ASR Lab Basic OSPF Configuration Lab

Learning Objectives

Upon completion of this lab, you will be able to:

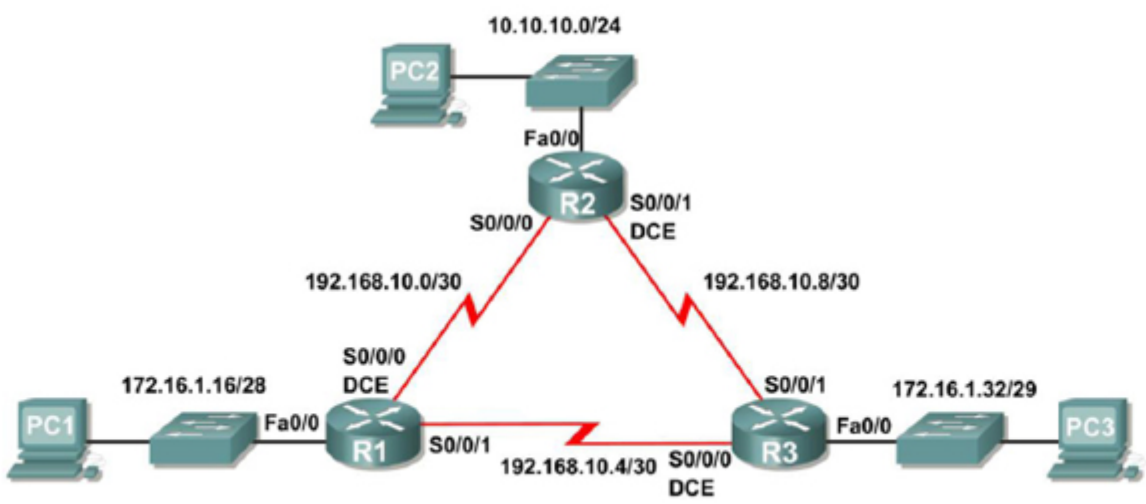
- Configure OSPF routing on all routers
- Configure OSPF router IDs
- Verify OSPF routing using show commands

Scenario

In the scenario, you will learn how to configure the routing protocol OSPF using the network shown in the Topology Diagram in Scenario A. The segments of the network have been subnetted using VLSM. OSPF is a classless routing protocol that can be used to provide subnet mask information in the routing updates. This will allow VLSM subnet information to be propagated throughout the network.

Scenario A: Basic OSPF Configuration

Topology Diagram



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	172.16.1.17	255.255.255.240	N/A
	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
	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
	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

Task 1: Prepare the Network.

Open the packet Tracer file labelled Lab OSPF Configure 3 Router Network.pkt

Task 2: Perform Basic Router Configurations.

The basic configuration of the R1, R2, and R3 routers have been completed according to the following guidelines:

1. Configured the router hostnames.
2. Configured and activated the interfaces.

Step 1: Configure interfaces on R1, R2, and R3.

Check the running-config of each router and compare to the addressing table**.**

Step 2: Verify IP addressing and interfaces.

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

When you have finished, be sure to save the running configuration to the NVRAM of the router.

Step 3: Check Ethernet interfaces of PC1, PC2, and PC3.

Hover briefly and check the Ethernet interfaces of PC1, PC2, and PC3 with the IP addresses and default gateways from the table under the Topology Diagram.

Step 4: Test the PC configuration by pinging the default gateway from the PC.

Task 4: Configure OSPF on the R1 Router

Step 1: 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.

First, the router ospf 1 global command puts the user in OSPF configuration mode, and sets the OSPF process-id. This number just needs to be unique on the local router, allowing the router to support multiple OSPF processes in a single router by using different process IDs. (The router command uses the process-id to distinguish between the processes.) The process-id does not have to match on each router, and it can be any integer between 1 and 65,535.

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

Step 2: Configure the `network` statement for the LAN network.
Once you are in the Router OSPF configuration sub-mode, configure the LAN network 172.16.1.16/28 to be included in the OSPF updates that are sent out of R1.

The OSPF **`network`** command uses a combination of *network-address* and *wildcard-mask* similar to that which can be used by EIGRP. Unlike EIGRP, the wildcard mask in OSPF is required.

Use an area ID of 0 for the OSPF *area-id* parameter. 0 will be used for the OSPF area ID in all of the **`network`** statements in this topology.

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

Step 3: Configure the router to advertise the 192.168.10.0/30 network attached to the Serial0/0/0 interface.

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

Step 4: Configure the router to advertise the 192.168.10.4/30 network attached to the Serial0/0/1 interface.

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

Step 5: When you are finished with the OSPF configuration for R1, return to privileged EXEC mode.

```
R1(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R1#
```

Task 5: Configure OSPF on the R2 and R3 Routers

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

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

Step 2: 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
R2(config-router)#
```

Step 3: Configure the router to advertise the 192.168.10.0/30 network attached to the Serial0/0/0 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
```

Notice that 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.

Step 4: Configure the router to advertise the 192.168.10.8/30 network attached to the Serial0/0/1 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
%SYS-5-CONFIG_I: Configured from console by console
R2#
```

Step 5: 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#
```

Notice that 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.

Task 6: Configure OSPF Router IDs

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's loopback addresses.
3. Highest active IP address on any of the router's physical interfaces.

Step 1: Examine the current router IDs in the topology.

Since 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? ________________ (Router ID 192.168.10.5)
What is the router ID for R2? ________________ Router ID 192.168.10.9
What is the router ID for R3? ________________ Router ID 192.168.10.10

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

<output omitted>


R3#show ip ospf

<output omitted>

R3#show ip ospf interface

<output omitted>

R3#

R1#show ip route


     10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0 [110/65] via 192.168.10.2, 00:07:48, 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, 00:06:12, 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 192.168.10.2, 00:05:54, Serial0/0/0
                     [110/128] via 192.168.10.6, 00:05:54, Serial0/0/1
```

The code of "O" on the left identifies a route as being learned by OSPF. The output lists three such IP routes. Next, take a look at the first OSPF route (to subnet 10.0.0.0). It lists the subnet ID and mask, identifying the subnet. It also lists two numbers in brackets. The first, 110, is the administrative distance of the route. All the OSPF routes in this example use the default of 110. The second number, 65, is the OSPF metric for this route.

Step 2: 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
```

A loopback interface is a virtual interface that can be configured with the interface loopback interface-number command, where interface-number is an integer. Loopback interfaces are always in an "up and up" state unless administratively placed in a shutdown state. For example, a simple configuration of the command interface loopback 0, followed by ip address 2.2.2.2 255.255.255.255, would create a loopback interface and assign it an IP address. Because loop-back interfaces do not rely on any hardware, these interfaces can be up/up whenever IOS is running, making them good interfaces on which to base an OSPF RID.

Step 3: Reload the routers to force the new Router IDs to be used.

When a new Router ID is configured, it will not be 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? __________10.1.1.1____________
When the router is reloaded, what is the router ID for R2? __________10.2.2.2____________
When the router is reloaded, what is the router ID for R3? __________10.3.3.3____________

OSPF routers use a three-step process to eventually add OSPF- learned routes to the IP routing table. First, they create neighbor relationships. Then they build and flood LSAs, so each router in the same area has a copy of the same LSDB. Finally, each router independently computes its own IP routes using the SPF algorithm and adds them to its routing table.
The **show ip ospf neighbor**, **show ip ospf database**, and **show ip route** commands display information for each of these three steps, respectively. To verify OSPF, you can use the same sequence. Or, you can just go look at the IP routing table, and if the routes look correct, OSPF probably worked.

Step 4: Use the `show ip ospf neighbors` 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          0FULL/  -           00:00:33    192.168.10.2 Serial0/0/0
```

The detail in the output mentions several important facts, and for most people, working right to left works best in this case. For example, looking at the headings:

Interface: This is the **local router's interface** connected to the neighbor. For example, the first neighbor in the list is reachable through R1's S0/0/1 interface.

Address: This is the neighbor's IP address on that link. Again, for this first neighbor, the neighbor, which is R3, uses IP address 192.168.10.6

State: While many possible states exist, for the details discussed in this chapter, **FULL** is the correct and fully working state in this case.

Neighbor ID: This is the **router ID of the neighbor.**

```
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
```

Step 5: 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 Task 7.

```
R1(config)#router ospf 1
R1(config-router)#router-id 10.4.4.4
Reload or use "clear ip ospf process" command, for this to take effect
```

If this command is used on an OSPF router process which 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#
```

Step 6: 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
```

Step 7: 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 "clear ip ospf process" command, for this to take effect
```

Step 8: 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
R1#
```

```
Note: It may be necessary to save your running-configuration to NVRAM
(copy run start) and reload so that loopback now becomes the RID again.
```

Task 7: Verify OSPF Operation

Step 1: 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, and 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#
```

Step 2: On the R1 router, use the `show ip protocols` command to view information about the routing protocol operation.

Notice that the information that was configured in the previous Tasks, 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)

R1#
```

Task8: 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#
```

OSPF Metrics (Cost)

SPF calculates the metric for each route, choosing the route with the best metric for each destination subnet. OSPF routers can influence that choice by changing the OSPF interface cost on any and all interfaces.
Cisco routers allow two different ways to change the OSPF interface cost. The one straightforward way is to set the cost directly, with an interface subcommand: ip ospf cost x.

R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int serial 0/0/0
R1(config-if)#ip ospf cost 20
R1(config-if)#exit

R1#show ip ospf interface serial 0/0/0

Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.1/30, Area 0
  Process ID 1, Router ID 192.168.10.5, Network Type POINT-TO-POINT, Cost: 20

Other Additional Information

Setting the Cost Based on Interface Bandwidth

The default OSPF cost values can actually cause a little confusion, for a couple of reasons. So, to get through some of the potential confusion, this section begins with some examples.

First, IOS uses the following formula to choose an interface's OSPF cost. IOS puts the inter- face's bandwidth in the denominator, and a settable OSPF value called the reference band- width in the numerator:

Reference_bandwidth / Interface_bandwidth With this formula, the following sequence of logic happens:

1. A higher interface bandwidth—that is, a faster bandwidth—results in a lower number in the calculation.

2. A lower number in the calculation gives the interface a lower cost.

3. An interface with a lower cost is more likely to be used by OSPF when calculating the best routes.

Now for some examples. Assume a default reference bandwidth, set to 100 Mbps, which is the same as 100,000 Kbps. (The upcoming examples will use a unit of Kbps just to avoid math with fractions.) Assume defaults for interface bandwidth on serial, Ethernet, and Fast Ethernet interfaces, as shown in the output of the **show interfaces** command, respectively, of 1544 Kbps, 10,000 Kbps (meaning 10 Mbps), and 100,000 Kbps (meaning 100 Mbps). Table 8-3 shows the results of how IOS calculates the OSPF cost for some interface examples.

Table 8-3 OSPF Cost Calculation Examples with Default Bandwidth Settings

Interface	Interface Default Bandwidth (Kbps)	Formula (Kbps)	OSPF Cost
Serial	1544 Kbps	100,000/1544	64
Ethernet	10,000 Kbps	100,000/10,000	10
Fast Ethernet	100,000 Kbps	100,000/100,000	1