Department of Computer Science and Engineering
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Laboratory Report

CSE 4512: Computer Networks Lab

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Title: Configuration of OSPF in a network topology

Objective:

1) Describe the concept of OSPF and related terminologies
2) Explain the advantages of OSPF over RIP
3) Configure OSPF in a network topology following the given specifications

Devices/ software Used:

1. Device: Windows PC
2. Software: Cisco Packet Tracer 7.3.0

Theory:

Link State (LS) Routing:

Link state routing is a methodology where each node in the network has information of the whole network i.e the list of nodes and links, how they are connected, the type, cost (metric), and the condition of the links (up or down). This is achieved by a router sending the information of its neighbors to all the nodes of the networking through a process called flooding. The nodes use the Dijkstra algorithm to build the routing table.

- **Link-State Database (LSDB):** The information of the whole network is collected by the routers into a single database called link-state database (LSDB) by OSPF. This database is shared and synchronized among the other routers of the network. The database allows the routers of the network to calculate the shortest path to the other routers using the Dijkstra algorithm**.**

- **Link State Packet:** The routers in OSPF exchange information by packetizing them in Link State Routing Protocol. This packet contains information about that router's neighbors and such a packet is called Link State Packet (LSP). These packets are fundamentally special datagrams that determine the name, cost, or distance to any of the neighboring routers of a particular router.

Open Shortest Path First (OSPF):

Open Shortest Path First or OSPF is an Intra-domain Unicast Routing Protocol that is based on Link-State Routing.

- **Metric:** A metric is a measurement or cost of going from one router to another in the network. In OSPF, this cost is derived from the interface bandwidth i.e higher bandwidth lowers the cost. The metric for a route is the summation of interface costs for all outgoing interfaces. In the default value of the reference, bandwidth is set to 100 Mbps. But this value can be manually configured.

- **Autonomous System (AS):** A collection of IP networks under a common administration, sharing a common routing strategy, and running a single routing protocol is called an Autonomous System (AS) in OSPF.

- **Areas:** Areas are logical groupings of the routers in an Autonomous System and are identified by some assigned numbers. An OSPF network must have at least one area and the default area is set as area 0. When there are more areas, the area-0 is called the Backbone area and is used to connect other areas.

- **Area Border Router (ABD):** Every area has an area border router to establish connections between different areas. Every area border router is connected to the backbone router. The area border router makes it possible for routers between different areas to communicate.

- **Designated Router (DR):** In a multi-access network, the router used to exchange OSPF routing information and serve as a central point to the other routers is called Designated Router (DR). Non-DR routers exchange routing information with DRs only. Then DRs will distribute the information to every other router in the network and thus reduce OSPF traffic. DRs have backup routers called Backup Designated Router which will be used if a DR fails.

- **Link State Advertisement (LSA):** Link state advertisement is the means to relay routing information from one router to another in OSPF.

- **OSPF Implementation:** OSPF is a protocol that uses LSR, and according to the guidelines of LSR, the routers send the information to their neighbors, which in return conveys the information to their neighbors, and so on. This process is called flooding. However, the information shared is just the information of the router's neighbors only. In each node or router, Dijkstra's algorithm finds the shortest path to any destination in the network. Whenever there is a change in the network, the algorithm is run again which makes it CPU-intensive.

- **OSPF Process ID:** A process ID has to be mentioned so that the functions of OSPF are performed under that process. A single router can have multiple such processes and each process will have its own routing table, database, and so on.

- **Router ID in OSPF:** Router ID is used to identify a router in an AS. It is a 32-bit number that can be manually set. However, in case the ID is not manually configured, then the highest IP address of the loopback address will be used. If the loopback address is not available then the highest active IP address of the interface will be used.

- **Wildcard Mask:** The network command in OSPF supports classless routing. This is achieved by using the Wildcard Mask command. The mask acts as an inverted subnet mask. The 0 bits in the mask indicate the corresponding bit positions that must match the same bit positions in the IP address. The 1 bits indicate the corresponding bit positions don't need to match the same bit

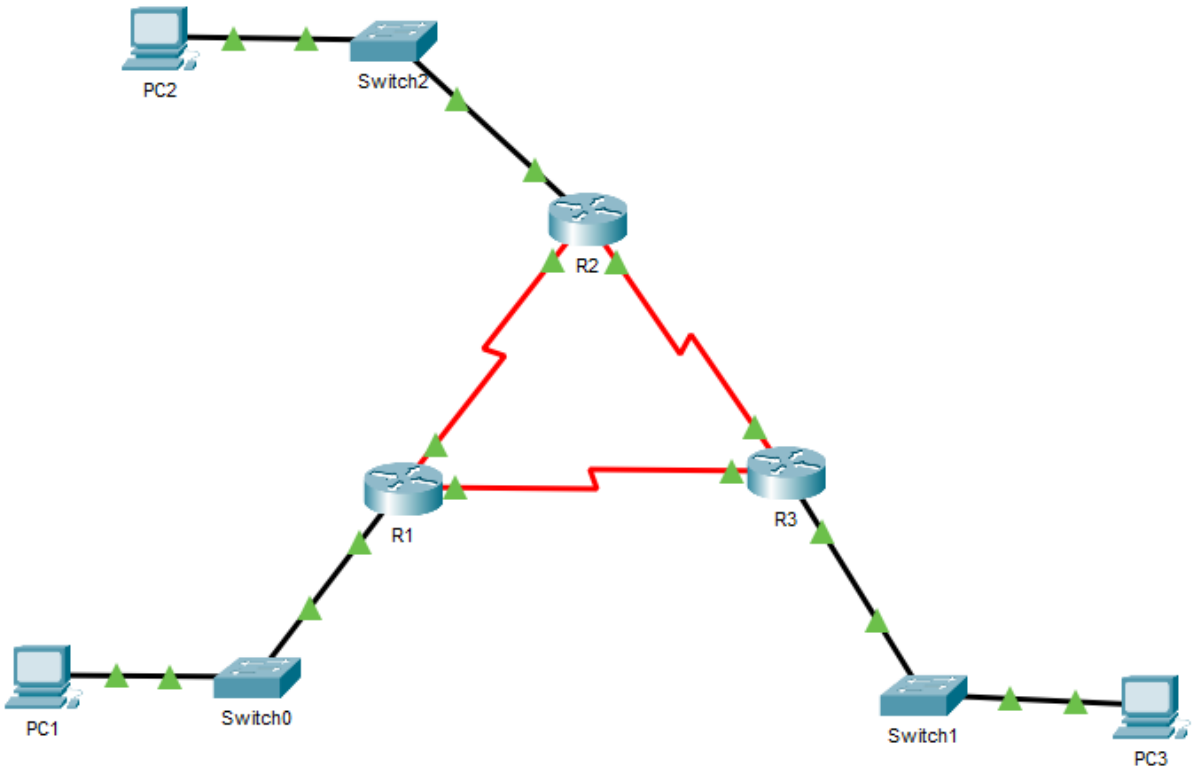
positions in the IP address. For example - for a directly connected subnet 10.0.1.0 that we want to advertise in OSPF, we can use

```
network 10.0.1.0 0.0.0.255 area 0
```

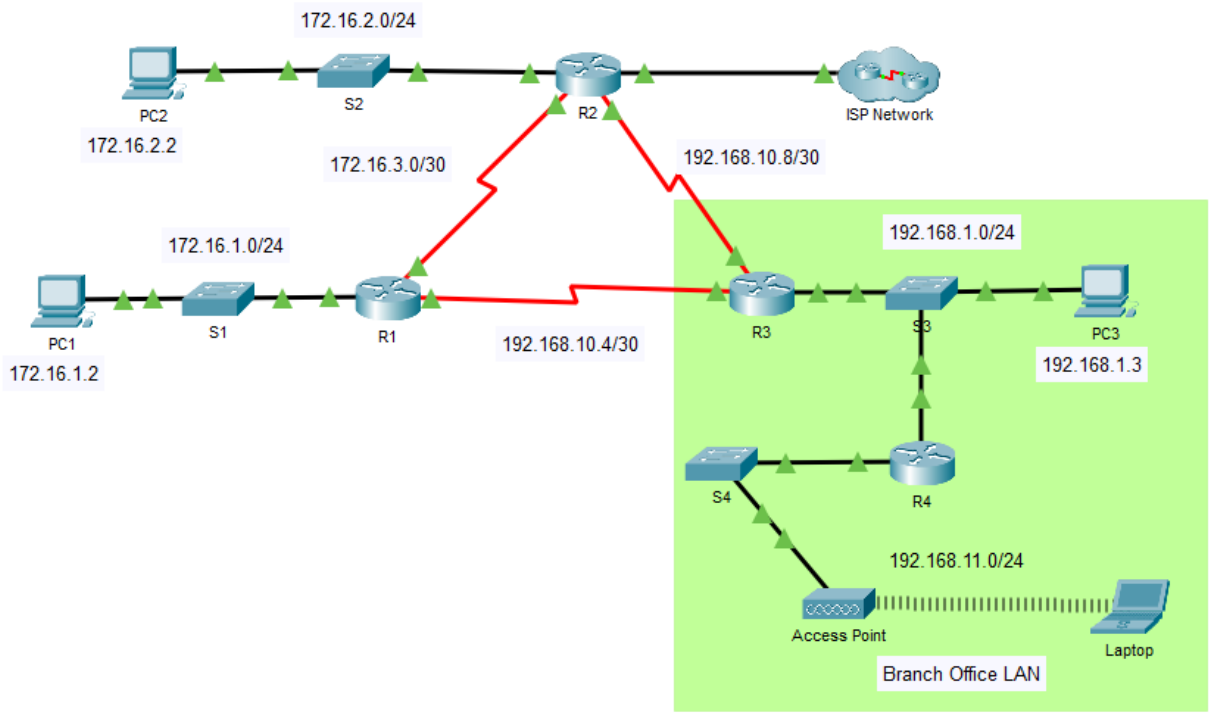
Here, the first 24 bits of the address must match but the rest 8 don't need to match. So, any interface having an IP address in the format 10.0.1.X will match in this case.

Diagram of the experiment:

Task #01:



Task #02:



Working Procedure:

Task #01:

Part #01: Step 1: Configure the routers

On the routers, enter global configuration mode and configure the hostname as shown on the chart. Then configure the console, virtual terminal line password (both "cisco") and privileged EXEC password ("class"). The following commands were used:

```
Router#en
Router#conf t
Router(config)#hostname R2
R2(config)#enable secret class
R2(config)#line con 0
R2(config-line)#password cisco
R2(config-line)#login
R2(config-line)#line vty 0 4
R2(config-line)#password cisco
R2(config-line)#login
R2(config-line)#exit
```

R1:

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#enable secret class
R1(config)#line con 0
R1(config-line)#password cisco
R1(config-line)#login
R1(config-line)#line vty 0 4
R1(config-line)#password cisco
R1(config-line)#login
R1(config-line)#exit
R1(config)#
```

R2:

```
Router#en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#enable secret class
R2(config)#line con 0
R2(config-line)#password cisco
R2(config-line)#login
R2(config-line)#line vty 0 4
R2(config-line)#password cisco
R2(config-line)#login
R2(config-line)#exit
```

R3:

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#enable secret class
R3(config)#line con 0
R3(config-line)#password cisco
R3(config-line)#login
R3(config-line)#line vty 0 4
R3(config-line)#password cisco
R3(config-line)#login
R3(config-line)#exit
R3(config)#exit
R3#
%SYS-5-CONFIG_I: Configured from console by console

R3#
```

Step 2: Disable DNS lookup

```
R1(config)#no ip domain-lookup
```

Step 3: Configure the interfaces on R1, R2, and R3

Configure the interfaces on the R1, R2, and R3 routers with the IP addresses from the table under the Topology Diagram. The following commands are used for R1:

```
R1(config)#int fa0/0
R1(config-if)#ip add 172.16.1.17 255.255.255.240
R1(config-if)#no shut

R1(config-if)#int s0/1/0
R1(config-if)#ip add 192.168.10.1 255.255.255.252
R1(config-if)#no shut

R1(config-if)#int s0/1/1
R1(config-if)#ip add 192.168.10.9 255.255.255.252
R1(config-if)#no shut
```

The screenshots of Step-2 and 3 for the routers are given below:

R1:

```
R1(config)#no ip domain-lookup
R1(config)#int fa0/0
R1(config-if)#ip add 172.16.1.17 255.255.255.240
R1(config-if)#no shut

R1(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

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

R1(config-if)#int s0/1/0
R1(config-if)#ip add 192.168.10.1 255.255.255.252
R1(config-if)#no shut

R1(config-if)#
%LINK-5-CHANGED: Interface Serial0/1/0, changed state to up

R1(config-if)#int s0/1/1
R1(config-if)#ip add 192.168.10.1 255.255.255.252
%LINEPROTO-5-UPDOWN: Line protocol on Interfac
R1(config-if)#ip add 192.168.10.5 255.255.255.252
R1(config-if)#no shut

%LINK-5-CHANGED: Interface Serial0/1/1, changed state to down
```

R2:

```
R2(config)#no ip domain-lookup
R2(config)#int fa0/0
R2(config-if)#ip add 10.10.10.1 255.255.255.0
R2(config-if)#no shut

R2(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

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

R2(config-if)#int s0/1/0
R2(config-if)#ip add 192.
                     ^
% Invalid input detected at '^' marker.

R2(config-if)#ip add 192.168.10.2 255.255.255.252
R2(config-if)#no shut

%LINK-5-CHANGED: Interface Serial0/1/0, changed state to down
R2(config-if)#int s0/1/1
R2(config-if)#ip add 192.168.10.9 255.255.255.252
R2(config-if)#no shut

%LINK-5-CHANGED: Interface Serial0/1/1, changed state to down
R2(config-if)#exit
R2(config)#
```

R3:

```
R3#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#interface FastEthernet0/0
R3(config-if)#ip address
% Incomplete command.
R3(config-if)#ip add 172.16.1.33 255.255.255.248
R3(config-if)#no shut

R3(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

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

R3(config-if)#int s0/1/0
R3(config-if)#ip add 192.168.10.6 255.255.255.252
R3(config-if)#no shut

R3(config-if)#
%LINK-5-CHANGED: Interface Serial0/1/0, changed state to up

R3(config-if)#int s0/1/1
R3(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/1/0, changed state to up

R3(config-if)#ip add 192.168.10.10 255.255.255.252
R3(config-if)#no shut

R3(config-if)#
%LINK-5-CHANGED: Interface Serial0/1/1, changed state to up

R3(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/1/1, changed state to up

R3(config-if)#exit
R3(config)#no ip domain-lookup
```

:

Step 4: 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. The following command was used:

```
R1#show ip int brief
```

R1:

```
R1#show ip int brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        172.16.1.17     YES manual up                    up
FastEthernet0/1        unassigned      YES unset  administratively down down
Serial0/1/0            192.168.10.1    YES manual up                    up
Serial0/1/1            192.168.10.5    YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
R1#
```

R2:

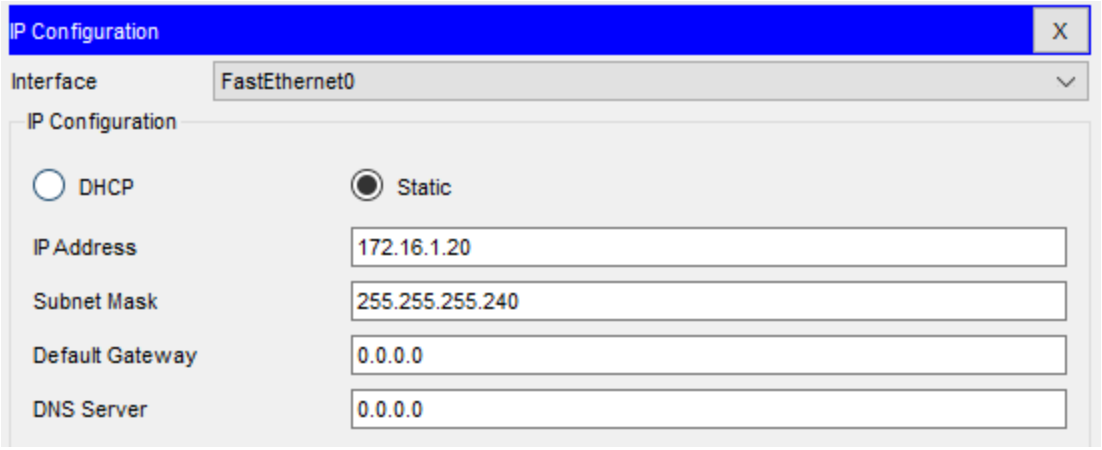
```
R2#show ip int brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        10.10.10.1      YES manual up                    up
FastEthernet0/1        unassigned      YES unset  administratively down down
Serial0/1/0            192.168.10.2    YES manual up                    up
Serial0/1/1            192.168.10.9    YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
R2#
```

R3:

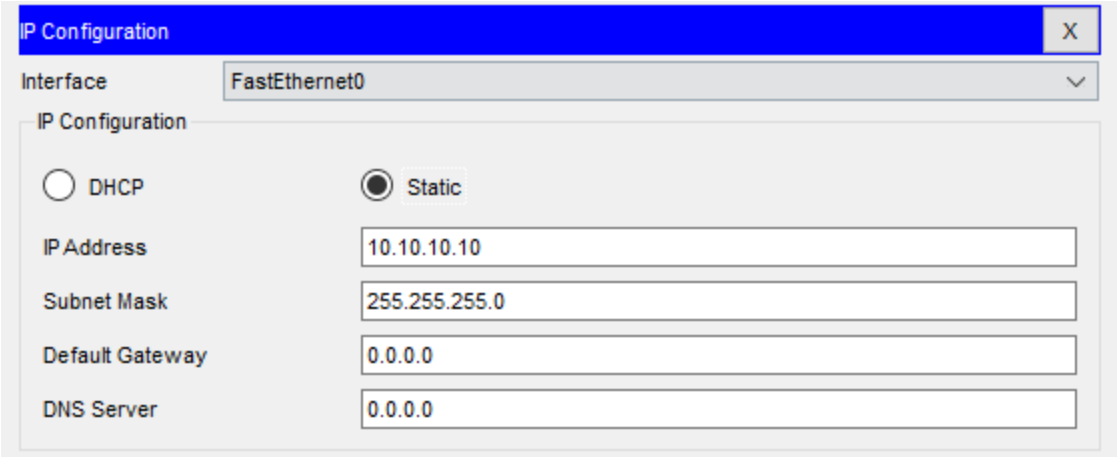
```
R3#show ip int brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        172.16.1.33     YES manual up                    up
FastEthernet0/1        unassigned      YES unset  administratively down down
Serial0/1/0            192.168.10.6    YES manual up                    up
Serial0/1/1            192.168.10.10   YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
R3#
```

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

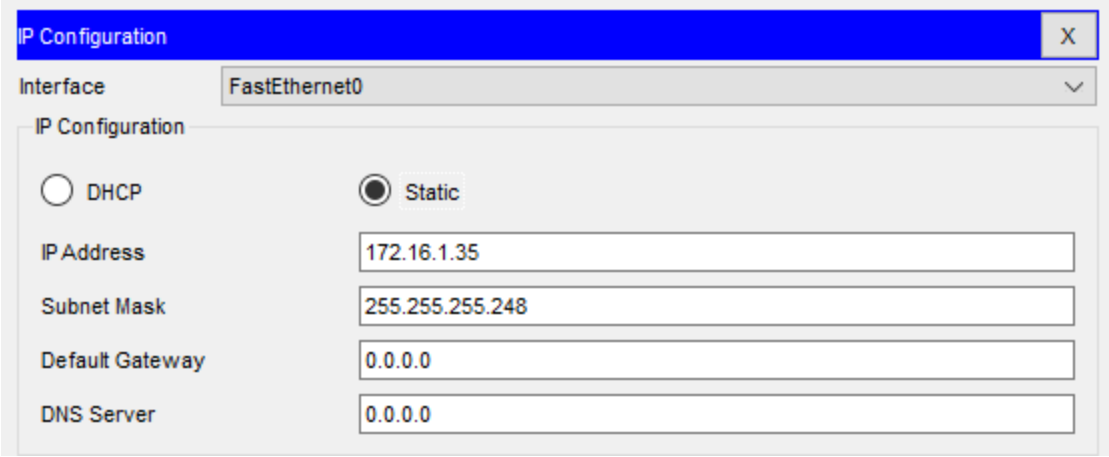
R1:



R2:



R3:



Part-2: 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.

```
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 submode, 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#
```

The screenshot is given below:

```
R1#conf terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
R1(config-router)#end
R1#
%SYS-5-CONFIG_I: Configured from console by console
```

Part-3: 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)#network 192.168.10.8 0.0.0.3 area 0
R3(config-router)#
03:06:42: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.9 on
Serial0/1/1 from LOADING to FULL, Loading Done
R3(config-router)#end
```

R2:

```
R2#conf terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router ospf 1
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
R2(config-router)#
03:04:08: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on Serial0/1/0 from
LOADING to FULL, Loading Done

R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
R2(config-router)#end
R2#
%SYS-5-CONFIG_I: Configured from console by console
```

R3:

```
R3#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
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)#networ
03:06:13: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on Serial0/1/0 from LOADING to
FULL, Loading
R3(config-router)#network 192.168.10.8 0.0.0.3 area 0
R3(config-router)#
03:06:42: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.9 on Serial0/1/1 from LOADING to
FULL, Loading Done

R3(config-router)#end
R3#
%SYS-5-CONFIG_I: Configured from console by console

R3#
```

Part-4: Configure OSPF Router IDs

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

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.

R1:

```
R1#show ip ospf
 Routing Process "ospf 1" with ID 10.1.1.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 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
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 8 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x0234bd
        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
```

R2:

```
R2#show ip ospf
 Routing Process "ospf 1" with ID 10.2.2.2
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 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
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 13 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x0234bd
        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
```

R3:

```
R3#show ip ospf
 Routing Process "ospf 1" with ID 10.3.3.3
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 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
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 4 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x0234bd
        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 2: Use loopback addresses to change the router IDs of the routers in the topology

The commands for R1 are:

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

R1:

```
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface loopback 0

R1(config-if)#
%LINK-5-CHANGED: Interface Loopback0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up

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

The commands for R2 are:

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

R2:

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#interface loopback 0

R2(config-if)#
%LINK-5-CHANGED: Interface Loopback0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to
up

R2(config-if)#ip address 10.2.2.2 255.255.255.255
R2(config-if)#
```

The commands for R3 are:

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

R3:

```
R3(config)#interface loopback 0

R3(config-if)#
%LINK-5-CHANGED: Interface Loopback0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up

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

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

The commands are:

```
R1#copy running-config startup-config
R1#reload
```

R1:

```
R1#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
R1#
R1#reload
Proceed with reload? [confirm]
System Bootstrap, Version 12.3(8r)T8, RELEASE SOFTWARE (fc1)
Initializing memory for ECC
..
C1841 processor with 524288 Kbytes of main memory
Main memory is configured to 64 bit mode with ECC enabled

Readonly ROMMON initialized

Self decompressing the image :
################################################################################
[OK]
```

R2:

```
R2>en
Password:
R2#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
R2#
R2#reload
Proceed with reload? [confirm]
System Bootstrap, Version 12.3(8r)T8, RELEASE SOFTWARE (fc1)
Initializing memory for ECC
..
C1841 processor with 524288 Kbytes of main memory
Main memory is configured to 64 bit mode with ECC enabled

Readonly ROMMON initialized

Self decompressing the image :
################################################################################
[OK]
               Restricted Rights Legend
```

R3:

```
R3#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
R3#
R3#reload
Proceed with reload? [confirm]
System Bootstrap, Version 12.3(8r)T8, RELEASE SOFTWARE (fc1)
Initializing memory for ECC
..
C1841 processor with 524288 Kbytes of main memory
Main memory is configured to 64 bit mode with ECC enabled

Readonly ROMMON initialized

Self decompressing the image :
################################################################################
[OK]
```

Step 4: Use the show ip ospf neighbors command to verify that the router IDs have changed

R1:

```
R1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          0   FULL/  -        00:00:36    192.168.10.6    Serial0/1/1
10.2.2.2          0   FULL/  -        00:00:31    192.168.10.2    Serial0/1/0
R1#
```

R2:

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.1.1          0   FULL/  -        00:00:36    192.168.10.1    Serial0/1/0
10.3.3.3          0   FULL/  -        00:00:37    192.168.10.10   Serial0/1/1
R2#
```

R3:

```
R3#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.2.2.2          0   FULL/  -        00:00:33    192.168.10.9    Serial0/1/1
10.1.1.1          0   FULL/  -        00:00:38    192.168.10.5    Serial0/1/0
```

Step 5: Use the router-id command to change the router ID on the R1 router

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#router-id 10.4.4.4
R1(config-router)#Reload or use "clear ip ospf process" command, for this to take effect


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

R1#clear ip ospf process
Reset ALL OSPF processes? [no]:

R1#clear ip ospf process
Reset ALL OSPF processes? [no]: yes

R1#
00:24:02: %OSPF-5-ADJCHG: Process 1, Nbr 10.3.3.3 on Serial0/1/1 from FULL to DOWN, Neighbor Down: Adjacency forced to reset

00:24:02: %OSPF-5-ADJCHG: Process 1, Nbr 10.3.3.3 on Serial0/1/1 from FULL to DOWN, Neighbor Down: Interface down or detached

00:24:02: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset

00:24:02: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from FULL to DOWN, Neighbor Down: Interface down or detached

R1#
00:24:10: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from LOADING to FULL, Loading Done

00:24:20: %OSPF-5-ADJCHG: Process 1, Nbr 10.3.3.3 on Serial0/1/1 from LOADING to FULL, Loading Done
```

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
10.4.4.4          0   FULL/  -        00:00:38    192.168.10.1    Serial0/1/0
10.3.3.3          0   FULL/  -        00:00:39    192.168.10.10   Serial0/1/1
R2#
```

Step 7: Remove the configured router ID with the no form of the router-id command

Step 8: Restart the OSPF process using the clear ip ospf process command

The screenshots of the above steps are given below:

```
R1#conf terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#router-id 10.1.1.1
R1(config-router)#Reload or use "clear ip ospf process" command, for this to take effect


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

R1#clear ip ospf process
Reset ALL OSPF processes? [no]: yes

R1#
00:27:11: %OSPF-5-ADJCHG: Process 1, Nbr 10.3.3.3 on Serial0/1/1 from FULL to DOWN, Neighbor
Down: Adjacency forced to reset

00:27:11: %OSPF-5-ADJCHG: Process 1, Nbr 10.3.3.3 on Serial0/1/1 from FULL to DOWN, Neighbor
Down: Interface down or detached

00:27:11: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from FULL to DOWN, Neighbor
Down: Adjacency forced to reset

00:27:11: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from FULL to DOWN, Neighbor
Down: Interface down or detached

R1#
00:27:20: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from LOADING to FULL, Loading
Done

00:27:25: %OSPF-5-ADJCHG: Process 1, Nbr 10.3.3.3 on Serial0/1/1 from LOADING to FULL, Loading
Done
```

Part-5: 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

```
R1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          0   FULL/  -        00:00:37    192.168.10.6    Serial0/1/1
10.2.2.2          0   FULL/  -        00:00:33    192.168.10.2    Serial0/1/0
R1#
```

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

```
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:
    172.16.1.32 0.0.0.7 area 0
    192.168.10.4 0.0.0.3 area 0
    192.168.10.8 0.0.0.3 area 0
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.1.1.1             110      00:16:29
    10.2.2.2             110      00:16:35
    10.3.3.3             110      00:16:29
    10.4.4.4             110      00:49:34
  Distance: (default is 110)

R1#
```

Part-6: Examine OSPF Routes in the Routing Tables

R1:

```
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, 01:14:51, Serial0/1/0
     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, 00:47:41, Serial0/1/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/1/0
C       192.168.10.4 is directly connected, Serial0/1/1
O       192.168.10.8 [110/128] via 192.168.10.2, 00:47:41, Serial0/1/0
                     [110/128] via 192.168.10.6, 00:47:41, Serial0/1/1
```

R2:

```
R2>en
Password:
R2#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       10.2.2.2/32 is directly connected, Loopback0
C       10.10.10.0/24 is directly connected, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.16/28 [110/65] via 192.168.10.1, 00:48:21, Serial0/1/0
O       172.16.1.32/29 [110/65] via 192.168.10.10, 01:13:48, Serial0/1/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/1/0
O       192.168.10.4 [110/128] via 192.168.10.1, 00:48:21, Serial0/1/0
                     [110/128] via 192.168.10.10, 00:48:21, Serial0/1/1
C       192.168.10.8 is directly connected, Serial0/1/1

R2#
```

R3:

```
R3#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       10.3.3.3/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/65] via 192.168.10.9, 01:14:27, Serial0/1/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.16/28 [110/65] via 192.168.10.5, 00:48:51, Serial0/1/0
C       172.16.1.32/29 is directly connected, FastEthernet0/0
     192.168.10.0/30 is subnetted, 3 subnets
O       192.168.10.0 [110/128] via 192.168.10.9, 00:48:51, Serial0/1/1
                     [110/128] via 192.168.10.5, 00:48:51, Serial0/1/0
C       192.168.10.4 is directly connected, Serial0/1/0
C       192.168.10.8 is directly connected, Serial0/1/1

R3#
```

Part-7: Configure OSPF Cost

Step 1: 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
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, 01:14:51, Serial0/1/0
     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, 00:47:41, Serial0/1/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/1/0
C       192.168.10.4 is directly connected, Serial0/1/1
O       192.168.10.8 [110/128] via 192.168.10.2, 00:47:41, Serial0/1/0
                     [110/128] via 192.168.10.6, 00:47:41, Serial0/1/1
```

Step 2: Use the show interfaces serial0/0/0 command on the R1 router to view the bandwidth of the Serial 0/1/0 interface

```
R1#show interfaces serial0/1/0
Serial0/1/0 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,
     reliability 255/255, txload 1/255, rxload 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
  Queueing strategy: weighted fair
  Output queue: 0/1000/64/0 (size/max total/threshold/drops)
     Conversations  0/0/256 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)
     Available Bandwidth 1158 kilobits/sec
  5 minute input rate 56 bits/sec, 0 packets/sec
  5 minute output rate 56 bits/sec, 0 packets/sec
     514 packets input, 36472 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     508 packets output, 35400 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
     DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

Step 3: 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:

```
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int serial0/1/0
R1(config-if)#band 64
R1(config-if)#int serial0/1/1
R1(config-if)#band 64
R1(config-if)#exit
R1(config)#
```

R2:

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int s0/1/0
R2(config-if)#band 64
R2(config-if)#int s0/1/1
R2(config-if)#band 64
R2(config-if)#exit
R2(config)#
```

Step 4: Use the show ip ospf interface command on the R1 router to verify the cost of the serial links.

```
R1#show ip ospf interface

FastEthernet0/0 is up, line protocol is up
  Internet address is 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
    Hello due in 00:00:01
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/1/0 is up, line protocol is up
  Internet address is 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 00:00:01
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 10.2.2.2
  Suppress hello for 0 neighbor(s)
Serial0/1/1 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,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  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 10.3.3.3
  Suppress hello for 0 neighbor(s)
R1#
```

Step 5: Use the ip ospf cost command to configure the OSPF cost on the R3 router

```
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#int s0/1/0
R3(config-if)#ip ospf cost 1562
R3(config-if)#int s0/1/1
R3(config-if)#ip ospf cost 1562
R3(config-if)#exit
R3(config)#
```

Step 6: Use the show ip ospf interface command on the R3 router to verify that the cost of the link the cost of each of the Serial links is now 1562

```
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 10.3.3.3, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 10.3.3.3, Interface address 172.16.1.33
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/1/1 is up, line protocol is up
  Internet address is 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 00:00:02
  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)
Serial0/1/0 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,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.1.1
  Suppress hello for 0 neighbor(s)
R3#
R3#
```

Part-8: Redistribute an OSPF Default Route

Step 1: Configure a loopback address on the R1 router to simulate a link to an ISP

Step 2: Configure a static default route on the R1 router

Step 3: Use the default-information originate command to include the static route in the OSPF updates that are sent from the R1 router.

```
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int loopback1

R1(config-if)#
%LINK-5-CHANGED: Interface Loopback1, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1, changed state to up

R1(config-if)#ip address 172.30.1.1 255.255.255.252
R1(config-if)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback1
R1(config)#router ospf 1
R1(config-router)#default-information originate
R1(config-router)#
```

Step 4: View the routing table on the R2 router to verify that the static default route is being redistributed via OSPF

```
R2>en
Password:
R2#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 192.168.10.1 to network 0.0.0.0

     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.2.2.2/32 is directly connected, Loopback0
C       10.10.10.0/24 is directly connected, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.16/28 [110/1563] via 192.168.10.1, 00:17:50, Serial0/1/0
O       172.16.1.32/29 [110/1563] via 192.168.10.10, 00:17:50, Serial0/1/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/1/0
O       192.168.10.4 [110/3124] via 192.168.10.1, 00:09:56, Serial0/1/0
                     [110/3124] via 192.168.10.10, 00:09:56, Serial0/1/1
C       192.168.10.8 is directly connected, Serial0/1/1
O*E2 0.0.0.0/0 [110/1] via 192.168.10.1, 00:01:05, Serial0/1/0
```

Part-9: Configure Additional OSPF Features

Step 1: Use the auto-cost reference-bandwidth command to adjust the reference bandwidth value. Increase the reference bandwidth to 10000 to simulate 10GigE speeds. Configure this command on all routers in the OSPF routing domain.

R1:

```
R1(config-router)#auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
        Please ensure reference bandwidth is consistent across all routers.
R1(config-router)#
```

R2:

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router ospf 1
R2(config-router)#auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
        Please ensure reference bandwidth is consistent across all routers.
R2(config-router)#
```

R2:

```
R3>en
Password:
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router ospf 1
R3(config-router)#auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
        Please ensure reference bandwidth is consistent across all routers.
R3(config-router)#
```

Step 2: Examine the routing table on the R1 router to verify the change in the OSPF cost metric.

```
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 0.0.0.0 to network 0.0.0.0

     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 [110/6576] via 192.168.10.2, 00:03:45, Serial0/1/0
     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 [110/6576] via 192.168.10.6, 00:03:07, Serial0/1/1
     172.30.0.0/30 is subnetted, 1 subnets
C       172.30.1.0 is directly connected, Loopback1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/1/0
C       192.168.10.4 is directly connected, Serial0/1/1
O       192.168.10.8 [110/12952] via 192.168.10.2, 00:03:45, Serial0/1/0
S*   0.0.0.0/0 is directly connected, Loopback1
```

Step 3: Use the show ip ospf neighbor command on R1 to view the Dead Time counter. The Dead Time counter is counting down from the default interval of 40 seconds.

```
R1#
R1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          0   FULL/  -        00:00:36    192.168.10.6    Serial0/1/1
10.2.2.2          0   FULL/  -        00:00:31    192.168.10.2    Serial0/1/0
```

Step 4: Configure the OSPF Hello and Dead intervals. The OSPF Hello and Dead intervals can be modified manually using the ip ospf hellointerval and ip ospf dead-interval interface commands. Use these commands to change the hello interval to 5 seconds and the dead interval to 20 seconds on the Serial 0/0/0 interface of the R1 router

```
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface serial0/1/0
R1(config-if)#ip ospf hello-interval 5
R1(config-if)#ip ospf dead-interval 20
R1(config-if)#
R1(config-if)#
02:11:54: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from FULL to DOWN,
Neighbor Down: Dead timer expired

02:11:54: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/1/0 from FULL to DOWN,
Neighbor Down: Interface down or detached
```

Step 5: Modify the Dead Timer and Hello Timer intervals. Modify the Dead Timer and Hello Timer intervals on the Serial 0/0/0 interface in the R2 router to match the intervals configured on the Serial 0/0/0 interface of the R1 router.

```
R2>en
Password:
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int serial0/1/0
R2(config-if)#ip ospf hello-interval 5
R2(config-if)#ip ospf dead-interval 20
R2(config-if)#
R2(config-if)#
02:58:42: %OSPF-5-ADJCHG: Process 1, Nbr 10.1.1.1 on Serial0/1/0 from
LOADING to FULL, Loading Done
```

Step 6: Use the show ip ospf interface serial0/0/0 command to verify that the Hello Timer and Dead Timer intervals have been modified.

```
R2#show ip ospf int s0/1/0

Serial0/1/0 is up, line protocol is up
  Internet address is 192.168.10.2/30, Area 0
  Process ID 1, Router ID 10.2.2.2, Network Type POINT-TO-POINT, Cost: 6476
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 5, Dead 20, Wait 20, Retransmit 5
    Hello due in 00:00:00
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.1.1
  Suppress hello for 0 neighbor(s)
```

Step 7: Use the show ip ospf neighbor command on R1 to verify that the neighbor adjacency with R2 has been restored

```
R1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          0   FULL/  -        00:00:33    192.168.10.6    Serial0/1/1
10.2.2.2          0   FULL/  -        00:00:19    192.168.10.2    Serial0/1/0
R1#
```

Task #02:

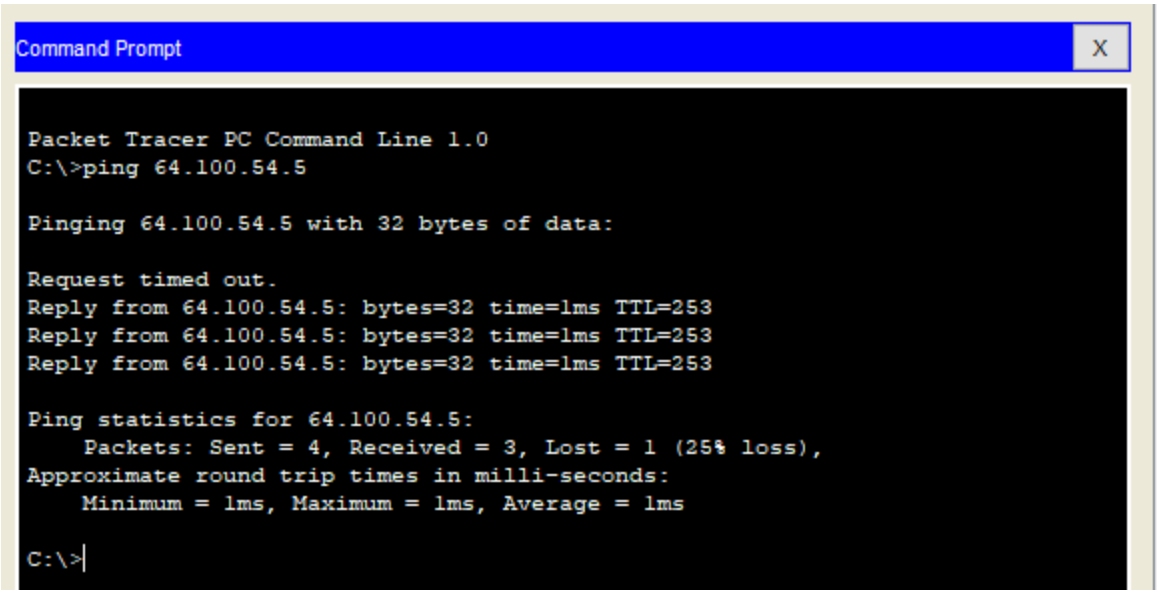
Part 1: Verify the existing OSPFv2 network operation.

Step 1: Verify OSPFv2 operation.

R1:

```
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 172.16.3.2 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
C       172.16.1.0/24 is directly connected, GigabitEthernet0/0
L       172.16.1.1/32 is directly connected, GigabitEthernet0/0
O       172.16.2.0/24 [110/65] via 172.16.3.2, 00:01:48, Serial0/0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
L       172.16.3.1/32 is directly connected, Serial0/0/0
O    192.168.1.0/24 [110/65] via 192.168.10.6, 00:01:38, Serial0/0/1
     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.10.4/30 is directly connected, Serial0/0/1
L       192.168.10.5/32 is directly connected, Serial0/0/1
O       192.168.10.8/30 [110/128] via 172.16.3.2, 00:01:38, Serial0/0/0
                        [110/128] via 192.168.10.6, 00:01:38, Serial0/0/1
O*E2 0.0.0.0/0 [110/1] via 172.16.3.2, 00:01:48, Serial0/0/0

R1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -        00:00:37    192.168.10.6    Serial0/0/1
2.2.2.2           0   FULL/  -        00:00:35    172.16.3.2      Serial0/0/0
```

Ping:



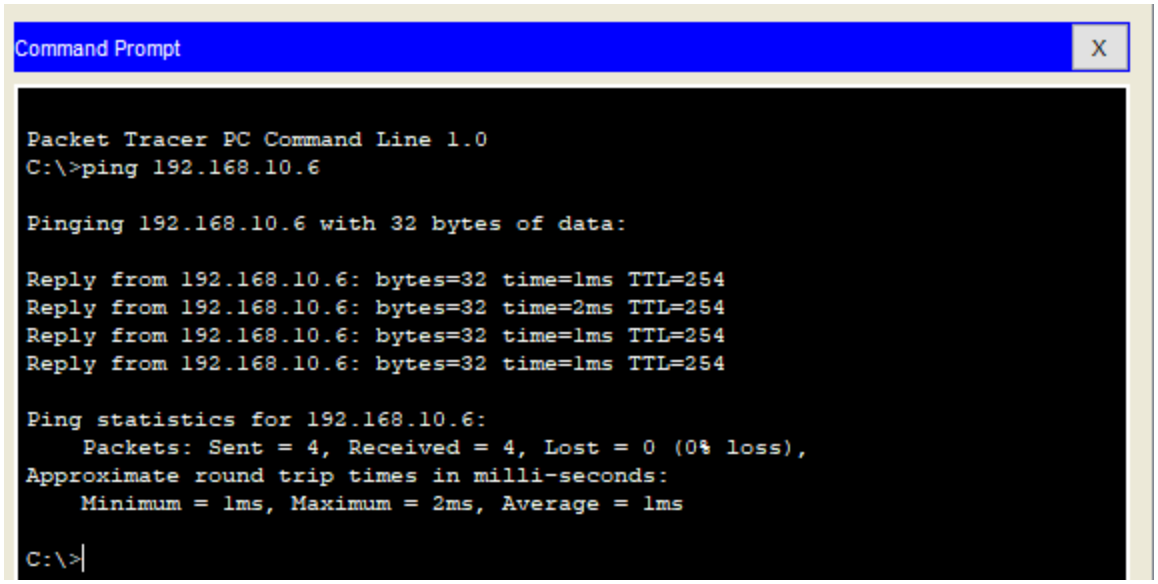
Step 2: Verify OSPFv2 operation on R2

R2:

```
R2#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 64.100.54.5 to network 0.0.0.0

     64.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       64.100.54.4/30 is directly connected, GigabitEthernet0/1
L       64.100.54.6/32 is directly connected, GigabitEthernet0/1
     172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
O       172.16.1.0/24 [110/65] via 172.16.3.1, 00:04:01, Serial0/0/0
C       172.16.2.0/24 is directly connected, GigabitEthernet0/0
L       172.16.2.1/32 is directly connected, GigabitEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
L       172.16.3.2/32 is directly connected, Serial0/0/0
O    192.168.1.0/24 [110/65] via 192.168.10.10, 00:04:01, Serial0/0/1
     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
O       192.168.10.4/30 [110/128] via 192.168.10.10, 00:04:01, Serial0/0/1
                        [110/128] via 172.16.3.1, 00:04:01, Serial0/0/0
C       192.168.10.8/30 is directly connected, Serial0/0/1
L       192.168.10.9/32 is directly connected, Serial0/0/1
S*   0.0.0.0/0 [1/0] via 64.100.54.5
```

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

GigabitEthernet0/0 is up, line protocol is up
  Internet address is 172.16.2.1/24, Area 0
  Process ID 10, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 172.16.2.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    No Hellos (Passive interface)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

Ping:

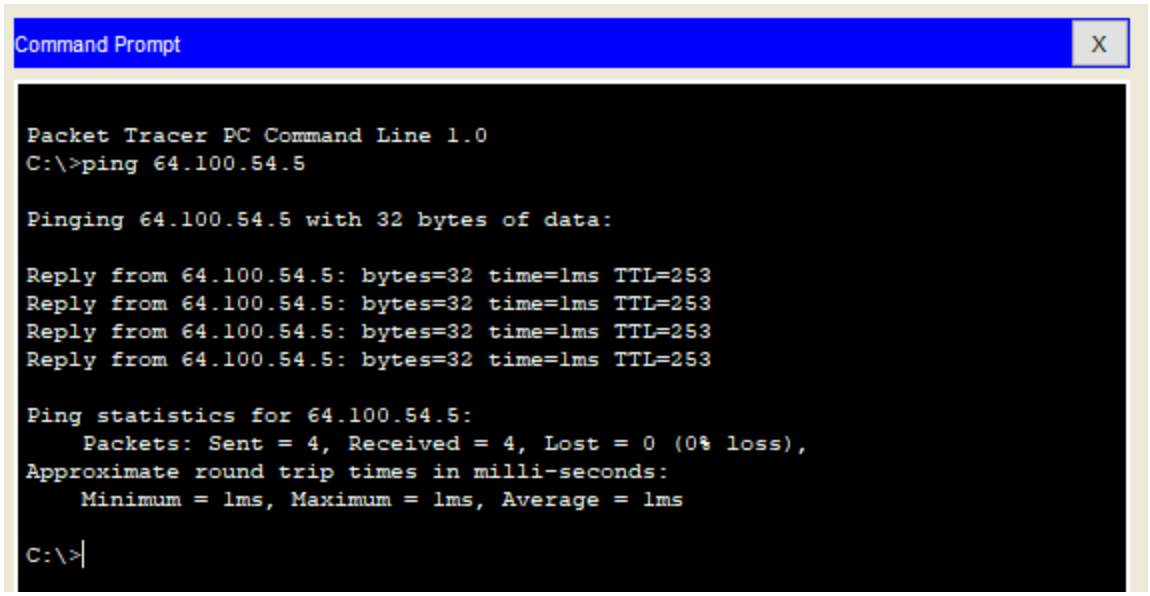


R3:

```
R3>show ip protocols

Routing Protocol is "ospf 10"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 3.3.3.3
  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
    192.168.10.4 0.0.0.3 area 0
    192.168.10.8 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:05:59
    2.2.2.2              110      00:06:04
    3.3.3.3              110      00:06:04
  Distance: (default is 110)
```

```
R3>show ip ospf neighbor detail
 Neighbor 2.2.2.2, interface address 192.168.10.9
    In the area 0 via interface Serial0/0/1
    Neighbor priority is 0, State is FULL, 7 state changes
    DR is 0.0.0.0 BDR is 0.0.0.0
    Options is 0x00
    Dead timer due in 00:00:39
    Neighbor is up for 00:06:40
    Index 1/1, retransmission queue length 0, number of retransmission 0
    First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
    Last retransmission scan length is 0, maximum is 1
    Last retransmission scan time is 0 msec, maximum is 0 msec
 Neighbor 1.1.1.1, interface address 192.168.10.5
    In the area 0 via interface Serial0/0/0
    Neighbor priority is 0, State is FULL, 6 state changes
    DR is 0.0.0.0 BDR is 0.0.0.0
    Options is 0x00
    Dead timer due in 00:00:36
    Neighbor is up for 00:06:43
    Index 2/2, retransmission queue length 0, number of retransmission 0
    First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
    Last retransmission scan length is 0, maximum is 1
    Last retransmission scan time is 0 msec, maximum is 0 msec
```

Ping:



Part 2: Add the new Branch Office LAN to the OSPFv2 network

Step 1: Verify the OSPFv2 configuration on router R4. Open configuration window Execute a show run | begin router ospf command on router R4. Verify that the network statements are present for the networks that are configured on the router.

```
R4>en
R4#show run | begin router ospf
router ospf 10
 router-id 4.4.4.4
 log-adjacency-changes
 passive-interface GigabitEthernet0/0/1
 network 192.168.1.0 0.0.0.255 area 0
 network 192.168.11.0 0.0.0.255 area 0
!
ip classless
!
ip flow-export version 9
!
!
!
!
!
!
!
!
line con 0
!
line aux 0
!
line vty 0 4
 login
!
!
!
end
```

Step 2: Connect the Branch Office router R4 to the OSPFv2 network.

```
R4>en
R4#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           1   FULL/DR         00:00:36    192.168.1.1     GigabitEthernet0/0/0
R4#
```

Ping:

```
C:\>ping 172.16.2.2

Pinging 172.16.2.2 with 32 bytes of data:

Reply from 172.16.2.2: bytes=32 time=4ms TTL=128
Reply from 172.16.2.2: bytes=32 time=1ms TTL=128
Reply from 172.16.2.2: bytes=32 time=4ms TTL=128
Reply from 172.16.2.2: bytes=32 time=2ms TTL=128

Ping statistics for 172.16.2.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 4ms, Average = 2ms
```

Questions (Answer to the point):

TASK #01 - Part (Configure OSPF Router IDs) – Step 1:

1. What is the router ID for **R1**?
   Ans: 192.168.10.5
2. What is the router ID for **R2**?
   Ans: 192.168.10.9
3. What is the router ID for **R3**?
   Ans: 192.168.10.10

TASK #01 - Part (Configure OSPF Router IDs) – Step 3:

1. When the router is reloaded, what is the router ID for **R1**?
   Ans: 10.1.1.1
2. When the router is reloaded, what is the router ID for **R2**?
   Ans: 10.2.2.2
3. When the router is reloaded, what is the router ID for **R3**?
   Ans: 10.3.3.3

TASK #02 - Part 1 – Step 1:

b)

1. How did router **R1** receive the default route?
   Ans: Using OSPF
2. From which router did **R1** receive the default route?
   Ans: R2
3. How can you filter the output of **show ip route** to show only the routes learned through OSPF?
   Ans: Using show ip route ospf command

c)

1. Which routers have formed adjacencies with router **R1**?
   Ans: R2, R3
2. What are the router IDs and state of the routers shown in the command output?
   Ans: 2.2.2.2 Full/ and 3.3.3.3 Full/
3. Are all of the adjacent routers shown in the output?
   Ans: Yes

TASK #02 - Part 1 – Step 2:

a) How did router **R2** learn the default route to the ISP?
   Ans: Configured my admin manually

b)

1. What type of OSPF network is attached to the interface **g0/0** of **R2**?
   Ans: Broadcast network
2. Are OSPF hello packets being sent out through this interface? Explain.

Ans: No, the interface is configured as passive interface

TASK #02 - Part 1 – Step 3:

a) Router **R3** is routing for which networks?
Ans: 192.168.1.0/24,
192.168.10.4/30, and
192.168.10.8/30

b) What is the neighbor priority shown for the OSPF neighbor routers?
Ans: 0

TASK #02 - Part 2 – Step 1:

a) Which interface of **R4** is configured to not send OSPF update packets?
Ans: GigabitEtherenet0/1/1

TASK #02 - Part 2 – Step 2:

a) What state is displayed for router **R3**?
Ans: FULL/DR

b) Why is the state of router R4 different from the state of **R1** and **R2**?
Ans: Because R4 acts as a backup designated router and will only work when the designated routers fail.

Observation:

Challenges: