EEE3080F Lab 1

Basics of the Network Lab

Student Lab Manual

• Before you start the lab exercises see the lab administrator or EEE3080F tutor to get assigned to your routers.
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Basics

1.1 Resources used in the labs

Objective
To briefly introduce students with functions of resources used in the labs.

Workstations
The end systems that you use for the network labs are workstations. The lab manuals assume the use of Windows XP. Some of the commands are specific to the use of the Windows XP/2000/NT and they do not apply to other earlier systems like Windows 98.

Routers
A router is a network device that forwards network traffic along optimized paths. Router uses network protocols (set of network rules, and algorithms) to connect different network segments. A router allows users in a network to share a single connection to the Internet or a WAN.

A router can also be viewed as a specialized computer that is designed to forward packets very efficiently. Like a computer, a typical router consists of the following: CPU, Memory, System Bus, and network interfaces (Figure 1). These components are described below.

(a) CPU – The Central Processing Unit performs the computation and logical operations.

(b) Interfaces – These are the network connections through which packets transverse the router. The console and auxiliary ports are examples of the router interfaces. The console port is the asynchronous data port for the direct terminal access to the router. Remote router access can be provided by a modem connection to the aux port. The aux port can also be used for WAN connection.
(c) Memory – Routers have four types of memory:

1) ROM (Read Only Memory) – ROM contains power-on diagnostics, the bootstrap program, and the operating system software loader.

2) RAM (Random Access Memory) – RAM is for storing routing tables, the ARP cache, fast-switching caches, and packet queuing and buffering. This memory provides temporary (or Running) memory for the router’s configurations while the router is powered on. When the router is powered off, all the data in the RAM, including the running configuration and routing tables, will be cleared.

3) NVRAM (Nonvolatile RAM) – This is where the router’s configurations are saved. As this would suggest, the NVRAM content is retained when you power down or reboot the router.

4) Flash (Erasable, Programmable ROM) – Flash memory holds the operating system image (IOS Software) and macrocodes. Using flash memory allows you to update software without removing or replacing chips on the processor. Flash contents are retained when you power down or reboot the router.

Switches

Switches are link-layer devices that forward frames (link layer packets) based on LAN destination addresses. When a frame comes into a switch interface, the
switch examines the link layer destination address of the frame and attempts to forward it on the interface that leads to the destination.

A typical switch consists of all the hardware components that are explained above for a router.

**Cables**

Three different types of cables will be used for the labs. They are straight-through cable, console (rollover) cable and crossover cable. They differ from one another as to how the component wires of the cable are inserted into the pins of the adapters at the two ends of the cable (see Figure 2). In the figure, the numbers refer to pins in the adapters.

![Cable Diagrams]

Figure 2. Types of cables
1.2 PC Network TCP/IP Configuration

Objective

The purpose of this session is to gather network information (IP address, MAC address...etc), learn to use the TCP/IP Packet Internet Groper (ping) command, and learn to use the Traceroute command from the workstation. You will also be able to observe name resolution occurrences using DNS servers.

Introduction

An IP address is a unique network layer numbering system that end systems use in order to identify and communicate with each other. It is a dotted decimal notation with four numbers ranging from 0 to 255 separated by periods. The numbers currently used in IP addresses range from 1.0.0.0 to 255. 255. 255. 255, though some of these values are reserved for specific purposes. The decimals represent Octets of the bits in the binary representation of the IP addresses. For example, 255 is equal to $2^8$ and represents 11111111.

This does not provide enough possibilities for every Internet device to have its own permanent number. Subnet routing is one of the methods currently in practice to allow LANs to use the same IP address as other networks elsewhere, though both are connected to the Internet.

A Subnet (short for subnetwork) is a division of the network that is identified by a subnet mask. A subnet mask is an IP address that is used to tell how many bits in an Octet(s) identify the subnet and how many bits provide room for host addresses. For example, the Subnet Mask 255. 255. 255.0 tells that the first 24 bits represent the subnet, while the rest 8 bits identify the hosts in the subnet.

A default gateway is a node on a computer network that serves as an access device to another network. The default gateway address is usually (and applies to this lab) an interface belonging to the LAN’s border router.

This lab is a non-destructive lab and can be done on any machine without concern of changing the system configuration. It should be performed in a classroom (or other LAN environment) that connects to the Internet so that the computer that you use has an IP address.

Packet Internet Groper (ping) command is used to provide a basic test of whether a particular host is operating properly and is reachable on the network from the testing host. It provides estimates of round trip time and packet loss rate between hosts.

The traceroute (tracert) traces all the routers that a network layer packet has to pass through to get to a destination.
Preparation

A workstation connected to the internet is required.

Experiment

1. Verify the connectivity of your workstation to the internet.
2. Open the Command Prompt of the operating system using either of the following methods:
   - Click on Start > All Programs > Accessories > Command Prompt or
   - Click on Start > Run, enter cmd (short for command) and click on ok.
   A Command Prompt screen should open.
3. Gather TCP/IP configuration information:
   - Type ipconfig (short for IP configuration) and press Enter.
   The screen will show the IP address, subnet mask, and default gateway for your computer’s connection.
   - Notice the values in the Command Prompt. The IP address and the default gateway should be in the same network or subnet, otherwise this host would not be able to communicate outside the network. In Fig. 3, the subnet mask tells us that the first three octets of the IP address and the default gateway must be the same in order to be in the same network.

![Command Prompt](image)

**Figure 3. The TCP/IP configuration information of a workstation**

4. Check more detailed TCP/IP configuration information:
   - Type ipconfig /all and press Enter. What are the DNS and DHCP server addresses? What are their functions? What is the MAC of the network interface card?
5. Ping the IP address of another computer. Note that for the ping and tracert commands to work the PC firewalls have to be disabled. Why do you think this is so?
Ask the IP address of the workstation that is being used by another group of students. Then type **ping**, space, and the IP address that you received, then press **Enter**. Notice the outputs.

Fig. 4 shows a successful result of a ping to a given IP address.

![Ping Output Image](image)

**Figure 4. A successful result of a ping to a certain IP address**

6. Ping the IP address of the gateway router from the details that have been observed in the output of step 4 above. If the ping is successful, it means that there is a physical connectivity to the router on the local network and probably the rest of the world.

7. Ping the Loopback IP address of your computer. Type the following command: **ping 127.0.0.1**.
   The IP address 127.0.0.1 is reserved for loopback testing. If the ping is successful, then TCP/IP is properly installed and functioning on this computer.

8. You can also ping using names like websites. Ping the IP address of the cisco website.
   Type **ping**, space and **www.cisco.com**, then press **Enter**. Notice the outputs. A DNS server will resolve the name to an IP address and the ping will be successful only in the existence of the DNS server.

9. Ping **www.ee.uct.ac.za** and observe the results. Is there a difference in time between the results shown by pinging **www.cisco.com** and **www.ee.uct.ac.za**. If so why and if not why?

10. Trace the route to the Cisco website. Type **tracert www.cisco.com** and press **enter**. In a successful output, you will see listings of all routers the tracert requests had to pass through to get to the destination.
11. Trace the route to the website of the Department of Electrical Engineering. Type `tracert www.ee.uct.ac.za` and press `enter`. The output should take less time than that of step 9.

11.

### 1.3 Connecting 2 Computers together using a Crossover cable

This exercise should be carried out between 2 students who are sitting on adjacent computers. PC1 will be connected to PC2, PC3 to PC4, PC5 to PC6 and so on.

1. Go to Control Panel, Network Connections, right click on Local Area Connections, click on Properties, Internet Protocol (TCP/IP) and select Use the following IP address. Enter the IP address, subnet mask and default gateway (the IP address for the router) and click `ok`. Here use the following values:

   - IP address (of your computer): 10.128.20.use the label number of your PC (e.g 1 for PC1)
   - Subnet mask: 255.255.0.0
   - Default gateway: 10.128.20.254
2. Find out the IP address of the PC connected to your PC. Ping the IP address of the PC connected to your PC. If the ping is successful, it means that the 2 PCs are connected together and the TCP/IP configuration is okay.

1.4 Establishing a Console Session with HyperTerminal

Objective

To introduce users to using the HyperTerminal program.

Introduction

Switches and Routers are the network processors that will be used throughout the network labs. Cisco and Huawei switches and routers are provided for the practical labs. They all apply very similar installation procedures and commands. Therefore, we will explain the steps to interact with a router. Students should use similar concepts to interact with the other devices in the later labs.

HyperTerminal is a simple Windows-based terminal emulation program that can be used to connect to the console port on the router. Establishing a Console session with a HyperTerminal is the most basic way to access a router for checking or changing its configuration. This will provide the router with a keyboard and monitor.

Preparation

The following resources are required:

- Workstation
- Router
- Console (rollover) cable

Diagram
Figure 6. A router connected to a workstation using a console cable

Experiment

1. The router should be turned off. Connect a console (rollover) cable to the console port on the router and the other end to the PC with a DB-9 adapter to the COM1 port.
2. From the windows taskbar, locate the HyperTerminal program:
   \texttt{Start > All Programs > Accessories > communications > HyperTerminal}
3. Name the Hyperterminal session:
   At the “Connection Description” popup, enter a name in the \textit{Name:} field and select \texttt{OK}.

![Connection Description](image)

Figure 7. Naming a Hyperterminal session

4. Specify the computer’s connecting interface:
   At the “Connect To” popup, use the drop down arrow in the \textit{Connect using:} field to select \texttt{COM1} and select \texttt{OK}.
5. Specify the interface connection properties:
   At the “COM1 Properties” popup, use the drop down arrows to select:
   - Bits per second: **9600**
   - Data bits: **8**
   - Parity: **None**
   - Stop bits: **1**
   - Flow control: **None**
   Then select **OK**.
   Now the Hyper Terminal session window should come up.

6. Plug in the power cord of the router and turn on the router. Or if the router is already on, press the **Enter** key.
   Now, there should be a response from the router.

7. After a moment, when the command “press RETURN to get started” appears press **Enter**. You will finally see the command prompt:
   **Router>**

8. To close the console session, select **File > Exit**. When the hyper terminal disconnect warning popup appears, select **Yes**. Again when it asks if the session is to be saved, select **Yes**.

9. To reopen the connection, open the HyperTerminal as in (2) above. At the “connection Description” popup, select **Cancel**. Then select: **File > Open** and double click on the file name.

10. To terminate the HyperTerminal session, close the HyperTerminal session and shut down the router.
1.5 Common Commands

Objective
To familiarize students with common commands used to interact with switches and routers.

Introduction
To connect to the router we execute Internetworking Operating System (IOS) commands. IOS is a software that runs on all routers and allows the user to manage and configure the processes that occur on the router. IOS is command-line interface (CLI) software which accepts user commands and displays router output.

As a security feature, Cisco IOS provides separate commands into two different access level modes; user EXEC level and privileged EXEC level.

User EXEC level: allows a person to access only a limited number of basic monitoring commands. In this mode, the router or switch prompt is displayed as:

hostname>

The right arrow (>) in the prompt indicates that the router or switch is at the user EXEC mode.

Privileged EXEC level: allows a person to access all router commands (including configuration and management) and can be password protected to allow only authorized people to access the router. In this mode the symbol "# " is displayed as the prompt.

hostname#

There is also a sublevel of the Privileged Exec level, the configuration level. From privileged mode, you can monitor devices, view the status of interfaces, or run debugging. However, if you want to change the configuration of the router, you must enter configuration mode.
In this section you will be introduced to basic router commands that will run either in the user exec or privileged level. You are required to familiarize yourself by using the commands as instructed and looking at the outputs.

**Preparation**

The following resources are required:

- Workstation
- Router
- Console (rollover) cable
- Crossover cable

Connect the console cable to the router port labeled “CON”, in blue, at the front or the back of the router, and to the back of the PC on COM1. Connect the crossover cable to the port labeled f0/0, in yellow, at the front or the back of the router, and to the back of the PC on the lower network card.

**Experiment**

1. Start a HyperTerminal session.
2. Now you should be prompted with **Router >** which shows that you are working in the **user exec** level. Use the Help command **?** to see the list of available commands in the **user exec** level.

   **Router > ?**

3. When the word “more” appears, press the space bar to display the next page of information.
4. Practice the frequently used user exec commands from table 1 by typing the commands and pressing **Enter**.

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Router &gt; show</strong></td>
<td>Show running system information</td>
</tr>
<tr>
<td><strong>Router &gt; where</strong></td>
<td>List active connections</td>
</tr>
<tr>
<td><strong>Router &gt; sh?</strong></td>
<td>List all commands that begin with “sh”. Note: there is no space before ? Try also arbitrary letters other than “sh”.</td>
</tr>
<tr>
<td><strong>Router &gt; show ?</strong></td>
<td>List all available arguments that match with some command (eg. show) Note: there is space before ? Try also valid command words other than “show”.</td>
</tr>
</tbody>
</table>

**Table 1. Few frequently used commands in the User Exec level.**
Commands are often abbreviated to the minimum number of letters that identifies a unique selection. The CLI is smart enough to recognize abbreviated commands. For example “sh” would be enough instead of “show” to issue the command: Router> show ? because “show” is the only valid command that begins with “sh”. In addition, if you enter the first few letters of a command and hit Tab, it will display the remainder of the command.

5. Press the up arrow to see or reuse the last entered command. Press it again to go to the command before that. Press the down arrow to go back through the list.

6. Enter the Privileged EXEC level.
   
   **Router > enable [Enter]**
   
Enter the password given to you by the lab administrator when prompted.

7. Use the Help command ? to see the list of available commands in the **privileged** level.
   
   **Router # ?**
   
   Practice the frequently used privileged commands from table 2.

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Router# dir</strong></td>
<td>List files on a file system</td>
</tr>
<tr>
<td><strong>Router# show ip interface</strong></td>
<td>Learn about the status of the interfaces of this router</td>
</tr>
<tr>
<td><strong>Router# show run</strong></td>
<td>View the configuration of the router</td>
</tr>
<tr>
<td><strong>Router# show running-config</strong></td>
<td>View the Running Configuration. (There are two different configurations stored on the router; the Running Configuration and the Start-Up Configuration. The Running Configuration is your current, working configuration. It is stored in the RAM memory of the router.)</td>
</tr>
<tr>
<td><strong>r1# show startup-config</strong></td>
<td>View the Start-Up configuration. It is the configuration that is loaded when the router initializes its boot sequence and it is stored in the NVRAM of the router.</td>
</tr>
<tr>
<td><strong>Router# show version</strong></td>
<td>Find the version and system information about your router</td>
</tr>
<tr>
<td><strong>r1# show memory</strong></td>
<td>Find memory information about the router</td>
</tr>
</tbody>
</table>
Table 2. Few frequently used commands in the privileged level.

8. Enter the Configuration level.

Router# configure terminal [Enter]

Practice the frequently used configuration commands from table 3. Use also the help command “?” to see available commands.

<table>
<thead>
<tr>
<th>Command</th>
<th>purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Router(config)# hostname r1</td>
<td>Change the router name from “Router” to “r1”. The command prompt will look now r1(config)#</td>
</tr>
</tbody>
</table>
| Router(config-if)# no statement | Delete a configuration statement line. Eg. to reverse the result of the router name change: r1(config)# no hostname r1  
Eg. Router> no ip address 192.168.13.1 255.255.255.0  
To delete the statement ip address 192.168.13.1 255.255.255.0 |
| Router(config)# <CTRL>+Z | Switch from configuration to privileged mode |

Table 3. Few frequently used commands in the configuration level.

9. In the Privileged EXEC level use the show command to see detailed information about the network interfaces of the router.

Router # show interfaces [Enter]

10. Now enter the Configuration level to assign an IP address to the router.

Router# configure terminal [Enter]

Use an IP address given by the tutor (eg. 10.128.20.254) and subnet mask 255.255.0.0 for the values. Then do the following:

Router(config) # interface fa 0/0 [Enter]

This will ensure that you are configuring the 0/0 interface since there could be multiple interfaces with names 0/0, 0/1 …etc.

Router(config-if ) # ip address (given ip address) (given subnet mask) [Enter]

Router(config-if ) # no shutdown [Enter] This will ensure that the ip address configuration is administratively up. i.e. The ip address is being used for routing purpose.
Using 255.255.0.0 for the IP address specifies the subnet and the workstation and the router should be in the same subnet mask for them to be able to communicate. Connect the router to the PC using the Crossover cable. Change the IP address of your computer by doing the following.

Go to **Control Panel, Network Connections**, right click on **Local Area Connections**, click on **Properties, Internet Protocol (TCP/IP)** and select **Use the following IP address**. Enter the IP address, subnet mask and default gateway (the IP address for the router) and click **ok**. Here use the following values:

- **IP address (of your computer):** 10.128.20.1
- **Subnet mask:** 255.255.0.0
- **Default gateway:** 10.128.20.254

11. To check the connection between your computer and the router, ping the ip address of the router (go back to section 1.2 to find the syntax). Type ping from the PC DOS window and from the router privileged EXEC login window (in hyperterminal).

### 1.6 Setting Router Passwords

So far we have been working on a router with no access restrictions enabled. In the real world, this is not the case. The most basic form of access restriction would be by the use of passwords. Passwords can be set for console access, telnet access and privileged EXEC access. Table 4 below illustrates the various password commands on a Cisco router. The commands have to be typed out in privileged EXEC mode.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Cisco Command</th>
</tr>
</thead>
</table>
| Set a console password to cisco | Router(config)#line con 0  
Router(config-line)#login  
Router(config-line)#password cisco |
| Set a telnet password. This command is also used to enable telnet access for up to 5 simultaneous logins | Router(config)#line vty 0 4  
Router(config-line)#login  
Router(config-line)#password cisco |
| Stop console timing out in cases of inactivity | Router(config)#line con 0  
Router(config-line)#exec-timeout 0 |
Table 4: Password configuration commands for a Cisco router.  
(http://www.tomax7.com/mcse/cisco_routerconfig.htm)

Experiment

1. Using the commands shown in Table 4 above set the router console to cisco, the telnet password to cisco and the enable secret password to cisco. Type `exit` twice and exit from the console mode. Close the Hyperterminal program.

2. Open the Hyperterminal program and login using the console password. Go into privileged EXEC mode and ping your PC’s IP address. Were you successful.

3. From your PC command line window, or “RUN” dialog box, telnet to the router’s IP address and login. Go into privileged EXEC mode and ping your PC’s IP address. Were you successful?

4. To exit the privileged EXEC level use the command

   **Router # exit [Enter]**

5. At the end of the practical lesson, close the Hyperterminal program and shut down the router.