CEG 3180 Lab Manual

Version 1.2

Compiled by
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Acknowledgement

We would like to thank Cisco for their generous donation of their 2600 and 3600 Routers. We also like to thank Mushi Jin, Hao Zhang, H. Yodollahi, D. Lapointe, F. Liang and L. Wong for their contribution in the verification, modification and extension of the contents of this manual.

Prof. O. Yang

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Version 1.0 (Jan 2002): ELG 4182 Lab Manual
Version 1.1 (May 2002): ELG 3182 Lab Manual
Version 1.2 (Jan 2004) ELG 3182 Lab Manual

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Introduction

The purpose of the experiments in this manual is to help you learn about the hardware, software, and configuration procedures of a router, and the associated protocols of networking and inter-networking. In the process, you will also be experiencing with the functionality of two popular types of Cisco routers.

1. Organization

This lab manual contains 4 labs:
Lab 1: Protocols, Hardware and Software Components of Internetworking
Lab 2: Configure Cisco Routers Using a Static Routing Protocol in a Single Area Network
Lab 3: Configure Cisco Routers Using the OSPF Routing Protocol in a Single Area Network
Lab 4: Configure Cisco Routers Using the OSPF Routing Protocol in a Multiple Area Network

Each lab explains the step-by-step procedure that the students must follow to get the correct output. Remarks are also provided to help the student understand the steps better. If there is any difficulty, please check your work and refer to the Appendix for further trouble-shooting guidance.

As part of the lab test and if time allows, you may also be asked to demonstrate one of the labs during the end of the term.

2. Router setup

The first three labs involve a network topology consisting of a pod of 3 routers connected like a triangle and routing between the routers is facilitated using the static or OSPF (Open Shortest Path First) routing protocol. The second network topology (used in lab 4) consists of connecting two networks (pods) of the first type together. So you should find enough groups to work together before you start!

Students will be assigned in groups of two or three, depending on the availability of lab time slots and teaching assistants, and each group is responsible to configure its own router. All groups in the pod are responsible to ensure communication among them, and eventually among the pods in lab4. All the router nodes are “pinged” to confirm that routing is properly set up. As well, the routing tables are displayed to ensure that proper routing is configured. So your duty is not just to get your router work, but also to work among your peers.

3. Conventions used in this report

1) Router **<R2 >** is used for demonstrating the lab procedure in lab 2**.**
2) Router **<R1 >** is used for demonstrating the lab procedure in lab 3**.**

3) Steps should be repeated for each **router** and **workstation** that you are configuring.
4) Commands and keywords are in **Boldface**.
5) At any point you may enter a question mark '**?**' for help.
6) Use **Ctrl-c** to abort configuration dialog at any prompt.
7) Default settings are in square brackets '**[ ]**'.
8) Comments are ***Italicized*** when accompanied by a definition or discussion of the term.

4. Grade

The tentative marking schemes for these labs are as follows:
Lab 1: 0%.
Lab 2: 30%.
Lab 3: 30%.
Lab 4: 40%.

Your instructor will inform you of any change. Your marks will consist of attendance, lab preparation and lab reports. Please record your results and observations in a lab book and have it initialized by the TA before leaving.

5. Preparatory material

You need to prepare the lab before reporting to the lab. This usually requires you to do certain reading and to answer the questions. The TA will come around to check your preparation. Some questions may be conducted to test your preparation.

Below are some materials you may find in the CEG3180 Lab Handbook, a companion handbook of this lab. Please also check your textbook for more details. The Cisco website http://www.cisco.com has more background knowledge about networking and specifications of its 2600/3600 Series Routers.

1) 7-Layer OSI Model
Discusses the various layers of the model and the purpose of such a model. This section is included to help students get an idea about the big picture of network engineering and where routing fits into the picture.

2) Common Networking Definitions
Definitions for networking terms such as LAN, WAN and backbone are given. Explained also are the purposes of common networking hardware such as routers, switches, and hubs.

3) Routing Protocols
The two different types of routing protocols, link state and distance vector, are described. Their operational differences are compared and analyzed. Also described are the differences between static and dynamic routing.

4) Subnet Masks
The purpose of subnet masks is explained. The configuration of subnet masks is also explained completely with examples.

5) Cisco IOS Commands
The Cisco IOS commands that the students will be required to use and understand during the laboratory will be presented.

6. Trouble-shooting

In the Appendix, you will find some experience your predecessors have gained which you can share. Hopefully, it will save you some time. The requirement of lab report is also listed at the end.

7. Rules and regulations

1) Unless otherwise instructed, please do not disconnect cables between routers.
2) **Never** open (unscrew) or move the routers, the PCs and other lab equipments.
3) **Absolutely** no eating, drinking, or smoking permitted in the laboratories.
4) Replace any accessory piece of equipment after you have finished.
5) As much as possible leave your coats in your lockers and only bring to the lab what you require for that lab. Place your bags and knack sacs under the benches to keep the bench tops clear.
6) When your lab is done, do not stay around. Exit the lab after cleaning up your station.
7) Remember to power off all instruments.
8) Ask TA to check your setting-up and results.
9) **Lab attendance** is required. Your TA will ask you to sign in the attendance sheet.

8. Lab report

1) You must submit your Lab Report no later than the due date required by your instructor.

2) One report for each group. Each of the students in a group must contribute and sign on the report. Any member of the group may be questioned on the content of the report to clarify some aspects if necessary.

3) The report must be typed on 8”x11” paper. Use the graph paper or appropriate software to plot the graphs or draw the tables. Bring a floppy disk to the lab to save necessary output for your report.

4) The requirement of a lab report is to give **sufficient and necessary** information so that someone else could repeat exactly what you did without having to consult any document except your report, so the report must provide most of the following information which are necessary:
    a. Your name, student number, lab time, group number, or station number

b. An introduction
c. Objectives of the experiment
d. Preparation questions
e. Instruments list
f. Description of the test set-up and the experimental procedure
g. The results you get during the experiment
h. Difficulties and problems you encountered
i. Tabulate the measurement data (original data)
j. Calculations or graph plotting
k. Conclusion questions
l. Problems you encountered during the lab
m. Discussions about the lab, results or background of configuring the routers
n. Conclusions

5) The above contents are not exactly the ordered items of your report. Try to organize each part with your own words but not just copy the handbook or the manual. Redundant description, output or discussion should be **avoided** to keep the report in a reasonable length.

Lab 1
Protocols, Hardware and Software Components of Internetworking

Objectives
To learn about the hardware and the software components of the Cisco2600 and 3600 series routers, and to acquire general knowledge of networking protocols.

Preparation
1) Read Chapter 1 of the Lab Handbook to familiarize yourself with the terminologies of protocols.
2) Read Chapter 2 of the Lab Handbook to familiarize yourself with the terminologies of Cisco Hardware components.
3) Read Chapter 3 of the Lab Handbook to familiarize yourself with the terminologies of Cisco Software components.
4) Read through the part of the Network Layer in your text.
5) Browse Cisco website at http://www.cisco.com and search for any specification of Cisco2600 and Cisco3600 series routers. Bring the data sheet to the lab.

Questions
1) Why do we need crossover instead of straight through cables? Explain briefly in terms of data transmission direction in terms of hub-to-hub communication. Refer to related network books and search in the Internet.
2) At which layer of the 7-layer model does routing take place?
3) Explain how routers communicate.
4) If the IP address of a particular host is 162.233.19.3, and the subnet mask is 255.255.248.0, what would be the network address and host address?
5) If the IP address of a particular host is 0.51.34.1, in what class of networks does it belong to, and what is its network address?

Equipment List
1) Cisco 3600/2600 Series Routers (3)
2) Intel-Based computer with NIC card running Windows 2000 (3)
3) Cross-over RJ-45 Ethernet Cable (3)
4) Console Cable with an RJ-45 connector to DB9 adapter (3)
5) Serial link for connecting serial ports together (3)
6) Power supply (3)

Remark: *The list is the total equipment required by a single area network.*

Procedures

Step 1: Identification

Referring to the equipment list and the lab handbook, identify the following hardware components.

1) The connector types.
    a) RJ45
    b) EIA232
    c) DB9/DB25
2) The cable types, especially the crossover and straight through cables.
3) The cable assembly depicted in Section 2.3 of the Lab Handbook.

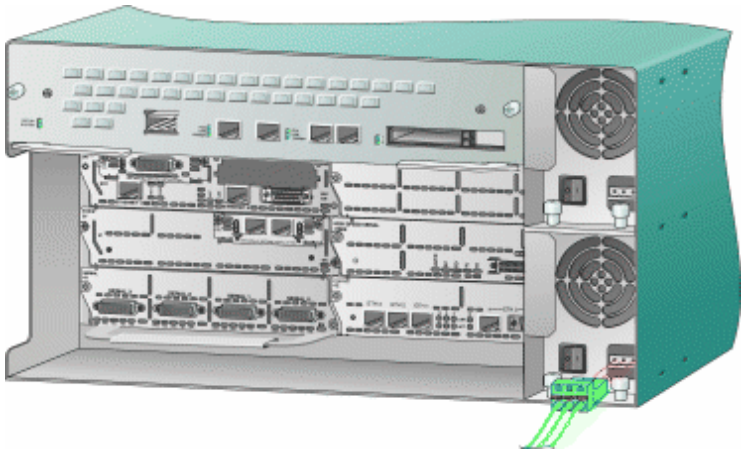

Figure 1.1 Cisco 3600 Router Rear View

Figure 1.2 Cisco 2600 Router Rear View

4) Identify the router type you have, and identify all ports from the view and list their functions. In your future lab report, please mark down in addition your station number, your router type, and your computer number.

Step 2: Interconnect the devices
(Important reminder: Make sure you can distinguish the rollover cable from the crossover cable and the straightforward cable. The lab handbook will tell you how to do that. If you still have the problem of telling the difference, ask your TA)

1) Connect the Console Cable
    a) Connect the RJ-45-to-RJ-45 rollover cable to the Console port on the router.
    b) Connect the other end of the rollover cable to a RJ-45-to-DB-9 serial connector. ***Remark:*** *Use either the RJ-45-to-DB-9 adapter or the RJ-45-to-DB-25 adapter, depending on your local terminal or PC.*
    c) Attach the serial connector to a serial port on a terminal or PC running emulation software to allow router configuration.

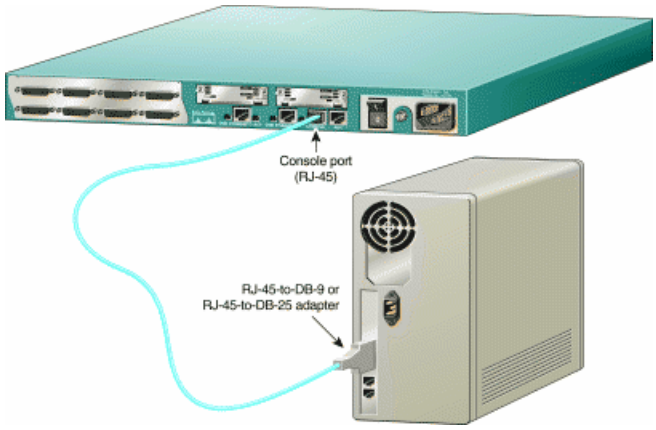

Figure 1.3 Connection of Console Cable

2) Connect the Serial Links
   Interconnect the routers using the serial cables.
   Remark: *The routers have been connected together already. Don't disconnect them! What you need to do in this step is to check the connection.*

3) Connect the Power Cable to the Router
   a) Connect the black power cord to the power connector on the rear panel of the router.
   b) Connect the other end of the power cord to the electrical outlet.

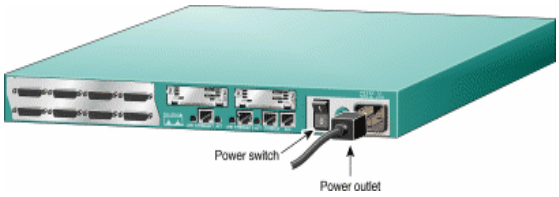

Figure 1.4 Power Connection

Step 3: Connecting the Ethernet Cables
Depending on the router model, connect your router to one or two LANs. Your LAN connection can be Ethernet, Fast Ethernet, Token Ring, or a combination. In this lab, we shall use Ethernet LAN represented by the router in the diagram.

1) Position the router so you can reach the rear panel. The cables and the router's ports are color-coded to help you make the right connections.
2) Connect the Ethernet cable to the 10BaseT port labeled Ethernet 0/0 on the rear panel of your router.
3) Connect the other end of the Ethernet cable to the NIC on your PC.

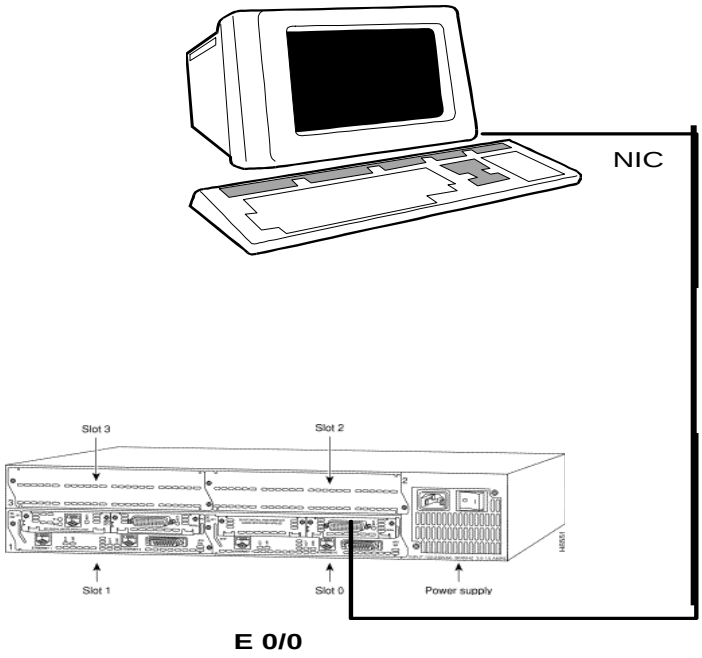

Figure 1.5 Connection of PC's NIC to router

Step 4: Understand the physical description
Compare your router against the physical description/specification you obtained from the web and the Handbook.

Step 5: Familiarization with both Cisco2600 and Cisco3600 Routers
For groups working with Cisco2600/3600, please exchange station with groups working with Cisco3600/2600.

If time permits, you may try Step 1-3 in Lab#2.

Lab 2
Configure Cisco Routers Using a Static Routing Protocol in a Single Area Network

Objectives
The purpose of this lab is to further your knowledge of networking and router configuration by using a static routing protocol in a single-area network.

Upon completing the lab, you will learn how to
1) Gain basic knowledge about interconnecting routers.
2) Interconnect routers according to specification.
3) Configure and set default gateway for workstations (PC's).
4) Configure routers to support LAN services.
5) Use Cisco software to identify router interfaces.
6) Configure Cisco routers using a static routing protocol.
7) Verify the operation of static routing.
8) Ping from a workstation to any other interface/PC's in the network.

Tasks
This lab will demonstrate the step-by-step approach to:
1) Interconnect the devices;
2) Configure a console port connection;
3) Configure a workstation for networking;
4) Configure the Cisco routers using the System Configuration Dialog;
5) Configure static routing in a single area network;
6) Ping from one workstation to another workstation in the MS-DOS window; and
7) Run test cases.

Preparation
1) Review Lab#1 for cable connection.
2) Read Section 1.4 of the Lab Handbook to understand Static Routing and its features.
3) Additional reading can be found in your text.

Questions
1) What are some of the features and drawbacks of a static routing?
2) Give one failure scenario of this experiment.
3) If the IP address of a particular host is 162.233.19.3, and the subnet mask is 255.255.248.0, what would be the network address and host address?

Equipment List
1) Cisco 3600/2600 Series Routers (3)
2) Intel-Based computer with NIC card running Windows 2000 (3)
3) Cross-over RJ-45 Ethernet Cable (3)
4) Console Cable with an RJ-45 connector to DB9 adapter (3)

5) Serial link for connecting serial ports together (3)
6) Power supply (3)

Procedures

This step-by-step procedure will allow you to make initial configuration dialog (Setup script) of Cisco routers, to configure Console Port connections, to setup network [TCP/IP] on the PC's and routers, to configure routing table, and finally to run test cases to verify your work.

Step 1: Interconnect the devices

1) Connections

The routers are controlled by connecting their console ports to the serial ports of Windows 2000 based computers. By setting up a host communications session on the computer, the router's operating system could be accessed.

The routers can be connected to each other using either their Ethernet ports or their serial ports. We use serial ports in this part.

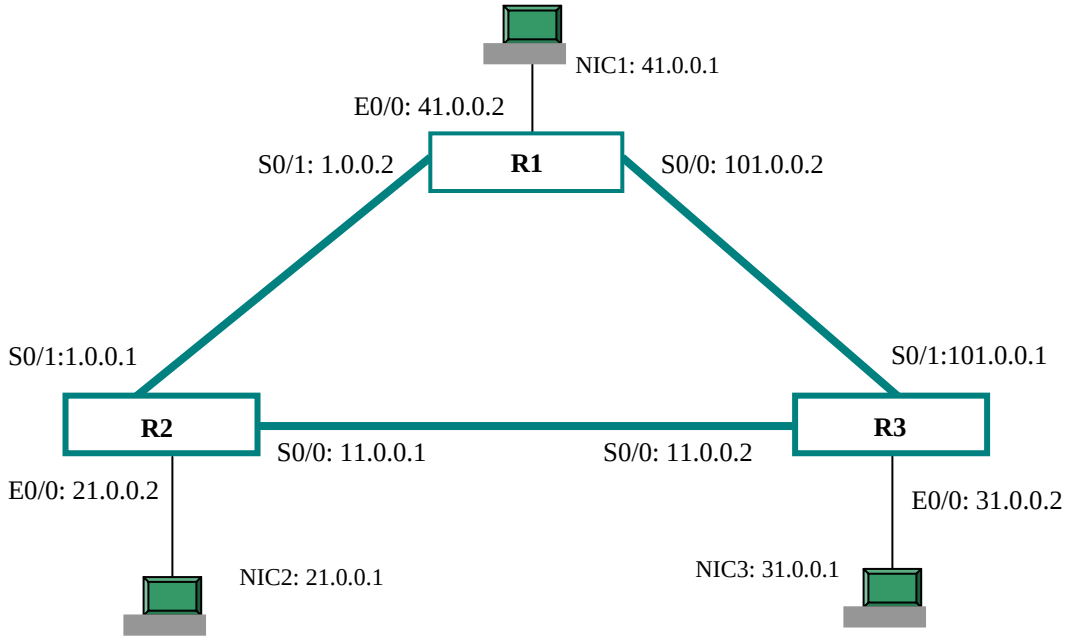

Figure 2.1 Interconnection of the devices

2) Routing and Network Configuration

The interfaces of the routers are configured using TCP/IP protocol where connected interfaces are set up to reside within the same subnet. This is imperative in allowing the interfaces to communicate. As in real networks, the interface on the router must have the same network address as the network (or interface on another router in this case) it is connected to.

The first network topology consists of a pod of 3 routers connected like a triangle, as shown in Fig 2.1, and routing between the routers is facilitated using the static routing protocol. All the nodes are "pinged" to confirm that routing is properly set up. As well, the routing tables are displayed to ensure that proper routing is configured.

Please check the connection of the serial ports to identify which router, R1/R2/R3, you are working with. Usually, R1 and R2 are 2600 routers and R3 is 3600 router.

The first router, identified **R3**, is used to demonstrate the lab procedure. The following steps must be done on each of the PCs and routers [i.e. second router **<R1>** and third router **<R2>** and PCs connected to them]. Normally, each group must configure their own router and interfaces and then connect the routers to neighboring routers using serial links (if this is not done).

Step 2: Configure the Console Port Connection

Remark: *Each router includes a female RJ-45 asynchronous console port wired as a data communications equipment (DCE) device. The default parameters for this port follow:*

1) Turn on the computer and monitor.
   User name: **……**, Password: **…...** (ask for your TA)
2) Run **Hyper Terminal** (**Start** -> **Programs** -> **Accessories->Communications)**
3) Click on **Hyper Terminal**
4) Set Connect using **Direct to Com2** or **Com1**
   Remark: *Make sure the console cable is connected to the right COM port as above setting.*
5) Click on **Configure**
6) Set Bits per second to: **9600**
7) Data bits to: **8**
8) Parity to: **None**
9) Stop bits to: **1**
10) Flow control to: **Hardware**
11) Click on **OK**
12) Click on **OK** in the next widow
13) Save as **Cisco Router Configuration** to the Desktop
14) Close the Hyper Terminal window.

Step 3: Configure a workstation for networking

1) Go to the control panel and double click on **Network and Dial-up Connections**, or go to the desktop and right click **My network place**, then choose **Properties**.
2) Right click on **Local Area Connection**, choose **Properties**
3) Choose **TCP/IP** and click on **Properties**
4) Set the IP address to the appropriate IP address of the PC configured *[i.e. 21.0.0.1 for R2. Refer to Fig 2.1]*
5) Set the **Subnet Mask** to **255.255.255.0**
6) Set the gateway address to the IP address of the Ethernet port of the router to which the PC's NIC is connected *[i.e. 21.0.0.2 for R2. Refer to Fig 2.1]*
7) Click on **OK**
8) Click on **OK** again

Sept 4: Configure the routers

Go to the desktop and open **Cisco Router Configuration**
Remark: *You can configure a router manually using the setup script in the System Configuration Dialog. The setup script prompts you to enter values appropriate for your router and network. Many prompts include default answers, shown in square brackets following the question. Enter your response, or simply press* ***Enter*** *to accept the default answer.*

Power **ON** the router.
Caution*: The power LED on the front panel should be on. Your router is now operational.*
Messages will begin to appear in your terminal emulation program window.
Do not press any keys on the keyboard until the messages stop. Any keys pressed during this time are interpreted as the first command typed. It will take a few minutes for the messages to stop.
Note: *The messages vary, depending on the Cisco IOS software release and feature set you selected. The screen displays in this section are for* ***reference only*** *and* ***might not exactly*** *reflect the messages on your screen. The beginnings of the messages look similar to the following.*

System Bootstrap, Version 11.3(1)XA, PLATFORM SPECIFIC RELEASED SOFTWARE (fc1)
Copyright (c) 1998 by Cisco Systems, Inc.
C2600 platform with 32768 Kbytes of main memory
<Additional messages omitted.>

Remark: *Wait until the boot up process is complete and press* ***Enter*** *to continue.*
Remark: *Boldface font at the command line interface represents user entries.*
Remark: *The examples in this manual are based on the 2600 router. If the message is different from what is given in the following, just press* ***Enter*** *to accept the default value.*

Note: Before you start to enter any command, choose **Transfer->Capture Text,** and save the file to the Desktop. At the end of the experiment, end the caption. The file content can be used for your lab report.

Router> **enable**
<Router#> **erase startup-config**
Erasing the nvram file system will remove all files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router# **reload**
Proceed with reload? [confirm]

<Additional messages omitted.>
< BE PATIENT, IT MAY TAKE SOME TIME>

<Router> **enable**
Router# **setup**

--- System Configuration Dialog ---

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

Remark: *At any point you may enter a question mark '?' for help. Use* ***Ctrl-c*** *to abort configuration dialog at any prompt. Default settings are in square brackets '[]'. Basic management setup configures only enough connectivity for management of the system, extended setup will ask you to configure each interface on the system.*
Remark: *Press* ***Enter*** *to accept the default entry in square brackets.*

Would you like to enter basic management setup? [yes/no]: **no**
First, would you like to see the current interface summary? [yes]:

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	unset	administratively down	down
Serial0/0	unassigned	YES	unset	administratively down	down
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/1	unassigned	YES	unset	administratively down	down

Configuring global parameters:

Enter host name [Router]: **R3** *[depends on which router is being configured]*

Remark*: The enable secret is a password used to protect access to privileged EXEC and configuration modes. This password, after entered, becomes encrypted in the configuration and cannot be seen when viewing the configuration.*
Enter enable secret: **lab**
NOTE: IF YOU DON'T USE THE SEPCIFIED PASSWORDS, YOU'LL WIN A PENALTY IN YOUR FINAL MARK.

Remark*: The enable password is used when you do not specify an enable secret password, with some older software versions, and some boot images. Enter an enable password that is different from the enable secret password. This password is not encrypted (less secure) and can be seen when viewing the configuration.*
Enter enable password: **guessme**

Remark*: The virtual terminal password is used to protect access to the router over a network interface. Enter the virtual terminal password, which prevents unauthenticated access to the router through ports other than the console port.*
Enter virtual terminal password: **guessagain**
Configure SNMP Network Management? [yes]: **n**
Configure DECnet? [no]:
Configure AppleTalk? [no]:
Configure IPX? [no]:
Configure IP? [yes]:
Configure IGRP routing? [yes]: **n**
Configure RIP routing? [no]:

Async lines accept incoming modems calls. If you will have users dialing in via modems, configure these lines.

Configure Async lines? [yes]: **n**

Step 5: Configure the interfaces

Configuring interface parameters:

Do you want to configure FastEthernet0/0 interface? [yes]:
Use the 100 Base-TX (RJ-45) connector? [yes]:
Operate in full-duplex mode? [no]:
Configure IP on this interface? [yes]:
IP address for this interface: **31.0.0.2**
Subnet mask for this interface [255.0.0.0]: **255.255.255.0**
Class A network is 31.0.0.0, 24 subnet bits; mask is /24

Do you want to configure Serial0/0 interface? [yes]:

Some supported encapsulations are
ppp/hdlc/frame-relay/lapb/x25/atm-dxi/smds
Choose encapsulation type [hdlc]:
Configure IP on this interface? [yes]:
Configure IP unnumbered on this interface? [no]:
IP address for this interface [101.0.1.1]: **101.0.0.1**
Subnet mask for this interface [255.0.0.0]: **255.255.255.0**
Class A network is 101.0.0.0, 24 subnet bits; mask is /24

Do you want to configure FastEthernet0/1 interface? [yes]: **n**

Do you want to configure Serial0/1 interface? [yes]:

Some supported encapsulations are
ppp/hdlc/frame-relay/lapb/x25/atm-dxi/smds
Choose encapsulation type [hdlc]:

Serial interface needs clock rate to be set in dce mode.
The following clock rates are supported on the serial interface.
1200, 2400, 4800, 9600, 14400, 19200
28800, 32000, 38400, 56000, 57600, 64000
72000, 115200, 125000, 128000, 148000, 500000
800000, 1000000, 1300000, 2000000, 4000000, 8000000

choose speed from above: [2000000]:
Configure IP on this interface? [yes]:
Configure IP unnumbered on this interface? [no]:
IP address for this interface: **11.0.0.2**
Subnet mask for this interface [255.0.0.0]: **255.255.255.0**
Class A network is 11.0.0.0, 24 subnet bits; mask is /24

The following configuration command script was created:
Remark: *Please* ***check*** *the port settings in the display.*

```
hostname R3
enable secret 5 $1$aqmC$K.m5uY52u5uhzxL7mBHZA1
enable password guessme
line vty 0 4
password guessagain
no snmp-server
!
no decnet routing
no appletalk routing
no ipx routing
ip routing
!
interface FastEthernet0/0
media-type 100BaseX
half-duplex
ip address 31.0.0.2 255.255.255.0
no mop enabled
!
interface Serial0/0
encapsulation hdlc
ip address 101.0.0.1 255.255.255.0
no mop enabled
!
interface FastEthernet0/1
shutdown
no ip address
!
interface Serial0/1
encapsulation hdlc
clock rate 2000000
ip address 11.0.0.2 255.255.255.0
no mop enabled
dialer-list 1 protocol ip permit
dialer-list 1 protocol ipx permit
!
end
```

[0] Go to the IOS command prompt without saving this config.
[1] Return back to the setup without saving this config.
[2] Save this configuration to nvram and exit.

Enter your selection [2]:
Building configuration...

Use the enabled mode 'configure' command to modify this configuration.

Press RETURN to get started!

Note: When the messages stop displaying on your screen, press **Return** to get the following prompt (N.B. prompt depends on host name variable):

R3>

Step 6: Configure Static Routing

Remark: *The following sequence of commands must be entered on PC3 (for router 3).*

R3>**enable**
Password: **lab**
R3#**config**
Configuring from terminal, memory, or network [terminal]?
Remark*: Enter configuration commands, one per line.* ***Ctrl-Z****, rather than* ***exit****, may be used to return to the R2# prompt in case of input error.*
R3(config)#**ip route 1.0.0.0 255.255.255.0 101.0.0.2**
Remark: *IP address 101.0.0.2 is the next hop destination for packets en route network 1.*
R3(config)#**ip route 41.0.0.0 255.255.255.0 101.0.0.2**
Remark: *IP address 101.0.0.2 is the next hop destination for packets en route network 41.*
R3(config)#**ip route 21.0.0.0 255.255.255.0 11.0.0.1**
Remark: *IP address 11.0.0.1 is the next hop destination for packets en route network 21.*
R3(config)#**exit**

Remark: *The following sequence of commands must be entered on PC2 (for router 2).*

R2#**config**
Configuring from terminal, memory, or network [terminal]?
Remark*: Enter configuration commands, one per line.* ***Ctrl-Z****, rather than* ***exit****, may be used to return to the R1# prompt in case of input error.*
R2(config)#**ip route 31.0.0.0 255.255.255.0 11.0.0.2**
Remark: *IP address 11.0.0.2 is the next hop destination for packets en route network 31.*
R2(config)#**ip route 41.0.0.0 255.255.255.0 1.0.0.2**
Remark: *IP address 1.0.0.2 is the next hop destination for packets en route network 41.*
R2(config)#**ip route 101.0.0.0 255.255.255.0 1.0.0.2**
Remark: *IP address 1.0.0.2 is the next hop destination for packets en route network 101.*
R2(config)#**exit**

Remark: *The following sequence of commands must be entered on PC1 (for router 1).*

R1#**config**
Configuring from terminal, memory, or network [terminal]?
Remark*: Enter configuration commands, one per line.* ***Ctrl-Z****, rather than* ***exit****, may be used to return to the R3# prompt in case of input error.*
R1(config)#**ip route 21.0.0.0 255.255.255.0 1.0.0.1**
Remark: *IP address 1.0.0.1 is the next hop destination for packets en route network 21.*

R1(config)#**ip route 31.0.0.0 255.255.255.0 101.0.0.1**
Remark: *IP address 101.0.0.1 is the next hop destination for packets en route network 31.*
R1(config)#**ip route 11.0.0.0 255.255.255.0 101.0.0.1**
Remark: *IP address 101.0.0.1 is the next hop destination for packets en route network 11.*
R1(config)#**exit**

Step 7: Run test cases[1]
Remark*: You should show the results in this section to your TA.*

Test case 1 [verify Routing operation]:
Remark*: The show commands should be run at the command-line interface (CLI), i.e., the R2# prompt. Use* ***enable*** *or* ***exit*** *command to get the # prompt.*

show version to display the configuration of the routers H/W and S/W version, names and source of configuration files, and boot images
show running-config to display the current [running] configuration in RAM
show cdp neighbors to display the routers connected to
show interface to display information on all the router interfaces
show ip interface to verify the IP address and Subnet mask setting
show ip route to display all the route learned by the router

Test case 2 [verify ping operation]:

Go to **Start** -> **Run**
Type "**cmd**" to open a command window
Ping from PC's to other PC's and routers in the command window
Save the results for your lab report

Test case 3 [verify exceptional case]:

Break one or two of the serial links and repeat test case 2

Step 8: Clear the setup parameters

But only after TA has checked the results for your group, run:

`#erase startup-config.

[1] Please refer to Section 3.3 of the Lab Handbook.

Lab 3
Configure Cisco Routers Using the OSPF Routing Protocol in a Single-Area Network

Objectives
The purpose of this lab is to further your knowledge of networking and router configuration by using an OSPF routing protocol in a single-area network.

Upon completing the lab, you will learn how to
1) Interconnect and configure routers and your workstation (PC) as in Lab#2.
2) Configure Cisco router using OSPF routing protocol.
3) Compare OSPF routing with the static routing.
4) Ping from your workstation to any other interface/PC's in the network.

Preparation
1) Review Lab#1 for cable connection.
2) Review Lab#2 for the interface settings of PC and routers.
3) Read Section 1.4 of the Lab Handbook to understand OSPF Routing and its features.
4) Additional reading can be found in your text and the lab handbook.

Questions
1) What is a link-state routing protocol?
2) What are some measures for the performance of a routing protocol?
3) What are some of the features and drawbacks of a dynamic routing?

Procedures

Remark: *Just as in the previous experiment, you should capture the output and save the test results for your lab report.*

1) Scenario of this experiment is the same as Lab 2 except the routing protocol we will use is OSPF (Open Shortest Path First) and the demonstration router is **R2**.

   Only the configuration of OSPF routing table and test cases are depicted below. As for the Console Port Connections, the Network [TCP/IP] settings on the PC's, the configuration of the routers, and the configuration of the interfaces, please refer to Lab#2.

   Displaying and verifying entered parameter values.
   After doing the setting steps 1-5 as Lab#2, run the following IOS commands. Compare the results with the output you got in the previous experiment.
   show version to display the configuration of the routers H/W and S/W version
   show running-config to display the configuration settings of the routers
   show cdp neighbors to find the routers connected to
   show interface to display all router interface information
   show ip interface to verify the IP address and subnet mask settings

2) Configure the OSPF routing protocol in a single area network
Remark: *The following sequence of commands must be entered at each router from the appropriate PC and using the appropriate IP addresses in the commands. The IP address portion of the command should correspond to the IP address of each of the three interfaces on the router being configured.*
Remark: *Enter configuration commands, one per line. Rather than using the exit commands below, simply use CNTL/Z once to return to the R1# prompt.*

R2#**config**
Configuring from terminal, memory, or network [terminal]?
R2(config)#**router ospf 1**
R2(config-router)#**network 1.0.0.1 0.0.0.0 area 1**
R2(config-router)#**network 11.0.0.1 0.0.0.0 area 1**
R2(config-router)#**network 21.0.0.2 0.0.0.0 area 1**
R2(config-router)#**exit**
R2(config)#**exit**

Remark: *For other two routers, set the network addresses to the appropriate interface IP addresses in Fig 2.1. Use the same area ID for all routers.*

Step 7: Run test cases[1]
Test case #1: verify configuration
show version to display the configuration of the routers H/W and S/W version, names and source of configuration files, and boot images
show running-config to display the current [running] configuration in RAM
show cdp neighbors to find the routers connected to
show interface to display information on all the router interfaces
show ip interface to verify the IP address and Subnet mask setting

Test case #2: verify OSPF operation
show ip protocol to verify OSPF is configured
show ip route to display all the route learned by the router
show ip ospf to display OSPF timer
show ip ospf interface to display area ID adjacency information
show ip ospf neighbor detail to display information about neighbors
show ip ospf database to display the link-state database

Test case #3: verify ping operation
Ping from PC's to other PC's in MS-DOS window by pinging all the addresses in your network by using the ping command:
-< *prompt*> ***ping*** <network address>

Which network addresses can your router ping successfully?

[1] Please refer to 3.3 of the Lab Handbook.

Test case #4: verify exceptional cases

a) Break one or more of the Serial link connections and repeat test case 3.
b) Change the IP address of any arbitrary interfaces and repeat test case 3. If you can't ping all the addresses, please explain why based on your knowledge of routers.

Exercises

1) The Cisco Discovery Protocol (CDP) may be used to find out which routers you are connected to:
   - <*router#*> **show cdp neighbor**

   Please give the results of this command after you have connected to the other two routers. You should be able to fill in the following fields:

   Device ID Local Intrface Holdtime Capability Platform Port ID

2) What interfaces on your router are administratively up? Administratively down?
   -<*router#*> **show interface**

   What are the settings on the serial0 (S0/0) interface of your router (i.e. bandwidth, reliability, transmit load, receive load, encapsulation type)?

Lab 4
Configure Cisco Routers Using the OSPF Routing Protocols in a Multiple Area Network

Introduction

This lab will give you a chance to simulate a small wide area network. This can be done by setting up the routers using the topology shown in Fig 4.1. The wide area network (WAN) is characterized by backbone connections between the two pods. A backbone in a real network is usually composed of high-speed cables that carry all information between any two or more networks separated by a great distance. A backbone in our lab will allow the router to communicate between different areas. The backbone is created here by assigning Area 0 to the interfaces that connect any 2 different areas. For example, in Fig 4.1, the OSPF area for the addresses 51.0.0.1 and 51.0.0.2 must be set to Area 0 since they will pass along routing information from Area 1 to Area 2 and vice-versa. Only interfaces that are in Area 0 can pass along routing information from different areas.

Objectives

The purpose of this lab is to enhance the knowledge of networking and router configuration you learned from previous two labs by using an OSPF routing protocol in a multiple area network. Furthermore, upon completing the lab, you will also learn how to configure a more complicated network.

WAN Setup

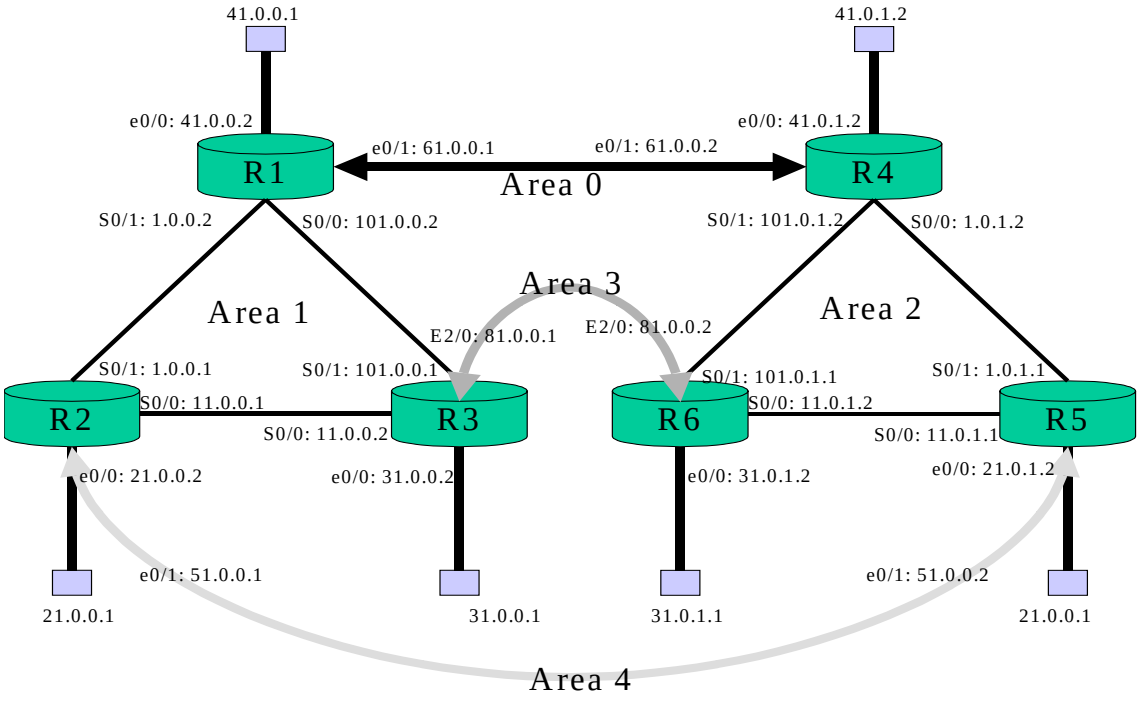

Figure 4.1 Connection of the devices

Preparation

1) Review Lab#1 for cable connection.
2) Review Lab#2 and Lab#3 for the setting procedure.
3) Read 1.4 of the Lab Handbook to understand OSPF Routing and its features.
4) Additional reading can be found in your text and the lab handbook.

Router Configuration

	E 0/0	S 0/0	E 0/1 or E 2/0	S 0/1	Area connected
Router 1	41.0.0.2 255.255.255.0	101.0.0.2 255.255.255.0	61.0.0.1 255.255.255.0	1.0.0.2 255.255.255.0	0 - 1
Router 2	21.0.0.2 255.255.255.0	11.0.0.1 255.255.255.0	51.0.0.1 255.255.255.0	1.0.0.1 255.255.255.0	1 - 4
Router 3	31.0.0.2 255.255.255.0	11.0.0.1 255.255.255.0	81.0.0.1 255.255.255.0	101.0.0.2 255.255.255.0	1 - 3
Router 4	41.0.1.2 255.255.255	101.0.1.2 255.255.255.0	61.0.0.2 255.255.255.0	1.0.1.2 255.255.255.0	2 - 0
Router 5	21.0.1.2 255.255.255.0	1.0.1.1 255.255.255.0	51.0.0.2 255.255.255.0	11.0.1.1 255.255.255	2 - 4
Router 6	31.0.1.2 255.255.255.0	101.0.1.1 255.255.255.0	81.0.0.2 255.255.255.0	11.0.1.2 255.255.255.0	2 - 3

Remark: *R3 and R6 are 3600 Series Routers.*

PC Configuration

	IP Address	Subnet Mask
Workstation 1	41.0.0.1	255.255.255.0
Workstation 2	21.0.0.1	255.255.255.0
Workstation 3	31.0.0.1	255.255.255.0
Workstation 4	41.0.1.1	255.255.255.0
Workstation 5	21.0.1.1	255.255.255.0
Workstation 6	31.0.1.1	255.255.255.0

Procedures

Remark: *Remember to save the output for your lab report.*

1) Set up the multiple area connections for all interfaces on the routers by referring to Fig 4.1. In this experiment, only area 0, area 1 and area 2 must be connected and configured; area3 and area4 are options for students who have time and interests. Note that this is an Ethernet connection and you will need an RJ-45 crossover cable to make the connection between the interfaces.

2) Set up the routers, interfaces and the OSPF Routing, referring to Lab#3. Make sure that the <area_id> used for your new interface between Area 1 and Area 2 is the same as the one being configured on the connected interface. Make sure that the other new <area_id>'s being configured on the other routers are not the same as the one you are using. Note that if only 1 connection existed between Area 1 and Area 2, then this connection would be called the backbone. The backbone is configured to be **Area0.**

3) Run test cases
   (Same as those in Lab#3.)

Questions

1) After the new connections have been set up, what is the new routing table for your router?

2) What subnets appear in the routing table?

3) What gateways can be seen by your router?
   -<*router#*> **show ip protocols**

4) How many addresses can you ping now from your router? Which ones are they?

5) What appears in the DOS prompt session after you ping another computer?

(In the report, please write down the steps and results of the lab. Also please list the problems you encountered during the lab. Further discussions about the lab and background of configuring routers are welcome.)

Appendix A: Pitfalls and Headaches to Avoid

1) Wiring problems surrounding the RJ-45 cables.
   a) Connecting the router to the serial port requires the use of a RJ-45 "Rollover" cable, supplied with each purchased router;

   b) Connecting the router to another router requires the use of a RJ-45 "Crossover" cable. Also, connecting both routers into a hub also works;

   c) Connecting router interfaces to PCs also require a RJ-45 "Crossover" cable or a hub;

2) Deleting the old configuration is a good idea before you start a new configuration. Otherwise, you'll have to delete them one by one to avoid confusion.

3) The "tracert" command does not necessarily always take the shortest path (using the cost metric). Although it does go from one address to another, it doesn't always go the "most efficient" way. More investigation needs to be done on this command.

4) Remember most, if not all problems are a result of changed settings on the piece of equipment you are working with. If an instrument appears to be malfunctioning, before calling for help, please do the following:

   a) Check your connections.

   b) Check your power supply.

   c) Check your settings on your instruments.