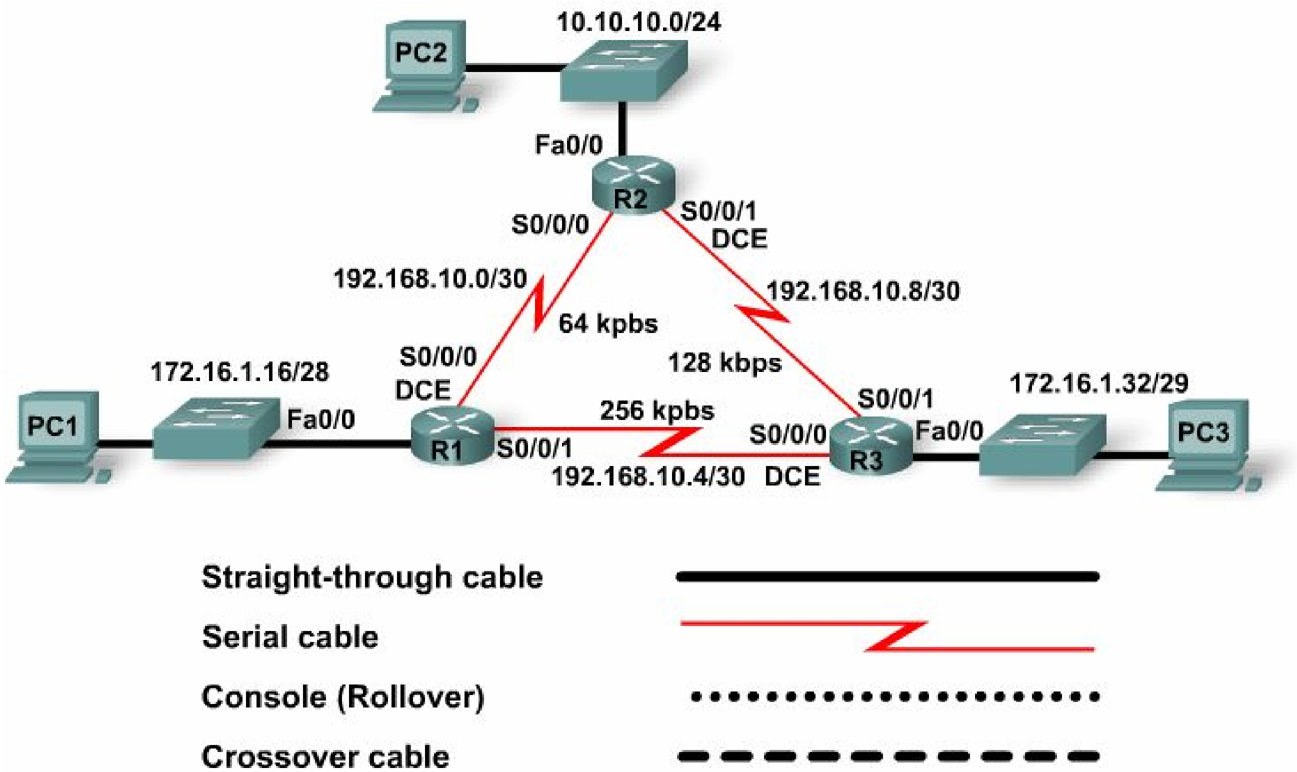
Lab 6.2.4 Part A: Configuring and Verifying Point-to-Point OSPF



Device	Interface	IP Address	Subnet Mask	Default Gateway	Enable Secret Password	Enable, vty, and Console Passwords
R1	Fa0/0	172.16.1.17	255.255.255.240	N/A	class	cisco
	S0/0/0	192.168.10.1	255.255.255.252	N/A		
	S0/0/1	192.168.10.5	255.255.255.252	N/A		
R2	Fa0/0	10.10.10.1	255.255.255.0	N/A	class	cisco
	S0/0/0	192.168.10.2	255.255.255.252	N/A		
	S0/0/1	192.168.10.9	255.255.255.252	N/A		
R3	Fa0/0	172.16.1.33	255.255.255.248	N/A	class	cisco
	S0/0/0	192.168.10.6	255.255.255.252	N/A		
	S0/0/1	192.168.10.10	255.255.255.252	N/A		
PC1	NIC	172.16.1.20	255.255.255.240	172.16.1.17		
PC2	NIC	10.10.10.10	255.255.255.0	10.10.10.1		
PC3	NIC	172.16.1.35	255.255.255.248	172.16.1.33		

Objectives

- Configure OSPF routing on all routers in a point-to-point WAN environment that includes LANs.
- Configure OSPF router IDs.
- Configure interface bandwidth and cost.
- Verify OSPF routing using **show** commands.

Background / Preparation

In this lab you will learn how to configure the routing protocol OSPF using the network shown in the topology diagram. The segments of the network have been subnetted using VLSM. OSPF is a classless routing protocol that provides subnet mask information in its routing updates. This allows VLSM subnet information to be propagated throughout the network.

This lab uses an 1841 router and Cisco IOS commands. Any router that meets the interface requirements displayed in the addressing table may be used. For example, router series 800, 1600, 1700, 1800, 2500, 2600, 2800, or any combination can be used.

The information in this lab applies to 1841 routers. Other routers may be used; however, the command syntax may vary. Depending on the router model, the interfaces may differ. For example, on some routers Serial 0 may be Serial 0/0, Serial 0/0/0 and Ethernet 0 may be FastEthernet 0/0. The Cisco Catalyst 2960 switch comes preconfigured and only needs to be assigned basic security information before being connected to a network.

The following resources are required:

- Three Cisco 2960 switches or other comparable switch (optional if using crossover cables between the PCs and routers)
- Three Cisco 1841 or comparable routers with 2 serial interfaces and 1 FastEthernet interface (preferably the same model number and IOS version)
- Three Windows-based PCs with a terminal emulation program and set up as hosts
- At least one RJ-45-to-DB-9 connector console cable to configure the routers and switches
- Six straight-through Ethernet cables to connect the router to the switch and the switch to the hosts
- Three serial crossover cables to connect the routers

NOTE: Make sure that the routers and the switches have been erased and have no startup configurations. Instructions for erasing both switch and router are provided in the Lab Manual, located on Academy Connection in the Tools section.

NOTE: SDM Enabled Routers – If the startup-config is erased in an SDM enabled router, SDM will no longer come up by default when the router is restarted. It will be necessary to build a basic router configuration using IOS commands. The steps provided in this lab use IOS commands and do not require the use of SDM. If you wish to use SDM, refer to the instructions in the Lab Manual, located on the Academy Connection in the Tools section or contact your instructor if necessary.

Step 1: Connect the equipment

a. Connect the Fa0/0 interface of each router to the Fa0/1 interface of each switch using a straight-through cable.

b. Connect each host to the Fa0/2 switch port of each switch using a straight-through cable.

c. Connect serial cables from each router to the other router as shown in the topology.

Step 2: Perform basic configurations on the routers

a. Connect a PC to the console port of the router to perform configurations using a terminal emulation program.

b. On all routers, configure the hostname, passwords, and message-of-the-day banner and disable DNS lookups according to the addressing table and topology diagram.

Step 3: Configure the router interfaces

Configure and activate the FastEthernet interface addresses on R1, R2, and R3 according to the information in the addressing table and topology diagram.

Step 4: Verify IP addressing and interfaces

a. Use the **`show ip interface brief`** or the **`show protocols`** command to verify that the IP addressing is correct and that the interfaces are active.

b. After all interfaces are verified, be sure to save the running configuration to the NVRAM of the router.

Step 5: Configure Ethernet interfaces of PC1, PC2, and PC3

a. Configure the Ethernet interfaces of PC1, PC2, and PC3 with the IP addresses and default gateways from the addressing table.

b. Test the PC configuration by pinging the default gateway from each PC.

Step 6: Configure OSPF on Router 1

a. Configure OSPF on the R1 router. Enter a process ID of 1 for the *`process-ID`* parameter.

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

b. Configure the network statement for the LAN. When you are in the Router OSPF configuration submode, configure the LAN 172.16.1.16/28 to be included in the OSPF updates that are sent out of R1. Use an area ID of 0 for the OSPF *`area-id`* parameter. Zero will be used for the OSPF area ID in all **`network`** statements in this topology.

```
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
```

c. Configure the router to advertise the 192.168.10.0/30 network attached to the Serial 0/0/0 interface.

```
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
```

d. Configure the router to advertise the 192.168.10.4/30 network attached to the Serial 0/0/1 interface.

```
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
```

e. Return to privileged EXEC mode and save the configuration.

Step 7: Configure OSPF on the R2 router

a. Enable OSPF routing on the R2 router using the **`router ospf`** command. Use a process ID of 1.

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

b. Configure the router to advertise the LAN network 10.10.10.0/24 in the OSPF updates.

```
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
```


c. Configure the router to advertise the 192.168.10.0/30 network attached to the Serial 0/0/0 interface.

```
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
R2(config-router)#
00:07:27: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on Serial0/0/0
from EXCHANGE to FULL, Exchange Done
```

When the network for the serial link from R1 to R2 is added to the OSPF configuration, the router sends a notification message to the console stating that a neighbor relationship with another OSPF router has been established.

d. Configure the router to advertise the 192.168.10.8/30 network attached to the Serial 0/0/1 interface. When you are finished, return to privileged EXEC mode.

```
R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
R2(config-router)#end
R2#
```

Step 8: Configure OSPF on the R3 router

Configure OSPF on the R3 router using the `router` **`ospf`** **and** **`network`** commands. Use a process ID of 1. Configure the router to advertise the three directly connected networks. When you are finished, return to privileged EXEC mode.

```
R3(config)#router ospf 1
R3(config-router)#network 172.16.1.32 0.0.0.7 area 0
R3(config-router)#network 192.168.10.4 0.0.0.3 area 0
R3(config-router)#
00:17:46: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on Serial0/0/0
from LOADING to FULL, Loading Done
R3(config-router)#network 192.168.10.8 0.0.0.3 area 0
R3(config-router)#
00:18:01: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.9 on Serial0/0/1
from EXCHANGE to FULL, Exchange Done
R3(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R3#
```

When the networks for the serial links from R3 to R1 and R3 to R2 are added to the OSPF configuration, the router sends a notification message to the console stating that a neighbor relationship with another OSPF router has been established.

Step 9: Configure OSPF router IDs

a. The OSPF router ID is used to uniquely identify the router in the OSPF routing domain. A router ID is an IP address. 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

2) Highest IP address of any of the router loopback addresses

3) Highest active IP address on any of the router physical interfaces

b. Examine the current router IDs in the topology.

   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.

   What is the router ID for R1? ________________________________

   What is the router ID for R2? ________________________________

   What is the router ID for R3? ________________________________

c. The router ID can also be seen in the output of the **show ip protocols**, **show ip ospf**, and **show ip ospf interfaces** commands.

```
R3#show ip protocols
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 192.168.10.10
R3#show ip ospf
 Routing Process "ospf 1" with ID 192.168.10.10
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs

<output omitted>

R3#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 172.16.1.33/29, Area 0
  Process ID 1, Router ID 192.168.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.10.10, Interface address 172.16.1.33
  No backup designated router on this network
<output omitted>
```

d. Use loopback addresses to change the router IDs of the routers in the topology.

```
R1(config)#interface loopback 0
R1(config-if)#ip address 10.1.1.1 255.255.255.255

R2(config)#interface loopback 0
R2(config-if)#ip address 10.2.2.2 255.255.255.255

R3(config)#interface loopback 0
R3(config-if)#ip address 10.3.3.3 255.255.255.255
```

e. Reload the routers to force the new router IDs to be used. When a new router ID is configured, it is not used until the OSPF process is restarted. Make sure that the current configuration is saved to NRAM, and then use the **reload** command to restart each of the routers.

   When the router is reloaded, what is the router ID for R1? _________________________

   When the router is reloaded, what is the router ID for R2? _________________________

   When the router is reloaded, what is the router ID for R3? _________________________

f. Use the **show ip ospf neighbor** command to verify that the router IDs have changed.

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State      Dead Time    Address         Interface
10.3.3.3          0   FULL/-     00:00:30     192.168.10.6    Serial0/0/1
10.2.2.2          0   FULL/-     00:00:33     192.168.10.2    Serial0/0/0
```

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State      Dead Time    Address         Interface
10.3.3.3          0   FULL/-     00:00:36     192.168.10.10   Serial0/0/1
10.1.1.1          0   FULL/-     00:00:37     192.168.10.1    Serial0/0/0
```

```
R3#show ip ospf neighbor

Neighbor ID     Pri   State      Dead Time    Address         Interface
10.2.2.2          0   FULL/-     00:00:34     192.168.10.9    Serial0/0/1
10.1.1.1          0   FULL/-     00:00:38     192.168.10.5    Serial0/0/0
```

g. Use the **router-id** command to change the router ID on the R1 router.

NOTE: Some IOS versions do not support the **router-id** command. If this command is not available, continue to Step 10.

```
R1(config)#router ospf 1
R1(config-router)#router-id 10.4.4.4
```

Reload or use the **clear ip ospf process** command for this to take effect.

If this command is used on an OSPF router process that is already active (has neighbors), the new router ID is used at the next reload or at a manual OSPF process restart. To manually restart the OSPF process, use the **clear ip ospf process** command.

```
R1#(config-router)#end
R1#clear ip ospf process
Reset ALL OSPF processes? [no]:yes
R1#
```

h. Use the **show ip ospf neighbor** command on router R2 to verify that the router ID of R1 has been changed.

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State       Dead Time    Address         Interface
10.3.3.3          0   FULL/-      00:00:36     192.168.10.10   Serial0/0/1
10.4.4.4          0   FULL/-      00:00:37     192.168.10.1    Serial0/0/0
```

i. Remove the configured router ID with the **no** form of the **router-id** command.

```
R1(config)#router ospf 1
R1(config-router)#no router-id 10.4.4.4
```

Reload or use the **clear ip ospf process** command for this to take effect.

j. Restart the OSPF process using the **clear ip ospf process** command.

Restarting the OSPF process forces the router to use the IP address configured on the Loopback 0 interface as the router ID.

```
R1(config-router)#end
R1#clear ip ospf process
Reset ALL OSPF processes? [no]:yes
```

Step 10: Verify OSPF operation

a. On the R1 router, use the **show ip ospf neighbor** command to view the information about the OSPF neighbor routers R2 and R3. You should be able to see the neighbor ID and IP address of each adjacent router as well as the interface that R1 uses to reach that OSPF neighbor.

```
R1#show ip ospf neighbor
Neighbor ID     Pri   State       Dead Time   Address         Interface
10.2.2.2          0   FULL/-      00:00:32    192.168.10.2    Serial0/0/0
10.3.3.3          0   FULL/-      00:00:32    192.168.10.6    Serial0/0/1
R1#
```

b. On the R1 router, use the **show ip protocols** command to view information about the routing protocol operation.

The information that was configured in the previous steps, such as protocol, process ID, neighbor ID, and networks, is shown in the output. The IP addresses of the adjacent neighbors are also shown.

```
R1#show ip protocols

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 10.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.2.2.2          110      00:11:43
    10.3.3.3          110      00:11:43
  Distance: (default is 110)
```

The output specifies the process ID and area ID used by OSPF. The area ID must be the same on all routers contained in the same area for OSPF to establish neighbor adjacencies and share routing information.

Step 11: Examine OSPF routes in the routing tables

View the routing table on the R1 router. OSPF routes are denoted in the routing table with an **O**.

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, 2 subnets, 2 masks
C       10.1.1.1/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/65] via 192.168.10.2, 00:01:02, Serial0/0/0
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.1.16/28 is directly connected, FastEthernet0/0
O       172.16.1.32/29 [110/65] via 192.168.10.6, 00:01:12, Serial0/0/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0/0
C       192.168.10.4 is directly connected, Serial0/0/1
O       192.168.10.8 [110/128] via 192.168.10.6, 00:01:12, Serial0/0/1
                     [110/128] via 192.168.10.2, 00:01:02, Serial0/0/0
R1#
```

Unlike RIPv2 and EIGRP, OSPF does not automatically summarize at major network boundaries.

Step 12: Configure OSPF cost

a. Use the **show ip route command** on the R1 router to view the OSPF cost to reach the 10.10.10.0/24 network.

```
R1#show ip route

<output omitted>

     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.1.1.1/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/65] via 192.168.10.2, 00:16:56, Serial0/0/0
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.1.16/28 is directly connected, FastEthernet0/0
O       172.16.1.32/29 [110/65] via 192.168.10.6, 00:17:06, Serial0/0/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0/0
C       192.168.10.4 is directly connected, Serial0/0/1
O       192.168.10.8 [110/128] via 192.168.10.6, 00:17:06, Serial0/0/1
                     [110/128] via 192.168.10.2, 00:16:56, Serial0/0/0
R1#
```

The path cost of 65 to the 10.10.10.0 network results from a WAN serial link cost of 64 plus the LAN FastEthernet link cost of 1.

b. Use the **`show interfaces serial0/0/0`** command on the R1 router to view the bandwidth of the Serial 0/0/0 interface.

```
R1#show interfaces serial0/0/0
Serial0/0/0 is up, line protocol is up (connected)
  Hardware is HD64570
  Internet address is 192.168.10.1/30
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely 255/255, load 1/255
  Encapsulation HDLC, loopback not set, keepalive set (10 sec)
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0 (size/max/drops); Total output drops: 0

<output omitted>
```

On most serial links, the bandwidth metric defaults to 1544 Kbits. This translates to an OSPF cost of 64 (100,000,000/1,544,000). If this is not the actual bandwidth of the serial link, the bandwidth needs to be changed so that the OSPF cost can be calculated correctly.

c. Use the **`show ip ospf interface`** command to see the OSPF cost currently associated with interfaces that are participating in OSPF updates. Because the bandwidth of the FastEthernet interface is 100,000,000 bps, its cost is 1 (100,000,000/100,000,000).

```
R1#show ip ospf interface <some output omitted>
Serial0/0/1 is up, line protocol is up
  Internet Address 192.168.10.5/30, Area 0
  Process ID 1, Router ID 10.1.1.1, 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
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.3.3.3
  Suppress hello for 0 neighbor(s)

Serial0/0/0 is up, line protocol is up
  Internet Address 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, 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
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.2.2.2
  Suppress hello for 0 neighbor(s)

FastEthernet0/0 is up, line protocol is up
  Internet Address 172.16.1.17/28, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 10.1.1.1, Interface address 172.16.1.17
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```


d. Use the **bandwidth** command to change the bandwidth of the serial interfaces of the R1 and R2 routers to the actual bandwidth, 64 kbps.

```
R1 router:
R1(config)#interface serial0/0/0
R1(config-if)#bandwidth 64
R1(config-if)#interface serial0/0/1
R1(config-if)#bandwidth 64

R2 router:
R2(config)#interface serial0/0/0
R2(config-if)#bandwidth 64
R2(config-if)#interface serial0/0/1
R2(config-if)#bandwidth 64
```

e. Use the **show ip ospf interface** command on the R1 router to verify the cost of the serial links. The cost of each of the serial links is now 1562, the result of the calculation: 10^8/64,000 bps.

```
R1#show ip ospf interface

<output omitted>

Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT-TO-POINT, Cost: 1562
  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 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 10.2.2.2
  Suppress hello for 0 neighbor(s)
Serial0/0/1 is up, line protocol is up
  Internet address is 192.168.10.5/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT-TO-POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,

<output omitted>
```

f. Use the **ip ospf cost** command to configure the OSPF cost on the R3 router.

g. An alternative to using the **bandwidth** command is to use the **ip ospf cost** command, which allows you to directly configure the cost. Use the **ip ospf cost** command to change the bandwidth of the serial interfaces of the R3 router to 1562.

```
R3(config)#interface serial0/0/0
R3(config-if)#ip ospf cost 1562
R3(config-if)#interface serial0/0/1
R3(config-if)#ip ospf cost 1562
```

h. Use the **`show ip ospf interface`** command on the R3 router to verify that the cost of each of the serial links is now 1562.

```
R3#show ip ospf interface

<output omitted>
Serial0/0/1 is up, line protocol is up
  Internet address is 192.168.10.10/30, Area 0
  Process ID 1, Router ID 10.3.3.3, Network Type POINT-TO-POINT, Cost: 1562
  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 10.2.2.2
  Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.6/30, Area 0
  Process ID 1, Router ID 10.3.3.3, Network Type POINT-TO-POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,

<output omitted>
```

Step 13: Reflection

What are some advantages of using OSPF as a routing protocol?

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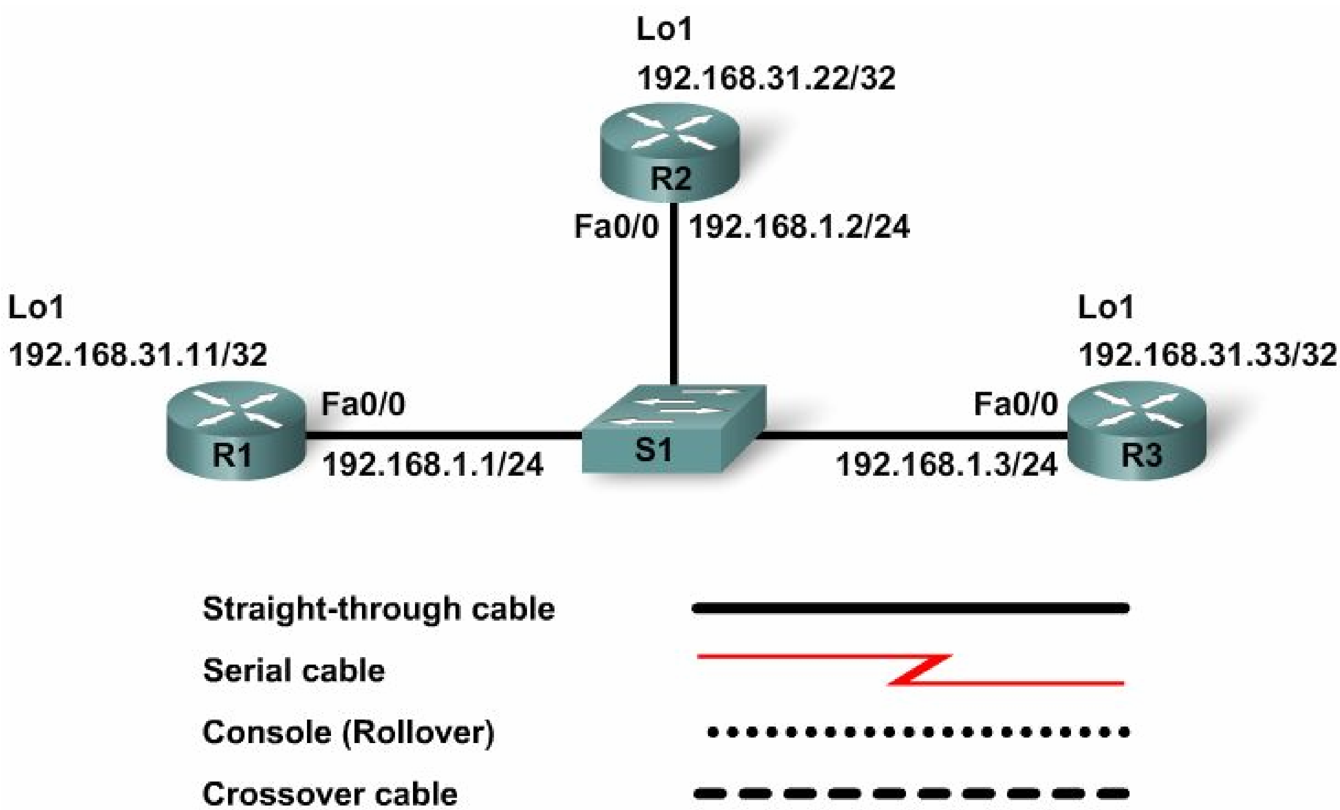
Lab 6.2.4 Part B: Configuring and Verifying Multi-access OSPF



Device	Interface	IP Address	Subnet Mask	Default Gateway	Enable Secret Password	Enable, vty, and Console Passwords
R1	Fa0/0	192.168.1.1	255.255.255.0	N/A	class	cisco
	Loopback1	192.168.31.11	255.255.255.255	N/A		
R2	Fa0/0	192.168.1.2	255.255.255.0	N/A	class	cisco
	Loopback1	192.168.31.22	255.255.255.255	N/A		
R3	Fa0/0	192.168.1.3	255.255.255.0	N/A	class	cisco
	Loopback1	192.168.31.33	255.255.255.255	N/A		

Objectives

- Configure OSPF on a multi-access network.
- Configure OSPF priority.
- Control the OSPF election process.
- Verify the OSPF configuration and DR/BDR/DROTHER status.

Background / Preparation

In this lab, you will learn to configure OSPF on a multi-access Ethernet network. You will also learn to use the OSPF election process to determine the designated router (DR), backup designated router (BDR), and DRother states. This lab uses 1841 routers and Cisco IOS commands.

The information in this lab applies to 1841 routers. Other routers may be used; however, the command syntax may vary. Depending on the router model, the interfaces may differ. For example, on some routers Serial 0 may be Serial 0/0, Serial 0/0/0 and Ethernet 0 may be FastEthernet 0/0. The Cisco Catalyst 2960 switch comes preconfigured and only needs to be assigned basic security information before being connected to a network.

The following resources are required:

- One Cisco 2960 switch or other comparable switch
- Three Cisco 1841 or comparable routers with 1 FastEthernet interface (preferably the same model number and IOS version)
- Three Windows-based PCs with a terminal emulation program
- At least one RJ-45-to-DB-9 connector console cable to configure the router
- Three straight-through Ethernet cables to connect the routers to the switch

NOTE: Make sure that the routers and the switches have been erased and have no startup configurations. Instructions for erasing both switch and router are provided in the Lab Manual, located on Academy Connection in the Tools section.

NOTE: SDM Enabled Routers – If the startup-config is erased in an SDM enabled router, SDM will no longer come up by default when the router is restarted. It will be necessary to build a basic router configuration using IOS commands. The steps provided in this lab use IOS commands and do not require the use of SDM. If you wish to use SDM, refer to the instructions in the Lab Manual, located on the Academy Connection in the Tools section or contact your instructor if necessary.

Step 1: Connect the equipment

Connect the Fa0/0 interface of each router to the switch using a straight-through cable. Three routers are sharing a common Ethernet multi-access network, 192.168.1.0/24. Each router will be configured with an IP address on the FastEthernet interface and a loopback address for the router ID.

Step 2: Perform basic configurations on the routers

a. Connect a PC to the console port of the router to perform configurations using a terminal emulation program.

b. Configure Routers 1, 2, and 3 with a hostname, and console, Telnet, and privileged passwords according to the information found in the table.

Step 3: Configure and activate Ethernet and Loopback addresses

Configure and activate the FastEthernet and loopback addresses on R1, R2, and R3 according to the information shown in the lab topology diagram and the table.

Step 4: Verify IP addressing and interfaces

a. Use the **`show ip interface brief`** or the **`show protocols`** command to verify that the IP addressing is correct and that the interfaces are active.

b. After all interfaces are verified, be sure to save the running configuration to the NVRAM of the router.

Step 5: Configure OSPF on the DR router

The DR and BDR election process takes place as soon as the first router has its interface enabled for OSPF on the multi-access network. If OSPF is already configured for an interface, this can happen as the routers are powered on. It can also happen when the OSPF **`network`** command for that interface is configured. If a new router enters the network after the DR and BDR have already been elected, it will not become the DR or BDR even if it has a higher OSPF interface priority or router ID than the current DR or BDR.

a. Configure the OSPF process on the router with the highest router ID first to ensure that this router becomes the DR.

   Based on the loopback addresses assigned in Step 3, which router should be come the DR? _____

b. Use the **`router ospf`** command in global configuration mode to enable OSPF on the R3 router. Enter a process ID of 1 for the *`process-ID`* parameter. Configure the router to advertise the 192.168.1.0/24 network. Use an area ID of 0 for the OSPF *`area-id`* parameter in the **`network`** statement.

```
R3(config)#router ospf 1
R3(config-router)#network 192.168.1.0 0.0.0.255 area 0
R3(config-router)#end
```

c. Use the **`show ip ospf interface`** command to verify that the OSPF has been configured correctly and that R3 is the DR.

```
R3#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.3/24, Area 0
  Process ID 1, Router ID 192.168.31.33, Network Type BROADCAST, Cost:
1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:07
  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)
```

NOTE: Wait at least 40 seconds for a hello packet to be sent in order to see the state change. If a state says WAITING, wait longer because it will change to a DR.

What type of network has OSPF detected for this interface? ________________________________

What is the IP address of this interface? _____________________________________

What is the OSPF cost for this interface? ____________________________________

What is the router ID of this router? _____________________________________

Step 6: Configure OSPF on the BDR router

a. Configure the OSPF process on the router with the second highest router ID to ensure that this router becomes the BDR. Use the **router ospf** command in global configuration mode to enable OSPF on the R2 router. Enter a process ID of 1 for the *process-ID* parameter. Configure the router to advertise the 192.168.1.0/24 network. Use an area ID of 0 for the OSPF *area-id* parameter in the **network** statement.

```
R2(config)#router ospf 1
R2(config-router)#network 192.168.1.0 0.0.0.255 area 0
R2(config-router)#end
```

It may take up to 40 seconds for the R3 router to send a hello packet.

What console message was displayed as a result of the OSPF commands on R2 and what does this mean?

____

____

b. Use the **show ip ospf interface** command to verify that the OSPF has been configured correctly and that R2 is the BDR.

```
R2#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.2/24, Area 0
  Process ID 1, Router ID 192.168.31.22, Network Type BROADCAST, Cost:
1
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated Router (ID) 192.168.31.22, Interface address
192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.1.3  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

c. Use the **show ip ospf neighbors** command in global configuration mode to view information about the other routers in the OSPF area.

Notice that R3 is the DR.

```
R2#show ip ospf neighbor
Neighbor ID     Pri   State     Dead Time   Address        Interface
192.168.31.33     1   FULL/DR   00:00:33    192.168.1.3    FastEthernet0/0
```


Step 7: Configure OSPF on the DRother router

a. Configure the OSPF process on the router with the lowest router ID last. This router will be designated as DRother instead of DR or BDR. Use the **`router ospf`** command in global configuration mode to enable OSPF on the R1 router. Enter a process ID of 1 for the *`process-ID`* parameter. Configure the router to advertise the 192.168.1.0/24 network. Use an area ID of 0 for the OSPF *`area-id`* parameter in the **`network`** statement.

```
R1(config)#router ospf 1
R1(config-router)#network 192.168.1.0 0.0.0.255 area 0
R1(config-router)#end

00:16:08: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from LOADING to FULL, Loading Done
00:16:12: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from EXCHANGE to FULL, Exchange Done
```

An adjacency is formed with the R2 and R3 routers. It may take up to 40 seconds for both the R2 and R3 routers to each send a hello packet.

b. Use the **`show ip ospf interface`** command to verify that the OSPF has been configured correctly and that R1 is a DRother.

```
R1#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.1/24, Area 0
  Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost:
1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated Router (ID) 192.168.31.22, Interface address
192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:00
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.31.33  (Designated Router)
    Adjacent with neighbor 192.168.31.22  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
```

c. Use the **`show ip ospf neighbors`** command in global configuration mode to view information about the other routers in the OSPF area.

Notice that R3 is the DR and R2 is the BDR.

```
R1#show ip ospf neighbor
Neighbor ID     Pri   State          Dead Time    Address         Interface
192.168.31.22     1   FULL/BDR       00:00:35     192.168.1.2     FastEthernet0/0
192.168.31.33     1   FULL/DR        00:00:30     192.168.1.3     FastEthernet0/0
```


Step 8: Use the OSPF priority to determine the DR and BDR

a. Use the **ip ospf priority interface** command to change the OSPF priority of the R1 router to 255. This is the highest possible priority.

```
R1(config)#interface fastEthernet0/0
R1(config-if)#ip ospf priority 255
R1(config-if)#end
```

b. Use the **ip ospf priority interface** command to change the OSPF priority of the R3 router to 100.

```
R3(config)#interface fastEthernet0/0
R3(config-if)#ip ospf priority 100
R3(config-if)#end
```

c. Use the **ip ospf priority interface** command to change the OSPF priority of the R2 router to 0. A priority of 0 causes the router to be ineligible to participate in an OSPF election and become a DR or BDR.

```
R2(config)#interface fastEthernet0/0
R2(config-if)#ip ospf priority 0
R2(config-if)#end
```

d. Shut down and re-enable the FastEthernet0/0 interfaces to force an OSPF election. As the interfaces are shut down, the OSPF adjacencies are lost.

R1:

```
R1(config)#interface fastethernet0/0
R1(config-if)#shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from FULL to Down: Interface down or detached
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from FULL to Down: Interface down or detached
```

R2:

```
R2(config)#interface fastethernet0/0
R2(config-if)#shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
02:17:06: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from FULL to Down: Interface down or detached
02:17:06: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.11 on
FastEthernet0/0 from FULL to Down: Interface down or detached
```


R3:

```
R3(config)#interface fastethernet0/0
R3(config-if)#shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from FULL to Down: Interface down or detached
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.11 on
FastEthernet0/0 from FULL to Down: Interface down or detached
```

e. Re-enable the FastEthernet 0/0 interface on the R2 router.

```
R2(config-if)#no shut
R2(config-if)#end
```

f. Re-enable the FastEthernet 0/0 interface on the R1 router.

```
R1(config-if)#no shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to up

02:31:43: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from EXCHANGE to FULL, Exchange Done
```

An adjacency is formed with the R2 router. It may take up to 40 seconds for the R2 router to send a hello packet.

g. Use the **show ip ospf neighbor** command on the R1 router to view the OSPF neighbor information for that router.

Even though the R2 router has a higher router ID than R1, the R2 router has been set to a state of DRother because the OSPF priority has been set to 0.

```
R1#show ip ospf neighbor
Neighbor ID     Pri   State          Dead Time   Address      Interface
192.168.31.22     0   FULL/DROTHER   0:00:33     192.168.1.2  FastEthernet0/0
R1#
```

h. Re-enable the FastEthernet 0/0 interface on the R3 router.

```
R3(config-if)#no shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to up

02:37:32: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.11 on
FastEthernet0/0 from LOADING to FULL, Loading Done
02:37:36: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from EXCHANGE to FULL, Exchange Done
```

An adjacency is formed with the R1 and R2 routers. It may take up to 40 seconds for both the R1 and R2 routers to each send a hello packet.

i. Use the **show ip ospf interface** command on the R3 router to verify that R3 has become the BDR.

```
R3#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.3/24, Area 0
  Process ID 1, Router ID 192.168.31.33, Network Type BROADCAST, Cost:
1
  Transmit Delay is 1 sec, State BDR, Priority 100
  Designated Router (ID) 192.168.31.11, Interface address 192.168.1.1

<output omitted>
```

Step 9: Reflection

a. When the OSPF process starts, what happens if there is no active interface on the router?

____

b. What can be done to ensure there will be an active interface on a router?

____

c. How are the DR and BDR elected in an OSPF network?

____

____

d. What OSPF interface priority value prevents a router from being elected as a DR? __________

