Iowa State University
Department of Electrical and Computer Engineering
Cpr E 489: Computer Networking and Data Communications
Lab Experiment #7
Using Cisco IOS XE to Configure Cisco Switches
(Total Points: 100)

Objective

To introduce students to the Cisco IOS XE and to configure static Ethernet interfaces on Cisco switches.

Pre-Lab

1. Familiarize yourself with the Virtual Local Area Network (VLAN). Briefly go through following page: https://help.ui.com/hc/en-us/articles/222183968-Intro-to-Networking-Introduction-to-Virtual-LANs-VLANs-and-Tagging

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

1) summarize what you learned in a few paragraphs **(20 points)**
2) complete each exercise and provide demonstrations of each task as requested in the exercises with screenshots at every step of exercise **(80 points in total, with 10 points each)**

Procedure

The Cisco Internetwork Operating System (IOS) interface is similar to a UNIX or DOS command shell in that you may inspect and configure the switches by typing commands at a prompt. Unlike a regular shell, however, IOS has a set of different command modes. These modes enable certain functions for modifying particular aspects of the CISCO switch (as an example, configuring a specific network interface is available in one mode, while configuring general switch behavior is available in a different mode. We will introduce each mode and some features exposed in each mode in the coming sections.

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

Each CISCO Switch is connected to two computers in the Coover 2061 lab. Odd numbered computers are connected to the management port of a CISCO switch. These computers will be responsible for configuring the CISCO Switch properties and behavior. This will mean that odd computers will be performing most of the operations for this lab. The even numbered computers are connected to the high data line "GigabitEthernet 1/0/1". In this lab, the even numbered computers will be connected to each other in accordance with the configuration specified by the odd computer through the management port. While the even computer will not have any special configuration commands to give to the CISCO Switch, the odd computer will. The first step for the odd computer is to SSH into the CISCO Switch management port. Follow the table below.

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 a list of switch-host setups in Coover 2061. 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#
```

Let's take a look at commands available in the IOS terminal.

IOS Terminal Usage

As with any terminal, there are a certain list of commands available to you. You can, for instance, invoke help by using the **`help`** command.

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

You can get a complete list of commands available by typing

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

It may be helpful to note that you can follow any command in Cisco IOS XE with a question mark to receive additional information about that command. For example, with the `ping` command, you could type **`ping ?`** in order to obtain more information about the possible parameters/subcommands you can issue with **`ping`**.

Additionally, when your terminal does not have enough room to display the information available, you will see `--More--` at the bottom of your terminal window. Pressing **Space bar** will give you the next "page" and pressing **Enter** will give you the next line. To avoid having to scroll to the end of the `--More--` view after you have found the information you were looking for, you can exit the `--More--` view by pressing any other key.

In IOS XE, if it is possible, commands can be shortened as long as there is only one command with no ambiguity that it will match with. For example, you can invoke help by typing "he".

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

Obviously, this example isn't incredibly helpful as 'ping' is a fairly short command, so let's introduce some longer commands.

Displaying the Current Configuration

You will often find it beneficial to know how your switch is configured. To perform the following commands, you need to be in Privileged EXEC Mode, which is the mode that you enter when you start up:

```
co2061-9300-01#show running-config      (Display details of the running configuration)
co2061-9300-01#show interfaces          (Display details of the configuration of interfaces)
co2061-9300-01#show startup-config      (Display the startup configuration)
co2061-9300-01#show ip route            (Display the current IP routing table)
co2061-9300-01#show ip interface brief  (Display IP and status of the interfaces)
```

To know which PC is connected to which interface on the switch, use the following command to see the status of the interface.

```
co2061-9300-01#show ip interface brief
```

For example, if the PC is currently connected to the interface GigabitEthernet 1/0/1, then you should see the corresponding output as following:

Interface	IP-Address	OK?	Method	Status	Protocol
Vlan1	192.168.1.1	YES	NVRAM	down	down
GigabitEthernet0/0	192.168.77.x	YES	NVRAM	administratively down	down
GigabitEthernet1/0/1	unassigned	YES	unset	up	up

Note that these values will not be modifiable until you enter Global Configuration mode, as the commands are not available under Privileged EXEC Mode. Likewise, if you enter Global Configuration mode, commands that you use in Privileged EXEC Mode may not be accessible. As an example, the above commands to show the configuration are available under Privileged EXEC Mode. To modify them, you have to enter Global Configuration mode, but in this mode, you cannot show the current configuration as the applicable commands from above are unavailable from this mode.

Since shortened commands are applicable, note that instead of typing **`show running-config`**, you can simply type **`show run`** and the running configuration will be displayed.

The next section will introduce the command modes and what can be accomplished in each.

Understanding Command Modes

As mentioned earlier, each command mode has different functions that can be performed while in that mode. There are four command modes in IOS XE:

Privileged EXEC Mode (Enable Mode)

When you log in to a switch, you are presented with a command line interface, and you are in Privileged EXEC Mode. Privileged EXEC Mode is similar to root privileges on a UNIX machine. Entering the Privileged EXEC Mode requires a password. In this mode, you can read configuration files, reboot the switch, etc. To configure parameters of the switch, one needs to proceed from Privileged EXEC Mode to the Global or Interface Configuration Modes.

User EXEC Mode (User Mode)

In this mode, only a limited number of commands can be executed, and no configuration parameters can be read or modified.

Global Configuration Mode

In this mode, global system parameters can be modified.

Interface Configuration Mode

In this mode, parameters of a specific interface can be modified.

Table 1 describes how to access and exit Cisco IOS XE command modes. It also shows examples of the command prompts that are displayed while in each mode.

Table 1 – Accessing and Exiting Command Modes

Command Mode	Access Method	Prompt	Exit Method
Privileged EXEC	Log in	**`Router#`**	Use the **`exit`** command or the **`logout`** command.
User EXEC	From privileged EXEC mode, use the **`disable`** command	**`Router>`**	Use the **`exit`** command or the **`logout`** command.
Global configuration	From privileged EXEC mode, use the	**`Router(config)#`**	To return to privileged EXEC mode from global

	configure terminal command.		configuration mode, use the **exit** command, **end** command, or press Ctrl+Z
Interface configuration	From global configuration mode, specify an interface using the **interface** command.	**Router(config-if)#**	To return to global configuration mode, use the **exit** command. To return to privileged EXEC mode, press Ctrl+Z or use the **end** command.

Using Privileged EXEC Mode

Picking up where we left off, you should now be logged into the switch in Privileged EXEC Mode. You should see the Privileged EXEC prompt (the switch number varies depends on which switch you actually logged into):

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

In this mode, you can query and set the operation and configuration of the switch. Most of your system configuration verification will occur in this mode. Again, you can get a complete list of commands by typing

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

Using Global Configuration Mode

To modify system wide configuration parameters, such as IP addresses, routing algorithms, the routing table, etc., you must be in the Global Configuration Mode. You can enter the Configuration Mode only from the Privileged EXEC Mode by typing

```
co2061-9300-01#configure terminal
```

The argument terminal tells the switch that you will be entering configuration commands from the terminal console. Alternatively,

```
co2061-9300-01#conf t
```

will also let you enter Global Configuration Mode. The command prompt in the Global Configuration Mode is

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

Now you can type global configuration commands, such as adding or removing routing table entries. You can once again get a complete list of commands available in this mode by typing

```
co2061-9300-01(config)#?
```

You may depart the Global Configuration Mode and return to the Privileged EXEC Mode by typing:

```
co2061-9300-01(config)#exit
```

Using Interface Configuration Mode

To modify the configuration parameters of a specific interface, you must enter the Interface Configuration Mode. You must be in the Global Configuration Mode to enter this mode.

To enter the Interface Configuration Mode for an interface, you have to enter the keyword **interface** followed by the interface name:

```
co2061-9300-01(config)#interface GigabitEthernet 1/0/1
```

where GigabitEthernet 1/0/1 is the name of the interface in this example. You can always check the interface names by using the following command when you are in the Privileged EXEC Mode:

```
co2061-9300-01#show ip interface brief
```

Once in Interface Configuration Mode, you will see the following prompt:

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

Now you can type commands to configure the interface. You can get a complete list of commands by typing

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

Additionally, you can disable and enable interfaces as follows:

```
co2061-9300-01(config-if)#shutdown        (Disable interface)
co2061-9300-01(config-if)#no shutdown     (Enable interface)
```

You can exit Interface Configuration Mode and return to the Global Configuration Mode by typing

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

You can return to Privileged EXEC Mode by instead pressing Ctrl-Z from the Interface Configuration Mode.

Using User EXEC Mode

There is also the User EXEC mode, which is useful for limiting the commands available to certain users. For the purposes of this lab, you will, on the other hand, find User EXEC Mode to be of little use.

To change to the User EXEC Mode, you need to exit from the current Privileged EXEC Mode by typing:

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

As stated earlier, you will not be able to change any configuration parameters while in User EXEC Mode. You will also be unable to re-enter Privileged EXEC mode unless you logout and re-login to the switch via ssh.

Example: Setting an IP Address for a Port

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 change the functionality of any of the interfaces from a “switch port” to a “routed port”. 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 192.168.14.1 255.255.255.0
```

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

```
co2061-9300-01#show running-config
```

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 192.168.14.1 255.255.255.0
```

To configure the port back to a “routed port”, simply use the command:

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

Note: make sure you remove the IP address of GigabitEthernet 1/0/1 and change it back to a switch port if you tried above instructions.

Exercises

Each switch in the lab connects to two PCs. One (odd numbered machines in Coover 2061) is connected to the management port of the switch, and another one (even numbered machines paired to the odd one) is connected to the GigabitEthernet1/0/1 interface. Please refer to the table in the first page about this setup.

The topology is given in Figure 1. Use this topology for the exercises.

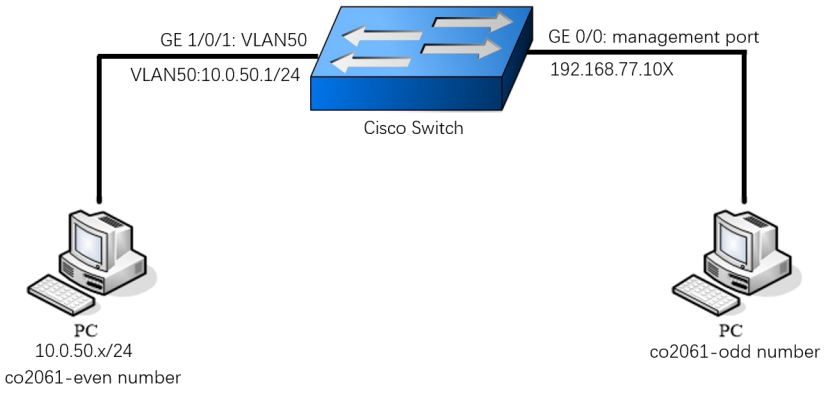

Figure 1 – Network topology for the exercises

Exercise 1 - VLAN

VLAN (Virtual Local Area Network) is a logically separate IP subnetwork which allows multiple IP networks and subnets to exist on the same-switched network. VLAN is a logical broadcast domain that can span multiple physical LAN segments. By using VLAN, a network administrator will be able to group together stations by logical function, or by applications, without regard to physical location of the users.

a. Set up a VLAN on the switch.

In the Global Configuration Mode, use the following command to create a new VLAN. Note that lowercase x could be any number you prefer as long as it is not 1 (1 is the default VLAN on the switch and should not be modified). In this lab, however, you will use vlan 50.

```
co2061-9300-01(config)# vlan 50
```

After you enter the above command, you will be in VLAN Configuration Mode. Enter the following command to assign the name “lab7” as the name of the VLAN:

```
co2061-9300-01(config-vlan)# name lab7
```

Now **exit** to the Global Configuration Mode and use the following command to enter the Interface Configuration Mode for the VLAN you just created.

```
co2061-9300-01(config)# interface vlan 50
```

This is a return to Interface Configuration Mode, except that we are configuring our switch’s interface to the VLAN we just created. We can therefore use the following command to assign an IP address for this VLAN just as we did in the example from earlier. It is good practice to explicitly include the VLAN number in the IP address to keep the network hierarchy organized.

```
co2061-9300-01(config-if)# ip address 10.0.50.1 255.255.255.0
co2061-9300-01(config-if)# no shutdown
```

The VLAN should now be created, but we can verify this by using the following commands in Privileged EXEC Mode:

```
co2061-9300-01# show vlan
co2061-9300-01# show run
```

***Task 1*: Include the output of**

1) show run
2) show vlan

that is related to what you have configured in this step. (10 points) For these tasks, do not simply include the entirety of the output; **only include the relevant parts that have been configured in the previous steps**.

b. Configure and connect one PC to the VLAN.

When you run "**`show vlan`**" from the previous step, you should see that all the ports are currently assigned to VLAN1 (again, this is the default VLAN). Now, we need to add the interface that connects to the even-numbered PC (via GigabitEthernet1/0/1) to the VLAN we just created. Go to the Interface Configuration Mode for GigabitEthernet1/0/1, and type the following commands:

```
co2061-9300-01(config-if)# switchport
co2061-9300-01(config-if)# switchport mode access
co2061-9300-01(config-if)# switchport access vlan 50
```

Next, we are going to assign a static IP address to the PC that is connected to GigabitEthernet1/0/1. It is now time to bring in the even-numbered PC, which has not been involved in many of the operations up until now, but is vital for ensuring that your setup this far is valid. Execute the following commands on the even-numbered PC. Note that, as IP addresses go, X can be any number in the range of 2 to 254 without any problems. For this lab, however, you will let X=2.

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 p2p2 10.0.50.X netmask 255.255.255.0
sudo /sbin/route add -net 10.0.50.0 netmask 255.255.255.0 gw 10.0.50.X p2p2
```

Use "show run" and "show vlan" again to verify the configurations.

***Task 2*: Include the output of**

1) show run (Use this command in odd-numbered/Management Port pc)
2) show vlan (Use this command in odd-numbered/Management Port pc)

that is related to what you have configured in this step (10 points)

***Task 3*: test your connection**

1) ping the VLAN50's address (10.0.50.1) from the terminal of the even-numbered PC.
2) ping the even-numbered PC (10.0.50.2) from the switch.

Include the screenshots for ping results, and comment on your observations of the results (10 points)

***Task 4:* observe your pings in Wireshark**

Open an instance of Wireshark on your even computer and send the pings from Task 3. What difference, if any, do you observe between the pings sent from (and received by) the even computer to your CISCO switch? Include the screenshots of Wireshark, and comment on your observations of the results. (10 points) Keep Wireshark open as you will need it running for the next exercise.

Exercise 2 - DHCP

The previous example is a simple way of setting up a single interface to receive an IP address. However, in busier environments, it is simply infeasible to expect the network administrator to manually assign an IP address to every connecting device. Therefore, in this next section, we will use Dynamic Host Configuration Protocol (DHCP) to assign IP addresses in lieu of the static IP addresses that we've assigned thus far.

a. Set up the switch to assign IP addresses to PCs attached to the **`10.0.50.1`** VLAN. It is important that the switch does not hand out the IP for its own interface (`10.0.50.1`). This can be prevented by switching to Global Configuration mode and entering the following command:

```
co2061-9300-01(config)# ip dhcp excluded-address 10.0.50.1
```

also exclude addresses 10.0.50.2, 10.0.50.3, and 10.0.50.254

You can exclude all addresses within a specified range as well by using:

```
co2061-9300-01(config)# ip dhcp excluded-address 10.0.50.1 10.0.50.3
```

Next, a DHCP pool must be created and assigned the necessary parameters. While still in Global Configuration mode, enter:

```
co2061-9300-01(config)# ip dhcp pool VLAN50
```
(VLAN50 is the name of the dhcp pool.)

Once you hit enter, you will be in DHCP Configuration mode. Next, establish the subnet of IP addresses that will be assigned by the switch. While in DHCP Configuration mode, enter:

```
co2061-9300-01(dhcp-config)# network 10.0.50.0 255.255.255.0
co2061-9300-01(dhcp-config)# default-router 10.0.50.1
co2061-9300-01(dhcp-config)# dns-server 4.8.9.50
co2061-9300-01(dhcp-config)# lease 0 2
co2061-9300-01(dhcp-config)# exit
```

The above commands specify the gateway and DNS addresses for the switch to hand out. The command **`lease 0 2`** specifies the duration of the DHCP lease as 0 days and 2 hours.

Then, execute the command **`debug ip dhcp server events`** from Privileged EXEC Mode. Finally, verify the DHCP settings were properly configured using the **`show running-config`** command.

Task 5: **Include the output of**

1) show run

that is related to what you have configured in this step. (10 points)

b. Next, you will need to simulate the introduction of a new connection to this VLAN. On the even-numbered PC, type **`ifconfig`** and note the IP address. Then perform the following steps:

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.

1. **`sudo /sbin/ifconfig p2p2 dynamic`** (this will allow your interface to change its address)
2. Next, reconfigure the p2p2 interface to accept DHCP information as follows:
    a. **`nmtui`**
    b. **`Select "Edit a connection"`**
    c. **`Select the p2p2 interface and press Enter`**
    d. **`Change the IPv4 CONFIGURATION to Automatic`**
    e. **`Select <Remove> next to the existing 192.168… IP address`**
    f. **`Make sure the Automatically Connect is checked (use spacebar to select)`**
    g. **`Go to the bottom and press OK, then back, and quit out of nmtui.`**

3. sudo /etc/init.d/network restart (Then, restart the interface)

Note that if your network restart doesn't work, try the following methods.

sudo /sbin/ifdown p2p2 OR sudo ifconfig p2p2 down
sudo /sbin/ifup p2p2 OR sudo ifconfig p2p2 up

Finally, type **/sbin/ifconfig** and verify that the PC has received an address handed out from the switch. In particular, the IP address should no longer be 10.0.50.2. Record the new IP address for the PC. On the odd-numbered computer, type **no debug ip dhcp server events**
to disable DHCP debugging.

Task 6: Provide a screenshot that demonstrates the final IP address from your computer was truly selected from the DHCP pool. (10 points)

Task 7: Wireshark should still be open at this point (If you closed Wireshark, reopen it and restart the network). Identify the packets that were sent to your even-numbered computer from the CISCO Switch in order to establish a DHCP IP address. Take a screenshot of the applicable packets (there should be at least four; you may have to filter the results to see only the necessary packets). Comment on your observation of these packets and the purpose you believe each of these packets serves. (10 points)

Task 8: You have performed quite a few steps to get to this point. On your odd-numbered computer, you should reverse all of the commands that you made to get to this point. Specify all of the commands required to return your CISCO switch to its condition at the beginning of the lab period (using the things that we have talked about in these lab instructions as a guide). Take a final snapshot of your list of commands. (10 points)