
10.0.0.0 0.0.0.3 area 0
192.168.1.1 0.0.0.0 area 0
10.0.0.12 0.0.0.3 area 2
Passive Interface(s):
Loopback0
Routing Information Sources:
Gateway Distance Last Update
1.1.1.1 110 00:03:12
2.2.2.2 110 00:03:12
3.3.3.3 110 00:03:12
4.4.4.4 110 00:11:49
5.5.5.5 110 00:03:12
```

```
6.6.6.6 110 00:11:53
Distance: (default is 110)
```
show ipv6 protocol:
```
R2#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Interfaces (Area 0)
Loopback0
Serial0/1/1
Interfaces (Area 1)
GigabitEthernet0/0/0
Interfaces (Area 2)
GigabitEthernet0/0/1
Redistribution:
None
```
show ip ospf border-router:
```
R2#show ip ospf border-router
OSPF Process 10 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route
```
show ipv6 ospf border-router:
```
R2#show ipv6 ospf border-router
OSPFv3 Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route
```
Router 3 Config:

show run:
```
R3#show run
Building configuration...

Current configuration : 1281 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R3
!
ip cef
ipv6 unicast-routing
!
no ipv6 cef
!
spanning-tree mode pvst
!
interface Loopback0
ip address 192.168.2.1 255.255.255.255
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:C::1/64
ipv6 ospf 1 area 1
!
interface GigabitEthernet0/0/0
ip address 10.0.0.9 255.255.255.252
duplex auto
speed auto
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:3::1/64
ipv6 ospf 1 area 1
!
interface GigabitEthernet0/0/1
ip address 10.0.0.6 255.255.255.252
ip ospf hello-interval 1
ip ospf dead-interval 3
duplex auto
speed auto
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:2::2/64
ipv6 ospf 1 area 1
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
```

```
router-id 3.3.3.3
log-adjacency-changes
passive-interface Loopback0
network 192.168.2.1 0.0.0.0 area 1
network 10.0.0.4 0.0.0.3 area 1
network 10.0.0.8 0.0.0.3 area 1
!
ipv6 router ospf 1
router-id 3.3.3.3
log-adjacency-changes
passive-interface Loopback0
!
ip classless
!
ip flow-export version 9
!
no cdp run
!
line con 0
!
line aux 0
!
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, E - EGP
i - IS-IS, 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

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
O IA 10.0.0.0/30 [110/65] via 10.0.0.5, 01:48:40, GigabitEthernet0/0/1
C 10.0.0.4/30 is directly connected, GigabitEthernet0/0/1
L 10.0.0.6/32 is directly connected, GigabitEthernet0/0/1
C 10.0.0.8/30 is directly connected, GigabitEthernet0/0/0
L 10.0.0.9/32 is directly connected, GigabitEthernet0/0/0
O IA 10.0.0.12/30 [110/2] via 10.0.0.5, 01:48:40, GigabitEthernet0/0/1
O IA 10.0.0.16/30 [110/3] via 10.0.0.5, 01:48:40, GigabitEthernet0/0/1
192.168.0.0/32 is subnetted, 1 subnets
O IA 192.168.0.1/32 [110/66] via 10.0.0.5, 01:48:40, GigabitEthernet0/0/1
192.168.1.0/32 is subnetted, 1 subnets
O IA 192.168.1.1/32 [110/2] via 10.0.0.5, 01:48:40, GigabitEthernet0/0/1
192.168.2.0/32 is subnetted, 1 subnets
C 192.168.2.1/32 is directly connected, Loopback0
192.168.3.0/32 is subnetted, 1 subnets
O 192.168.3.1/32 [110/2] via 10.0.0.10, 01:48:13, GigabitEthernet0/0/0
192.168.4.0/32 is subnetted, 1 subnets
O IA 192.168.4.1/32 [110/3] via 10.0.0.5, 01:48:40, GigabitEthernet0/0/1
192.168.5.0/32 is subnetted, 1 subnets
O IA 192.168.5.1/32 [110/4] via 10.0.0.5, 01:47:58, GigabitEthernet0/0/1
```

show ipv6 route:

```
R3#show ipv6 route
IPv6 Routing Table - 15 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route, M - MIPv6
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
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
D - EIGRP, EX - EIGRP external
OI 2001:DB8:ACAD:1::/64 [110/65]
via FE80::2, GigabitEthernet0/0/1
C 2001:DB8:ACAD:2::/64 [0/0]
via GigabitEthernet0/0/1, directly connected
L 2001:DB8:ACAD:2::2/128 [0/0]
via GigabitEthernet0/0/1, receive
C 2001:DB8:ACAD:3::/64 [0/0]
via GigabitEthernet0/0/0, directly connected
L 2001:DB8:ACAD:3::1/128 [0/0]
```

```
via GigabitEthernet0/0/0, receive
OI 2001:DB8:ACAD:4::/64 [110/2]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:5::/64 [110/3]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:A::1/128 [110/65]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:B::1/128 [110/1]
via FE80::2, GigabitEthernet0/0/1
C 2001:DB8:ACAD:C::/64 [0/0]
via Loopback0, directly connected
L 2001:DB8:ACAD:C::1/128 [0/0]
via Loopback0, receive
O 2001:DB8:ACAD:D::1/128 [110/1]
via FE80::4, GigabitEthernet0/0/0
OI 2001:DB8:ACAD:E::1/128 [110/2]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:F::1/128 [110/3]
via FE80::2, GigabitEthernet0/0/1
L FF00::/8 [0/0]
via Null0, receive
```

show ip ospf interface:

```
R3#show ip ospf interface

Loopback0 is up, line protocol is up
Internet address is 192.168.2.1/32, Area 1
Process ID 10, Router ID 3.3.3.3, Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 10.0.0.9/30, Area 1
Process ID 10, 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, Interface address 10.0.0.10
Backup Designated Router (ID) 3.3.3.3, Interface address 10.0.0.9
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:05
Index 2/2, flood queue length 0
Next 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 4.4.4.4 (Designated Router)
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/1 is up, line protocol is up
Internet address is 10.0.0.6/30, Area 1
Process ID 10, 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, Interface address 10.0.0.6
Backup Designated Router (ID) 2.2.2.2, Interface address 10.0.0.5
Timer intervals configured, Hello 1, Dead 3, Wait 3, Retransmit 5
Hello due in 00:00:00
Index 3/3, flood queue length 0
Next 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 2.2.2.2 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

show ipv6 ospf interface:

```
R3#show ipv6 ospf interface
Loopback0 is up, line protocol is up
Link Local Address FE80::3, Interface ID 3
Area 1, Process ID 1, Instance ID 0, Router ID 3.3.3.3
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::3, Interface ID 1
Area 1, Process ID 1, 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::3
Backup Designated Router (ID) 3.3.3.3, local address FE80::3
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:02
Index 2/2, flood queue length 0
Next 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 4.4.4.4 (Designated Router)
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/1 is up, line protocol is up
Link Local Address FE80::3, Interface ID 2
Area 1, Process ID 1, 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::3
Backup Designated Router (ID) 2.2.2.2, local address FE80::3
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:07
Index 3/3, flood queue length 0
Next 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 2.2.2.2 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

show ip ospf neighbor:

```
R3#show ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface
4.4.4.4 1 FULL/DR 00:00:38 10.0.0.10 GigabitEthernet0/0/0
2.2.2.2 1 FULL/BDR 00:00:02 10.0.0.5 GigabitEthernet0/0/1
```

show ip protocol:

```
R3# show ip protocol

Routing Protocol is "ospf 10"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 3.3.3.3
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
192.168.2.1 0.0.0.0 area 1
10.0.0.4 0.0.0.3 area 1
10.0.0.8 0.0.0.3 area 1
Passive Interface(s):
Loopback0
Routing Information Sources:
Gateway Distance Last Update
2.2.2.2 110 00:10:21
3.3.3.3 110 00:10:21
4.4.4.4 110 00:19:00
Distance: (default is 110)
```

show ipv6 protocol:

```
R3#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Interfaces (Area 1)
Loopback0
GigabitEthernet0/0/0
GigabitEthernet0/0/1
Redistribution:
None
```

show ip ospf border-router:

```
R3#show ip ospf border-router
OSPF Process 10 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [1] via 10.0.0.5, GigabitEthernet0/0/1, ABR, Area 1, SPF 1
```

show ipv6 ospf border-router:

```
R3#show ipv6 ospf border-router
OSPFv3 Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [1] via FE80::2, GigabitEthernet0/0/1, ABR, Area 1, SPF 2
```

Router 4 Config:

show run:

```
R4#show run
Building configuration...
```

```
Current configuration : 1068 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R4
!
ip cef
ipv6 unicast-routing
!
no ipv6 cef
!
spanning-tree mode pvst
!
interface Loopback0
ip address 192.168.3.1 255.255.255.255
ipv6 address FE80::4 link-local
ipv6 address 2001:DB8:ACAD:D::1/64
ipv6 ospf 1 area 1
!
interface GigabitEthernet0/0/0
no ip address
duplex auto
speed auto
shutdown
!
interface GigabitEthernet0/0/1
ip address 10.0.0.10 255.255.255.252
duplex auto
speed auto
ipv6 address FE80::4 link-local
ipv6 address 2001:DB8:ACAD:3::2/64
ipv6 ospf 1 area 1
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 4.4.4.4
log-adjacency-changes
passive-interface Loopback0
network 10.0.0.8 0.0.0.3 area 1
network 192.168.3.1 0.0.0.0 area 1
!
ipv6 router ospf 1
router-id 4.4.4.4
log-adjacency-changes
!
ip classless
!
ip flow-export version 9
!
no cdp run
!
line con 0
!
line aux 0
!
line vty 0 4
login
!
end
```

show ip 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, E - EGP
i - IS-IS, 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

Gateway of last resort is not set
```

```
10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O IA 10.0.0.0/30 [110/66] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
O 10.0.0.4/30 [110/2] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
C 10.0.0.8/30 is directly connected, GigabitEthernet0/0/1
L 10.0.0.10/32 is directly connected, GigabitEthernet0/0/1
O IA 10.0.0.12/30 [110/3] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
O IA 10.0.0.16/30 [110/4] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
192.168.0.0/32 is subnetted, 1 subnets
O IA 192.168.0.1/32 [110/67] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
192.168.1.0/32 is subnetted, 1 subnets
O IA 192.168.1.1/32 [110/3] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
192.168.2.0/32 is subnetted, 1 subnets
O 192.168.2.1/32 [110/2] via 10.0.0.9, 01:54:56, GigabitEthernet0/0/1
192.168.3.0/32 is subnetted, 1 subnets
C 192.168.3.1/32 is directly connected, Loopback0
192.168.4.0/32 is subnetted, 1 subnets
O IA 192.168.4.1/32 [110/4] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
192.168.5.0/32 is subnetted, 1 subnets
O IA 192.168.5.1/32 [110/5] via 10.0.0.9, 00:13:56, GigabitEthernet0/0/1
```

show ipv6 route:

```
R4#show ipv6 route
IPv6 Routing Table - 14 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route, M - MIPv6
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
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
D - EIGRP, EX - EIGRP external
OI 2001:DB8:ACAD:1::/64 [110/66]
via FE80::3, GigabitEthernet0/0/1
O 2001:DB8:ACAD:2::/64 [110/2]
via FE80::3, GigabitEthernet0/0/1
C 2001:DB8:ACAD:3::/64 [0/0]
via GigabitEthernet0/0/1, directly connected
L 2001:DB8:ACAD:3::2/128 [0/0]
via GigabitEthernet0/0/1, receive
OI 2001:DB8:ACAD:4::/64 [110/3]
via FE80::3, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:5::/64 [110/4]
via FE80::3, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:A::1/128 [110/66]
via FE80::3, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:B::1/128 [110/2]
via FE80::3, GigabitEthernet0/0/1
O 2001:DB8:ACAD:C::1/128 [110/1]
via FE80::3, GigabitEthernet0/0/1
C 2001:DB8:ACAD:D::/64 [0/0]
via Loopback0, directly connected
L 2001:DB8:ACAD:D::1/128 [0/0]
via Loopback0, receive
OI 2001:DB8:ACAD:E::1/128 [110/3]
via FE80::3, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:F::1/128 [110/4]
via FE80::3, GigabitEthernet0/0/1
L FF00::/8 [0/0]
via Null0, receive
```

show ip ospf interface:

```
R4#show ip ospf interface

Loopback0 is up, line protocol is up
Internet address is 192.168.3.1/32, Area 1
Process ID 10, 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
Internet address is 10.0.0.10/30, Area 1
Process ID 10, 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, Interface address 10.0.0.10
Backup Designated Router (ID) 3.3.3.3, Interface address 10.0.0.9
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:07
Index 2/2, flood queue length 0
Next 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 3.3.3.3 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```
show ipv6 ospf interface:
```
R4#show ipv6 ospf interface
Loopback0 is up, line protocol is up
Link Local Address FE80::4, Interface ID 3
Area 1, Process ID 1, 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::4, Interface ID 2
Area 1, Process ID 1, 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::4
Backup Designated Router (ID) 3.3.3.3, local address FE80::4
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:03
Index 2/2, flood queue length 0
Next 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 3.3.3.3 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```
show ip ospf neighbor:
```
R4#show ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface
3.3.3.3 1 FULL/BDR 00:00:34 10.0.0.9 GigabitEthernet0/0/1
```
show ip protocol:
```
R4#show ip protocol

Routing Protocol is "ospf 10"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 4.4.4.4
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
10.0.0.8 0.0.0.3 area 1
192.168.3.1 0.0.0.0 area 1
Passive Interface(s):
Loopback0
Routing Information Sources:
Gateway Distance Last Update
2.2.2.2 110 00:16:05
3.3.3.3 110 00:16:06
4.4.4.4 110 00:24:46
Distance: (default is 110)
```
show ipv6 protocol:
```
R4#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Interfaces (Area 1)
Loopback0
GigabitEthernet0/0/1
Redistribution:
None
```
show ip ospf border-router:
```
R4#show ip ospf border-router
OSPF Process 10 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [2] via 10.0.0.9, GigabitEthernet0/0/1, ABR, Area 1, SPF 2
```
show ipv6 ospf border-router:
```
R4#show ipv6 ospf border-router
OSPFv3 Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [2] via FE80::3, GigabitEthernet0/0/1, ABR, Area 1, SPF 2
```

Router 5 Config:

show run:

```
R5#show run
Building configuration...

Current configuration : 1256 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R5
!
ip cef
ipv6 unicast-routing
!
no ipv6 cef
!
spanning-tree mode pvst
!
interface Loopback0
ip address 192.168.4.1 255.255.255.255
ipv6 address FE80::5 link-local
ipv6 address 2001:DB8:ACAD:E::1/64
ipv6 ospf 1 area 2
!
interface GigabitEthernet0/0/0
ip address 10.0.0.17 255.255.255.252
duplex auto
speed auto
ipv6 address FE80::5 link-local
ipv6 address 2001:DB8:ACAD:5::1/64
ipv6 ospf 1 area 2
!
interface GigabitEthernet0/0/1
ip address 10.0.0.14 255.255.255.252
ip ospf hello-interval 1
ip ospf dead-interval 3
duplex auto
speed auto
ipv6 address FE80::5 link-local
ipv6 address 2001:DB8:ACAD:4::2/64
ipv6 ospf 1 area 2
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 5.5.5.5
log-adjacency-changes
passive-interface Loopback0
network 10.0.0.12 0.0.0.3 area 2
network 192.168.4.1 0.0.0.0 area 2
network 10.0.0.16 0.0.0.3 area 2
!
ipv6 router ospf 1
router-id 5.5.5.5
log-adjacency-changes
!
ip classless
!
ip flow-export version 9
!
no cdp run
!
line con 0
!
line aux 0
!
line vty 0 4
login
!
end
```

show ip 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, E - EGP
i - IS-IS, 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

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
O IA 10.0.0.0/30 [110/65] via 10.0.0.13, 02:08:39, GigabitEthernet0/0/1
O IA 10.0.0.4/30 [110/2] via 10.0.0.13, 02:08:49, GigabitEthernet0/0/1
O IA 10.0.0.8/30 [110/3] via 10.0.0.13, 02:08:39, GigabitEthernet0/0/1
C 10.0.0.12/30 is directly connected, GigabitEthernet0/0/1
L 10.0.0.14/32 is directly connected, GigabitEthernet0/0/1
C 10.0.0.16/30 is directly connected, GigabitEthernet0/0/0
L 10.0.0.17/32 is directly connected, GigabitEthernet0/0/0
192.168.0.0/32 is subnetted, 1 subnets
O IA 192.168.0.1/32 [110/66] via 10.0.0.13, 02:08:39, GigabitEthernet0/0/1
192.168.1.0/32 is subnetted, 1 subnets
O IA 192.168.1.1/32 [110/2] via 10.0.0.13, 02:08:39, GigabitEthernet0/0/1
192.168.2.0/32 is subnetted, 1 subnets
O IA 192.168.2.1/32 [110/3] via 10.0.0.13, 02:08:39, GigabitEthernet0/0/1
192.168.3.0/32 is subnetted, 1 subnets
O IA 192.168.3.1/32 [110/4] via 10.0.0.13, 02:07:59, GigabitEthernet0/0/1
192.168.4.0/32 is subnetted, 1 subnets
C 192.168.4.1/32 is directly connected, Loopback0
192.168.5.0/32 is subnetted, 1 subnets
O 192.168.5.1/32 [110/2] via 10.0.0.18, 02:08:14, GigabitEthernet0/0/0
```

show ipv6 route:

```
R5#show ipv6 route
IPv6 Routing Table - 15 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route, M - MIPv6
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
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
D - EIGRP, EX - EIGRP external
OI 2001:DB8:ACAD:1::/64 [110/65]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:2::/64 [110/2]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:3::/64 [110/3]
via FE80::2, GigabitEthernet0/0/1
C 2001:DB8:ACAD:4::/64 [0/0]
via GigabitEthernet0/0/1, directly connected
L 2001:DB8:ACAD:4::2/128 [0/0]
via GigabitEthernet0/0/1, receive
C 2001:DB8:ACAD:5::/64 [0/0]
via GigabitEthernet0/0/0, directly connected
L 2001:DB8:ACAD:5::1/128 [0/0]
via GigabitEthernet0/0/0, receive
OI 2001:DB8:ACAD:A::1/128 [110/65]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:B::1/128 [110/1]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:C::1/128 [110/2]
via FE80::2, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:D::1/128 [110/3]
via FE80::2, GigabitEthernet0/0/1
C 2001:DB8:ACAD:E::/64 [0/0]
via Loopback0, directly connected
L 2001:DB8:ACAD:E::1/128 [0/0]
via Loopback0, receive
O 2001:DB8:ACAD:F::1/128 [110/1]
via FE80::6, GigabitEthernet0/0/0
L FF00::/8 [0/0]
via Null0, receive
```

show ip ospf interface:

```
R5#show ip ospf interface

Loopback0 is up, line protocol is up
Internet address is 192.168.4.1/32, Area 2
Process ID 10, Router ID 5.5.5.5, Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
GigabitEthernet0/0/0 is up, line protocol is up
```

```
Internet address is 10.0.0.17/30, Area 2
Process ID 10, 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, Interface address 10.0.0.18
Backup Designated Router (ID) 5.5.5.5, Interface address 10.0.0.17
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:07
Index 2/2, flood queue length 0
Next 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 6.6.6.6 (Designated Router)
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/1 is up, line protocol is up
Internet address is 10.0.0.14/30, Area 2
Process ID 10, 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, Interface address 10.0.0.14
Backup Designated Router (ID) 2.2.2.2, Interface address 10.0.0.13
Timer intervals configured, Hello 1, Dead 3, Wait 3, Retransmit 5
Hello due in 00:00:00
Index 3/3, flood queue length 0
Next 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 2.2.2.2 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

show ipv6 ospf interface:

```
R5#show ipv6 ospf interface
Loopback0 is up, line protocol is up
Link Local Address FE80::5, Interface ID 3
Area 2, Process ID 1, Instance ID 0, Router ID 5.5.5.5
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::5, Interface ID 1
Area 2, Process ID 1, 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::5
Backup Designated Router (ID) 5.5.5.5, local address FE80::5
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:07
Index 2/2, flood queue length 0
Next 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 6.6.6.6 (Designated Router)
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0/1 is up, line protocol is up
Link Local Address FE80::5, Interface ID 2
Area 2, Process ID 1, 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::5
Backup Designated Router (ID) 2.2.2.2, local address FE80::5
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:03
Index 3/3, flood queue length 0
Next 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 2.2.2.2 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

show ip ospf neighbor:

```
R5#show ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface
6.6.6.6 1 FULL/DR 00:00:34 10.0.0.18 GigabitEthernet0/0/0
2.2.2.2 1 FULL/BDR 00:00:02 10.0.0.13 GigabitEthernet0/0/1
```

show ip protocol:

```
R5#show ip protocol
```

```
Routing Protocol is "ospf 10"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 5.5.5.5
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
10.0.0.12 0.0.0.3 area 2
192.168.4.1 0.0.0.0 area 2
10.0.0.16 0.0.0.3 area 2
Passive Interface(s):
Loopback0
Routing Information Sources:
Gateway Distance Last Update
2.2.2.2 110 00:00:56
5.5.5.5 110 00:00:56
6.6.6.6 110 00:09:39
Distance: (default is 110)
```

show ipv6 protocol:

```
R5#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Interfaces (Area 2)
Loopback0
GigabitEthernet0/0/0
GigabitEthernet0/0/1
Redistribution:
None
```

show ip ospf border-router:

```
R5#show ip ospf border-router
OSPF Process 10 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [1] via 10.0.0.13, GigabitEthernet0/0/1, ABR, Area 2, SPF 1
```

show ipv6 ospf border-router:

```
R5#show ipv6 ospf border-router
OSPFv3 Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [1] via FE80::2, GigabitEthernet0/0/1, ABR, Area 2, SPF 2
```

Router 6 Config:

show run:

```
R6#show run
Building configuration...

Current configuration : 1098 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R6
!
ip cef
ipv6 unicast-routing
!
no ipv6 cef
!
spanning-tree mode pvst
!
interface Loopback0
ip address 192.168.5.1 255.255.255.255
ipv6 address FE80::6 link-local
ipv6 address 2001:DB8:ACAD:F::1/64
ipv6 ospf 1 area 2
!
interface GigabitEthernet0/0/0
no ip address
duplex auto
speed auto
shutdown
!
interface GigabitEthernet0/0/1
```

```
ip address 10.0.0.18 255.255.255.252
duplex auto
speed auto
ipv6 address FE80::6 link-local
ipv6 address 2001:DB8:ACAD:5::2/64
ipv6 ospf 1 area 2
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 6.6.6.6
log-adjacency-changes
passive-interface Loopback0
network 10.0.0.16 0.0.0.3 area 2
network 192.168.5.1 0.0.0.0 area 2
!
ipv6 router ospf 1
router-id 6.6.6.6
log-adjacency-changes
passive-interface Loopback0
!
ip classless
!
ip flow-export version 9
!
no cdp run
!
line con 0
!
line aux 0
!
line vty 0 4
login
!
end
```

show ip 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, E - EGP
i - IS-IS, 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

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O IA 10.0.0.0/30 [110/66] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
O IA 10.0.0.4/30 [110/3] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
O IA 10.0.0.8/30 [110/4] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
O 10.0.0.12/30 [110/2] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
C 10.0.0.16/30 is directly connected, GigabitEthernet0/0/1
L 10.0.0.18/32 is directly connected, GigabitEthernet0/0/1
192.168.0.0/32 is subnetted, 1 subnets
O IA 192.168.0.1/32 [110/67] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
192.168.1.0/32 is subnetted, 1 subnets
O IA 192.168.1.1/32 [110/3] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
192.168.2.0/32 is subnetted, 1 subnets
O IA 192.168.2.1/32 [110/4] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
192.168.3.0/32 is subnetted, 1 subnets
O IA 192.168.3.1/32 [110/5] via 10.0.0.17, 02:15:37, GigabitEthernet0/0/1
192.168.4.0/32 is subnetted, 1 subnets
O 192.168.4.1/32 [110/2] via 10.0.0.17, 02:15:52, GigabitEthernet0/0/1
192.168.5.0/32 is subnetted, 1 subnets
C 192.168.5.1/32 is directly connected, Loopback0
```

show ipv6 route:

```
R6#show ipv6 route
IPv6 Routing Table - 14 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route, M - MIPv6
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
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
```

```
D - EIGRP, EX - EIGRP external
OI 2001:DB8:ACAD:1::/64 [110/66]
via FE80::5, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:2::/64 [110/3]
via FE80::5, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:3::/64 [110/4]
via FE80::5, GigabitEthernet0/0/1
O 2001:DB8:ACAD:4::/64 [110/2]
via FE80::5, GigabitEthernet0/0/1
C 2001:DB8:ACAD:5::/64 [0/0]
via GigabitEthernet0/0/1, directly connected
L 2001:DB8:ACAD:5::2/128 [0/0]
via GigabitEthernet0/0/1, receive
OI 2001:DB8:ACAD:A::1/128 [110/66]
via FE80::5, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:B::1/128 [110/2]
via FE80::5, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:C::1/128 [110/3]
via FE80::5, GigabitEthernet0/0/1
OI 2001:DB8:ACAD:D::1/128 [110/4]
via FE80::5, GigabitEthernet0/0/1
O 2001:DB8:ACAD:E::1/128 [110/1]
via FE80::5, GigabitEthernet0/0/1
C 2001:DB8:ACAD:F::/64 [0/0]
via Loopback0, directly connected
L 2001:DB8:ACAD:F::1/128 [0/0]
via Loopback0, receive
L FF00::/8 [0/0]
via Null0, receive
```

show ip ospf interface:

```
R6#show ip ospf interface

Loopback0 is up, line protocol is up
Internet address is 192.168.5.1/32, Area 2
Process ID 10, Router ID 6.6.6.6, Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
GigabitEthernet0/0/1 is up, line protocol is up
Internet address is 10.0.0.18/30, Area 2
Process ID 10, 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, Interface address 10.0.0.18
Backup Designated Router (ID) 5.5.5.5, Interface address 10.0.0.17
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:00
Index 2/2, flood queue length 0
Next 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 5.5.5.5 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

show ipv6 ospf interface:

```
R6#show ipv6 ospf interface
Loopback0 is up, line protocol is up
Link Local Address FE80::6, Interface ID 3
Area 2, Process ID 1, Instance ID 0, Router ID 6.6.6.6
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::6, Interface ID 2
Area 2, Process ID 1, 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::6
Backup Designated Router (ID) 5.5.5.5, local address FE80::6
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:02
Index 2/2, flood queue length 0
Next 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 5.5.5.5 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

show ip ospf neighbor:

```
R6#show ip ospf neighbor
```

```
Neighbor ID Pri State Dead Time Address Interface
5.5.5.5 1 FULL/BDR 00:00:37 10.0.0.17 GigabitEthernet0/0/1
```
show ip protocol:
```
R6#show ip protocol

Routing Protocol is "ospf 10"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 6.6.6.6
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
10.0.0.16 0.0.0.3 area 2
192.168.5.1 0.0.0.0 area 2
Passive Interface(s):
Loopback0
Routing Information Sources:
Gateway Distance Last Update
2.2.2.2 110 00:09:44
5.5.5.5 110 00:09:45
6.6.6.6 110 00:18:27
Distance: (default is 110)
```
show ipv6 protocol:
```
R6#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Interfaces (Area 2)
Loopback0
GigabitEthernet0/0/1
Redistribution:
None
```
show ip ospf border-router:
```
R6#show ip ospf border-router
OSPF Process 10 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [2] via 10.0.0.17, GigabitEthernet0/0/1, ABR, Area 2, SPF 2
```
show ipv6 ospf border-router:
```
R6#show ipv6 ospf border-router
OSPFv3 Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [2] via FE80::5, GigabitEthernet0/0/1, ABR, Area 2, SPF 2
```

Problems and Troubleshooting:

I encountered several problems when completing this lab. First. When configuring the routers for OSPF, I discovered that the previous configuration was not wiped by the people who used the router beforehand and had been copied to the startup-config. I then entered the `config register 0x2102`, clear the startup-config and reloaded the router. Another problem occurred when all six routers were set up with loopbacks and we looked at the OSPFv3 routing table. None of the Loopbacks other then the directly connected one had advertised routes. I pinged and tracerouted the addresses but had no luck. I then clear the ospf process through the command `clear ipv6 ospf process` and checked neighbor adjacencies to make sure the OSPF process was working properly. Since we could ping to the IPv4 and IPv6 addresses on routers in other areas, I knew it had to be a problem with the Loopback interfaces themselves. I first entered a `show ip interface brief` to check if the interface had somehow shut off. I then checked the addressing scheme for the Loopbacks to see if they had been entered incorrectly. What I realized is that the Loopback addresses were not specific enough and that was causing OSPF to not advertise them. The addresses were in the 2000::1/64 range which is nowhere near specific enough. After I changed the addressing scheme to the 2001:db8:acad:0::0/64 network the loopbacks worked. While going through the show runs of the routers, I realized that I had another problem. I had copied over my old config

from OSPFv2 single-area, and all the routers were in the same OSPFv2 area 0. I then went through each router changing the interface areas to their respective multiarea' s. The final problem I encountered was that interface Gig0/0/1 on R3 was not establishing a neighbor adjacency with R2. I issued a `show run` command and compared the configurations of R2 and R3. I discovered that G0/0/1 had no IPv6 OSPF 1 Area 1 command. When I entered that command, the adjacency was reestablished.

Conclusion

OSPFv3 and multiarea OSPF are useful in reducing network overhead especially in large and complicated networks. ABRs and ASBRs help manage traffic in between areas and outside networks. OSPFv3 allows for efficient IPv6 routing. I learned a lot about how to set up OSPFv3 and multiarea OSPF. There are many advantages and few disadvantages to using OSPF. However, OSPF is not the only routing protocol out there and is not the best in certain situation. In our next labs we will learn about BGP, EIGRP and stubby and not so stubby areas (NSSAs).