Multi-Area OSPF

CCNP Lab 1

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Cisco CCNP - Hoffman and Mason - Periods 6 and 7

Multi-Area OSPF Lab 1

Purpose

There were three reasons for doing this lab. The first was to review what OSPF and multi-area OSPF are and how to implement them. The second reason was to get some practice implementing multi-area OSPF in IPv4 and IPv6. The third one was to learn about the flow of the CCNP class, and get used to how everything works in the class.

Background Information

In this lab, we use a routing protocol called OSPF which stands for “Open Shortest Path First”. Think of it as like a person who is walking towards a destination, however he has many paths to choose from. Each path however, has different “parameters”, such as using bikes or cars on certain paths; or the lengths of the paths are different. However, the person’s goal is to just get to their destination as fast as possible, so they figure out an algorithm to optimize the time it takes to get to the destination, usually by finding the shortest path. In routing terms, this algorithm is called Dijkstra’s algorithm, or SPF for short (shortest path first), which is what routers use to determine which route packets should be sent through. This algorithm calculates the shortest path by using each path’s cost, bandwidth, delay and load.
OSPF enables routing devices to build a network topology on their own, by just using data, like their connections to other routing devices, also known as “neighbors”. A network topology is like a map of highways that vehicles travel on to get from place to place, except from a networking perspective, it is a map of routes that layer 3 devices use to transfer packets. The autonomous

generation of topologies by routing devices, like how google maps uses data to make an accurate representation of maps, and how roads connect together to get to a destination, makes it a very nifty protocol to use, when you are working with multiple routing devices.
However, at times, OSPF with only one area, becomes very demanding of every device, since each one has to do calculations to build their own topologies. This is where multi-area OSPF, an extension of OSPF comes in. It allows for grouping up multiple routers and layer 3 switches into different “areas”. These “areas” allow for each routing device to only worry about other devices in it’s own “area”, making it much easier to handle very large networks, and reducing the computational stress that layer 3 devices have to carry out. There also needs to be one backbone area, which is usually area 0, and all other areas must be connected to the backbone, since areas don’t have knowledge about other areas which would cause confusion while packets traverse the network. The backbone area handles all the traffic that need to travel between areas, like a rest stop on a highway. Think about it like the United Nations (UN), which is what most (if not all) countries are a part of. The UN has information about what is going on in each country, which not all countries have about each other.

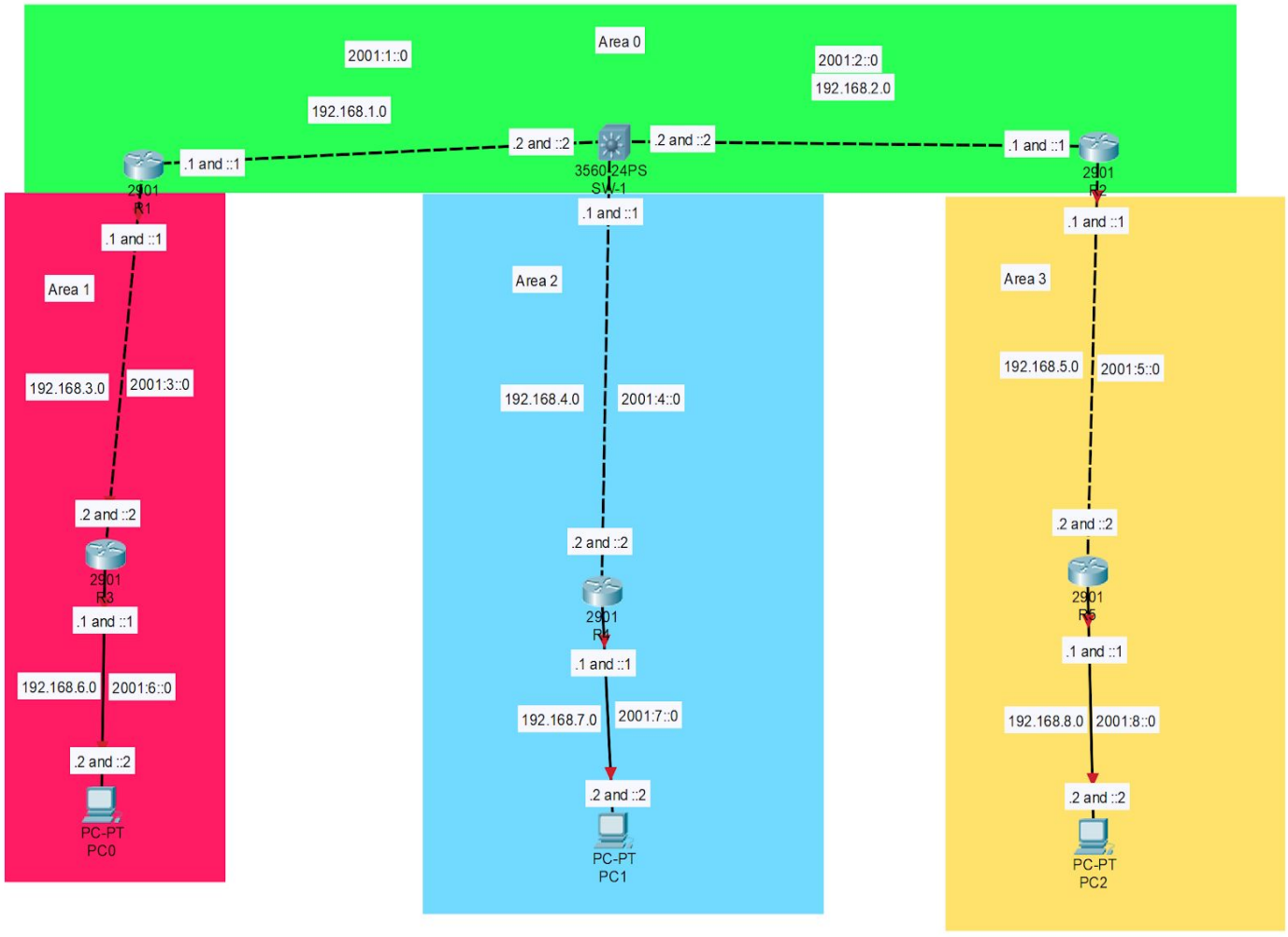
Lab Summary

In this lab we designed a network that implements multi-area OSPF as its routing protocol. To do this we used 5 routers and a multilayer switch, which was configured to function as another router. The multilayer switch and two routers have ports connected to area 0 (backbone area) and another area. We then developed a routing scheme for each device, using both IPv4 and IPv6. Then we configured the routers to use multi-area OSPF in both IPv4 and IPv6 and tested for full connectivity using the computers shown in the network diagram.

Lab Commands

ipv6 unicast-routing	Enables IPv6 routing on routers and multilayer switches
ip routing	Enables a multilayer switch to route and become a router
router ospf [process-id]	Enables OSPF process on router/multilayer switch for IPv4
network [network address] [wildcard mask] [area-id]	Creates the ospf network in designated area for IPv4
ipv6 router ospf [process-id]	Enables OSPF process on router/multilayer switch for IPv6
ipv6 ospf [process-id] area [area-id]	Group's the router's interface into an OSPF area for IPv6, so that it can start building its topology
show ip route	Generates the routing table for IPv4
show ipv6 route	Generates the routing table for IPv6
show ip ospf neighbors	Shows the adjacencies and neighbors that each device has from OSPF - IPv4
show ipv6 ospf neighbors	Shows the adjacencies and neighbors that each device has from OSPF - IPv6
ping [ip-address]	Shows the connectivity between the device and another one - works for IPv4 and IPv6
ip address [address]	Sets up the IPv4 address in an interface
ipv6 address [address]	Sets up the IPv6 address in an interface

Network Diagram



Configurations

Router 1 Configuration:

R1# show run

```
hostname R1
ipv6 unicast-routing
interface GigabitEthernet0/0
```

```
 description Link R1 to R3
 ip address 192.168.3.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:3::1/64
 ipv6 ospf 1 area 1
interface GigabitEthernet0/1
 description Link R1 to SW-1
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:1::1/64
 ipv6 ospf 1 area 0
router ospf 1
 router-id 1.1.1.1
 network 192.168.1.0 0.0.0.255 area 0
 network 192.168.3.0 0.0.0.255 area 1
ip forward-protocol nd
ipv6 router ospf 1
end
```

Router 1 OSPF Neighbors:

IPV4:

R1# show ip ospf neighbors

Neighbor ID	Pri	State	Dead Time	Address	Interface
7.7.7.7	1	FULL/DR	00:00:38	192.168.1.2	GigabitEthernet0/1
3.3.3.3	1	FULL/DR	00:00:38	192.168.3.2	GigabitEthernet0/0

IPV6:

R1# show ipv6 ospf neighbors

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
192.168.4.1	1	FULL/DR	00:00:37	1020	GigabitEthernet0/1
192.168.3.2	1	FULL/BDR	00:00:37	4	GigabitEthernet0/0

Router 1 Routing Tables:

IPV4:

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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/1
O     192.168.2.0/24 [110/2] via 192.168.1.2, 01:20:28, GigabitEthernet0/1
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, GigabitEthernet0/0
L        192.168.3.1/32 is directly connected, GigabitEthernet0/0
O IA  192.168.4.0/24 [110/2] via 192.168.1.2, 01:20:28, GigabitEthernet0/1
O IA  192.168.5.0/24 [110/3] via 192.168.1.2, 01:20:28, GigabitEthernet0/1
```

IPV6:

R1# show ipv6 route

```
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery
       l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:1::/64 [0/0]
     via GigabitEthernet0/1, directly connected
L   2001:1::1/128 [0/0]
     via GigabitEthernet0/1, receive
O   2001:2::/64 [110/2]
     via FE80::6FE:7FFF:FE20:85C3, GigabitEthernet0/1
C   2001:3::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:3::1/128 [0/0]
     via GigabitEthernet0/0, receive
OI  2001:4::/64 [110/2]
     via FE80::6FE:7FFF:FE20:85C3, GigabitEthernet0/1
OI  2001:5::/64 [110/3]
     via FE80::6FE:7FFF:FE20:85C3, GigabitEthernet0/1
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 2 Configuration:

R2# show run

```
hostname R2
ipv6 unicast-routing
interface GigabitEthernet0/0
 description Link R2 to SW-1
 ip address 192.168.2.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:2::1/64
 ipv6 ospf 1 area 0
interface GigabitEthernet0/1
 description Link R2 to R5
 ip address 192.168.5.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:5::1/64
 ipv6 ospf 1 area 3
router ospf 1
 router-id 2.2.2.2
 network 192.168.2.0 0.0.0.255 area 0
 network 192.168.5.0 0.0.0.255 area 3
ipv6 router ospf 1
end
```

Router 2 OSPF Neighbors:

IPV4:

R2# show ip ospf neighbors

```
Neighbor ID   Pri   State          Dead Time   Address         Interface
7.7.7.7         1   FULL/DR        00:00:34      192.168.2.2   GigabitEthernet0/0
5.5.5.5         1   FULL/DR        00:00:36      192.168.5.2   GigabitEthernet0/1
```

IPV6:

R2# show ipv6 ospf neighbors

```
Neighbor ID   Pri   State          Dead Time   Interface ID   Interface
192.168.4.1   1   FULL/BDR         00:00:35      1019          GigabitEthernet0/0
192.168.5.2   1   FULL/BDR         00:00:38      4             GigabitEthernet0/1
```

Router 2 Routing Tables:

IPV4:

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
       + - replicated route, % - next hop override

Gateway of last resort is not set

O     192.168.1.0/24 [110/2] via 192.168.2.2, 01:09:53, GigabitEthernet0/0
192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.2.0/24 is directly connected, GigabitEthernet0/0
L      192.168.2.1/32 is directly connected, GigabitEthernet0/0
O IA  192.168.3.0/24 [110/3] via 192.168.2.2, 01:09:53, GigabitEthernet0/0
O IA  192.168.4.0/24 [110/2] via 192.168.2.2, 01:44:38, GigabitEthernet0/0
       192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.5.0/24 is directly connected, GigabitEthernet0/1
L      192.168.5.1/32 is directly connected, GigabitEthernet0/1
```

IPV6:

R2# show ipv6 route

```
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery
       l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
O   2001:1::/64 [110/2]
      via FE80::6FE:7FFF:FE20:85C1, GigabitEthernet0/0
C   2001:2::/64 [0/0]
      via GigabitEthernet0/0, directly connected
L   2001:2::1/128 [0/0]
      via GigabitEthernet0/0, receive
OI  2001:3::/64 [110/3]
      via FE80::6FE:7FFF:FE20:85C1, GigabitEthernet0/0
OI  2001:4::/64 [110/2]
      via FE80::6FE:7FFF:FE20:85C1, GigabitEthernet0/0
C   2001:5::/64 [0/0]
      via GigabitEthernet0/1, directly connected
L   2001:5::1/128 [0/0]
```

```
            via GigabitEthernet0/1, receive
      L   FF00::/8 [0/0]
            via Null0, receive
```

Router 3 Configuration:

R3# show run

```
hostname R3
ipv6 unicast-routing
interface GigabitEthernet0/0
 description Link R3 to R1
 ip address 192.168.3.2 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:3::2/64
 ipv6 ospf 1 area 1
interface GigabitEthernet0/1
 ip address 192.168.6.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:6::1/64
 ipv6 ospf 1 area 1
router ospf 1
 router-id 3.3.3.3
 network 192.168.3.0 0.0.0.255 area 1
 network 192.168.6.0 0.0.0.255 area 1
ipv6 router ospf 1
end
```

Router 3 OSPF Neighbors:

IPV4:

R3# show ip ospf neighbors

```
Neighbor ID  Pri   State      Dead Time   Address      Interface
1.1.1.1       1   FULL/BDR    00:00:31    192.168.3.1  GigabitEthernet0/0
```

IPV6:

R3# show ipv6 ospf neighbors

```
Neighbor ID  Pri   State      Dead Time   Interface ID    Interface
```

```
192.168.3.1    1    FULL/DR     00:00:38    4               GigabitEthernet0/0
```

Router 3 Routing Tables:

IPV4:

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
       + - replicated route, % - next hop override

Gateway of last resort is not set
O IA  192.168.1.0/24 [110/2] via 192.168.3.1, 00:38:30, GigabitEthernet0/0
O IA  192.168.2.0/24 [110/3] via 192.168.3.1, 00:38:30, GigabitEthernet0/0
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, GigabitEthernet0/0
L        192.168.3.2/32 is directly connected, GigabitEthernet0/0
O IA  192.168.4.0/24 [110/3] via 192.168.3.1, 00:38:30, GigabitEthernet0/0
O IA  192.168.5.0/24 [110/4] via 192.168.3.1, 00:38:30, GigabitEthernet0/0
```

IPV6:

R3# show ipv6 route

```
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery
       l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
OI  2001:1::/64 [110/2]
     via FE80::AEF2:C5FF:FE55:9788, GigabitEthernet0/0
OI  2001:2::/64 [110/3]
     via FE80::AEF2:C5FF:FE55:9788, GigabitEthernet0/0
C   2001:3::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:3::2/128 [0/0]
     via GigabitEthernet0/0, receive
OI  2001:4::/64 [110/3]
     via FE80::AEF2:C5FF:FE55:9788, GigabitEthernet0/0
OI  2001:5::/64 [110/4]
     via FE80::AEF2:C5FF:FE55:9788, GigabitEthernet0/0
L   FF00::/8 [0/0]
```

```
            via Null0, receive
```

Router 4 Configuration:

R4# show run

```
hostname R4
ipv6 unicast-routing
interface GigabitEthernet0/0
 description Link R4 to SW-1
 ip address 192.168.4.2 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:4::2/64
 ipv6 ospf 1 area 2
interface GigabitEthernet0/1
 ip address 192.168.7.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:7::1/64
 ipv6 ospf 1 area 2
router ospf 1
 router-id 4.4.4.4
 network 192.168.4.0 0.0.0.255 area 2
 network 192.168.7.0 0.0.0.255 area 2
ipv6 router ospf 1
end
```

Router 4 OSPF Neighbors:

IPV4:

R4# show ip ospf neighbors

```
Neighbor ID   Pri   State          Dead Time   Address         Interface
7.7.7.7         1   FULL/DR        00:00:38      192.168.4.1   GigabitEthernet0/0
```

IPV6:

R4# show ipv6 ospf neighbors

```
Neighbor ID   Pri   State          Dead Time   Interface ID   Interface
192.168.4.1   1   FULL/BDR         00:00:38      1021         GigabitEthernet0/0
```

Router 4 Routing Tables:

IPV4:

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
       + - replicated route, % - next hop override

Gateway of last resort is not set

O IA  192.168.1.0/24 [110/2] via 192.168.4.1, 00:35:47, GigabitEthernet0/0
O IA  192.168.2.0/24 [110/2] via 192.168.4.1, 00:35:47, GigabitEthernet0/0
O IA  192.168.3.0/24 [110/3] via 192.168.4.1, 00:35:47, GigabitEthernet0/0
      192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks
C     192.168.4.0/24 is directly connected, GigabitEthernet0/0
L     192.168.4.2/32 is directly connected, GigabitEthernet0/0
O IA  192.168.5.0/24 [110/3] via 192.168.4.1, 00:35:47, GigabitEthernet0/0
```

IPV6:

R4# show ipv6 route

```
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery
       l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
OI  2001:1::/64 [110/2]
      via FE80::6FE:7FFF:FE20:85C4, GigabitEthernet0/0
OI  2001:2::/64 [110/2]
      via FE80::6FE:7FFF:FE20:85C4, GigabitEthernet0/0
OI  2001:3::/64 [110/3]
      via FE80::6FE:7FFF:FE20:85C4, GigabitEthernet0/0
C   2001:4::/64 [0/0]
      via GigabitEthernet0/0, directly connected
L   2001:4::2/128 [0/0]
      via GigabitEthernet0/0, receive
OI  2001:5::/64 [110/3]
      via FE80::6FE:7FFF:FE20:85C4, GigabitEthernet0/0
L   FF00::/8 [0/0]
      via Null0, receive
```

Router 5 Configuration:

R5# show run

```
hostname R5
ipv6 unicast-routing
interface GigabitEthernet0/0
 description Link R5 to R2
 ip address 192.168.5.2 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:5::2/64
 ipv6 ospf 1 area 3
interface GigabitEthernet0/1
 ip address 192.168.8.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:8::1/64
 ipv6 ospf 1 area 3
router ospf 1
 router-id 5.5.5.5
 network 192.168.5.0 0.0.0.255 area 3
 network 192.168.8.0 0.0.0.255 area 3
ipv6 router ospf 1
end
```

Router 5 OSPF Neighbors:

IPV4:

R5# show ip ospf neighbors

```
Neighbor ID   Pri   State          Dead Time   Address         Interface
2.2.2.2         1   FULL/BDR       00:00:37      192.168.5.1   GigabitEthernet0/0
```

IPV6:

R5# show ipv6 ospf neighbors

```
Neighbor ID   Pri   State          Dead Time   Interface ID   Interface
192.168.5.1   1   FULL/DR          00:00:35      5            GigabitEthernet0/0
```

Router 5 Routing Tables:

IPV4:

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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/1
O     192.168.2.0/24 [110/2] via 192.168.1.2, 01:20:28, GigabitEthernet0/1
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, GigabitEthernet0/0
L        192.168.3.1/32 is directly connected, GigabitEthernet0/0
O IA  192.168.4.0/24 [110/2] via 192.168.1.2, 01:20:28, GigabitEthernet0/1
O IA  192.168.5.0/24 [110/3] via 192.168.1.2, 01:20:28, GigabitEthernet0/1
```

IPV6:

R5# show ipv6 route

```
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery
       l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:1::/64 [0/0]
     via GigabitEthernet0/1, directly connected
L   2001:1::1/128 [0/0]
     via GigabitEthernet0/1, receive
O   2001:2::/64 [110/2]
     via FE80::6FE:7FFF:FE20:85C3, GigabitEthernet0/1
C   2001:3::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:3::1/128 [0/0]
     via GigabitEthernet0/0, receive
OI  2001:4::/64 [110/2]
     via FE80::6FE:7FFF:FE20:85C3, GigabitEthernet0/1
```

```
       OI  2001:5::/64 [110/3]
            via FE80::6FE:7FFF:FE20:85C3, GigabitEthernet0/1
       L   FF00::/8 [0/0]
            via Null0, receive
```

Multilayer Switch 1 Configuration:

SW-1# show run

```
hostname SW-1
ip routing
ipv6 unicast-routing
interface FastEthernet1/0/1
 description Link SW-1 to R2
 no switchport
 ip address 192.168.2.2 255.255.255.0
 ipv6 address 2001:2::2/64
 ipv6 ospf 1 area 0
interface FastEthernet1/0/2
 description Link SW-1 to R1
 no switchport
 ip address 192.168.1.2 255.255.255.0
 ipv6 address 2001:1::2/64
 ipv6 ospf 1 area 0
interface FastEthernet1/0/3
 description Link SW-1 to R4
 no switchport
 ip address 192.168.4.1 255.255.255.0
 ipv6 address 2001:4::1/64
 ipv6 ospf 1 area 2
router ospf 1
 router-id 7.7.7.7
 network 192.168.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 0
 network 192.168.4.0 0.0.0.255 area 2
ipv6 router ospf 1
end
```

Multilayer Switch 1 OSPF Neighbors:

IPV4:

SW-1# show ip ospf neighbors

```
Neighbor ID   Pri   State     Dead Time   Address         Interface
2.2.2.2         1   FULL/BDR  00:00:32    192.168.2.1     FastEthernet1/0/1
1.1.1.1         1   FULL/BDR  00:00:32    192.168.1.1     FastEthernet1/0/2
4.4.4.4         1   FULL/BDR  00:00:32    192.168.4.2     FastEthernet1/0/3
```

IPV6:

SW-1# show ipv6 ospf neighbors

```
Neighbor ID   Pri   State    Dead Time   Interface ID    Interface
192.168.3.1     1   FULL/BDR 00:00:36    5               FastEthernet1/0/2
192.168.5.1     1   FULL/DR  00:00:35    4               FastEthernet1/0/1
192.168.4.2     1   FULL/DR  00:00:31    4               FastEthernet1/0/3
```

Multilayer Switch 1 Routing Tables:

IPV4:

SW-1# 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
       + - replicated route, % - next hop override

Gateway of last resort is not set

    192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, FastEthernet1/0/2
L        192.168.1.2/32 is directly connected, FastEthernet1/0/2
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, FastEthernet1/0/1
L        192.168.2.2/32 is directly connected, FastEthernet1/0/1
O IA  192.168.3.0/24 [110/2] via 192.168.1.1, 01:10:39, FastEthernet1/0/2
      192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.4.0/24 is directly connected, FastEthernet1/0/3
L        192.168.4.1/32 is directly connected, FastEthernet1/0/3
O IA  192.168.5.0/24 [110/2] via 192.168.2.1, 01:45:15, FastEthernet1/0/1
```

IPV6:

SW-1# show ipv6 route

```
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
```

```
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery
       l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:1::/64 [0/0]
     via FastEthernet1/0/2, directly connected
L   2001:1::2/128 [0/0]
     via FastEthernet1/0/2, receive
C   2001:2::/64 [0/0]
     via FastEthernet1/0/1, directly connected
L   2001:2::2/128 [0/0]
     via FastEthernet1/0/1, receive
OI  2001:3::/64 [110/2]
     via FE80::AEF2:C5FF:FE55:9789, FastEthernet1/0/2
C   2001:4::/64 [0/0]
     via FastEthernet1/0/3, directly connected
L   2001:4::1/128 [0/0]
     via FastEthernet1/0/3, receive
OI  2001:5::/64 [110/2]
     via FE80::4255:39FF:FEB7:61E8, FastEthernet1/0/1
L   FF00::/8 [0/0]
     via Null0, receive
```

Problems

During the lab there were certain problems that took some time to resolve. The first one was configuring the wrong ip address on the wrong interface on the wrong routers. This was easily solved by entering a “no ip address” command on the router interface and then correctly retyping the ip address with a “no shut” command on the interface to enable it once again. The second problem we faced was OSPF not creating neighbors with certain routers. This was fixed by checking ping output between routers, and pinpointing which configurations were wrong, and then fixing it by retyping network statements, or enabling interfaces that were shut down. Finally, the biggest hurdle was getting the computers to ping between one another. We had made 3 new OSPF areas for the computers and their respective router interfaces to be located in. However this didn’t work, since the computers

weren't able to ping past their own default gateways. So, to solve this, we realized that if the computer and router interface were in their own area, they would not be able to see the other interface, which is in another area, as their neighbor. To fix this we just added that router interface into the existing area, and that fixed the problem immediately.

Conclusion

In conclusion, we set up multi-area OSPF in a network for both IPv4 and IPv6. There were only some problems, most being very small, such as wrong ip addressing, with one major problem; the computers and their respective routers being the wrong area - but that too had a very simple fix. We learned how to troubleshoot issues within the network, and how the flow of the class works. And in the end we got more practice implementing multi-area OSPF.