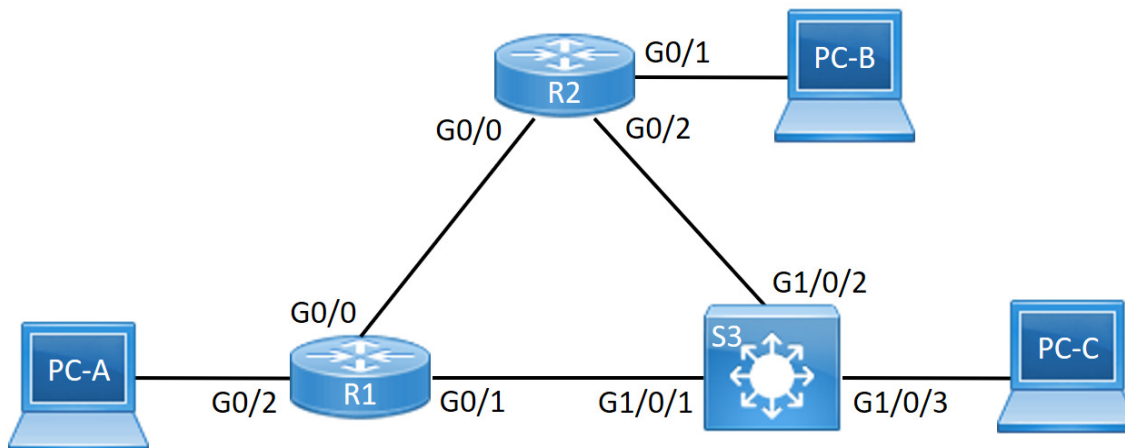


Lab - Configuring Basic Single-Area OSPFv2

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/2	192.168.1.1	255.255.255.0	N/A
	G0/0	192.168.12.1	255.255.255.252	N/A
	G0/1	192.168.13.1	255.255.255.252	N/A
R2	G0/1	192.168.2.1	255.255.255.0	N/A
	G0/0	192.168.12.2	255.255.255.252	N/A
	G0/2	192.168.23.1	255.255.255.252	N/A
S3	G1/0/3	192.168.3.1	255.255.255.0	N/A
	G1/0/1	192.168.13.2	255.255.255.252	N/A
	G1/0/2	192.168.23.2	255.255.255.252	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.2.3	255.255.255.0	192.168.2.1
PC-C	NIC	192.168.3.3	255.255.255.0	192.168.3.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify OSPF Routing

Part 3: Change Router ID Assignments

Part 4: Configure OSPF Passive Interfaces

Part 5: Change OSPF Metrics

Background / Scenario

Open Shortest Path First (OSPF) is a link-state routing protocol for IP networks. OSPFv2 is defined for IPv4 networks, and OSPFv3 is defined for IPv6 networks. OSPF detects changes in the topology, such as link failures, and converges on a new loop-free routing structure very quickly. It computes each route using Dijkstra's algorithm, a shortest path first algorithm.

In this lab, you will configure the network topology with OSPFv2 routing, change the router ID assignments, configure passive interfaces, adjust OSPF metrics, and use a number of CLI commands to display and verify OSPF routing information.

Note: Make sure that the routers and layer-3 switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Layer-3 Switch (Cisco 3650 with Cisco IOS-XE Release 3.3.5SE image or comparable)
- 3 PCs (Windows 10 with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you set up the network topology and configure basic settings on the PC hosts and routers.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switch as necessary.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Configure the IP address listed in the Addressing Table for all interfaces.

Step 4: Configure PC hosts.

Step 5: Test connectivity.

The routers should be able to ping one another, and each PC should be able to ping its default gateway. The PCs are unable to ping other PCs until OSPF routing is configured. Verify and troubleshoot if necessary.

Part 2: Configure and Verify OSPF Routing

In Part 2, you will configure OSPFv2 routing on all routers in the network and then verify that routing tables are updated correctly.

Step 1: Configure OSPF on R1.

- a. Use the **router ospf** command in global configuration mode to enable OSPF on R1.

```
R1(config)# router ospf 1
```

Note: The OSPF process id is kept locally and has no meaning to other routers on the network.

- b. Configure the **network** statements for the networks on R1. Use an area ID of 0.

```
R1(config-router)# network 192.168.1.0 0.0.0.255 area 0
```

```
R1(config-router)# network 192.168.12.0 0.0.0.3 area 0
```

```
R1(config-router)# network 192.168.13.0 0.0.0.3 area 0
```

Step 2: Configure OSPF on R2 and S3.

Use the **router ospf** command and add the **network** statements for the networks on R2 and S3. Neighbor adjacency messages display on R1 when OSPF routing is configured on R2 and S3.

```
R1#
00:22:29: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.1 on GigabitEthernet0/0 from
LOADING to FULL, Loading Done
R1#
00:23:14: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.2 on GigabitEthernet0/1 from
LOADING to FULL, Loading Done
R1#
```

Step 3: Verify OSPF neighbors and routing information.

- a. Issue the **show ip ospf neighbor** command to verify that each router lists the other routers in the network as neighbors.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.23.2	1	FULL/DR	00:00:33	192.168.13.2	GigabitEthernet0/1
192.168.23.1	1	FULL/DR	00:00:30	192.168.12.2	GigabitEthernet0/0

- b. Issue the **show ip route** command to verify that all networks display in the routing table on all routers.

```
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
```

```
192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.1.0/24 is directly connected, GigabitEthernet0/0
L       192.168.1.1/32 is directly connected, GigabitEthernet0/0
O       192.168.2.0/24 [110/2] via 192.168.12.2, 00:32:33, GigabitEthernet0/0
O       192.168.3.0/24 [110/2] via 192.168.13.2, 00:31:48, GigabitEthernet0/1
192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.12.0/30 is directly connected, Serial0/0/0
L       192.168.12.1/32 is directly connected, Serial0/0/0
192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.13.0/30 is directly connected, Serial0/0/1
L       192.168.13.1/32 is directly connected, Serial0/0/1
192.168.23.0/30 is subnetted, 1 subnets
O       192.168.23.0/30 [110/2] via 192.168.13.2, 00:31:38, GigabitEthernet0/1
O       [110/2] via 192.168.12.2, 00:31:38, GigabitEthernet0/0
```

What command would you use to only see the OSPF routes in the routing table?

Step 4: Verify OSPF protocol settings.

The **show ip protocols** command is a quick way to verify vital OSPF configuration information. This information includes the OSPF process ID, the router ID, networks the router is advertising, the neighbors the router is receiving updates from, and the default administrative distance, which is 110 for OSPF.

```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.13.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.1.0 0.0.0.255 area 0
    192.168.12.0 0.0.0.3 area 0
    192.168.13.0 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.23.2     110          00:19:16
    192.168.23.1     110          00:20:03
  Distance: (default is 110)
```

Step 5: Verify OSPF process information.

Use the **show ip ospf** command to examine the OSPF process ID and router ID. This command displays the OSPF area information, as well as the last time the SPF algorithm was calculated.

```
R1# show ip ospf
Routing Process "ospf 1" with ID 192.168.13.1
  Start time: 00:20:23.260, Time elapsed: 00:25:08.296
  Supports only single TOS(TOS0) routes
  Supports opaque LSA
  Supports Link-local Signaling (LLS)
  Supports area transit capability
  Supports NSSA (compatible with RFC 3101)
  Event-log enabled, Maximum number of events: 1000, Mode: cyclic
  Router is not originating router-LSAs with maximum metric
  Initial SPF schedule delay 5000 msecs
  Minimum hold time between two consecutive SPF's 10000 msecs
  Maximum wait time between two consecutive SPF's 10000 msecs
  Incremental-SPF disabled
  Minimum LSA interval 5 secs
  Minimum LSA arrival 1000 msecs
  LSA group pacing timer 240 secs
  Interface flood pacing timer 33 msecs
  Retransmission pacing timer 66 msecs
```

```
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
```

Area BACKBONE (0)

```
Number of interfaces in this area is 3
Area has no authentication
SPF algorithm last executed 00:22:53.756 ago
SPF algorithm executed 7 times
Area ranges are
Number of LSA 6. Checksum Sum 0x046F75
Number of opaque link LSA 0. Checksum Sum 0x000000
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0
```

Step 6: Verify OSPF interface settings.

- a. Issue the **show ip ospf interface brief** command to display a summary of OSPF-enabled interfaces.

```
R1# show ip ospf interface brief
```

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs F/C
Gi0/1	1	0	192.168.13.1/30	1	BDR	1/1
Gi0/0	1	0	192.168.12.1/30	1	BDR	1/1
Gi0/2	1	0	192.168.1.1/24	1	DR	0/0

- b. For a more detailed list of every OSPF-enabled interface, issue the **show ip ospf interface** command.

```
R1# show ip ospf interface
```

```
GigabitEthernet0/1 is up, line protocol is up
Internet Address 192.168.13.1/30, Area 0, Attached via Network Statement
Process ID 1, Router ID 192.168.13.1, Network Type BROADCAST, Cost: 1
Topology-MTID      Cost      Disabled      Shutdown      Topology Name
0                  1          no             no             Base
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 192.168.23.2, Interface address 192.168.13.2
Backup Designated Router (ID) 192.168.13.1, Interface address 192.168.13.1
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  oob-resync timeout 40
  Hello due in 00:00:01
Supports Link-local Signaling (LLS)
Cisco NSF helper support enabled
IETF NSF helper support enabled
```

```
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 192.168.23.2 (Designated Router)
  Suppress hello for 0 neighbor(s)
GigabitEthernet0/0 is up, line protocol is up
  Internet Address 192.168.12.1/30, Area 0, Attached via Network Statement
  Process ID 1, Router ID 192.168.13.1, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
        0             1         no           no           Base
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.23.1, Interface address 192.168.12.2
  Backup Designated Router (ID) 192.168.13.1, Interface address 192.168.12.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:03
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
Index 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 192.168.23.1 (Designated Router)
  Suppress hello for 0 neighbor(s)
GigabitEthernet0/2 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 192.168.13.1, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
        0             1         no           no           Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.13.1, Interface address 192.168.1.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:01
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
Index 1/1, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 0, maximum is 0
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)
```

Step 7: Verify end-to-end connectivity.

Each PC should be able to ping the other PCs in the topology. Verify and troubleshoot if necessary.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Part 3: Change Router ID Assignments

The OSPF router ID is used to uniquely identify the router in the OSPF routing domain. Cisco routers derive the router ID in one of three ways and with the following precedence:

- 1) IP address configured with the OSPF **router-id** command, if present
- 2) Highest IP address of any of the router's loopback addresses, if present
- 3) Highest active IP address on any of the router's physical interfaces

Because no router IDs or loopback interfaces have been configured on the three routers, the router ID for each router is determined by the highest IP address of any active interface.

In Part 3, you will change the OSPF router ID assignment using loopback addresses. You will also use the **router-id** command to change the router ID.

Step 1: Change router IDs using loopback addresses.

- a. Assign an IP address to loopback 0 on R1.

```
R1(config)# interface lo0
R1(config-if)# ip address 1.1.1.1 255.255.255.255
R1(config-if)# end
```
- b. Assign IP addresses to Loopback 0 on R2 and S3. Use IP address 2.2.2.2/32 for R2 and 3.3.3.3/32 for S3.
- c. Save the running configuration to the startup configuration on all three routers.
- d. You must reload the routers in order to reset the router ID to the loopback address. Issue the **reload** command on all three routers. Press Enter to confirm the reload.
- e. After the router completes the reload process, issue the **show ip protocols** command to view the new router ID.

```
R1# show ip protocols
```

```
*** IP Routing is NSF aware ***
```

```
Routing Protocol is "ospf 1"
```

```
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:
```

```
192.168.1.0 0.0.0.255 area 0
```

```
192.168.12.0 0.0.0.3 area 0
```

```
192.168.13.0 0.0.0.3 area 0
```

```
Routing Information Sources:
```

Gateway	Distance	Last Update
---------	----------	-------------

3.3.3.3	110	00:01:00
---------	-----	----------

2.2.2.2	110	00:01:14
---------	-----	----------

```
Distance: (default is 110)
```


- f. Issue the **show ip ospf neighbor** command to display the router ID changes for the neighboring routers.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	1	FULL/DR	00:00:35	192.168.13.2	GigabitEthernet0/1
2.2.2.2	1	FULL/DR	00:00:32	192.168.12.2	GigabitEthernet0/0

```
R1#
```

Step 2: Change the router ID on R1 using the router-id command.

The preferred method for setting the router ID is with the **router-id** command.

- a. Issue the **router-id 11.11.11.11** command on R1 to reassign the router ID. Notice the informational message that appears when issuing the **router-id** command.

```
R1(config)# router ospf 1
```

```
R1(config-router)# router-id 11.11.11.11
```

```
Reload or use "clear ip ospf process" command, for this to take effect
```

```
R1(config)# end
```

- b. You will receive an informational message telling you that you must either reload the router or use the **clear ip ospf process** command for the change to take effect. Issue the **clear ip ospf process** command on all three routers. Type **yes** to reply to the reset verification message, and press ENTER.
- c. Set the router ID for R2 to **22.22.22.22** and the router ID for S3 to **33.33.33.33**. Then use **clear ip ospf process** command to reset ospf routing process.
- d. Issue the **show ip protocols** command to verify that the router ID changed on R1.

```
R1# show ip protocols
```

```
*** IP Routing is NSF aware ***
```

```
Routing Protocol is "ospf 1"
```

```
Outgoing update filter list for all interfaces is not set
```

```
Incoming update filter list for all interfaces is not set
```

```
Router ID 11.11.11.11
```

```
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
```

```
Maximum path: 4
```

```
Routing for Networks:
```

```
192.168.1.0 0.0.0.255 area 0
```

```
192.168.12.0 0.0.0.3 area 0
```

```
192.168.13.0 0.0.0.3 area 0
```

```
Routing Information Sources:
```

Gateway	Distance	Last Update
---------	----------	-------------

33.33.33.33	110	00:00:19
-------------	-----	----------

22.22.22.22	110	00:00:31
-------------	-----	----------

3.3.3.3	110	00:00:41
---------	-----	----------

2.2.2.2	110	00:00:41
---------	-----	----------

```
Distance: (default is 110)
```

- e. Issue the **show ip ospf neighbor** command on R1 to verify that new router ID for R2 and S3 is listed.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
33.33.33.33	1	FULL/DR	00:00:36	192.168.13.2	GigabitEthernet0/1
22.22.22.22	1	FULL/DR	00:00:32	192.168.12.2	GigabitEthernet0/0

Part 4: Configure OSPF Passive Interfaces

The **passive-interface** command prevents routing updates from being sent through the specified router interface. This is commonly done to reduce traffic on the LANs as they do not need to receive dynamic routing protocol communication. In Part 4, you will use the **passive-interface** command to configure a single interface as passive. You will also configure OSPF so that all interfaces on the router are passive by default, and then enable OSPF routing advertisements on selected interfaces.

Step 1: Configure a passive interface.

- a. Issue the **show ip ospf interface g0/2** command on R1. Notice the timer indicating when the next Hello packet is expected. Hello packets are sent every 10 seconds and are used between OSPF routers to verify that their neighbors are up.

```
R1# show ip ospf interface g0/2
```

```
GigabitEthernet0/2 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 11.11.11.11, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0                1         no           no           Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 11.11.11.11, Interface address 192.168.1.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:02
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  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)
```

- b. Issue the **passive-interface** command to change the G0/2 interface on R1 to passive.

```
R1(config)# router ospf 1
```

```
R1(config-router)# passive-interface g0/2
```

- c. Re-issue the **show ip ospf interface g0/2** command to verify that G0/2 is now passive.

```
R1# show ip ospf interface g0/2
```

```
GigabitEthernet0/2 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 11.11.11.11, Network Type BROADCAST, Cost: 1
```

```
Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0              1         no           no             Base
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 11.11.11.11, Interface address 192.168.1.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
oob-resync timeout 40
No Hellos (Passive interface)
Supports Link-local Signaling (LLS)
Cisco NSF helper support enabled
IETF NSF helper support enabled
Index 1/1, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 0, maximum is 0
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)
```

- d. Issue the **show ip route** command on R2 and S3 to verify that a route to the 192.168.1.0/24 network is still available.

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

```
2.0.0.0/32 is subnetted, 1 subnets
C      2.2.2.2 is directly connected, Loopback0
O      192.168.1.0/24 [110/2] via 192.168.12.1, 00:58:32, 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      192.168.3.0/24 [110/2] via 192.168.23.2, 00:58:19, GigabitEthernet0/2
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks C
        192.168.12.0/30 is directly connected, GigabitEthernet0/0
L      192.168.12.2/32 is directly connected, GigabitEthernet0/0
      192.168.13.0/30 is subnetted, 1 subnets
O      192.168.13.0 [110/2] via 192.168.23.2, 00:58:19, GigabitEthernet0/2
        [110/2] via 192.168.12.1, 00:58:32, GigabitEthernet0/0
      192.168.23.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.23.0/30 is directly connected, GigabitEthernet0/2
L      192.168.23.1/32 is directly connected, GigabitEthernet0/2
```

Step 2: Set passive interface as the default on a router.

- a. Issue the **show ip ospf neighbor** command on R1 to verify that R2 is listed as an OSPF neighbor.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
33.33.33.33	1	FULL/DR	00:00:31	192.168.13.2	GigabitEthernet0/1
22.22.22.22	1	FULL/	00:00:32	192.168.12.2	GigabitEthernet0/0

- b. Issue the **passive-interface default** command on R2 to set the default for all OSPF interfaces as passive.

```
R2(config)# router ospf 1
```

```
R2(config-router)# passive-interface default
```

```
R2(config-router)#
```

```
*Apr  3 00:03:00.979: %OSPF-5-ADJCHG: Process 1, Nbr 11.11.11.11 on GigabitEthernet0/0  
FULL to DOWN, Neighbor Down: Interface down or detached
```

```
*Apr  3 00:03:00.979: %OSPF-5-ADJCHG: Process 1, Nbr 33.33.33.33 on GigabitEthernet0/2  
FULL to DOWN, Neighbor Down: Interface down or detached
```

- c. Re-issue the **show ip ospf neighbor** command on R1. After the dead timer expires, R2 will no longer be listed as an OSPF neighbor.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
33.33.33.33	1	FULL/DR	00:00:34	192.168.13.2	GigabitEthernet0/1

- d. Issue the **show ip ospf interface G0/0** command on R2 to view the OSPF status of interface G0/0.

```
R2# show ip ospf interface g0/0
```

```
GigabitEthernet0/0 is up, line protocol is up
```

```
Internet Address 192.168.12.2/30, Area 0, Attached via Network Statement
```

```
Process ID 1, Router ID 22.22.22.22, Network Type BROADCAST, Cost: 1
```

Topology-MTID	Cost	Disabled	Shutdown	Topology Name
0	1	no	no	Base

```
Transmit Delay is 1 sec, State DR, Priority 1
```

```
Designated Router (ID) 22.22.22.22, Interface address 192.168.12.2
```

```
No backup designated router on this network
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
oob-resync timeout 40
```

```
No Hellos (Passive interface)
```

```
Supports Link-local Signaling (LLS)
```

```
Cisco NSF helper support enabled
```

```
IETF NSF helper support enabled
```

```
Index 2/2, flood queue length 0
```

```
Next 0x0(0)/0x0(0)
```

```
Last flood scan length is 0, maximum is 0
```

```
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)
```

- e. If all interfaces on R2 are passive, then no routing information is being advertised. In this case, R1 and S3 should no longer have a route to the 192.168.2.0/24 network. You can verify this by using the **show ip route** command.

- f. On R2, issue the **no passive-interface** command so the router will send and receive OSPF routing updates. After entering this command, you will see an informational message that a neighbor adjacency has been established with R1.

```
R2(config)# router ospf 1
```

```
R2(config-router)# no passive-interface g0/0
```

```
R2(config-router)#
```

```
*Apr  3 00:18:03.463: %OSPF-5-ADJCHG: Process 1, Nbr 11.11.11.11 on GigabitEthernet0/0  
from LOADING to FULL, Loading Done
```

- g. Re-issue the **show ip route** and **show ip ospf neighbor** commands on R1 and S3, and look for a route to the 192.168.2.0/24 network.

What interface is S3 using to route to the 192.168.2.0/24 network?

What is the accumulated cost metric for the 192.168.2.0/24 network on S3?

Does R2 show up as an OSPF neighbor on R1?

Does R2 show up as an OSPF neighbor on S3?

What does this information tell you?

- h. Change interface G0/2 on R2 to allow it to advertise OSPF routes. Record the commands used below.

- i. Re-issue the **show ip route** command on S3.

What interface is S3 using to route to the 192.168.2.0/24 network?

What is the accumulated cost metric for the 192.168.2.0/24 network on S3 now and how is this calculated?

Is R2 listed as an OSPF neighbor to S3?

Part 5: Change OSPF Metrics

In Part 5, you will change OSPF metrics using the **auto-cost reference-bandwidth** command, the **bandwidth** command, and the **ip ospf cost** command.

Step 1: Change the reference bandwidth on the routers.

The default reference-bandwidth for OSPF is 100Mb/s (Fast Ethernet speed). However, most modern infrastructure devices have links that are faster than 100Mb/s. Because the OSPF cost metric must be an integer, all links with transmission speeds of 100Mb/s or higher have a cost of 1. This results in Fast Ethernet, Gigabit Ethernet, and 10G Ethernet interfaces all having the same cost. Therefore, the reference-bandwidth must be changed to a higher value to accommodate networks with links faster than 100Mb/s.

- a. Issue the **show interface** command on R1 to view the default bandwidth setting for the G0/2 interface.

```
R1# show interface g0/2
```

```
GigabitEthernet0/2 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is c471.fe45.7520 (bia c471.fe45.7520)
  Internet address is 192.168.1.1/24
  MTU 1500 bytes, BW 1000000 Kbit/sec, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full Duplex, 100Mbps, media type is RJ45
  output flow-control is unsupported, input flow-control is unsupported
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output 00:17:31, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    0 packets input, 0 bytes, 0 no buffer
    Received 0 broadcasts (0 IP multicasts)
    0 runs, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    0 watchdog, 0 multicast, 0 pause input
    279 packets output, 89865 bytes, 0 underruns
    0 output errors, 0 collisions, 1 interface resets
    0 unknown protocol drops
    0 babbles, 0 late collision, 0 deferred
    1 lost carrier, 0 no carrier, 0 pause output
    0 output buffer failures, 0 output buffers swapped out
```

Note: The bandwidth setting on G0/2 may differ from what is shown above if the PC host interface can only support Fast Ethernet speed. If the PC host interface is not capable of supporting gigabit speed, then the bandwidth will most likely be displayed as 100000 Kbit/sec.

- b. Issue the **show ip route ospf** command on R1 to determine the route to the 192.168.3.0/24 network.

```
R1# show ip route ospf
```

```
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      192.168.2.0/24 [110/2] via 192.168.12.2, 00:01:08, GigabitEthernet0/0
O      192.168.3.0/24 [110/2] via 192.168.13.2, 00:00:57, GigabitEthernet0/1
192.168.23.0/30 is subnetted, 1 subnets
```

```
O          192.168.23.0 [110/2] via 192.168.13.2, 00:00:57, GigabitEthernet0/1
          [110/2] via 192.168.12.2, 00:01:08, GigabitEthernet0/0
```

Note: The accumulated cost to the 192.168.3.0/24 network from R1 is 2.

- c. Issue the **show ip ospf interface** command on S3 to determine the routing cost for G1/0/3.

```
S3# show ip ospf interface g1/0/3
```

```
GigabitEthernet1/0/3 is up, line protocol is up (connected)
  Internet Address 192.168.3.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 33.33.33.33, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0                1          no            no            Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 33.33.33.33, Interface address 192.168.3.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:05
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  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)
```

- d. Issue the **show ip ospf interface g0/1** command on R1 to view the routing cost for G0/1.

```
R1# show ip ospf interface g0/1
```

```
GigabitEthernet0/1 is up, line protocol is up
  Internet Address 192.168.13.1/30, Area 0, Attached via Network Statement
  Process ID 1, Router ID 11.11.11.11, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0                1          no            no            Base
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 33.33.33.33, Interface address 192.168.13.2
  Backup Designated router (ID) 11.11.11.11, Interface address 192.168.13.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:04
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  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 33.33.33.33 (Designated Router)
  Suppress hello for 0 neighbor(s)
```

The sum of the costs of these two interfaces is the accumulated cost for the route to the 192.168.3.0/24 network on S3 ($1 + 1 = 2$), as can be seen in the output from the **show ip route** command.

- e. Issue the **auto-cost reference-bandwidth 10000** command on R1 to change the default reference bandwidth setting. With this setting, 10Gb/s interfaces will have a cost of 1, 1 Gb/s interfaces will have a cost of 10, and 100Mb/s interfaces will have a cost of 100.

```
R1(config)# router ospf 1
```

```
R1(config-router)# auto-cost reference-bandwidth 10000
```

```
% OSPF: Reference bandwidth is changed.
```

```
Please ensure reference bandwidth is consistent across all routers.
```

- f. Issue the **auto-cost reference-bandwidth 10000** command on routers R2 and S3.
- g. Re-issue the **show ip ospf interface** command to view the new cost of G1/0/3 on S3, and G0/1 on R1.

```
S3# show ip ospf interface g1/0/3
```

```
GigabitEthernet1/0/3 is up, line protocol is up (connected)
```

```
Internet Address 192.168.3.1/24, Area 0, Attached via Network Statement
```

```
Process ID 1, Router ID 33.33.33.33, Network Type BROADCAST, Cost: 10
```

Topology-MTID	Cost	Disabled	Shutdown	Topology Name
0	100	no	no	Base

```
Transmit Delay is 1 sec, State DR, Priority 1
```

```
Designated Router (ID) 33.33.33.33, Interface address 192.168.3.1
```

```
No backup designated router on this network
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
oob-resync timeout 40
```

```
Hello due in 00:00:02
```

```
Supports Link-local Signaling (LLS)
```

```
Cisco NSF helper support enabled
```

```
IETF NSF helper support enabled
```

```
Index 1/1, flood queue length 0
```

```
Next 0x0(0)/0x0(0)
```

```
Last flood scan length is 0, maximum is 0
```

```
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)
```

Note: If the device connected to the G1/0/3 interface does not support Gigabit Ethernet speed, the cost will be different than the output display. For example, the cost will be 100 for Fast Ethernet speed (100Mb/s).

```
R1# show ip ospf interface g0/1
```

```
GigabitEthernet0/1 is up, line protocol is up
```

```
Internet Address 192.168.13.1/30, Area 0, Attached via Network Statement
```

```
Process ID 1, Router ID 11.11.11.11, Network Type BROADCAST, Cost: 10
```

Topology-MTID	Cost	Disabled	Shutdown	Topology Name
0	10	no	no	Base

```
Transmit Delay is 1 sec, State BDR, Priority 1
```

```
Designated Router (ID) 33.33.33.33, Interface address 192.168.13.2
```

```
Backup Designated router (ID) 11.11.11.11, Interface address 192.168.13.1
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
oob-resync timeout 40
```

```
Hello due in 00:00:05
```

```
Supports Link-local Signaling (LLS)
```

```
Cisco NSF helper support enabled
```



```
IETF NSF helper support enabled
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 33.33.33.33 (Designated Router)
Suppress hello for 0 neighbor(s)
```

- h. Re-issue the **show ip route ospf** command to view the new accumulated cost for the 192.168.3.0/24 route (10 + 10 = 20).

Note: If the device connected to the G1/0/3 interface does not support Gigabit Ethernet speed, the total cost will be different than the output display. For example, the accumulated cost will be 110 if G1/0/3 is operating at Fast Ethernet speed (100Mb/s).

```
R1# show ip route ospf
```

```
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      192.168.2.0/24 [110/20] via 192.168.12.2, 00:05:40, GigabitEthernet0/0
O      192.168.3.0/24 [110/20] via 192.168.13.2, 00:01:08, GigabitEthernet0/1
      192.168.23.0/30 is subnetted, 1 subnets
O          192.168.23.0 [110/20] via 192.168.13.2, 00:05:17, GigabitEthernet0/1
          [110/20] via 192.168.12.2, 00:05:17, GigabitEthernet0/0
```

Note: Changing the default reference-bandwidth on the routers from 100 to 10,000 in effect changed the accumulated costs of all routes, but the cost of each interface link and route is now more accurately reflected.

- i. To reset the reference-bandwidth back to its default value, issue the **auto-cost reference-bandwidth 100** command on all three routers.

```
R1(config)# router ospf 1
```

```
R1(config-router)# auto-cost reference-bandwidth 100
```

```
% OSPF: Reference bandwidth is changed.
```

```
Please ensure reference bandwidth is consistent across all routers.
```

Why would you want to change the OSPF default reference-bandwidth?

Step 2: Change the bandwidth for an interface.

Note: A common misconception is to assume that the **bandwidth** command will change the physical bandwidth, or speed, of the link. The command modifies the bandwidth metric used by OSPF to calculate routing costs, and does not modify the actual bandwidth (speed) of the link.

- a. Issue the **show interface g0/0** command on R1 to view the current bandwidth setting on G0/0.

```
R1# show interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is c471.fe45.7520 (bia c471.fe45.7520)
  Internet address is 192.168.12.1/30
  MTU 1500 bytes, BW 1000000 Kbit/sec, DLY 10 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
<Output omitted>
```

- b. Issue the **show ip route ospf** command on R1 to view the accumulated cost for the route to network 192.168.23.0/24 using G0/0. Note that there are two equal-cost (2) routes to the 192.168.23.0/24 network, one via G0/0 and one via G0/1.

```
R1# show ip route ospf
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        192.168.2.0/24 [110/2] via 192.168.12.2, 00:00:26, GigabitEthernet0/0
O        192.168.3.0/24 [110/2] via 192.168.13.2, 00:00:26, GigabitEthernet0/1
O        192.168.23.0/30 is subnetted, 1 subnets
O          192.168.23.0 [110/2] via 192.168.13.2, 00:00:26, GigabitEthernet0/1
O          192.168.23.0 [110/2] via 192.168.12.2, 00:00:26, GigabitEthernet0/0
```

- c. Issue the **bandwidth 128** command to set the bandwidth on G0/0 to 128Kb/s.

```
R1(config)# interface g0/0
R1(config-if)# bandwidth 128
```

- d. Re-issue the **show ip route ospf** command. The routing table no longer displays the route to the 192.168.23.0/24 network over the G0/0 interface. This is because the best route, the one with the lowest cost, is now via G0/1.

```
R1# show ip route ospf
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      192.168.2.0/24 [110/3] via 192.168.13.2, 00:01:47, GigabitEthernet0/1
O      192.168.3.0/24 [110/2] via 192.168.13.2, 00:04:51, GigabitEthernet0/1
      192.168.23.0/30 is subnetted, 1 subnets
O      192.168.23.0 [110/2] via 192.168.13.2, 00:04:51, GigabitEthernet0/1
```

- e. Issue the **show ip ospf interface brief** command. The cost for G0/0 has changed from 1 to 781.

```
R1# show ip ospf interface brief
```

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Gi0/2	1	0	192.168.1.1/24	1	DR	0/0	
Gi0/1	1	0	192.168.13.1/30	1	BDR	1/1	
Gi0/0	1	0	192.168.12.1/30	781	DR	1/1	

- f. Change the bandwidth for interface G0/1 to the same setting as G0/0 on R1.
- g. Re-issue the **show ip route ospf** command to view the accumulated cost of both routes to the 192.168.23.0/24 network. Note that there are again two equal-cost (782) routes to the 192.168.23.0/24 network, one via G0/0 and one via G0/1.

```
R1# show ip route ospf
```

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      192.168.2.0/24 [110/782] via 192.168.12.2, 00:00:09, GigabitEthernet0/0
O      192.168.3.0/24 [110/782] via 192.168.13.2, 00:00:09, GigabitEthernet0/1
      192.168.23.0/30 is subnetted, 1 subnets
O      192.168.23.0 [110/782] via 192.168.13.2, 00:00:09, GigabitEthernet0/1
                  [110/782] via 192.168.12.2, 00:00:09, GigabitEthernet0/0
```

Explain how the costs to the 192.168.3.0/24 and 192.168.23.0/30 networks from R1 were calculated.

- h. Issue the **show ip route ospf** command on S3. The accumulated cost of the 192.168.1.0/24 is still showing as 2.

```
S3# show ip route ospf
```

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 192.168.13.1, 00:30:58, GigabitEthernet1/0/1
O    192.168.2.0/24 [110/2] via 192.168.23.1, 00:30:58, GigabitEthernet1/0/2
    192.168.12.0/30 is subnetted, 1 subnets
O        192.168.12.0 [110/2] via 192.168.23.1, 00:30:58, GigabitEthernet1/0/2
```

- i. Issue the **bandwidth 128** command on all remaining interfaces connecting the routers and layer-3 switch in the topology. What is the new accumulated cost to the 192.168.23.0/24 network on R1? Why?

Step 3: Change the link cost.

OSPF uses the bandwidth setting to calculate the cost for a link by default. However, you can override this calculation by manually setting the cost of a link using the **ip ospf cost** command. Like the **bandwidth** command, the **ip ospf cost** command only affects the side of the link where it was applied.

- a. Issue the **show ip route ospf** on R1.

```
R1# show ip route ospf
```

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    192.168.2.0/24 [110/782] via 192.168.12.2, 00:00:26, GigabitEthernet0/0
O    192.168.3.0/24 [110/782] via 192.168.13.2, 00:02:50, GigabitEthernet0/1
    192.168.23.0/30 is subnetted, 1 subnets
O        192.168.23.0 [110/1562] via 192.168.13.2, 00:02:40, GigabitEthernet0/1
                [110/1562] via 192.168.12.2, 00:02:40, GigabitEthernet0/0
```

- b. Apply the **ip ospf cost 1565** command to the G0/1 interface on R1. A cost of 1565 is higher than the accumulated cost of the route through R2 which is 1562.

```
R1(config)# interface G0/1
```

```
R1(config-if)# ip ospf cost 1565
```

- c. Re-issue the **show ip route ospf** command on R1 to display the effect this change has made on the routing table. All OSPF routes for R1 are now being routed through R2.

R1# **show ip route ospf**

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      192.168.2.0/24 [110/782] via 192.168.12.2, 00:02:06, GigabitEthernet0/0
O      192.168.3.0/24 [110/1563] via 192.168.12.2, 00:05:31, GigabitEthernet0/0
      192.168.23.0/30 is subnetted, 1 subnets
O          192.168.23.0 [110/1562] via 192.168.12.2, 01:14:02, GigabitEthernet0/0
```

Note: Manipulating link costs using the **ip ospf cost** command is the easiest and preferred method for changing OSPF route costs. In addition to changing the cost based on bandwidth, a network administrator may have other reasons for changing the cost of a route, such as preference for a particular service provider or the actual monetary cost of a link or route.

Explain why the route to the 192.168.3.0/24 network on R1 is now going through R2?

Reflection

1. Why is it important to control the router ID assignment when using the OSPF protocol?
2. Why would you want to set an OSPF interface to passive?