Iowa State University
Department of Electrical and Computer Engineering
Cpr E 489: Computer Networking and Data Communications
Lab Experiment #8
Using Cisco IOS XE to Configure OSPF Routing
(Total Points: 100)

Objective

To introduce students to OSPF routing using Cisco IOS XE.

Pre-Lab

In this Lab, you will configure OSPF routing using the Cisco Catalyst 9300 Switch. Familiarize yourself with addressing and routing since these skills will help you troubleshoot any problems you might encounter during this lab. In addition, it may be helpful to review Lab #7 since this lab relies on your experience from Lab #7.

Lab Expectations

Work through the lab and let the TA know if you have any questions. After the lab, write up a lab report. Be sure to include the following:

1) **Summarize** what you learned in a few paragraphs. **(15 points)**
2) **Complete** Exercise 1 "Static Routing" **(20 points)** and Exercise 2 "OSPF" **(45 points)** and answer the questions asked in the exercises.
3) **Demonstrate (10 points) that you have "Reset the Student Switch" and show it to the TA:** It is crucial that each team completes the "Reset the Student Switch" Tasks 1 and 2 so future labs are not affected. Include your answer to both tasks in the lab report. **(10 points)**

Procedure

In this lab, we are going to build upon the experience attained from Lab #7 in order to configure OSPF routing and compare it to static routing. This lab must be done with TA's help; otherwise, you may have to configure at least two switches on your own. The TA's switch doesn't retain the configuration.

Important Note: **For this lab experiment you must log on with the local user account.**
Username: **489labuser** *Password:* **489labuser**
Also ensure that you have signed up to use this computer pair.

Connect to a Cisco Switch

Switch Name	Switch Management IP	Connected Host – Management Port	Connected Host – GigabitEthernet1/0/1
co2061-9300-01	192.168.77.101	co2061-01	co2061-02
co2061-9300-02	192.168.77.102	co2061-03	co2061-04
co2061-9300-03	192.168.77.103	co2061-05	co2061-06
co2061-9300-04	192.168.77.104	co2061-07	co2061-08
co2061-9300-05	192.168.77.105	co2061-09	co2061-10
co2061-9300-06	192.168.77.106	co2061-11	co2061-12
co2061-9300-07	192.168.77.107	co2061-13	co2061-14
co2061-9300-08	192.168.77.108	co2061-15	co2061-16
co2061-9300-09	192.168.77.109	co2061-17	co2061-18
co2061-9300-10	192.168.77.110	co2061-19	co2061-20
co2061-9300-11	192.168.77.111	co2061-21	co2061-22
co2061-9300-12	192.168.77.112	co2061-23	co2061-24
co2061-9300-13	192.168.77.113		

Above is the same list of switch-host setups in Coover 2061 from Lab #7. You can login to the IOS XE interface of each switch from the specified hosts that are listed under [Connected Host – Management Port].

For example, to log into switch co2061-9300-01 from desktop co2061-01, do:

ssh admin@192.168.77.101

password is: cat9.3k

If the connection is successful, you will see a prompt like:

```
co2061-9300-01#
```

Brief Review of some Cisco IOS XE commands

After login, you can always enter the Global Configuration mode by entering **configure terminal** (or **conf t** for short).

Some useful commands in the Privileged EXEC mode:

```
show ip route          // Display the current IP routing table
show ip int br         // Display IP and status of the interfaces
show run               // Display the current routing configuration
```

If you are in any **configuration** mode (Global, Interface, Router ... etc), the above show commands won't run, but you can precede them with **do** to make them run. For example, **do show ip int br**

Setting an IP Address for a Port

You will need to set up the IP addresses related to your switch as shown in Figure 1. First of all, to enable the routing capability of the switch, type the following command in the Global Configuration Mode:

```
co2061-9300-01(config)#ip routing
```

To set or change the IP address of an interface, you must enter the Interface Configuration Mode for the interface you wish to change. For example, if we want to configure **GigabitEthernet 1/0/1** on the switch, we would proceed through the modes and select **GigabitEthernet 1/0/1** for the interface:

Privileged EXEC→ Global Configuration→ Interface Configuration for **GigabitEthernet 1/0/1**

Cisco Catalyst 9300 Series Switch provides layer 3 capabilities, which means that we can convert the interfaces from "switch ports" to "routed ports". Use the following command to configure the selected interface as a "routed port":

```
co2061-9300-01(config-if)#no switchport
```

Once we set the port to a "routed port", we can assign an IP address for this interface using the following syntax:

```
co2061-9300-01(config-if)#ip address <IP address> <netmask>
```

Now **exit** to the Privileged EXEC Mode, type the following to verify the IP address of GigabitEthernet 1/0/1.

```
co2061-9300-01#show ip int br
```

To remove the IP address of GigabitEthernet 1/0/1, you must return to the Interface Configuration Mode and enter the following:

```
co2061-9300-01(config-if)#no ip address <IP address> <netmask>
```

To configure the port back to a "switch port", simply use the command:

```
co2061-9300-01(config-if)#switchport
```

Network Diagram

Figure 1 shows the network diagram used in this lab. You can observe the network diagram is divided into two parts: the TA has configured the upper part; the student is responsible for configuring the lower part.

The letter "X" is the number of the even-numbered PC you are using.

For example: the TA's switch is connected to computer number 2, so, instead of 10.X.X.X, the loopback interface of the TA's switch will have an IP address of 10.2.2.2.

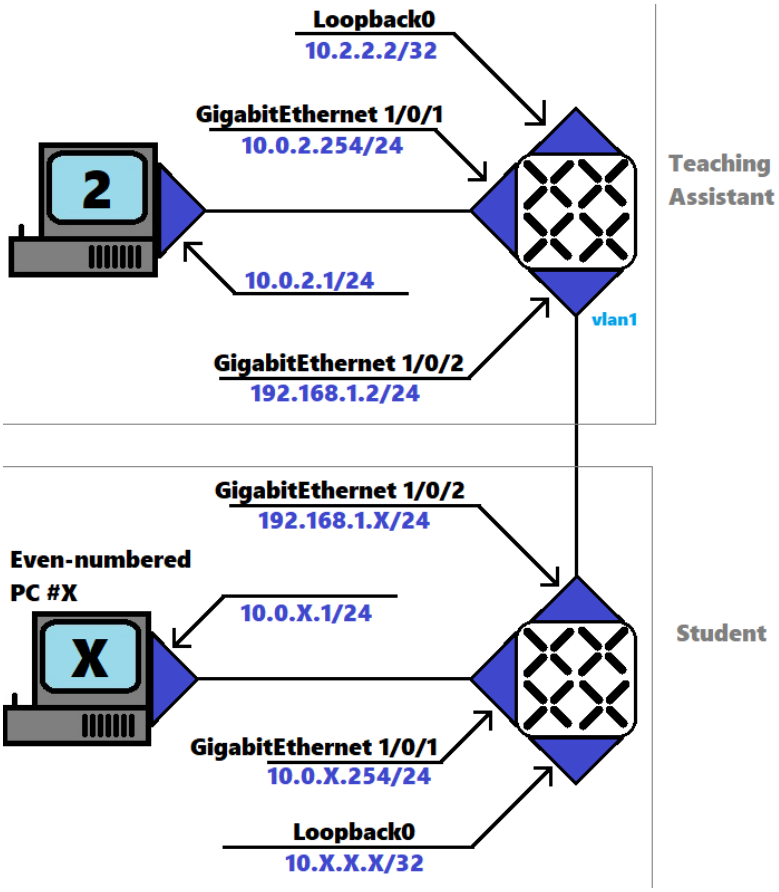

Figure 1: Lab 8 Network Diagram

Basic Setup of the Switch

We will start with the loopback interface. With Cisco switches, loopback interfaces can be used to simulate networks. They can also be used by OSPF to identify the switch (Switch ID) as we will see later on. To configure the loopback interface, use the following commands (**make sure to change the IP address to the one you are supposed to use**):

```
co2061-9300-01(config)#interface Loopback0
co2061-9300-01(config-if)#ip address 10.X.X.X 255.255.255.255
co2061-9300-01(config-if)#exit
```

Configure the rest of the interfaces on your switch (GE 1/0/1 and GE 1/0/2) in accordance with Figure 1. If the port is currently a switchport, you will have to switch it over to a routed port in order to assign an IP address to it.

Test your configuration by pinging the three interfaces (192.168.1.X/24, 10.0.X.254/24, and 10.X.X.X) from your switch. After all the tests are successful, make sure to ping the TA's switch IP which is 192.168.1.2. This ping should be done from your switch (in Privileged EXEC Mode) as it will fail if it's done from your computer even if the connection is fine.

Configure your computer for this lab by using the following commands (after changing the IPs to match yours) similarly to how we did in Lab #7.

NOTE: please do NOT modify any interfaces on the odd-numbered PC as this could lead to troubles accessing the switch and other unexpected issues.

```
sudo /sbin/ifconfig enp3s0f1 10.0.X.1 netmask 255.255.255.0
sudo /sbin/route add -net 10.0.0.0 netmask 255.0.0.0 gw 10.0.X.1 enp3s0f1
sudo /sbin/route add -net 192.168.1.0 netmask 255.255.255.0 gw 10.0.X.1 enp3s0f1
```

After configuring the computer, try to ping both GigabitEthernet interfaces (10.0.X.254 and 192.168.1.X) on your switch from the even-numbered computer. Do they both work?

Setting Static Routing Table Entries

In order to add or remove routing table entries, you must be in Global Configuration mode. Setting static routing table entries is not very different from the corresponding UNIX `route` commands. The following command adds a route to the network or gateway with IP address <destination address> via gateway <next_hop address>:

```
co2061-9300-01(config)#ip route <destination address> <mask> <next_hop address> <cost>
```

The following command deletes a route from the routing table:

```
co2061-9300-01(config)#no ip route <destination address> <mask> <next_hop address>
<cost>
```

As an example, if we want to create a static route to the remote network of 172.16.1.0, with a mask of 255.255.255.0, the next hop as 172.16.2.1, and at a cost of 5 hops, we would type the following:

```
co2061-9300-01(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.1 5
```

Note: If you add this route to the configuration, you will need to remove it before continuing on.

Exercise 1 – Static Routing

Create two static routes on your (Student) switch: one to the network 10.0.2.0/24, and another one to the loopback interface IP 10.2.2.2 of the TA's switch.

Follow that by pinging these IP addresses both **from your switch**, and **from the even-numbered computer**:

- 192.168.1.X
- 192.168.1.2
- 10.2.2.2
- 10.0.2.254

Question 1: Provide the following: (a) Use show run command and take a screenshot of the static routes created. (b) Capture screenshots of each ping results. (c) Prepare a table that shows which ping attempts were successful and which ones failed. (d) Provide comments on why you think certain ping attempts failed, even after setting static routes on your switch. (**10 points**)

Question 2: Considering our network in the CprE 489 lab which has 12 switches, and assuming that each router has two local networks (including the simulated network by the loopback interface), how many static routes should be configured on all the switches to make sure that all networks are reachable? (**10 points**)

Routing Protocols vs. Static Routing

Static routes are mainly used in small networks where traffic is predictable, and less bandwidth is available for routing updates. Dynamic routing using any routing protocol would consume a certain amount of bandwidth in order to update all routers of all available routes. Static routes can also be used to specify a gateway of last resort (a default router to which all non-routable packets are sent).

OSPF – Open Shortest Path First

OSPF is an Interior Gateway Routing (IGP) protocol that uses link state rather than distance vectors for path selection. OSPF sends/receives link-state advertisements (LSAs) and converges more quickly than RIP. All switches have an identical link-state database.

Some of the advantages of OSPF over RIP are:

- OSPF LSAs are sent less frequently than RIP, and updates are only sent when needed. This would save bandwidth.
- RIP networks are flat networks without the areas and boundaries that exist in OSPF. OSPF areas can be used to split a huge network into smaller ones, keeping the size of the link-state database on each switch manageable.
- OSPF uses cost to do routing decisions. It helps OSPF to avoid sending data to links with less bandwidth, for example. While the default calculation is 100M / BW, the cost can also be set manually.

Configuring OSPF

To configure OSPF, you must be in Global Configuration mode. You should first enter the following command:

```
co2061-9300-01(config)#router ospf <process-ID>
```

The process-ID doesn't need to be the same for all routers in your network. It is locally significant and is used to differentiate multiple instances of OSPF on the same switch. It can generally be any positive integer. The following command uses process-id of 102:

```
co2061-9300-01(config)#router ospf 102
```

Also, make sure to have the following command entered in switch configuration mode:

```
co2061-9300-01(config-router)#log-adjacency-changes
```

The above command will show updates about finding adjacent switches. You should see its output immediately after enabling a certain interface to participate in OSPF advertisements.

To define the IP addresses on which OSPF runs, we need to use the command **network <IP Address> <Wildcard-mask> area <area_id>**. Any IP interface on the switch that has an IP address within the specified IP range will run OSPF. This command also defines the area ID for the specified interface.

The **wildcard-mask** specifies how much of the IP address must match exactly. It's actually the **inverse** of the **subnet mask**. One way to calculate it is by subtracting the subnet mask from 255.255.255.255. For example, a network with subnet mask **255.255.255.0** can be represented by wildcard mask of **0.0.0.255**. A network with subnet mask **255.255.255.240** would have a wildcard mask of **0.0.0.15**.

Three examples of the **network** command are listed below:

```
co2061-9300-01(config-router)#network 10.0.17.0 0.0.0.255 area 0
co2061-9300-01(config-router)#network 10.17.17.17 0.0.0.0 area 0
co2061-9300-01(config-router)#network 192.168.2.0 0.0.0.31 area 0
```

Exercise 2 – OSPF

In this exercise, we will assume that all switches belong to **area 0**. Configure OSPF on your switch by using the commands described in the previous section, and make sure to use the IPs that are relevant to your switch. You

should advertise all three subnets to which your switch is directly connected and pay attention to their subnet masks in order to create the equivalent wildcard masks.

Question 3: Include the output of the **show run** command that is related to the OSPF setups. (**10 points**)

Question 4: Ping these three IPs **from the even-numbered computer again**:
- 192.168.1.X
- 192.168.1.2
- 10.2.2.2
- 10.0.2.254

Include screenshots and explain the results. (**10 points**)

Questions 5-9: Include the output of the following commands (executed on your switch), and answer the questions:

- **show ip route**
  - **Question 5:** Which routes are directly connected? Which routes are via OSPF, if any? Of the OSPF routes, is there a route from an area other than **area 0**? (**5 points**)
- **show ip protocols**
  - **Question 6:** What is the **Router ID**? If you look at your interfaces' IP addresses, which one of them is similar to the router ID? (**5 points**)
  - **Question 7:** Look for the line "Distance: (default is …)." What is the number? (**5 points**)
- **Show ip ospf neighbor**
  - **Question 8:** Find the neighbor with the ID: 10.2.2.2. What is the **Address** field in this record? (**5 points**)
- **show ip ospf interface**
  - **Question 9:** Look for the **Cost** set on each interface. List these numbers for all your interfaces. (**5 points**)

Reset the Student Switch

You are required to reset the student switch to the initial configuration before the end of lab section regardless of whether you have completed Exercises 1 and 2. This is to ensure that all switches are reset to the initial configuration so that future lab sections are not impacted in any way. **Demonstrate** you have successfully reset the switch to the TA before the end of lab section **(10 points)** and **include** your answers to Tasks 1 and 2 in the lab report **(10 points)**.

Task 1: Remove all static routes created in Exercise 1:

Even number PC:

```
sudo /sbin/route del -net 10.0.0.0 netmask 255.0.0.0 gw 10.0.X.1 enp3s0f1
sudo /sbin/route del -net 192.168.1.0 netmask 255.255.255.0 gw 10.0.X.1 enp3s0f1
```

Cisco switch:

no ip route <destination address> <mask> <next_hop address>

Task 2: Undo the OSPF network commands and shut down the OSPF router created in Exercise 2. Set the interfaces (Loopback0, GE1/0/1, GE1/0/2) back to their default configurations by removing their IP addresses and switchport status.

HINT: Look through the screenshots you have taken so far and make sure none of the changes remain using commands like show run and show ip int br.

Other helpful OSPF commands

- **debug ip ospf adjacency** (used to debug neighborhood adjacencies and routing update issues)
- **debug ip ospf events** (used to debug routing updates issues and interface flapping)
- **debug ip ospf packets** (used to display each OSPF packet received)
- **show ip ospf database** (displays all link state advertisements)