IK1203 VT19 - Networks and Communication

Lab 3 – Network Addressing and Routing

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Task 1

Lab Preparation

1.1 Introduction

1.1.1 Purpose

This lab will give you some hands-on experience working with **Cisco** routers. The lab requires all of the knowledge that you have acquired in the previous two labs. A proper understanding of how to connect various network elements is also an essential prerequisite to this lab. To complete this lab in the time that has been allocated, students need to be familiar with Cisco router configurations. It is vital that the student knows how to activate, and configure a router interface with an appropriate IP address. Furthermore, it is necessary for students to know the functions of a router and to be able to explain why a router is needed to connect LAN segments.

Note: Before coming to the lab session, it is mandatory to go through the lab manual, in particular the appendix on configuring Cisco routers, which is given at the end of this manual.

IMPORTANT: You must bring a laptop with Ethernet port in the lab session.

1.1.2 Learning Objectives

Upon completion of this lab, students will be able to demonstrate:

- How a network can be designed and explain the design considerations.
- How to distribute an address range within an organization.
- How to connect network elements together.
- How to configure a router to connect different LAN segments together by adding static routes.
- How to troubleshoot a network for connectivity problem.

1.2 Lab Equipment

There are 5 working tables in our Networking Lab, each with a patch panel connected to a rack located inside the server room, as shown in Figure 1.1. Each rack has an identical setup as shown in Figure 1.2. The equipment is as follows:

- A patch panel that connects to the table in the working area.
- A hub used for sniffing traffic.
- HP2530 gigabit switch that connects to the management network of the networking lab infrastructure (subnet 192.168.0.0/24).
- Four Cisco 7301 routers (RTA-RTD from top to bottom).
- Four 100Mbps HP2524 switch.
- HP DL320e server that hosts 4 lab VMs, which are to be used as hosts (host A-D) in the lab. They run Ubuntu server 14.04.2 LTS.

Each rack is already connected to the table patch panel according to the topology in Figure 1.3. Throughout the lab session, students will sit and work in groups (4 students per group) at the first 4 tables (table1-4). Table 5 is reserved for the teaching staff's setup.

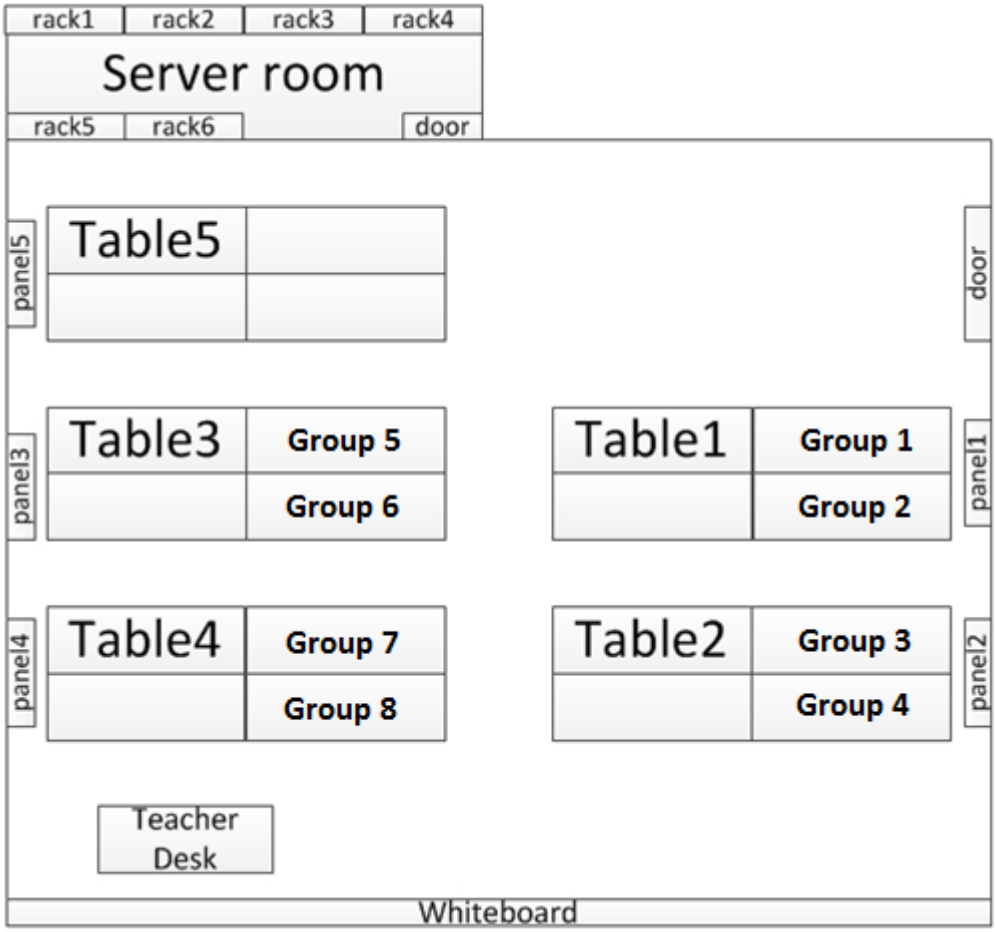

Figure 1.1: Networking Lab

1.3 Accessing the equipment on student rack

All routers and lab VMs can be accessed via the management network. You can use your laptop to connect to one of the management ports (port 1-4 on your patch panel). You should get an IP address automatically from the 192.168.0.0/24 subnet. You **MUST NOT** set your IP address manually when connecting to the lab network!

1.3.1 Accessing Cisco Routers

IMPORTANT: Don't execute any command until you finish this section and start Task 2. This section is just intended to provide you some introductory information about how the system works.

In order to configure the routers, you will have to access the router console via the terminal server. This can be done by connecting to the management network (port 1-4 on the table patch panel as shown in Figure 1.3) and SSH to the corresponding router. Note that the routers are relatively old and require you to use specific options when SSH. You must run the following command on your laptop: (password: `time2work`)

ssh -oKexAlgorithms=+diffie-hellman-group1-sha1 -c aes128-cbc student@192.168.0.1 -p 20XX
where XX is the port number (see details on which port connects to which router on Table 1)

For Windows users, it is recommended to use Putty to access the routers (**login as:** student **password:** time2work).

If you have problem, try to set parameters under Connection->SSH->Kex and Connection->SSH->Cipher.

Here are the list of routers on each table and their corresponding port that you should use to connect:

TABLE	ROUTER	PORT
1	RTA	2001
1	RTB	2002
1	RTC	2003
1	RTD	2004
2	RTA	2005
2	RTB	2006
2	RTC	2007
2	RTD	2008
3	RTA	2009
3	RTB	2010
3	RTC	2011
3	RTD	2012
4	RTA	2013
4	RTB	2014
4	RTC	2015
4	RTD	2016

Table 1.1: SSH ports for routers in the networking lab

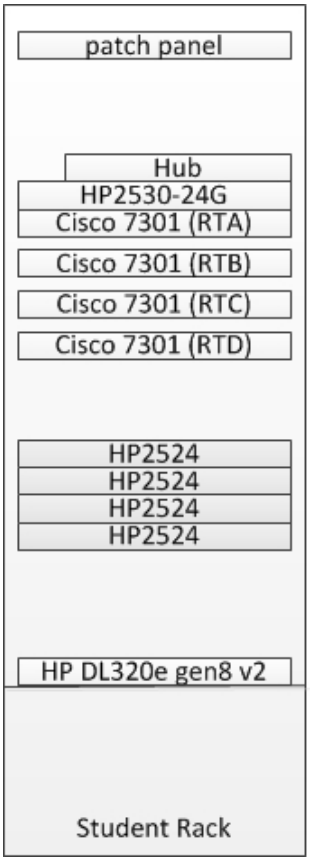

Figure 1.2: Equipment on the student rack

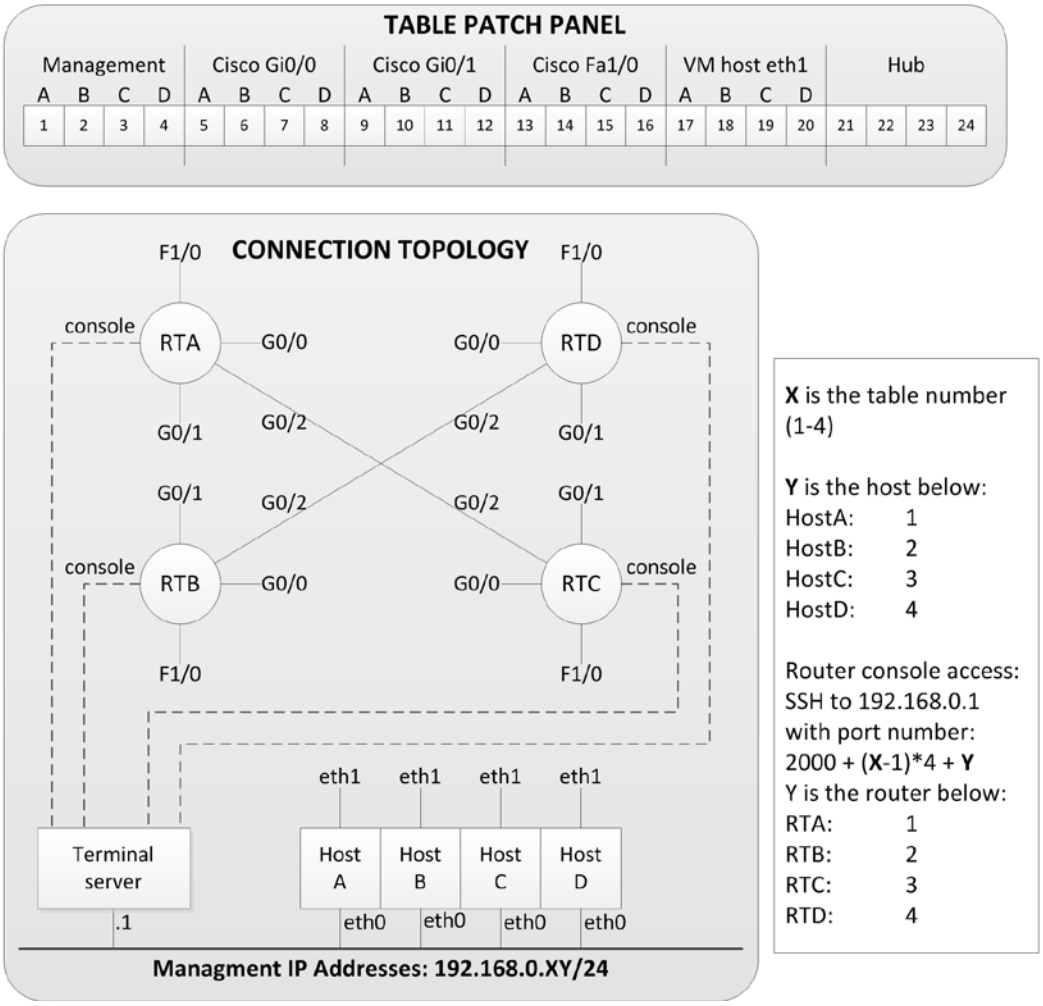

Figure 1.3: Lab topology

1.3.2 Accessing Lab VMs

Our lab VMs run Ubuntu 14.04.2 LTS. Thus, you will see that a host related command in our lab instruction is based on command for Ubuntu. Other Linux distributions might have different locations of files and different name for configuration script.

To access lab VMs, you must connect to the management network and SSH to a corresponding host as described above, for example

`ssh -Y student@192.168.0.x1` to access Table `x` host A.
`ssh -Y student@192.168.0.x2` to access Table `x` host B.
`ssh -Y student@192.168.0.x3` to access Table `x` host C.
`ssh -Y student@192.168.0.x4` to access Table `x` host D.

The credentials for lab VMs are: **username**: `student` **password**: `time2work`
(For Putty, Host Name (or IP address) should be the IP address given in the above commands and port number is 22)

IMPORTANT: **Don't** change **eth0** configuration on lab VMs! (The lab VM will be disconnected from the network)

Task 2

Setting up the Network

We will build up a small-scale network with layer 3 routers and analyze the routing of packets through the network from client to the server, as shown in Figure 2.1. The process involves dividing the total network range assigned to a group to several sub networks for three different LANs and then configure the equipment in order to communicate correctly within them. The groups have to configure the routers to make the network functional. Understanding the tools like ICMP echo (ping) and traceroute will help the students to get a clear idea about how to analyze and troubleshoot a network. After the network is fully connected and functional, then the student will have to start network services like DNS, DHCP and HTTP.

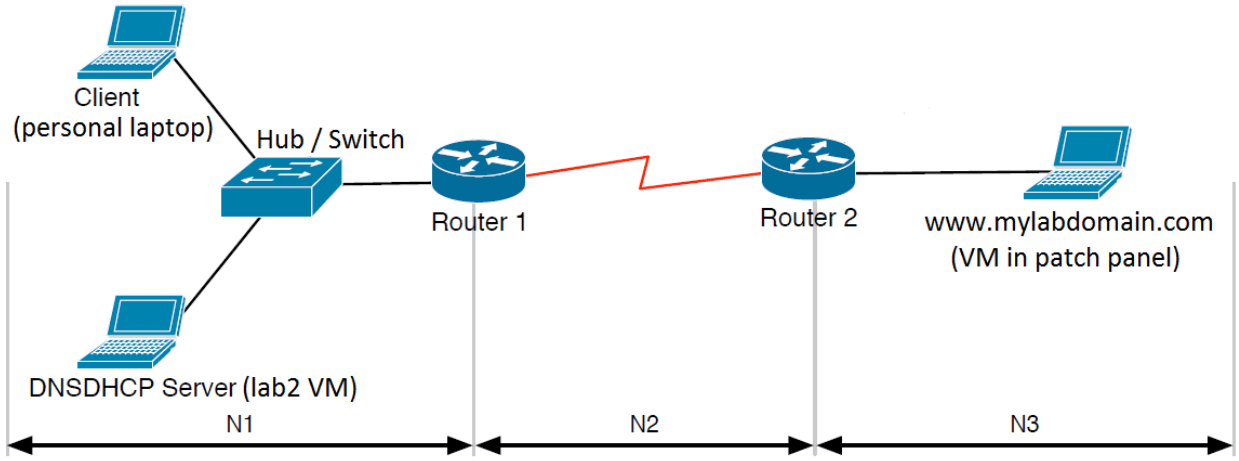

Figure 2.1: Network Topology

First step after a network topology is prepared is to assign network addresses to the nodes of the network. It needs careful design decisions to assign network addresses taking into consideration the need for future expansion of the network. The total address range assigned to you needs to be divided into optimized sub-ranges to be assigned to the LANs of the network.

You have been given the range **10.N.0.0/16** for the network topology shown above. N is your group number and ranges from 1 to 8 (group numbers correspond to the table where you are sitting, according to Fig. 1.1). Since there are three LANs in the network, you need to divide the network range into three parts. Taking into consideration the need for possible expansion of the network, the most efficient way to divide the range is as follows:

N1	N2	N3
10.N.0.0/18	10.N.64.0/18	10.N.128.0/18

Note that /18 refers to a subnet mask of **255.255.192.0**. The next step is to assign an IP address to each interface in the three LANs. In Figure 2.1, mark all the interfaces with the assigned IP (from the network ranges given in above table) and **show it to the lab assistant** before proceeding to the next step.

Now, you need to configure all the network equipment according to Fig. 2.1. However, before proceeding with the configuration, you need to identify which equipment on the table belongs to your group.

2.1 Identifying the equipment for each group

As shown in Figure 2.1, you need the following equipment for this lab:

- **Routers**: Each group needs to have access to **2 routers**. As shown in Figure 1.3, there are 4 routers on each table that will be shared by 2 groups. The odd numbered groups (1,3,5) will use the routers **RTA** and **RTC** while the even numbered groups (2,4,6) will use the routers **RTB** and **RTD**. Note that the routers **RTA-RTC** and **RTB-RTD** are already connected with a crossover cable inside the server room through **G0/2** interfaces. Hence, you do not need to connect the routers with a cable. Moreover, one more interface is required in each router apart from **G0/2** interface, for connecting them to hub/switch and VM in the patch panel. The odd numbered groups will use **G0/0** interfaces of the routers (slots 5 and 7 on the patch panel for **RTA** and **RTC** respectively) while even numbered groups will use **G0/1** interfaces of the routers (slots 10 and 12 on the patch panel for **RTB** and **RTD** respectively).
- **Hub/Switch**: As can be seen in Figure 1.3, there is a hub with 4 ports connected to slots 21-24 of the patch panel. Inside the equipment box, there is one switch available. The odd numbered groups will use the hub while the even numbered groups will use the switch.
- **VM in patch panel**: There are 4 slots on the patch panel for each of the 4 VMs. Since we need only one VM in patch panel, odd numbered groups can use any of the two VMs (**Host A** and **B**) on slots 17-18 while the even numbered groups can use any of the two VMs (**Host C** and **D**) on slots 19-20 of the patch panel.
- **Lab2 VM**: You can use the server VM that was used in lab2 for the configuration of **DHCP** and **DNS** servers. Before starting the VM, you need to go to Network Settings of the VM. Change **NAT** to **Bridged Adapter** for adapter 1 and select the Ethernet interface. Also you need to disable adapter 2. Then, you can start the VM.
- **Personal Laptops**: Each group needs to have 2 personal laptops with Ethernet ports, one is where lab2 VM is running, one acting as a Client as in Figure 2.1 (If it is really hard to find the second laptop with Ethernet port, at least one is needed running VMs from lab 2). Another personal laptop is required to connect to the management network using WiFi: networklab in order to configure the routers and VM.
- **Cables**: Each group needs to have 5 straight Ethernet cables which are available in the equipment box, color blue and white.

2.2 Configuring the Networks

In order to gain a better understanding, we will proceed with configuration of each LAN step-by-step. We will first configure the network **N1**, followed by **N3** and then we will proceed with the configuration of **N2**.

2.2.1 Configuring Network N1

The first step in the configuration of network **N1** is to configure the Router 1 in Figure 2.1 (i.e., **RTA** for odd numbered groups and **RTB** for even numbered groups). The router can be configured by accessing the router console as explained in Section 1.3.1. Do the following steps:

1. Connect your laptop to the management network.
2. Verify that you get an IP address from **DHCP** server of the management network by using **ifconfig** command (or **ipconfig** if you are using Windows).
3. **SSH** to the router that is reserved for your group, by following instructions in Section 1.3.1.
4. When you see an **OK** message, press enter twice and verify that you get access to the router console. It is likely that the router has been reset earlier and you will see the message below:

   ```
   Would you like to enter the initial configuration dialog? [yes/no]:
   ```

   Just answer `no` and press enter. Then, press another enter to accept the default answer to the next question.
5. Connect the router interface to a hub/switch with a cable, as assigned to your group (**G0/0** for odd numbered groups and **G0/1** for even numbered groups). Name the router as **RTA/RTB/RTC/RTD** depending on which router you are using and configure the router interface with an IP address by following the procedure described in Appendix Section A and B. (You should skip Section C for now)

Next step is to configure the lab2 VM. Make sure that you have changed the Network Settings of VM to **Bridged Adapter** and disabled adapter 2 before starting the VM. Configure the **eth0** interface of the VM with an IP address. You also need to assign an IP address to the Ethernet interface of your laptop where VM is running. This must be the same interface that was selected while changing the Network Settings of VM to **Bridged Adapter**. Connect your laptop to the hub/switch with a cable and try to ping the router interface (**G0/0** or **G0/1**) from inside the VM. You may need to disable your WiFi connection first. If it does not work, ask a lab assistant to help you. You should not proceed with the next step until it works.

Finally, you need to add the default gateway in the VM. The gateway should be the IP address assigned to the router interface (**G0/0** or **G0/1**). This can be done by entering the following command in the VM:

```
sudo route add default gw 10.N.x.x
```

where `10.N.x.x` is the IP address assigned to the router interface.

Note: you do not need to connect the Client laptop at this stage.

2.2.2 Configuring Network N3

First of all, you need to configure the Router 2 in Figure 2.1 (i.e., **RTC** for odd numbered groups and **RTD** for even numbered groups). This can be done by following the same steps as done earlier for Router 1. The only difference is that the router should be now connected to a VM in the patch panel, instead of a hub/switch. Note that you can only use the VMs that have been assigned to your group.

Next step is to get access to the VM in patch panel and configure the **eth1** interface of VM with an IP address (**IMPORTANT:** you must **NOT** change **eth0** interface!). The VM can be accessed by following the procedure described in Section 1.3.2. Verify that the IP address has been assigned correctly by using **ifconfig** command. Try to ping the router interface (**G0/0** or **G0/1**) from inside the VM. If it does not work, ask a lab assistant to help you. You should not proceed with the next step until it works.

Finally, you have to add a default gateway in the VM pointing to the IP address of router interface. This can be done by using the same command as described earlier.

2.2.3 Configuring Network N2

Now, you need to configure the **G0/2** interfaces of both routers which are already connected with a cable in the server room. Assign an IP address to the **G0/2** interface of each of the routers following the same procedure as described earlier. Now, try to ping the **G0/2** interface of Router 1 from lab2 VM and ping **G0/2** interface of Router 2 from VM in the patch panel. If it does not work, ask a lab assistant to help you. You should not proceed with the next step until it works.

Add a static route in both of the routers by following the procedure as described in Appendix. Carefully think about the parameters for `ip route` command. If you are not sure, discuss with a lab assistant before entering the command.

Try to ping the lab2 VM from the VM in patch panel and vice versa. It should now work if the routes have been added correctly inside the routers. Ask a lab assistant for help if it does not work.

2.3 Starting the DHCP/DNS/HTTP Servers

Now, you can start the **DHCP** and **DNS** servers in lab2 VM. However, note that before starting the servers, you need to configure them once again in order to make them work with the new network **10.N.0.0/18**, instead of

192.168.100.0/24. This can be done by changing your previous configuration from lab2 with new parameters. Be careful in deciding which parameters must be changed. You can refer to the lab2 manual to make sure that you have changed all the necessary parameters in order to make your configuration work with the new network. Here are a couple of hints for some of the parameters:

For DHCP server, under **Edit Client Options**, you should have the following parameters:

- **Domain name**: mylabdomain.com
- **DNS servers**: 10.N.0.x
- **Default routers**: 10.N.0.y

where 10.N.0.x corresponds to the IP address of lab2 VM (where DNS server is running) in Fig. 2.1 and 10.N.0.y corresponds to the IP address of Router 1 interface that is connected to the hub/switch, whereas N is your group number.

For DNS server, you should remove the existing **Address** records from lab2 and have two records as follows:

- **www.mylabdomain.com**: 10.N.128.z
- **ns1.mylabdomain.com**: 10.N.0.x

where 10.N.128.z corresponds to the IP address of VM in patch panel (where we will run HTTP server) in Fig. 2.1 and 10.N.0.x is the IP address of lab2 VM.

After making these changes, you should start the DHCP and DNS servers.

Next task is to start the **HTTP** server inside the VM in patch panel. You can remove the default apache server index webpage and create your group's own webpage by entering these commands:

```
cd /var/www/html
sudo rm index.html
sudo nano index.html
```

<HEAD>This is Group # N</HEAD>

Add your group number instead of N in the html file and then press CTRL-X to save and exit. Afterwards, restart the apache server. This can be done by using the following command:

```
sudo /etc/init.d/apache2 restart
```

2.4 Connecting the Client

After everything is configured in the network, the final step is to connect a Client laptop to the hub/switch. Force the Client to get an IP address from the **DHCP** server running inside the lab2 VM. This can be done by using the following command:

`ipconfig /renew` (in Windows)

`dhclient –v eth0` (in Linux)

Make sure that the Client got an IP address from the **DHCP** server within the range specified in **DHCP** server configuration. Try to ping the VM in patch panel which is now running the **HTTP** server. If the ping works, you can start a web browser and type `www.mylabdomain.com` in the address field. You should be able to see a Webpage, which indicates that you have properly configured your network. Call a lab assistant to show that it works.

2.5 And you are done…

Before concluding the lab, you need to reset both of the routers by going through the following steps:

1. Run `erase startup-config` command in privileged mode
2. Restart the router using `reload` command (Confirm and **DO NOT** save the configuration!)
3. You can disconnect from the router console access once the router starts to reboot. To do this, you simply need to terminate the SSH session by sending an SSH escape sequence, which is "**~.**" (Tilde followed by a full stop).

IMPORTANT: You must **"neatly"** pack up all the cables before getting signatures from the lab assistant.

Congratulations!!

This concludes the lab.

Appendix

Configuring Cisco Routers

A. Configuring a Router Name

One of the first basic configuration tasks is to name a router. This task helps with network management and uniquely identifies each router within a network. Use the global configuration mode to name a router. The name of a router is called the hostname and will be displayed as the system prompt. If a router is not named, then the system default will be Router.

1. Enter the privileged mode

```
Router>enable
Router#
```

2. Enter global configuration mode

```
Router#configure terminal
Router(config)#
```

3. Set the hostname parameter

```
Router(config)#hostname R1
R1(config)#
```

4. Exit global configuration mode

```
R1(config)#exit
R1#
```

IMPORTANT: Before you start configuring the router, make sure that there is no previous configuration on the routers. In order to erase the previous configuration, do the following:

4. Run `erase startup-config` command in privileged mode
5. Restart the router using `reload` command (Confirm and **DO NOT** save the configuration!)
6. After reboot, **DO NOT** enter the initial configuration dialog. Just type "**No**" when you get a prompt with the following question:

```
Would you like to enter the initial configuration dialog? [yes/no]: No
```

B. Configuring an Ethernet Interface

An Ethernet interface of the router can be configured by following the steps given below. By default, the interfaces are disabled. Use the **no shutdown** command to enable an interface. Use the **shutdown** command to turn off an interface if it needs to be disabled for maintenance or troubleshooting. The following set of commands is used to configure **Gigabit Ethernet 0/0** interface. The interface will change to up after entering these commands.

1. Enter global configuration mode

```
R1#configure terminal
R1(config)#
```

2. Enter interface mode

```
R1(config)#interface gigabitEthernet 0/0
```

3. Specify the interface address and subnet mask. (The IP address and netmask are only illustrative)

```
R1(config-if)#ip address 10.1.1.2 255.255.192.0
```

4. Turn on the interface

```
R1(config-if)#no shutdown
```

5. Exit configuration mode

```
R1(config-if)#exit
R1(config)#exit
R1#
```

C. Configuring Static Routes

Do the following steps in order to configure static routes:

1. Determine the desired destination network, its subnet mask and default gateway. A gateway can be either a local interface or a next hop address that leads to the desired destination. In the example given below, we have the following:

Destination Network	Subnet Mask	Default Gateway (Next hop)
10.1.128.0	/18 or 255.255.192.0	10.1.64.2

2. Enter global configuration mode

```
R1#configure terminal
R1(config)#
```

3. Type the ip route command with the address and subnet mask of the destination followed by their corresponding gateway from Step 1.

```
R1(config)#ip route 10.1.128.0 255.255.192.0 10.1.64.2
```

4. Exit global configuration mode

```
R1(config)#exit
```

Note: If you happen to misspell a command, the router interprets it as a host name and tries to contact a DNS server, as follows:

```
Translating "configr"...domain server (255.255.255.255)
```

Press ctrl-shift-6 to abort the DNS lookup. To disable this feature, you can use this command:

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

Appendix

This lab instruction has been through many iterations of updates by the following people:
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