CCNP ROUTING AND SWITCHING

Configuring Single Area OSPF

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Purpose:

The purpose of this lab is to configure single-area OSPFv2 on five routers, allowing them to share routing information and networks without the need for the configuration of static routes. Students will also learn terms like wildcard masks, router-id, process-ids, and area-ids and OSPF specific commands.

Background Information

Open Shortest Path First (OSPF) is a routing protocol that is an alternative of Routing Information Protocol (RIP). Advantages of using OSPF includes faster convergence, easier scalability, and minimized overhead. OSPF serves as a good alternative to configuring RIP and static routes.

Static routes are routes configured by network administrators manually determining routes through the network. Configuring static routes has many benefits including increased network security, less use of network resources and bandwidth and easier troubleshooting. However static routes do have many drawbacks, including the complex documentation needed to keep track of all static routes in large networks and limited scalability.

Routing Information Protocol (RIP) is a routing protocol that uses distance or hop count to determine the fastest route to a destination. RIP preferred in some cases over than static routes due to ease of configuration and automatic updates if topology changes. The major limitations of RIP are the hop count limit of 15, restricting RIP's use to small networks and making it unsuitable for scalability over larger networks. Convergence is also slow due to timers, so if a link goes down, significant network resources can be wasted finding alternate paths. It also broadcasts its complete routing table to neighboring routers every 30 seconds, consuming more network resources and bandwidth of needed links.

Open Shortest Path First (OSPF) is a routing protocol that uses a link-state routing protocol. It analyzes different sources like speed, path congestion, and cost to identify the shortest path. OSPF generates link-state packets containing local information for each router. OSPF routers exchange messages like hello, database description, link-state request, update and acknowledgement packets which are used to create and maintain the neighbor and topology table. Hello packets are sent to discover neighbors and establish adjacencies with those neighbors. It also advertises parameters, elects the DR and BDR in multiaccess networks.

OSPF has seven operational states while building adjacencies with neighboring routers. Those include the down, init, two-way, exstart, exchange, loading and full state. When the routers has not received any hello packets it is in the down state. Once hello packets have been received from the neighbor, down transitions to the init state. When bidirectional communication is established between the two routers, the two-way state is entered. In this state, routers elect a DR and a BDR. They then transition to the ExStart state, where routers decide which one will initiate the DBD packet exchange and the sequence number. In the Exchange state, routers exchange DBD packets. Database Description Packets (DBD) are packets with descriptions of the link-state databases of other neighboring routers. After DBD packets are exchanged, the Loading state is entered where LSRs and LSUs are used to gain additional information, Link State Acknowledgements (LSAs) acknowledge delivery of said packets, and routes are processed using the SPF algorithm. Link state requests (LSRs) are requests sent by other OSPF routers for specific link-state records. Link state updates (LSUs) are used to forward routing updates and can contain 11 different types of OSPF Link-state advertisements (LSAs). These include summary, router and multicast OSPF LSAs as well as updates that check database synchronization. The routing table is built using the calculations of the Dijkstra shortest-past first algorithm. The SPF algorithm is based on the cumulative cost to reach a destination. The SPF tree is created by placing each router at the root of the tree and calculating the shortest path to each node. The tree is then used to calculate the best routes and those best routes are put into the forwarding database, later used to make the routing

table. After the routes are all processed and the link-state database is fully synchronized, the full state is entered, with full adjacency achieved between the two routers.

OSPF and RIP solve the limitations of static routes. Being a dynamic routing protocol, routing tables are automatically created, maintained and updated, removing the need for administrators to manually configure routes and making scalability much easier. These routing protocols also allow for fault tolerance as different paths can be chosen to a destination if a link goes down. RIP does have limitations that OSPF can solve. Unlike RIP, OSPF has no hop limit as it does not use distance as it's metric, meaning scalability to large networks is easy. Convergence is fast as route changes are transmitted to all OSPF routers through link-state updates and the relevant tables are updated. Routers only send updates during link-state changes and not at predetermined intervals, meaning that OSPF is less bandwidth intensive than RIP. OSPF also does not use broadcast, instead using multicast addresses only used by OSPF routers, reducing traffic on unneeded links.

Lab Summary

When configuring OSPFv2, I set up five PCs, five 4321 Cisco Routers with one NIM-2T WAN Interface Card. I connected five cooper straight-through cables from the GigabitEthernet 0/0/0 to the FastEthernet 0/0 interface of the PCs. I connected the serial interfaces of the routers with DCE cables. I then set the IPv4 addresses and default gateways for the PC's in their respective networks. The routers used the 10.0.0.0 network with a /30 subnet, from 10.0.0.0-10.0.0.15. The host ip addresses and the router interface connected to them are part of the 192.168.0.0-192.168.40.0 network with a /24 subnet. I also configured OSPFv2 on all five routers using the commands listed below and set the Gig0/0/0 interface which connects to the LAN networks as a passive-interface to ensure network security and efficiency. Finally, I pinged all addresses in the OSPF area to ensure all routes and OSPF was working.

Lab Commands

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

Definition: This command enables OSPFv2 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 10 for my network.

`Router(config-router)#`**`router-id`** *`router-id`*

Definition: This command configures the router-id on a router. The router ID is used to identify an OSPF router and is included in all packets sent by that router.

`Router(config-router)#`**`network`** *`network-address wild-card mask`* **`area`** *`area-id`*

Definition: The network command specifies the interfaces that belong to an OSPF point-to-point network. The area-id refers to the OSPF area. In single-area OSPFv2 all routers in that area should be configured with the same area-id, preferably 0. Any interfaces on a router that match the network address in the network command can send and receive OSPF packets.

`Router(config-router)#`**`passive-interface`** *`interface`*

Definition: Configuring an interface as a passive-interface prevents the transmission of OSPF routing messages through that interface but still allows the network to be advertised to other routers. This helps prevent unauthorized access to routers.

`Router#`**`show ip ospf interface`**

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

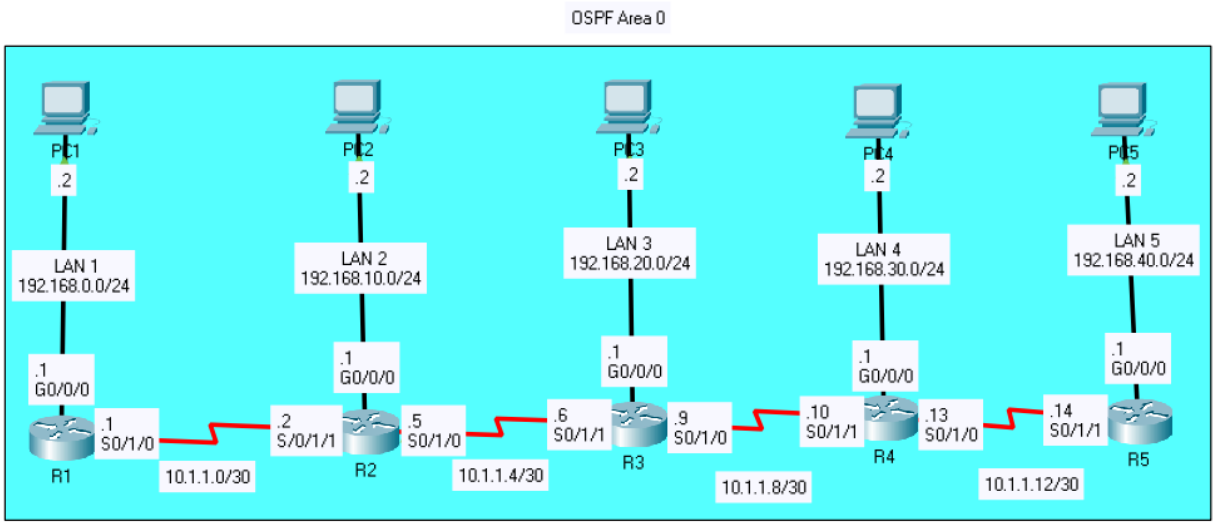
`Router#`**`show ip route`**

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

`Router#`**`show ip ospf neighbor`**

Definition: This command shows neighboring OSPFv2 routers. The router-id, priority, state, hello and dead timers, ip address and interfaces of the neighbors are also shown.

Diagram of Network Topology



Device	Interface	IP Address	Default Gateway
Router 1	G 0/0/0	**192.168.0.1**/24	N/A
	S 0/1/0	**10.0.0.1**/30	
Router 2	G 0/0/0	**192.168.10.1**/24	N/A
	S 0/1/0	**10.0.0.5**/30	
	S 0/1/1	**10.0.0.2**/30	
Router 3	G 0/0/0	**192.168.20.1**/24	N/A
	S 0/1/0	**10.0.0.9**/30	
	S 0/1/1	**10.0.0.6**/30	
Router 4	G 0/0/0	**192.168.30.1**/24	N/A
	S 0/0/0	**10.0.0.13**/30	
	S 0/1/1	**10.0.0.10**/30	
Router 5	G 0/0/0	**192.168.40.1**/24	N/A
	S 0/1/1	**10.0.0.14**/30	
PC 1	NIC	**192.168.0.2**/24	192.168.0.1
PC 2	NIC	**192.168.10.2**/24	192.168.10.1
PC 3	NIC	**192.168.20.2**/24	192.168.20.1

PC 4	NIC	**192.168.30.2**/24	192.168.30.1
PC 5	NIC	**192.168.40.2**/24	192.168.40.1

```
R1#ping 10.1.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/23/44 ms

R1#ping 10.1.1.6

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/26/50 ms

R1#ping 10.1.1.10

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.10, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 3/31/60 ms

R1#ping 10.1.1.14

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.14, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/39/71 ms

R1#ping 192.168.0.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

R1#ping 192.168.10.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 10/22/38 ms

R1#ping 192.168.20.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/21/40 ms

R1#ping 192.168.30.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 15/45/65 ms

R1#ping 192.168.40.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/41/71 ms
```

Pings between all networks:

Router 1 Config:

show run:

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

Current configuration : 875 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
no ipv6 cef
!
!
spanning-tree mode pvst
!
interface GigabitEthernet0/0/0
ip address 192.168.0.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/1/0
ip address 10.1.1.1 255.255.255.252
!
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 GigabitEthernet0/0/0
network 10.1.1.0 0.0.0.3 area 0
network 192.168.0.0 0.0.0.255 area 0
!
ip classless
!
ip flow-export version 9
!
!
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, 5 subnets, 2 masks
C 10.1.1.0/30 is directly connected, Serial0/1/0
L 10.1.1.1/32 is directly connected, Serial0/1/0
O 10.1.1.4/30 [110/128] via 10.1.1.2, 00:06:00, Serial0/1/0
O 10.1.1.8/30 [110/192] via 10.1.1.2, 00:06:00, Serial0/1/0
O 10.1.1.12/30 [110/256] via 10.1.1.2, 00:06:00, Serial0/1/0
192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.0.0/24 is directly connected, GigabitEthernet0/0/0
L 192.168.0.1/32 is directly connected, GigabitEthernet0/0/0
O 192.168.10.0/24 [110/65] via 10.1.1.2, 00:06:00, Serial0/1/0
O 192.168.20.0/24 [110/129] via 10.1.1.2, 00:06:00, Serial0/1/0
O 192.168.30.0/24 [110/193] via 10.1.1.2, 00:06:00, Serial0/1/0
O 192.168.40.0/24 [110/257] via 10.1.1.2, 00:06:00, Serial0/1/0
```

show ip ospf interface:

```
R1#show ip ospf interface

GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 192.168.0.1/24, Area 0
Process ID 10, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 1.1.1.1, Interface address 192.168.0.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
No Hellos (Passive interface)
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 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
Serial0/1/0 is up, line protocol is up
Internet address is 10.1.1.1/30, 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 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 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/ - 00:00:36 10.1.1.2 Serial0/1/0
```

Router 2 Config:

show run:

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

Current configuration : 922 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
no ipv6 cef
!
!
spanning-tree mode pvst
!
!
interface GigabitEthernet0/0/0
ip address 192.168.10.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/1/0
ip address 10.1.1.5 255.255.255.252
!
interface Serial0/1/1
ip address 10.1.1.2 255.255.255.252
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 2.2.2.2
log-adjacency-changes
passive-interface GigabitEthernet0/0/0
network 10.1.1.0 0.0.0.3 area 0
network 10.1.1.4 0.0.0.3 area 0
network 192.168.10.0 0.0.0.255 area 0
!
ip classless
!
ip flow-export version 9
!
!
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, 6 subnets, 2 masks
C 10.1.1.0/30 is directly connected, Serial0/1/1
L 10.1.1.2/32 is directly connected, Serial0/1/1
C 10.1.1.4/30 is directly connected, Serial0/1/0
L 10.1.1.5/32 is directly connected, Serial0/1/0
O 10.1.1.8/30 [110/128] via 10.1.1.6, 00:11:15, Serial0/1/0
O 10.1.1.12/30 [110/192] via 10.1.1.6, 00:11:15, Serial0/1/0
O 192.168.0.0/24 [110/65] via 10.1.1.1, 00:11:15, Serial0/1/1
```

```
192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.10.0/24 is directly connected, GigabitEthernet0/0/0
L 192.168.10.1/32 is directly connected, GigabitEthernet0/0/0
O 192.168.20.0/24 [110/65] via 10.1.1.6, 00:11:15, Serial0/1/0
O 192.168.30.0/24 [110/129] via 10.1.1.6, 00:11:15, Serial0/1/0
O 192.168.40.0/24 [110/193] via 10.1.1.6, 00:11:15, Serial0/1/0
```

show ip ospf interface

```
R2#show ip ospf interface

GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 192.168.10.1/24, Area 0
Process ID 10, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 2.2.2.2, Interface address 192.168.10.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
No Hellos (Passive interface)
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 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
Serial0/1/0 is up, line protocol is up
Internet address is 10.1.1.5/30, 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 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:08
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
Suppress hello for 0 neighbor(s)
Serial0/1/1 is up, line protocol is up
Internet address is 10.1.1.2/30, 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 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 1.1.1.1
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 0 FULL/ - 00:00:31 10.1.1.6 Serial0/1/0
1.1.1.1 0 FULL/ - 00:00:31 10.1.1.1 Serial0/1/1
```

Router 3:

show run:

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

Current configuration : 922 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
```

```
!
hostname R3
!
!
no ip cef
no ipv6 cef
!
!
spanning-tree mode pvst
!
!
interface GigabitEthernet0/0/0
ip address 192.168.20.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/1/0
ip address 10.1.1.9 255.255.255.252
!
interface Serial0/1/1
ip address 10.1.1.6 255.255.255.252
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 3.3.3.3
log-adjacency-changes
passive-interface GigabitEthernet0/0/0
network 10.1.1.4 0.0.0.3 area 0
network 10.1.1.8 0.0.0.3 area 0
network 192.168.20.0 0.0.0.255 area 0
!
ip classless
!
ip flow-export version 9
!
!
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, 6 subnets, 2 masks
O 10.1.1.0/30 [110/128] via 10.1.1.5, 00:16:52, Serial0/1/1
C 10.1.1.4/30 is directly connected, Serial0/1/1
L 10.1.1.6/32 is directly connected, Serial0/1/1
C 10.1.1.8/30 is directly connected, Serial0/1/0
```

```
L 10.1.1.9/32 is directly connected, Serial0/1/0
O 10.1.1.12/30 [110/128] via 10.1.1.10, 00:16:52, Serial0/1/0
O 192.168.0.0/24 [110/129] via 10.1.1.5, 00:16:42, Serial0/1/1
O 192.168.10.0/24 [110/65] via 10.1.1.5, 00:16:52, Serial0/1/1
192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.20.0/24 is directly connected, GigabitEthernet0/0/0
L 192.168.20.1/32 is directly connected, GigabitEthernet0/0/0
O 192.168.30.0/24 [110/65] via 10.1.1.10, 00:16:52, Serial0/1/0
O 192.168.40.0/24 [110/129] via 10.1.1.10, 00:16:42, Serial0/1/0
```

show ip ospf interface

```
R3#show ip ospf interface

GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 192.168.20.1/24, Area 0
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 192.168.20.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
No Hellos (Passive interface)
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 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
Serial0/1/1 is up, line protocol is up
Internet address is 10.1.1.6/30, Area 0
Process ID 10, Router ID 3.3.3.3, 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)
Serial0/1/0 is up, line protocol is up
Internet address is 10.1.1.9/30, Area 0
Process ID 10, Router ID 3.3.3.3, 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 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 4.4.4.4
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 0 FULL/ - 00:00:31 10.1.1.10 Serial0/1/0
2.2.2.2 0 FULL/ - 00:00:32 10.1.1.5 Serial0/1/1
```

Router 4 Config:

show run:

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

Current configuration : 925 bytes
!
version 15.4
```

```
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R4
!
!
no ip cef
no ipv6 cef
!
!
spanning-tree mode pvst
!
!
interface GigabitEthernet0/0/0
ip address 192.168.30.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/1/0
ip address 10.1.1.13 255.255.255.252
!
interface Serial0/1/1
ip address 10.1.1.10 255.255.255.252
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 4.4.4.4
log-adjacency-changes
passive-interface GigabitEthernet0/0/0
network 10.1.1.12 0.0.0.3 area 0
network 10.1.1.8 0.0.0.3 area 0
network 192.168.30.0 0.0.0.255 area 0
!
ip classless
!
ip flow-export version 9
!
!
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 10.1.1.0/30 [110/192] via 10.1.1.9, 00:20:49, Serial0/1/1
O 10.1.1.4/30 [110/128] via 10.1.1.9, 00:20:59, Serial0/1/1
C 10.1.1.8/30 is directly connected, Serial0/1/1
```

```
L 10.1.1.10/32 is directly connected, Serial0/1/1
C 10.1.1.12/30 is directly connected, Serial0/1/0
L 10.1.1.13/32 is directly connected, Serial0/1/0
O 192.168.0.0/24 [110/193] via 10.1.1.9, 00:20:49, Serial0/1/1
O 192.168.10.0/24 [110/129] via 10.1.1.9, 00:20:49, Serial0/1/1
O 192.168.20.0/24 [110/65] via 10.1.1.9, 00:20:59, Serial0/1/1
192.168.30.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.30.0/24 is directly connected, GigabitEthernet0/0/0
L 192.168.30.1/32 is directly connected, GigabitEthernet0/0/0
O 192.168.40.0/24 [110/65] via 10.1.1.14, 00:20:59, Serial0/1/0
```

show ip ospf interface:

```
R4#show ip ospf interface

GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 192.168.30.1/24, Area 0
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 192.168.30.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
No Hellos (Passive interface)
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 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
Serial0/1/1 is up, line protocol is up
Internet address is 10.1.1.10/30, Area 0
Process ID 10, Router ID 4.4.4.4, 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 00:00:01
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
Suppress hello for 0 neighbor(s)
Serial0/1/0 is up, line protocol is up
Internet address is 10.1.1.13/30, Area 0
Process ID 10, Router ID 4.4.4.4, 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 00:00:05
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 5.5.5.5
Suppress hello for 0 neighbor(s)
```

show ip ospf neighbor:

```
R4#show ip ospf neighbor


Neighbor ID Pri State Dead Time Address Interface
5.5.5.5 0 FULL/ - 00:00:33 10.1.1.14 Serial0/1/0
3.3.3.3 0 FULL/ - 00:00:33 10.1.1.9 Serial0/1/1
```

Router 5 Config:

show run:

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

```
Current configuration : 921 bytes
!
version 15.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R5
!
!
no ip cef
no ipv6 cef
!
!
spanning-tree mode pvst
!
!
interface GigabitEthernet0/0/0
ip address 192.168.40.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/1/0
no ip address
ip ospf priority 255
clock rate 2000000
shutdown
!
interface Serial0/1/1
ip address 10.1.1.14 255.255.255.252
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router ospf 10
router-id 5.5.5.5
log-adjacency-changes
passive-interface GigabitEthernet0/0/0
network 10.1.1.12 0.0.0.3 area 0
network 192.168.40.0 0.0.0.255 area 0
!
ip classless
!
ip flow-export version 9
!
!
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, 5 subnets, 2 masks
O 10.1.1.0/30 [110/256] via 10.1.1.13, 00:24:30, Serial0/1/1
O 10.1.1.4/30 [110/192] via 10.1.1.13, 00:24:30, Serial0/1/1
O 10.1.1.8/30 [110/128] via 10.1.1.13, 00:24:40, Serial0/1/1
C 10.1.1.12/30 is directly connected, Serial0/1/1
L 10.1.1.14/32 is directly connected, Serial0/1/1
O 192.168.0.0/24 [110/257] via 10.1.1.13, 00:24:30, Serial0/1/1
O 192.168.10.0/24 [110/193] via 10.1.1.13, 00:24:30, Serial0/1/1
O 192.168.20.0/24 [110/129] via 10.1.1.13, 00:24:30, Serial0/1/1
O 192.168.30.0/24 [110/65] via 10.1.1.13, 00:24:40, Serial0/1/1
192.168.40.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.40.0/24 is directly connected, GigabitEthernet0/0/0
L 192.168.40.1/32 is directly connected, GigabitEthernet0/0/0
```

show ip ospf interface:

```
R5#show ip ospf interface

GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 192.168.40.1/24, Area 0
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 192.168.40.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
No Hellos (Passive interface)
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 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
Serial0/1/1 is up, line protocol is up
Internet address is 10.1.1.14/30, Area 0
Process ID 10, Router ID 5.5.5.5, 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 00:00:07
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 4.4.4.4
Suppress hello for 0 neighbor(s)e
```

show ip ospf neighbor:

```
R5#show ip ospf neighbor


Neighbor ID Pri State Dead Time Address Interface
4.4.4.4 0 FULL/ - 00:00:37 10.1.1.13 Serial0/1/1
```

Problems and Troubleshooting:

I encountered two problems when completing this lab. First, after configuring OSPFv2 on routers 1-4, I noticed 4 and 5 were not showing a neighbor adjacency. I issued a `show ip ospf` command and there was no adjacency there either. I then checked the interface states through the `show ip interface brief` command I noticed that S0/1/1 was in the down. State. This indicated to me that this was a Layer 1 problem, and I checked the cabling. Sure enough, one of the cables was pinched and did not work. After replacing it the interface came online and I was able to continue setting up OSPF. Another problem I encountered was one of the LAN networks not showing up when I did the `show ip route` command on R5. LAN 4 (192.168.40.0) did not have a route to it so I performed a `show ip route` on R4. I noticed that instead of the 192.168.30.0 network route, it had the route of 192.168.39.0. I checked the interface and saw that I had incorrectly entered the ip address. After correcting the mistake and after waiting for the exchange of link state updates, the 192.168.30.0 network was once again in the routing table of neighboring routers.

Conclusion

OSPF is a very useful routing protocol especially in large and complicated networks. Single area networks can be very efficient in distributing routes. I learned a lot about how to set up OSPFv2, how it works and what its advantages and disadvantages are. However, there is still a lot of unnecessary traffic and OSPF messages taking up bandwidth on links. In our next lab, we will go more in depth into OSPFv3 and multiarea networks, passive interfaces, hello/dead timers and designated routers.