Chapter 7 — Adjust and Troubleshoot Single-Area OSPF

7.0.1.2 Class Activity – DR and BDR Elections

Objectives

Modify the OSPF interface priority to influence the Designated Router (DR) and Backup Designated Router (BDR) election.

Scenario

You are trying to decide how to influence the selection of the designated router and backup designated router for your OSPF network. This activity simulates that process.

Three separate designated-router election scenarios will be presented. The focus is on electing a DR and BDR for your group. Refer to the PDF for this activity for the remaining instructions.

If additional time is available, two groups can be combined to simulate DR and BDR elections.

Required Resources

- Router priorities paper sign example (student developed)
- Router ID paper sign example (student developed)

Directions

This is a group activity with four classmates comprising each group. Before reporting to the group, each student will prepare router priority and router ID signs to bring to the group.

Step 1: Decide the router priority.

a. Prior to joining your group, use a clean sheet of paper. On one side of the paper, write DEFAULT ROUTER PRIORITY = 1.

b. On the other side of the same sheet of paper, write ROUTER PRIORITY = (choose a number between 0 and 255).

Step 2: Decide the router ID.

a. On a second clean sheet of paper, on one side, write ROUTER ID = (any IPv4 number).

b. On the other side, write ROUTER ID = Loopback (any IPv4) number.

Step 3: Begin DR and BDR elections.

a. Start the first election process.

1) Students within the group will show each other the router priority numbers they selected for Step 1b.

2) After comparing their priority numbers, the student with the highest priority number is elected the DR and the student with the second-highest priority number is elected the BDR. Any student, who wrote 0 as their priority number, cannot participate in the election.
3) The elected DR student will announce the elections by saying “I am the DR for all of you in this group. Please send me any changes to your networks or interfaces to IP address 224.0.0.6. I will then forward those changes to all of you at IP address 224.0.0.5. Stay tuned for future updates.”

4) The BDR’s elected student will say, “I am your BDR. Please send all changes to your router interfaces or networks to the DR. If the DR does not announce your changes, I will step in and do that from that point onward.”

b. Start the second election process.

1) Students will hold up their DEFAULT ROUTER PRIORITY = 1 sign first. When it is agreed that all of the students have the same router priority, they will put that paper down.

2) Next, students will display their ROUTER ID = Loopback (IPv4) address signs.

3) The student with the highest loopback IPv4 address wins the election and repeats “I am the DR for all of you in this group. Our priorities are the same, but I have the highest loopback address on my router as compared to all of you; therefore, you have elected me as your DR. Please send all changes to your network addresses or interfaces to 224.0.0.6. I will then report any changes to all of you via 224.0.0.5.”

4) The BDR will repeat his/her respective phrase from Step 4a.

c. Start the third election process, but this time, all students can choose which sides of their papers to display. The DR/BDR election process uses the highest router priority first, highest loopback router ID second, and highest IPv4 router ID third, and elects a DR and BDR.

1) Elect a DR and BDR.

2) Justify your elections.

3) If you have time, get together with another group and go through the scenario processes again to solidify DR and BDR elections.
7.1.1.13 Lab – Configuring OSPFv2 on a Multiaccess Network

Topology

Addressing Table

<table>
<thead>
<tr>
<th>Device</th>
<th>Interface</th>
<th>IP Address</th>
<th>Subnet Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>G0/1</td>
<td>192.168.1.1</td>
<td>255.255.255.0</td>
</tr>
<tr>
<td></td>
<td>Lo0</td>
<td>192.168.31.11</td>
<td>255.255.255.255</td>
</tr>
<tr>
<td>R2</td>
<td>G0/0</td>
<td>192.168.1.2</td>
<td>255.255.255.0</td>
</tr>
<tr>
<td></td>
<td>Lo0</td>
<td>192.168.31.22</td>
<td>255.255.255.255</td>
</tr>
<tr>
<td>R3</td>
<td>G0/1</td>
<td>192.168.1.3</td>
<td>255.255.255.0</td>
</tr>
<tr>
<td></td>
<td>Lo0</td>
<td>192.168.31.33</td>
<td>255.255.255.255</td>
</tr>
</tbody>
</table>

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify OSPFv2 on the DR, BDR, and DROther

Part 3: Configure OSPFv2 Interface Priority to Determine the DR and BDR

Background / Scenario

A multiaccess network is a network with more than two devices on the same shared media. Examples include Ethernet and Frame Relay. On multiaccess networks, OSPFv2 elects a Designated Router (DR) to be the collection and distribution point for link-state advertisements (LSAs) that are sent and received. A Backup Designated Router (BDR) is also elected in case the DR fails. All other routers become DROthers as this indicates a router that is neither the DR nor the BDR.

Because the DR acts as a focal point for OSPF routing protocol communication, the router chosen should be capable of supporting a heavier traffic load than other routers in the network. A router with a powerful CPU and adequate DRAM is typically the best choice for the DR.
In this lab, you will configure OSPFv2 on the DR, BDR and DROther. You will then modify the priority of routers to control the outcome of the DR/BDR election process and ensure that the desired router becomes the DR.

**Note:** The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universal image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

**Note:** Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

### Required Resources
- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- Console cables to configure the Cisco IOS devices via the console port
- Ethernet cables as shown in the topology

### Part 1: Build the Network and Configure Basic Device Settings

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

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

Attach the devices shown in the topology diagram, and cable as necessary.

#### Step 2: Initialize and reload the routers.

#### Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device names as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords.
- e. Encrypt the plain text passwords.
- f. Configure a MOTD banner to warn users that unauthorized access is prohibited.
- g. Configure **logging synchronous** for the console line.
- h. Configure the IP addresses listed in the Addressing Table for all interfaces.
- i. Use the **show ip interface brief** command to verify that the IP addressing is correct and that the interfaces are active.
- j. Copy the running configuration to the startup configuration.
Part 2: **Configure and Verify OSPFv2 on the DR, BDR and DROther**

In Part 2, you will configure OSPFv2 on the DR, BDR, and DROther. The DR and BDR election process takes place as soon as the first router has its interface enabled on the multiaccess network. This can happen as the routers are powered-on or 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 does not become the DR or BDR, even if it has a higher OSPF interface priority or router ID than the current DR or BDR. Configure the OSPF process on the router with the highest router ID first to ensure that this router becomes the DR.

**Step 1: Configure OSPF on R3.**

Configure the OSPF process on R3 (the router with the highest router ID) to ensure that this router becomes the DR.

a. Assign 1 as the process ID for the OSPF process. 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.

What factor determined that R3 has the highest router ID?

b. Verify that OSPF has been configured and R3 is the DR.

What command would you use to verify that OSPF has been configured correctly and R3 is the DR?

**Step 2: Configure OSPF on R2.**

Configure the OSPF process on R2 (the router with the second highest router ID) to ensure that this router becomes the BDR.

a. Assign 1 as the process ID for the OSPF process. 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.

b. Verify that the OSPF has been configured and that R2 is the BDR. Record the command used for verification.
c. Issue the `show ip ospf neighbor` command to view information about the other routers in the OSPF area.

```
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 GigabitEthernet0/0
```

Notice that R3 is the DR.

Step 3: **Configure OSPF on R1.**

Configure the OSPF process on R1 (the router with the lowest router ID). This router will be designated as DROther instead of DR or BDR.

a. Assign 1 as the process ID for the OSPF process. 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.

b. Issue `show ip ospf interface brief` command to verify that OSPF has been configured and R1 is the DROther.

```
R1# show ip ospf interface brief
Interface PID Area IP Address/Mask Cost State Nbrs F/C
Gi0/1 1 0 192.168.1.1/24 1 DROTH 2/2
```

c. Issue the `show ip ospf neighbor` command to view information about the other routers in the OSPF area.

```
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 GigabitEthernet0/1
192.168.31.33 1 FULL/DR 00:00:30 192.168.1.3 GigabitEthernet0/1
```

What priority are both the DR and BDR routers? 

Part 3: **Configure OSPFv2 Interface Priority to Determine the DR and BDR**

In Part 3, you will configure router interface priority to determine the DR/BDR election, reset the OSPFv2 process, and then verify that the DR and BDR routers have changed. OSPF interface priority overrides all other settings in determining which routers become the DR and BDR.

Step 1: **Configure R1 G0/1 with OSPF priority 255.**

A value of 255 is the highest possible interface priority.

```
R1(config)# interface g0/1
R1(config-if)# ip ospf priority 255
R1(config-if)# end
```

Step 2: **Configure R3 G0/1 with OSPF priority 100.**

```
R3(config)# interface g0/1
R3(config-if)# ip ospf priority 100
R3(config-if)# end
```
Step 3: Configure R2 G0/0 with OSPF priority 0.

A priority of 0 causes the router to be ineligible to participate in an OSPF election and does not become a DR or BDR.

R2(config)# interface g0/0
R2(config-if)# ip ospf priority 0
R2(config-if)# end

Step 4: Reset the OSPF process.

a. Issue the `show ip ospf neighbor` command to determine the DR and BDR.

b. Has the DR designation changed? __________ Which router is the DR? __________

Has the BDR designation changed? __________ Which router is the BDR? __________

What is the role of R2 now? __________

Explain the immediate effects caused by the `ip ospf priority` command.

____________________________________________________________________________________

____________________________________________________________________________________

Note: If the DR and BDR designations did not change, issue the `clear ip ospf 1 process` command on all of the routers to reset the OSPF processes and force a new election.

If the `clear ip ospf process` command does not reset the DR and BDR, issue the `reload` command on all routers after saving the running configuration to the startup configuration.

c. Issue the `show ip ospf interface` command on R1 and R3 to confirm the priority settings and DR/BDR status on the routers.

R1# show ip ospf interface

GigabitEthernet0/1 is up, line protocol is up
  Internet Address 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 DR, Priority 255
  Designated Router (ID) 192.168.31.11, Interface address 192.168.1.1
  Backup Designated router (ID) 192.168.31.33, Interface address 192.168.1.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  cobb-resync timeout 40
  Hello due in 00:00:00
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 2
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 2, Adjacent neighbor count is 2
  Adjacent with neighbor 192.168.31.22
  Adjacent with neighbor 192.168.31.33 (Backup Designated Router)
Suppress hello for 0 neighbor(s)

R3# show ip ospf interface
GigabitEthernet0/1 is up, line protocol is up
  Internet Address 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
  Backup Designated router (ID) 192.168.31.33, Interface address 192.168.1.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:00
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 2
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.31.22
    Adjacent with neighbor 192.168.31.11 (Designated Router)
Suppress hello for 0 neighbor(s)

Which router is now the DR? ____________
Which router is now the BDR? ____________
Did the interface priority override the router ID in determining the DR/BDR? ____________

Reflection

1. List the criteria used from highest to lowest for determining the DR on an OSPF network.

2. What is the significance of a 255 interface priority?
### Router Interface Summary Table

<table>
<thead>
<tr>
<th>Router Model</th>
<th>Ethernet Interface #1</th>
<th>Ethernet Interface #2</th>
<th>Serial Interface #1</th>
<th>Serial Interface #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>1900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2801</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/1/0 (S0/1/0)</td>
<td>Serial 0/1/1 (S0/1/1)</td>
</tr>
<tr>
<td>2811</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
</tbody>
</table>

**Note:** To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.
7.1.4.8 Lab – Configuring OSPFv2 Advanced Features

Topology

Addressing Table

<table>
<thead>
<tr>
<th>Device</th>
<th>Interface</th>
<th>IP Address</th>
<th>Subnet Mask</th>
<th>Default Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>G0/0</td>
<td>192.168.1.1</td>
<td>255.255.255.0</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/0</td>
<td>192.168.12.1</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/1</td>
<td>192.168.13.1</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td>R2</td>
<td>Lo0</td>
<td>209.165.200.225</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/0</td>
<td>192.168.12.2</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/1 (DCE)</td>
<td>192.168.23.1</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td>R3</td>
<td>G0/0</td>
<td>192.168.3.1</td>
<td>255.255.255.0</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/0 (DCE)</td>
<td>192.168.13.2</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/1</td>
<td>192.168.23.2</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td>PC-A</td>
<td>NIC</td>
<td>192.168.1.3</td>
<td>255.255.255.0</td>
<td>192.168.1.1</td>
</tr>
<tr>
<td>PC-C</td>
<td>NIC</td>
<td>192.168.3.3</td>
<td>255.255.255.0</td>
<td>192.168.3.1</td>
</tr>
</tbody>
</table>

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify OSPF Routing
Part 3: Change OSPF Metrics

Part 4: Configure and Propagate a Static Default Route

Part 5: Configure OSPF Authentication

Background / Scenario

Open Shortest Path First (OSPF) has advanced features to allow changes to be made to control metrics, default route propagation, and security.

In this lab, you will adjust OSPF metrics on the router interfaces, configure OSPF route propagation, and use Message Digest 5 (MD5) authentication to secure OSPF routing information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

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

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

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

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

Step 2: Initialize and reload the routers as necessary.

Step 3: Configure basic settings for each router.

a. Disable DNS lookup.

b. Configure device name as shown in the topology.

c. Assign class as the privileged EXEC password.

d. Assign cisco as the console and vty passwords.

e. Encrypt the clear text passwords.

f. Configure a MOTD banner to warn users that unauthorized access is prohibited.

g. Configure logging synchronous for the console line.
h. Configure the IP addresses listed in the Addressing Table for all interfaces.

i. Set the clock rate for all DCE serial interfaces at 128000.

j. Copy the running configuration to the startup configuration.

Step 4: **Configure PC hosts.**

Refer to the Addressing Table for PC host address information.

Step 5: **Test connectivity.**

At this point, the PCs are unable to ping each other. However, the routers should be able to ping the directly connected neighbor interfaces, and the PCs should be able to ping their default gateway. Verify and troubleshoot if necessary.

**Part 2: Configure and Verify OSPF Routing**

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

Step 1: **Configure the router ID on all routers.**

Assign 1 as the process ID for this OSPF process. Each router should be given the following router ID assignments:

- R1 Router ID: 1.1.1.1
- R2 Router ID: 2.2.2.2
- R3 Router ID: 3.3.3.3

Step 2: **Configure OSPF network information on the routers.**

Step 3: **Verify OSPF routing.**

a. Issue the `show ip ospf neighbor` command to verify that each router is listing the other routers in the network.

b. Issue the `show ip route ospf` command to verify that all OSPF networks are present in the routing table on all routers.

Step 4: **Test end-to-end connectivity.**

Ping PC-C from PC-A to verify end-to-end connectivity. The pings should be successful. If they are not, troubleshoot as necessary.

**Note:** It may be necessary to disable the PC firewall for the pings to be successful.

**Part 3: Change OSPF Metrics**

In Part 3, you will change OSPF metrics using the `bandwidth` command, the `auto-cost reference-bandwidth` command, and the `ip ospf cost` command. Making these changes will provide more accurate metrics to OSPF.

**Note:** All DCE interfaces should have been configured with a clocking rate of 128000 in Part 1.
Step 1: Change the bandwidth on all serial interfaces to 128Kb/s.

a. Issue the show ip ospf interface brief command to view the default cost settings on the router interfaces.

```
R1# show ip ospf interface brief
Interface   PID  Area  IP Address/Mask  Cost  State  Nbrs  F/C
Se0/0/1     1     0    192.168.13.1/30  64    P2P    1/1
Se0/0/0     1     0    192.168.12.1/30  64    P2P    1/1
Gi0/0       1     0    192.168.1.1/24   1     DR     0/0
```

b. Use the bandwidth 128 interface command on all serial interfaces.

c. Issue the show ip ospf interface brief command to view the new cost settings.

```
R1# show ip ospf interface brief
Interface   PID  Area  IP Address/Mask  Cost  State  Nbrs  F/C
Se0/0/1     1     0    192.168.13.1/30  781   P2P    1/1
Se0/0/0     1     0    192.168.12.1/30  781   P2P    1/1
Gi0/0       1     0    192.168.1.1/24   1     DR     0/0
```

Step 2: Change the reference bandwidth on the routers.

a. Issue the auto-cost reference-bandwidth 1000 command on the routers to change the default reference bandwidth setting to account for Gigabit Ethernet Interfaces.

b. Re-issue the show ip ospf interface brief command to view how this command has changed cost values.

```
R1# show ip ospf interface brief
Interface   PID  Area  IP Address/Mask  Cost  State  Nbrs  F/C
Se0/0/1     1     0    192.168.13.1/30  7812  P2P    0/0
Se0/0/0     1     0    192.168.12.1/30  7812  P2P    0/0
Gi0/0       1     0    192.168.1.1/24   1     DR     0/0
```

Note: If the router had Fast Ethernet interfaces instead of Gigabit Ethernet interfaces, then the cost would now be 10 on those interfaces.

Step 3: Change the route cost.

a. Issue the show ip route ospf command to display the current OSPF routes on R1. Notice that there are currently two routes in the table that use the S0/0/1 interface.

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
```
+ - replicated route, % - next hop override

Gateway of last resort is not set

+ 192.168.3.0/24 [110/7822] via 192.168.13.2, 00:00:12, Serial0/0/1
  192.168.23.0/30 is subnetted, 1 subnets
+ 192.168.23.0 [110/15624] via 192.168.13.2, 00:00:12, Serial0/0/1
    [110/15624] via 192.168.12.2, 00:20:03, Serial0/0/0

b. Apply the `ip ospf cost 16000` command to the S0/0/1 interface on R1. A cost of 16,000 is higher than the accumulated cost of the route through R2 which is 15,624.

c. Issue the `show ip ospf interface brief` command on R1 to view the cost change to S0/0/1.

```
R1# show ip ospf interface brief
Interface  PID  Area       IP Address/Mask  Cost  State  Nbrs  F/C
Se0/0/1    1    0          192.168.13.1/30 16000 P2P  1/1
Se0/0/0    1    0          192.168.12.1/30  7812 P2P  1/1
Gi0/0      1    0          192.168.1.1/24   1    DR    0/0
```

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

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
        + - replicated route, % - next hop override

Gateway of last resort is not set

+ 192.168.3.0/24 [110/15625] via 192.168.12.2, 00:05:31, Serial0/0/0
  192.168.23.0/30 is subnetted, 1 subnets
+ 192.168.23.0 [110/15624] via 192.168.12.2, 01:14:02, Serial0/0/0
```

Explain why the route to the 192.168.3.0/24 network on R1 is now going through R2?
Part 4: Configure and Propagate a Static Default Route

In Part 4, you will use a loopback interface on R2 to simulate an ISP connection to the Internet. You will create a static default route on R2, and then OSPF will propagate that route to the other two routers on the network.

Step 1: Configure a static default route on R2 to loopback 0.

Configure a default route using the loopback interface configured in Part 1, to simulate a connection to an ISP.

Step 2: Have OSPF propagate the default static route.

Issue the `default-information originate` command to include the static default route in the OSPF updates that are sent from R2.

```
R2(config)# router ospf 1
R2(config-router)# default-information originate
```

Step 3: Verify OSPF static route propagation.

a. Issue the `show ip route static` command on R2.

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

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

Gateway of last resort is 0.0.0.0/0 is directly connected, Loopback0
```

b. Issue the `show ip route` command on R1 to verify the propagation of the static route from R2.

```
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
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
        + - replicated route, % - next hop override
```
Gateway of last resort is 192.168.12.2 to network 0.0.0.0

```
O*E2  0.0.0.0/0  [110/1] via 192.168.12.2, 00:02:57, Serial0/0/0
    192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
    C  192.168.1.0/24 is directly connected, GigabitEthernet0/0
    L  192.168.1.1/32 is directly connected, GigabitEthernet0/0
    O  192.168.3.0/24 [110/15634] via 192.168.12.2, 00:03:35, Serial0/0/0
    192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
    C  192.168.12.0/30 is directly connected, Serial0/0/0
    L  192.168.12.1/32 is directly connected, Serial0/0/0
    O  192.168.13.0/24 [110/15624] via 192.168.12.2, 00:05:18, Serial0/0/0
    192.168.13.0/30 is directly connected, Serial0/0/1
    L  192.168.13.1/32 is directly connected, Serial0/0/1
    192.168.23.0/30 is subnetted, 1 subnets
    O  192.168.23.0 [110/15624] via 192.168.12.2, 00:05:18, Serial0/0/0
```

c. Verify end-to-end connectivity by issuing a ping from PC-A to the ISP interface address 209.165.200.225.
   Were the pings successful? ______________

Part 5: Configure OSPF Authentication

OSPF authentication can be set up at the link level or the area level. There are three authentication types available for OSPF authentication: Null, plain text, or MD5. In Part 5, you will set up OSPF MD5 authentication, which is the strongest available.

Step 1: Set up MD5 OSPF authentication on a single link.

a. Issue the `debug ip ospf adj` command on R2 to view OSPF adjacency messages.

   ```bash
   R2# debug ip ospf adj
   OSPF adjacency debugging is on
   ```

b. Assign an MD5 key for OSPF Authentication on R1, interface S0/0/0.

   ```bash
   R1(config)# interface s0/0/0
   R1(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
   ```

c. Activate MD5 authentication on R1, interface S0/0/0.

   ```bash
   R1(config-if)# ip ospf authentication message-digest
   ```

OSPF debug messages informing you of a Mismatched Authentication type displays on R2.

>`Mar 19 00:03:18.187: OSPF-1 ADJ  Se0/0/0: Rcv pkt from 192.168.12.1 : Mismatched Authentication type. Input packet specified type 2, we use type 0`

d. Issue the `show` command, which is the shortest version of the `undebug all` command on R2 to disable debugging.

e. Configure OSPF authentication on R2, interface S0/0/0. Use the same MD5 password you entered for R1.
f. Issue a `show ip ospf interface s0/0/0` command on R2. This command displays the type of authentication at the bottom of the output.

```
R2# show ip ospf interface s0/0/0
Serial0/0/0 is up, line protocol is up
    Internet Address 192.168.12.2/30, Area 0, Attached via Network Statement
    Process ID 1, Router ID 2.2.2.2, Network Type POINT_TO_POINT, Cost: 7812
    Topology-MTID Cost Disabled Shutdown Topology Name
    0 7812 no no Base
    Transmit Delay is 1 sec, State POINT_TO_POINT
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:03
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    Index 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 1.1.1.1
    Suppress hello for 0 neighbor(s)
    Message digest authentication enabled
    Youngest key id is 1
```

Step 2: Set up OSPF Authentication at the area level.

a. Issue the `area 0 authentication` command to set MD5 authentication for OSPF Area 0 on R1.

```
R1(config)# router ospf 1
R1(config-router)# area 0 authentication message-digest
```

b. This option still requires that you assign the MD5 password at the interface level.

```
R1(config)# interface s0/0/1
R1(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
```

c. Issue the `show ip ospf neighbor` command on R3. R1 no longer has an adjacency with R3.

```
R3# show ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface
2.2.2.2 0 FULL/ - 00:00:31 192.168.23.1 Serial0/0/1
```

d. Set up area authentication on R3 and assign the same MD5 password to interface S0/0/0.

```
R3(config)# router ospf 1
```
R3(config-router)# area 0 authentication message-digest
R3(config-router)# interface s0/0/0
R3(config-if)# ip ospf message-digest-key 1 md5 MD5KEY

e. Issue the `show ip ospf neighbor` command on R3. Notice that R1 is now showing as a neighbor, but R2 is missing.

R3# show ip ospf neighbor

<table>
<thead>
<tr>
<th>Neighbor ID</th>
<th>Pri</th>
<th>State</th>
<th>Dead Time</th>
<th>Address</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1.1</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:38</td>
<td>192.168.13.1</td>
<td>Serial0/0/0</td>
</tr>
</tbody>
</table>

Why is R2 no longer showing as an OSPF neighbor?

f. Configure R2 to perform area-level MD5 authentication.

R2(config)# router ospf 1
R2(config-router)# area 0 authentication message-digest

g. Assign `MD5KEY` as the MD5 password for the link between R2 and R3.

h. Issue the `show ip ospf neighbor` command on all routers to verify that all adjacencies have been re-established.

R1# show ip ospf neighbor

<table>
<thead>
<tr>
<th>Neighbor ID</th>
<th>Pri</th>
<th>State</th>
<th>Dead Time</th>
<th>Address</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3.3.3</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:39</td>
<td>192.168.13.2</td>
<td>Serial0/0/1</td>
</tr>
<tr>
<td>2.2.2.2</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:35</td>
<td>192.168.12.2</td>
<td>Serial0/0/0</td>
</tr>
</tbody>
</table>

R2# show ip ospf neighbor

<table>
<thead>
<tr>
<th>Neighbor ID</th>
<th>Pri</th>
<th>State</th>
<th>Dead Time</th>
<th>Address</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3.3.3</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:36</td>
<td>192.168.23.2</td>
<td>Serial0/0/1</td>
</tr>
<tr>
<td>1.1.1.1</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:32</td>
<td>192.168.12.1</td>
<td>Serial0/0/0</td>
</tr>
</tbody>
</table>

R3# show ip ospf neighbor

<table>
<thead>
<tr>
<th>Neighbor ID</th>
<th>Pri</th>
<th>State</th>
<th>Dead Time</th>
<th>Address</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.2.2</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:33</td>
<td>192.168.23.1</td>
<td>Serial0/0/1</td>
</tr>
<tr>
<td>1.1.1.1</td>
<td>0</td>
<td>FULL/ -</td>
<td>00:00:39</td>
<td>192.168.13.1</td>
<td>Serial0/0/0</td>
</tr>
</tbody>
</table>
Reflection

1. What is the easiest and preferred method of manipulating OSPF route costs?

__________________________________________________________________________________

2. What does the default-information originate command do for a network using the OSPF routing protocol?

__________________________________________________________________________________

3. Why is it a good idea to use OSPF authentication?

__________________________________________________________________________________

__________________________________________________________________________________

Router Interface Summary Table

<table>
<thead>
<tr>
<th>Router Model</th>
<th>Ethernet Interface #1</th>
<th>Ethernet Interface #2</th>
<th>Serial Interface #1</th>
<th>Serial Interface #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>1900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2801</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/1/0 (S0/1/0)</td>
<td>Serial 0/1/1 (S0/1/1)</td>
</tr>
<tr>
<td>2811</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
</tbody>
</table>

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.
7.2.3.3 Lab – Troubleshooting Basic Single-Area OSPFv2 and OSPFv3

Topology
### Addressing Table

<table>
<thead>
<tr>
<th>Device</th>
<th>OSPF Router ID</th>
<th>Interface</th>
<th>IP Address</th>
<th>Default Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>1.1.1.1</td>
<td>G0/0</td>
<td>192.168.1.1/24</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2001:DB8:ACAD:A::1/64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FE80::1 link-local</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>S0/0/0</td>
<td>192.168.12.1/30</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2001:DB8:ACAD:12::1/64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FE80::1 link-local</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>S0/0/1</td>
<td>192.18.13.1/30</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2001:DB8:ACAD:13::1/64</td>
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<tr>
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<tr>
<td>R2</td>
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<td>2001:DB8:ACAD:B::2/64</td>
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<td></td>
<td>FE80::2 link-local</td>
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<tr>
<td></td>
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<td>S0/0/0</td>
<td>192.168.12.2/30</td>
<td>N/A</td>
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<td></td>
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<td>FE80::2 link-local</td>
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<tr>
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<td></td>
<td>S0/0/1</td>
<td>192.168.23.1/30</td>
<td>N/A</td>
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<td>2001:DB8:ACAD:23::2/64</td>
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</tr>
<tr>
<td>R3</td>
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<td></td>
<td>FE80::3 link-local</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>S0/0/0</td>
<td>192.168.13.2/30</td>
<td>N/A</td>
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<td>FE80::3 link-local</td>
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<td>S0/0/1</td>
<td>192.168.23.2/30</td>
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<td>2001:DB8:ACAD:23::3/64</td>
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<td>FE80::3 link-local</td>
<td></td>
</tr>
<tr>
<td>PC-A</td>
<td>NIC</td>
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</tr>
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<td>FE80::1</td>
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<td>NIC</td>
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<td>192.168.2.1</td>
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<td>2001:DB8:ACAD:B::B/64</td>
<td>FE80::2</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>2001:DB8:ACAD:C::C/64</td>
<td>FE80::3</td>
</tr>
</tbody>
</table>

### Objectives

**Part 1: Build the Network and Load Device Configurations**

**Part 2: Troubleshoot Layer 3 Connectivity**

**Part 3: Troubleshoot OSPFv2**

**Part 4: Troubleshoot OSPFv3**
Background / Scenario

Open Shortest Path First (OSPF) is a link-state routing protocol for IP networks. OSPFv2 is defined for IPv4 networks, and OSPFv3 is defined for IPv6 networks. OSPFv2 and OSPFv3 are completely isolated routing protocols, changes in OSPFv2 do not affect OSPFv3 routing, and vice versa.

In this lab, a single-area OSPF network running OSPFv2 and OSPFv3 is experiencing problems. You have been assigned to find the problems with the network and correct them.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universal image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

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

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Load Device Configurations

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

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

Step 2: Configure PC hosts.

Step 3: Load router configurations.

Load the following configurations into the appropriate router. All routers have the same passwords. The privileged EXEC password is cisco. The password for console and vty access is class.

Router R1 Configuration:

    conf t
    service password-encryption
    no ip domain lookup
    hostname R1
    enable secret class
    line con 0
    logging synchronous
    password cisco
    login
    line vty 0
password cisco
login
banner motd @Unauthorized Access is Prohibited!@
ipv6 unicast-routing
ipv6 router ospf 1
  router-id 1.1.1.1
  passive-interface g0/0
interface g0/0
  ip address 192.168.1.1 255.255.255.0
  ipv6 address 2001:db8:acad:a::1/64
  ipv6 address fe80::1 link-local
interface s0/0/0
  clock rate 128000
  ip address 192.168.12.1 255.255.255.0
  ipv6 address 2001:db8:acad:12::1/64
  ipv6 address fe80::1 link-local
  ipv6 ospf 1 area 0
  no shutdown
interface s0/0/1
  ip address 192.168.13.1 255.255.255.0
  ipv6 address 2001:db8:acad:13::1/64
  ipv6 address fe80::1 link-local
  ipv6 ospf 1 area 0
  no shutdown
router ospf 1
  network 192.168.1.0 0.0.0.255 area 0
  network 129.168.12.0 0.0.0.3 area 0
  network 192.168.13.0 0.0.0.3 area 0
  passive-interface g0/0

end

Router R2 Configuration:

conf t
service password-encryption
don ip domain lookup
hostname R2
enable secret class
line con 0
  logging synchronous
  password cisco
  login
line vty 0
  password cisco
  login
banner motd @Unauthorized Access is Prohibited!@
ipv6 unicast-routing
ipv6 router ospf 1
  router-id 2.2.2.2

interface g0/0
  ip address 192.168.2.1 255.255.255.0
  ipv6 address 2001:db8:acad:B::2/64
  ipv6 address fe80::1 link-local

  no shutdown
interface s0/0/0
  ip address 192.168.12.2 255.255.255.252
  ipv6 address 2001:db8:acad:12::2/64
  ipv6 address fe80::2 link-local
  ipv6 ospf 1 area 0
  no shutdown
interface s0/0/1
  clock rate 128000

  ipv6 address 2001:db8:acad:23::2/64
  ipv6 address fe80::2 link-local

  no shutdown
router ospf 1
  network 192.168.2.0 0.0.0.255 area 0
network 192.168.12.0 0.0.0.3 area 0
network 192.168.23.0 0.0.0.3 area 0

end

**Router R3 Configuration:**

```
conf t
service password-encryption
no ip domain lookup
enable secret class
hostname R3
line con 0
  logging synchronous
  password cisco
login
line vty 0
  password cisco
login
banner motd @Unauthorized Access is Prohibited!!@
interface g0/0

  ipv6 address 2001:db8:acad:c::3/64
  ipv6 address fe80::3 link-local

interface s0/0/0
  clock rate 128000
  ip address 192.168.13.1 255.255.255.252

  ipv6 address 2001:db8:acad:13::3/64
  ipv6 address fe80::3 link-local

no shutdown
interface s0/0/1
  ip address 192.168.23.2 255.255.255.252
  ipv6 address 2001:db8:acad:23::3/64
  ipv6 address fe80::3 link-local
```
router ospf 1
network 192.168.3.0 0.0.0.255 area 0

passive-interface g0/0
end

Part 2: Troubleshoot Layer 3 Connectivity

In Part 2, you will verify that Layer 3 connectivity is established on all interfaces. You will need to test both IPv4 and IPv6 connectivity for all device interfaces.

Step 1: Verify that the interfaces listed in the Addressing Table are active and configured with the correct IP address information.

a. Issue the `show ip interface brief` command on all routers to verify that the interfaces are in an up/up state. Record your findings.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

b. Issue the `show run interface` command to verify IP address assignments on all router interfaces. Compare the interface IP addresses against the Addressing Table and verify the subnet mask assignments. For IPv6, verify that the link-local address has been assigned. Record your findings.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
c. Resolve all problems that are found. Record the commands used to correct the issues.


d. Using the ping command, verify that each router has network connectivity with the serial interfaces on the neighbor routers. Verify that the PCs can ping their default gateways. If problems still exist, continue troubleshooting Layer 3 issues.

Part 3: Troubleshoot OSPFv2

In Part 3, you will troubleshoot OSPFv2 problems and make the necessary changes needed to establish OSPFv2 routes and end-to-end IPv4 connectivity.

Note: LAN (G0/0) interfaces should not advertise OSPF routing information, but routes to these networks should be in the routing tables.

Step 1: Test IPv4 end-to-end connectivity.

From each PC host, ping the other PC hosts in the topology to verify end-to-end connectivity.

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

a. Ping from PC-A to PC-B. Were the pings successful? ____________

b. Ping from PC-A to PC-C. Were the pings successful? ____________

c. Ping from PC-B to PC-C. Were the pings successful? ____________

Step 2: Verify that all interfaces are assigned to OSPFv2 area 0 on R1.

a. Issue the show ip protocols command to verify that OSPF is running and that all networks are advertised in area 0. Verify that the router ID is set correctly. Record your findings.
b. Make the necessary changes to the configuration on R1 based on the output from the `show ip protocols` command. Record the commands used to correct the issues.

c. Issue the `clear ip ospf process` command if necessary.

d. Re-issue the `show ip protocols` command to verify that your changes had the desired effect.

e. Issue the `show ip ospf interface brief` command to verify that all interfaces are listed as OSPF networks assigned to area 0.

f. Issue the `show ip ospf interface g0/0` command to verify that G0/0 is a passive interface.

   **Note:** This information is also in the `show ip protocols` command.

g. Resolve any problems discovered on R1. List any additional changes made to R1. If no problems were found on the device, then respond with "no problems were found".

---

Step 3: Verify that all interfaces are assigned to OSPFv2 area 0 on R2.

a. Issue the `show ip protocols` command to verify that OSPF is running and that all networks are being advertised in area 0. Verify that the router ID is set correctly. Record your findings.
b. Make the necessary changes to the configuration on R2 based on the output from the `show ip protocols` command. Record the commands used to correct the issues.

c. Issue the `clear ip ospf process` command if necessary.

d. Re-issue the `show ip protocols` command to verify that your changes had the desired effect.

e. Issue the `show ip ospf interface brief` command to verify that all interfaces are listed as OSPF networks assigned to area 0.

f. Issue the `show ip ospf interface g0/0` command to verify that G0/0 is a passive interface.

   **Note:** This information is also available from the `show ip protocols` command.

g. Resolve any problems discovered on R2. List any additional changes made to R2. If no problems were found on the device, then respond with “no problems were found”.

---

**Step 4:** Verify that all interfaces are assigned to OSPFv2 area 0 on R3.

a. Issue the `show ip protocols` command to verify that OSPF is running and that all networks are being advertised in area 0. Verify that the router ID is set correctly as well. Record your findings.
b. Make the necessary changes to the configuration on R3 based on the output from the `show ip protocols` command. Record the commands used to correct the issues.

c. Issue the `clear ip ospf process` command if necessary.

d. Re-issue the `show ip protocols` command to verify that your changes had the desired effect.

e. Issue the `show ip ospf interface brief` command to verify that all interfaces are listed as OSPF networks assigned to area 0.

f. Issue the `show ip ospf interface g0/0` command to verify that G0/0 is a passive interface.

   **Note:** This information is also in the `show ip protocols` command.

  g. Resolve any problems discovered on R3. List any additional changes made to R3. If no problems were found on the device, then respond with "no problems were found".

  **Step 5:** **Verify OSPF neighbor information.**

  a. Issue the `show ip ospf neighbor` command on all routers to view the OSPF neighbor information.
Step 6: Verify OSPFv2 Routing Information.

a. Issue the \texttt{show ip route ospf} command to verify that each router has OSPFv2 routes to all non-adjointing networks.

Are all OSPFv2 routes available? \\
If any OSPFv2 routes are missing, what is missing?

b. If any routing information is missing, resolve these issues.

Step 7: Verify IPv4 end-to-end connectivity.

From each PC, verify that IPv4 end-to-end connectivity exists. PCs should be able to ping the other PC hosts in the topology. If IPv4 end-to-end connectivity does not exist, then continue troubleshooting to resolve any remaining issues.

\textbf{Note}: It may be necessary to disable the PC firewall to ping between PCs.

Part 4: Troubleshoot OSPFv3

In Part 4, you will troubleshoot OSPFv3 problems and make the necessary changes needed to establish OSPFv3 routes and end-to-end IPv6 connectivity.

\textbf{Note}: LAN (G0/0) interfaces should not advertise OSPFv3 routing information, but routes to these networks should be contained in the routing tables.

Step 1: Test IPv6 end-to-end connectivity.

From each PC host, ping the IPv6 addresses of the other PC hosts in the topology to verify IPv6 end-to-end connectivity.

\textbf{Note}: It may be necessary to disable the PC firewall to ping between PCs.

Step 2: Verify that IPv6 unicast routing has been enabled on all routers.

a. An easy way to verify that IPv6 routing has been enabled on a router is to use the \texttt{show run | section ipv6 unicast} command. By adding this pipe (|) section to the \texttt{show run} command, the \texttt{ipv6 unicast-routing} command displays if IPv6 routing has been enabled.

\textbf{Note}: The \texttt{show run} command can also be issued without any pipe, and then a manual search for the \texttt{ipv6 unicast-routing} command can be done.

Issue the command on each router. Record your findings.
b. If IPv6 unicast routing is not enabled on one or more routers, enable it now. Record the commands used to correct the issues.

Step 3:  Verify that all interfaces are assigned to OSPFv3 area 0 on R1.

a. Issue the `show ipv6 protocols` command and verify that the router ID is correct. Also verify that the expected interfaces display under area 0.

   **Note:** If no output is generated from this command, then the OSPFv3 process has not been configured. Record your findings.

b. Make the necessary configuration changes to R1. Record the commands used to correct the issues.

c. Issue the `clear ipv6 ospf process` command if necessary.

d. Re-issue the `show ipv6 protocols` command to verify that your changes had the desired effect.

e. Issue the show ipv6 ospf interface brief command to verify that all interfaces are listed as OSPF networks assigned to area 0.

f. Issue the `show ipv6 ospf interface g0/0` command to verify that this interface is set not to advertise OSPFv3 routes.
g. Resolve any problems discovered on R1. List any additional changes made to R1. If no problems were found on the device, then respond with "no problems were found".

Step 4: Verify that all interfaces are assigned to OSPFv3 area 0 on R2.

a. Issue the `show ipv6 protocols` command and verify the router ID is correct. Also verify that the expected interfaces display under area 0.

   **Note:** If no output is generated from this command, then the OSPFv3 process has not been configured. Record your findings.

b. Make the necessary configuration changes to R2. Record the commands used to correct the issues.

c. Issue the `clear ipv6 ospf process` command if necessary.

d. Re-issue the `show ipv6 protocols` command to verify that your changes had the desired effect.

e. Issue the `show ipv6 ospf interface brief` command to verify that all interfaces are listed as OSPF networks assigned to area 0.

f. Issue the `show ipv6 ospf interface g0/0` command to verify that this interface is not set to advertise OSPFv3 routes.
g. List any additional changes made to R2. If no problems were found on the device, then respond with "no problems were found".

---

Step 5: Verify that all interfaces are assigned to OSPFv3 area 0 on R3.

a. Issue the `show ipv6 protocols` command and verify that the router ID is correct. Also verify that the expected interfaces display under area 0.

   **Note:** If no output is generated from this command, then the OSPFv3 process has not been configured. Record your findings.

b. Make the necessary configuration changes to R3. Record the commands used to correct the issues.

c. Issue the `clear ipv6 ospf process` command if necessary.

d. Re-issue the `show ipv6 protocols` command to verify that your changes had the desired effect.

e. Issue the `show ipv6 ospf interface brief` command to verify that all interfaces are listed as OSPF networks assigned to area 0.

f. Issue the `show ipv6 ospf interface g0/0` command to verify that this interface is set not to advertise OSPFv3 routes.
g. Resolve any problems discovered on R3. List any additional changes made to R3. If no problems were found on the device, then respond with "no problems were found".

No problems were found as long as G0/0 was configured as a passive OSPFv3 interface in Step 5b.

Step 6: Verify that all routers have correct neighbor adjacency information.

a. Issue the `show ipv6 ospf neighbor` command to verify that adjacencies have formed between neighboring routers.

b. Resolve any OSPFv3 adjacency issues that still exist.

Step 7: Verify OSPFv3 routing information.

a. Issue the `show ipv6 route ospf` command, and verify that OSPFv3 routes exist to all non-adjointing networks.
Are all OSPFv3 routes available? 

If any OSPFv3 routes are missing, what is missing? 

b. Resolve any routing issues that still exist.

Step 8: **Verify IPv6 end-to-end connectivity.**

From each PC, verify that IPv6 end-to-end connectivity exists. PCs should be able to ping each interface on the network. If IPv6 end-to-end connectivity does not exist, then continue troubleshooting to resolve remaining issues.

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

**Reflection**

Why would you troubleshoot OSPFv2 and OSPFv3 separately?

---

**Router Interface Summary Table**

<table>
<thead>
<tr>
<th>Router Model</th>
<th>Ethernet Interface #1</th>
<th>Ethernet Interface #2</th>
<th>Serial Interface #1</th>
<th>Serial Interface #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>1900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2801</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/1/0 (S0/1/0)</td>
<td>Serial 0/1/1 (S0/1/1)</td>
</tr>
<tr>
<td>2811</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
</tbody>
</table>

**Note:** To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.
7.2.3.4 Lab – Troubleshooting Advanced Single-Area OSPFv2

Topology

Addressing Table

<table>
<thead>
<tr>
<th>Device</th>
<th>Interface</th>
<th>IP Address</th>
<th>Subnet Mask</th>
<th>Default Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>G0/0</td>
<td>192.168.1.1</td>
<td>255.255.255.0</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/0 (DCE)</td>
<td>192.168.12.1</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/1</td>
<td>192.168.13.1</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td>R2</td>
<td>Lo0</td>
<td>209.165.200.225</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/0</td>
<td>192.168.12.2</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/1 (DCE)</td>
<td>192.168.23.1</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td>R3</td>
<td>G0/0</td>
<td>192.168.3.1</td>
<td>255.255.255.0</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/0 (DCE)</td>
<td>192.168.13.2</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>S0/0/1</td>
<td>192.168.23.2</td>
<td>255.255.255.252</td>
<td>N/A</td>
</tr>
<tr>
<td>PC-A</td>
<td>NIC</td>
<td>192.168.1.3</td>
<td>255.255.255.0</td>
<td>192.168.1.1</td>
</tr>
<tr>
<td>PC-C</td>
<td>NIC</td>
<td>192.168.3.3</td>
<td>255.255.255.0</td>
<td>192.168.3.1</td>
</tr>
</tbody>
</table>

Objectives

Part 1: Build the Network and Load Device Configurations

Part 2: Troubleshoot OSPF
Background / Scenario

OSPF is a popular routing protocol used by businesses worldwide. A Network Administrator should be able to isolate OSPF issues and resolve those issues in a timely manner.

In this lab, you will troubleshoot a single-area OSPFv2 network and resolve all issues that exist.

**Note:** The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

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

**Required Resources**

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables, as shown in the topology

**Part 1: Build the Network and Load Device Configurations**

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

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

**Step 2:** Configure PC hosts.

**Step 3:** Load router configurations.

Load the following configurations into the appropriate router. All routers have the same passwords. The privileged EXEC password is **class**. The password for console and vty lines is **cisco**.

**Router R1 Configuration:**

```
conf t
hostname R1
enable secret class
no ip domain lookup
interface GigabitEthernet0/0
  ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
no shut
interface Serial0/0/0
bandwidth 128
```
ip address 192.168.12.1 255.255.255.252
ip ospf message-digest-key 1 md5 MD5LINKS
clock rate 128000
no shut
interface Serial0/0/1
  bandwidth 64

ip ospf message-digest-key 1 md5 MD5LINKS
ip address 192.168.13.1 255.255.255.252
no shut
router ospf 1
  auto-cost reference-bandwidth 1000

area 0 authentication message-digest
  passive-interface g0/0
  network 192.168.1.0 0.0.0.255 area 0
  network 192.168.12.0 0.0.0.3 area 0
  network 192.168.13.0 0.0.0.3 area 0

banner motd ^
  Unauthorized Access is Prohibited!
^

line con 0
  password cisco
logging synchronous
login
line vty 0 4
  password cisco
login
  transport input all
end

Router R2 Configuration:

conf t
hostname R2
enable secret class
no ip domain lookup
interface Loopback0
  ip address 209.165.200.225 255.255.255.252
interface Serial0/0/0
bandwidth 182

ip ospf message-digest-key 1 md5 MD5LINKS
ip address 192.168.12.2 255.255.255.252
no shut
interface Serial0/0/1
  bandwidth 128
  ip ospf message-digest-key 1 md5 MD5LINKS
  ip address 192.168.23.1 255.255.255.252
  clock rate 128000
  no shut
router ospf 1
  router-id 2.2.2.2
  auto-cost reference-bandwidth 1000
  area 0 authentication message-digest
  passive-interface g0/0
  network 192.168.12.0 0.0.0.3 area 0
  network 192.168.23.0 0.0.0.3 area 0

ip route 0.0.0.0 0.0.0.0 Loopback0
banner motd ^
  Unauthorized Access is Prohibited!
^
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
  login
  transport input all
end

Router R3 Configuration:
  conf t
  hostname R3
  enable secret class
  no ip domain lookup
interface GigabitEthernet0/0
  ip address 192.168.3.1 255.255.255.0
duplex auto
speed auto
no shut
interface Serial0/0/0
  bandwidth 128
  ip ospf message-digest-key 1 md5 MD5LINKS
  ip address 192.168.13.2 255.255.255.252
  clock rate 128000
  no shut
interface Serial0/0/1
  bandwidth 128
  ip address 192.168.23.2 255.255.255.252
  no shut
router ospf 1
  router-id 3.3.3.3

  area 0 authentication message-digest
  passive-interface g0/0
  network 192.168.3.0 0.0.0.255 area 0
  network 192.168.13.0 0.0.0.3 area 0
  network 192.168.23.0 0.0.0.3 area 0
  banner motd ^
    Unauthorized Access is Prohibited!
^
  line con 0
    password cisco
  logging synchronous
  login
  line vty 0 4
    password cisco
  login
  transport input all
end

Step 4: **Test end-to-end connectivity.**

All interfaces should be up and the PCs should be able to ping the default gateway.

**Part 2: Troubleshoot OSPF**

In Part 2, verify that all routers have established neighbor adjacencies, and that all network routes are available.

Additional OSPF Requirements:
• Each router should have the following router ID assignments:
  - R1 Router ID: 1.1.1.1
  - R2 Router ID: 2.2.2.2
  - R3 Router ID: 3.3.3.3

• All serial interface clocking rates should be set at 128 Kb/s and a matching bandwidth setting should be available to allow OSPF cost metrics to be calculated correctly.

• The 1941 routers have Gigabit interfaces, so the default OSPF reference bandwidth should be adjusted to allow cost metrics to reflect appropriate costs for all interfaces.

• OSPF should propagate a default route to the Internet. This is simulated by using Loopback interface 0 on R2.

• All interfaces advertising OSPF routing information should be configured with MD5 authentication, using MD5LINKS as the key.

List the commands used during your OSPF troubleshooting process:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

List the changes made to resolve the OSPF issues. If no problems were found on the device, then respond with “no problems were found”.

**R1 Router:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**R2 Router:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**R3 Router:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Reflection

How would you change the network in this lab so all LAN traffic was routed through R2?

Router Interface Summary Table

<table>
<thead>
<tr>
<th>Router Model</th>
<th>Ethernet Interface #1</th>
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<th>Serial Interface #1</th>
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<tbody>
<tr>
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<td>Fast Ethernet 0/0 (F0/0)</td>
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<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
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<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2801</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/1/0 (S0/1/0)</td>
<td>Serial 0/1/1 (S0/1/1)</td>
</tr>
<tr>
<td>2811</td>
<td>Fast Ethernet 0/0 (F0/0)</td>
<td>Fast Ethernet 0/1 (F0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
<tr>
<td>2900</td>
<td>Gigabit Ethernet 0/0 (G0/0)</td>
<td>Gigabit Ethernet 0/1 (G0/1)</td>
<td>Serial 0/0/0 (S0/0/0)</td>
<td>Serial 0/0/1 (S0/0/1)</td>
</tr>
</tbody>
</table>

**Note:** To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.
7.3.1.1 Class Activity – OSPF Troubleshooting Mastery

Objective

Explain the process and tools used to troubleshoot a single-area OSPF network.

Scenario

You have decided to change your routing protocol from RIPv2 to OSPFv2. Your small- to medium-sized business network topology will not change from its original physical settings. Use the diagram on the PDF for this activity as your company’s small- to medium- business network design.

Your addressing design is complete and you then configure your routers with IPv4 and VLSM. OSPF has been applied as the routing protocol. However, some routers are sharing routing information with each other and some are not.

Open the PDF file that accompanies this modeling activity and follow the directions to complete the activity.

When the steps in the directions are complete, regroup as a class and compare recorded activity correction times. The group taking the shortest time to find and fix the configuration error will be declared the winner only after successfully explaining how they found the error, fixed it, and proved that the topology is now working.

Required Resources

- Topology diagram
- Packet Tracer software
- Timer

Topology Diagram
Directions

Choose a partner from the class with whom to work on this activity. Use Packet Tracer to create the topology diagram shown for this activity.

Step 1: **Build the topology based on the modeling activity page for this scenario.**

Step 2: **Configure the routers.**
   a. Use IPv4 for all interfaces.
   b. Incorporate VLSM into the addressing scheme.
   c. Make one intentional configuration error.
   d. Verify that the network does not work based upon the intentional error.
   e. Save your file to be used with Step 3.

Step 3: **Exchange your Packet Tracer file with another group.**
   a. Find the configuration error on the Packet Tracer network file you received from another group.
   b. Fix the OSPF configuration error so that the network operates fully.
   c. Record the time it took to find and fix the OSPF network error.
   d. When complete, meet with your class to determine the Master Troubleshooter for the day.
Chapter 8 — Multi-Area OSPF

8.0.1.2 Class Activity – Leaving on a Jet Plane

Objective

Explain the operation of multiarea OSPF to enable internetworking in a small- to medium-sized business network.

Scenario

You and a classmate are starting a new airline to serve your continent. In addition to your core area or headquarters airport, you will locate and map four intra-continental airport service areas and one trans-continental airport service area that can be used for additional source and destination travel.

Use the blank world map provided to design your airport locations. Additional instructions for completing this activity can be found in the accompanying PDF.

Required Resources

- Blank world map diagram
- Word processing software or alternative graphics software for marking airport locations and their connections

Blank World Map Diagram