ROUTING AND SWITCHING

Project report submitted to the department of ***Electrical and Computer Engineering*** and department of ***Computing Science*** as partial requirement for M. Sc (Master of Science) degree.

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Abstract

Now a days in modern world nearly every organization uses a substantial numbers of computers and communication devices, they are very often isolated form other organizations or outer world. Internetworking is the key solution to allow users to communicate remote programs, databases in same organization or public sources.

The main goal of this project work is to make the new users familiar with the different networking devices, protocols who have least knowledge about the networking environment. After finishing all the labs a user will be able to know the different network environment, configure devices, communicate between devices, run the devices in different protocols and some degree of troubleshooting.

Table of Contents

List of Figures

Chapter 1

Router, IOS, Cable

Lab Manual

Instructor Manual

Lab Manual

1. Introduction

A Router is a layer 3 network device through which data moves between different network segments and determine the best path for a packet to travel by looking into the packet header. Routers can connect network segments that use different protocols. They also allow all users in a network to share a single connection to the Internet or a WAN. A router improve the network performance by-

- Segmentation of network and creating separate collision & broadcast domains.
- Reduce competition for bandwidth.
- Block broadcasting to other network segments.
- Increases security by implementing Access Lists.

Figure 1.1 Some Physical Components of a Cisco router

1.1 Internal Router Components

ROM

ROM store the router's bootstrap start-up program, operating system software, and power-on diagnostic tests programs. To upgrade ROM pluggable chips on the motherboard needs to remove and replace.

Flash Memory

Flash memory holds operating system image(s). Flash memory is erasable, reprogrammable ROM. You can perform Cisco® IOS software upgrades without having

to remove and replace chips. Flash content is retained when you switch off or restart the router.

RAM

RAM is temporary storage device of a router. All the running configurations of a router save in RAM. All the routing tables, caches are saved into RAM.

NVRAM

NVRAM (non-volatile RAM) is a permanent storage device. NVRAM is used to store the router's start-up configuration file. It does not lose data when power is switched off. So the contents of the start-up configuration file are maintained even after switching off or restarting the router.

Network Interfaces

The router's network interfaces are located on the motherboard or on separate interface modules. Ethernet or Token Ring interfaces are configured to allow connection to a LAN. The synchronous serial interfaces are configured to allow connection to WANs. ISDN BRI interfaces are configured to allow connection to an ISDN WAN.

1.2 External Router Components

- A router can be configured over any of its network interfaces. Configuration information can be supplied to a router using - TFTP servers: Trivial File Transfer Protocol; A simplified version of FTP that allows files to be transferred from one computer to another over a network.
- virtual terminals
- network management stations

Router's Start-up Procedure

Each time the router is switched on, it goes through power-on self-test diagnostics to verify basic operation of the CPU, memory and network interfaces. The system bootstrap software in ROM (boot image) executes and searches for valid router operating system software (Cisco® IOS image). IOS is acronym for Internetwork Operating System.

The Cisco® IOS image is loaded in the following places

- Flash memory
- A TFTP server on the network
- ROM

Cisco Command Modes:

A hierarchical level of Cisco® IOS software. Each command mode permits us to configure different configuration components. For example, we configure global parameters in global configuration mode, interface parameters in interface configuration mode, and line parameters in line configuration mode. There are five command modes. Each mode is represented by a different prompt, as shown in the table below:

Command Mode	Prompt	Command to enter mode
User EXEC	Router1>	Login
Privileged EXEC	Router1#	**enable**
Global configuration	Router1(config)#	**configure terminal**
Interface configuration	Router1(config-if)#	**interface** *type number* (from global configuration mode)
Sub interface configuration	Router1(config-subif)#	**interface** *type number* (to configure a sub interface from within interface configuration mode)
Router configuration	Router1(config-router)#	**router** *routing_protocol* (from global configuration mode)
Line configuration	Router1(config-line)#	**line** *line_type line_number* *ending_line_number* (from global configuration mode)

1.3 Cables

DCE (Data Communications Equipment) and **DTE** (Data Terminal Equipment) are descriptions of the role an Ethernet interface (also other Interfaces but we will concentrate on Ethernet here) plays in 2-way communication. DCE is typically the upstream device (network end), and DTE the downstream device (user end). DTE is an end station, while DCE is a server, router, or hub.

Straight Cable: We use straight cable when we connect different devices like PC to Switch, Router to HUB, LAN port to Switch, Hub or PC etc.

Crossover Cable: We use straight cable when we connect same types of devices like PC to PC, PC to Router, Router to Router, Switch to Switch, Hub to Hub etc.

Console: The console consists of the physical plugs and jacks on the router. The purpose of the console is to provide access for configurations.

Interfaces: The interfaces provide connectivity to LAN, WAN, and Console/Aux. They can be RJ-45 jacks soldered onto the motherboard, transceiver modules, or card modules. Cisco routers, especially the higher-end models, can be configured in many different ways. They can use a combination of transceivers, card modules and onboard interfaces.

1.4 Introduction to Alcatel-Lucent 7710 SR Series

Figure 1.2 Front view of an Alcatel Lucent 7710 router

1.4.1 Physical Components

It is important to understand all of the different physical components that comprise an A1cate1-Lucent 7710 SR ESS system. The system consists of a physical chassis with slots that house the cards that integrate into the card slots. The cards provide either the intelligence of the system if the card is a SF/CPM or physical interfaces if the card is an IOM.

The IOMs are hot-swappable modules responsible for queuing, processing, and forwarding of data. An IOM contains two 10-Gbps traffic processing programmable fast-path complexes. Each complex supports a pluggable MDA that allows a common programmable fast path to support all of the possible interface types. The IOM also contains a CPU section for managing the forwarding hardware in each Flexible Fast Path. MDAs provide one or more physical interfaces, such as Ethernet, ATM, or SONET/ Synchronous Digital Hierarchy (SDH). MDAs perform Layer 2 handling and pass

incoming frames to the IOM CPU for processing. On egress, MDAs transmit outgoing frames out of the appropriate physical interface in the correct format. Small Form Factor Pluggable (SFP) transceivers are small optical modules available in a variety of formats.

1.4.2 Basic Bootup Components

AS with all computer systems, the A1cate1-Lucent 7710 SR series systems require a configuration or boot file that contains key information that is necessary for the system to function correctly. The 7710 SR system use a Boot Options File (BOF) to configure the system for operations during the power-on process.

There is a Compact Flash (CF) card that contains the files required to start the system. Each product can have three compact flashes: cf1, cf2, cf3. The flash size can be 256M, 512M, 1G and 2G.

The cf3 card contains the following directories and files located off of the root directory.

- Boot.ldr- This file contains the system bootstrap image.
- Bof.cfg- The boot.cfg file is user configurable and contains user information such as:
    - Management port IP address
    - Location of image file
    - Location of configuration file
- TiMOS~m.n.Y.z- This directory is named according to major minor software release, type of release and version.
- Config.cfg- This file contains the default configuration file. The configuration file is very basis and provides just enough information to make the system operational.

1.4.3 Basic Boot Option

The most basis BOF configuration should have the following information.

- Managing IP address
- Primary image location
- Primary configuration location

There are several parameters that configured in BOF:

1. Setup the CPM Ethernet port (speed, duplex, auto).
2. Create an IP address for the CPM Ethernet port.
3. Create a static route for the CPM Ethernet port.
4. Set the console port speed.

5. Configure the DNS domain name.
6. Configure the primary, secondary, tertiary configuration source.
7. Configure the primary, secondary, tertiary image source.
8. Configure persistence

1.4.4 Basic Commands

Common Global Commands	
Command	Result
info	Provides info on the configuration
logout	Terminates the CLI session
password	Changes the user CLI login password
ping	Verify the reachability of a remote host
ssh	Open a secure shell connection to a host
telnet	telnet a host
traceroute	Determine the route to a host
tree	Display a list of all the current level and all sublevels

Some most used commands that differ from CISCO commands	
Cicso	**Alcatel**
enable	Configure
show run	admin display-config
write	Save

1.5 Pre lab questions

1. What are the differences between a Layer 3 switch and a router?

2. What three components of a router retain their memory when power is not present?

3. In what three ways can we configure a router?

4. What will you do when a router has no working IOS image on its flash?

5. Of the two management ports, which one is preferred, and why?

6. Besides the PC and the router, what three components (software and hardware) are required to connect a PC to a router's management port?

7. When we use DTE and DCE serial port?

8. When Crossover and Straight cable uses?

9. What is ***line vty 0 0*** means?

10. What is the requirement to enable ssh on a Cisco router?

11. In ***enable password 0*** <*password*>**,** what is '0' stands for?

12. Which of the following descriptions is correct?
a. bof.cfg – 7710 configuration file
b. cpm.tim – IOM image file
c. config.cfg – Backup configuration file
d. boot.ldr – Bootstrap image file

13. Which file contains the system bootstrap image?
a. boot.cfg
b. image.ldr
c. boot.ldr
d. bof.cfg

1.6 Lab Exercise

1. Suppose the person working before you in a company is fired from the job. He has all the passwords and didn't share before leaving. Recover/reset enable password on a Cisco 2800 router.

2. Setup a tftp server for backup and restore configurations from a Cisco router.

3. Connect to a router through telnet and ssh (without using console port).

Note: You may use 192.168.X.1 as your host computer, where X is the rack number.

1.6.1 What to hand in

1. The list of commands issued on the router.
2. The output of show commands.

Instructor Manual

1.7 Pre lab answers

1. What are the differences between a Layer 3 switch and a router?

Ans. Router is a layer 3 device (software based) that simply do routing. Layer 3 switch is primarily a switch that has been enhanced some routing capabilities also.

2. What three components of a router retain their memory when power is not present?
Ans. ROM, NVRAM and Flash memory.

3. In what three ways we can configure a router?
Ans. By console port, through telnet and by Auxiliary port.

4. What will you do when a router has no working IOS image on its flash?
Ans. Copy ISO image to flash using tftp server.

5. Of the two management ports, which one is preferred, and why?
Ans. The Console port is preferred because you receive log messages from the router, including error messages and boot messages. In addition, you can perform password recovery through the Console port.

6. Besides the PC and the router, what three components (software and hardware) are required to connect a PC to a router's management port?
Ans. Rollover (console) Cable, RJ-45 connector to DB-9 connector and terminal.

7. When we use DTE and DCE serial port?
Ans. For connecting routers in WAN environment.

8. When Crossover and Straight cable are used?

Ans. We use straight cable when we connect different devices like PC to Switch, Router to HUB, LAN port to Switch, Hub or PC etc and we use straight cable when we connect same types of devices like PC to PC, PC to Router, Router to Router, Switch to Switch, Hub to Hub etc.

9. What does ***line vty 0 0*** means?
Ans. To enable only 1 terminal session.

10. What is the requirement to enable ssh on a Cisco router?
Ans. The Cisco IOS image used must be a k9(crypto) image in order to support SSH. For example c3750e-universalk9-tar.122-35.SE5.tar is a k9 (crypto) image.

11. In ***enable password 0*** <*password*>**,** what is '0' stands for?
Ans. Enable password will not be encrypted.

12. Which of the following descriptions is correct?
a. bof.cfg – 7710 configuration file
b. cpm.tim – IOM image file
e. config.cfg – Backup configuration file
f. boot.ldr – Bootstrap image file

13. Which file contains the system bootstrap image?
a. boot.cfg
b. image.ldr
c. boot.ldr
d. bof.cfg

1.8 Lab Exercise Solution

Problem 1

Suppose the person working before you in a company is fired from the job. He has all the passwords and didn't share before leaving. Recover/reset enable password on a Cisco 2800 router.

Solution:

Step 1: Open terminal on the desktop and telnet to the router. In this case we are using CISCO 2800 router on rack 4, which IP address is 10.3.31.77.

Step 2: First of all we need to know the current version of the router. Type ***show version*** to see the version.

Note: The configuration register is usually set to 0x2102. (The last line of the output of ***sh version*** command.

Step 3: Turn off the router, then turn on back.

Step 4: Press **Ctrl+]** then type ***send brk*** in order to put the router into ROMmon.

Step 4: Type ***confreg 0x2142*** at the `rommon 1>` prompt in order to boot from Flash.

Step 5: Type **reset** at the `rommon 2>` prompt.

The router will boot now. Type ***no*** for all setup questions asked.

Step 6: type ***enable***. The router will go to privilege mode without asking for password.

Step 7: Type ***copy startup-config running-config*** in order to copy the nonvolatile RAM (NVRAM) into memory.

Warning: Do not type ***copy running-config startup-config*** or ***write***. These commands erase your startup configuration.
Step 8: Go to configuration mode by typing ***config t***.

Step 9: Type ***enable secret*** <*password*> in order to change the **enable secret** password.

Step 10: Type ***no shutdown*** command on every interface that you use.

Step 11: Type ***config-register 0x2102***

Step 12: Leave the configuration mode by pressing **Ctrl+z.**

Step 13: Type **wr** or **copy running-config startup-config** in order to save the changes.

Step 14: Type ***reload*** to reboot the router.

Example of password recovery procedure:

mzrahman@menthe:~$ telnet 10.3.31.77
Trying 10.3.31.77...
Connected to 10.3.31.77.
Escape character is '^]'.

User Access Verification

Password:
Password OK

Router>sh ver
Cisco IOS Software, 2800 Software (C2800NM-ADVENTERPRISEK9-M), Version 12.4(22)T, RELEASE SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport

---------- *Line omitted*

DRAM configuration is 64 bits wide with parity enabled.
239K bytes of non-volatile configuration memory.
62720K bytes of ATA CompactFlash (Read/Write)

Configuration register is 0x2102

System Bootstrap, Version 12.4(1r) [hqluong 1r], RELEASE SOFTWARE (fc1)
Copyright (c) 2005 by cisco Systems, Inc.

Initializing memory for ECC

telnet> send brk

!--- The router was just powercycled, and during bootup a
!--- break sequence was sent to the router.

monitor: command "boot" aborted due to user interrupt
rommon 1 > confreg 0x2142

You must reset or power cycle for new config to take effect
rommon 2 >reset

c2821 processor with 262144 Kbytes of main memory
Main memory is configured to 64 bit mode with ECC enabled

Readonly ROMMON initialized

program load complete, entry point: 0x8000f000, size: 0x378c1b8
Self decompressing the image :
##
##
##
##
################################## [OK]

--- *Line omitted*

---
dialog? [yes/no]: no
% There may not be enough space available to collect the complete crashinfo

% It would be advisable to have 280755 bytes free space on flash:crashinfo

Press RETURN to get started!

Router>enable
Router#copy startup-config running-config
Destination filename [running-config]?

1190 bytes copied in 0.868 secs (1371 bytes/sec)
Router#
*Aug 17 18:38:37.907: %CONTROLLER-5-UPDOWN: Controller T1 0/3/0, changed state to down (LOS detected)
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#enable secret mint
Router(config)#interface gigabitEthernet 0/0
Router(config-if)#no shutdown
Router(config-if)#
*Aug 17 18:40:32.743: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Aug 17 18:40:33.743: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up
Router(config-if)#^Z
Router#
*Aug 17 18:40:47.827: %SYS-5-CONFIG_I: Configured from console by console
Router#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
Router#sh ver
Cisco IOS Software, 2800 Software (C2800NM-ADVENTERPRISEK9-M), Version ----------
---------- *Line omitted*

62720K bytes of ATA CompactFlash (Read/Write)

Configuration register is 0x2142

Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#config-register 0x2102

Router(config)#^Z
Router#
*Aug 17 18:44:34.779: %SYS-5-CONFIG_I: Configured from console by console
Router#sh ver
Cisco IOS Software, 2800 Software (C2800NM-ADVENTERPRISEK9-M), Version ----
----
---------- *Line omitted*

62720K bytes of ATA CompactFlash (Read/Write)

Configuration register is 0x2142 (will be 0x2102 at next reload)

Router#reload

Problem 2:

Setup a tftp server for backup and restore configurations from a Cisco router.

Solution:

Backup running configuration from a router to the TFTP Server:

Step 1: Download latest tftp server, install in your computer and open the tftp server. Leave the window open for sending and receiving configurations with the router.

Step 2: Connect a cable from the Ethernet or Gigabyte port of the router to the tftp server. Make sure IP address of both end should be in same subnet. In our case the IP address of the Gigabyte port is 192.168.100.100 and the IP address of tftp server is 192.168.100.101.

Step 3: Now connect to router from the terminal through telnet.

Step 4: Type ***copy running-config tftp:***

Step 5: For remote host address put the IP of tftp server i.e. 192.168.100.101

Step 6: Press Return key for default destination file name.

You will see the configuration file named **router-config** is saved in the tftp server root directory. You can open the file with **WordPad** to view.

Restore startup configuration from a file on TFTP Server:

Step 1: Download latest tftp server, install in your computer and open the tftp server. Leave the window open for sending and receiving configurations with the router.

Step 2: Connect a cable from the Ethernet or Gigabyte port of the router to the tftp server. Make sure IP address of both end should be in same subnet. In our case the IP address of the Gigabyte port is 192.168.100.100 and the IP address of tftp server is 192.168.100.101.

Step 3: Now connect to router from the terminal through telnet.

Step 4: Type ***copy tftp: running-config***

Step 5: For remote host address put the IP of tftp server i.e. 192.168.100.101

Step 6: Enter the source filename for restore to startup configuration.

Step 7: Enter the destination filename.

The file is restored in the startup-configuration.

Problem 3

Connect to a router through telnet and ssh (without using console port).

Connect to a router through telnet

Step 1: Open terminal on the desktop and telnet to the router. In this case we are using CISCO 2800 router on rack 4, which IP address is 10.3.31.77.

Step 2: Follow the configuration steps to enable telnet on Cisco router

```
mzrahman@menthe:~$ telnet 10.3.31.77
Trying 10.3.31.77...
Connected to 10.3.31.77.
Escape character is '^]'.


User Access Verification

Password:*******
Password OK

router2800>en
Password:******
router2800#
router2800(config)#enable password mint

router2800(config)#line vty 0 4
router2800(config-line)#login
% Login disabled on line 66, until 'password' is set
% Login disabled on line 67, until 'password' is set
```

```
% Login disabled on line 68, until 'password' is set
% Login disabled on line 69, until 'password' is set
% Login disabled on line 70, until 'password' is set

router2800(config-line)#password mintlab
router2800(config-line)#no transport input
router2800(config-line)#transport input telnet
router2800(config-line)#^Z
```

Step 3: Now connect your computer to the Gigabyte port of the router and telnet.

Connect to a router through ssh

First of all we need to know that the Cisco IOS image used must be a k9(crypto) image in order to support SSH. For example c3750e-universalk9-tar.122-35.SE5.tar is a k9 (crypto) image. We can check it from the version of the router.

Step 1: Open terminal on the desktop and telnet to the router. In this case we are using CISCO 2800 router on rack 4, which IP address is 10.3.31.77.

Step 2: Follow the configuration steps to enable telnet on Cisco router

```
mzrahman@menthe:~$ telnet 10.3.31.77
Trying 10.3.31.77...
Connected to 10.3.31.77.
Escape character is '^]'.


User Access Verification

Password:****
Password OK

router2800>en
Password:****
router2800#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
router2800(config)#enable password mint
router2800(config)#aaa new-model
router2800(config)#username cisco password 0 cisco
```

Note: this is the ssh user name (cisco) and password (cisco)

router2800(config)#ip domain-name www.mint.com
router2800(config)#crypto key generate rsa
% You already have RSA keys defined named router2800.www.mint.com.
% Do you really want to replace them? [yes/no]: yes
Choose the size of the key modulus in the range of 360 to 2048 for your
General Purpose Keys. Choosing a key modulus greater than 512 may take
a few minutes.

How many bits in the modulus [512]:780

Note: for version 2 the key size should more than 779

*Aug 23 07:54:23.266: %SSH-5-DISABLED: SSH 1.5 has been disabled
% Generating 780 bit RSA keys, keys will be non-exportable...[OK]
*Aug 23 07:54:39.298: %SSH-5-ENABLED: SSH 1.99 has been enabled

router2800(config)#ip ssh time-out 60
router2800(config)#ip ssh authentication-retries 2
router2800(config)#line vty 0 4
router2800(config-line)#no transport in
router2800(config-line)#no transport input
router2800(config-line)#transport input SSH
router2800(config-line)#exit
router2800(config)#no ip ssh version
router2800(config)#ip ssh version 2

Step 3: Now connect your computer to the Gigabyte port of the router and open ssh. Give the user name and password.

Chapter 2

IP Addressing, Subnetting, NAT

Lab Manual

Instructor Manual

Lab Manual

2. Introduction

Subnetting allows creating multiple logical networks within a single Class A, B, or C network. , It allows to create a network of interconnecting subnetworks.

In NAT a network device, usually a firewall, assigns a public address to a computer or group of computers inside a private network. The main use of NAT is to limit the number of public IP addresses an organization or company must use. It helps in both economy and security purposes.

VLSM provides more flexibility to use more than one subnet mask within the same network address place.

2.1 Pre lab questions

1. What is the subnetwork number of a host with an IP address of 172.16.210.0/22?
A. 172.16.42.0
B. 172.16.107.0
C. 172.16.208.0
D. 172.16.252.0
E. 172.16.254.0

2. What is the subnetwork address for a host with the IP address 200.10.5.68/28?
A. 200.10.5.56
B. 200.10.5.32
C. 200.10.5.64
D. 200.10.5.0

3. The network address of 172.16.0.0/19 provides how many subnets and hosts?
A. 7 subnets, 30 hosts each
B. 7 subnets, 2046 hosts each
C. 7 subnets, 8190 hosts each
D. 8 subnets, 30 hosts each
E. 8 subnets, 2046 hosts each
F. 8 subnets, 8190 hosts each

4. You need 500 subnets, each with about 100 usable host addresses per subnet. What mask will you assign using a Class B network address?
A. 255.255.255.252
B. 255.255.255.128
C. 255.255.255.0
D. 255.255.254.0

5. What mask would you assign to the network ID of 172.16.0.0 if you needed about 100 subnets with about 500 hosts each?
A. 255.255.255.0
B. 255.255.254.0
C. 255.255.252.0
D. 255.255.0.0

6. You are given two address / mask combinations, written with the prefix/length notation, which have been assigned to two devices. Your task is to determine if these devices are on the same subnet or different subnets.

Device A: 172.16.17.30/20
Device B: 172.16.28.15/20

7. Given the Class C network of 204.15.5.0/24, subnet the network in order to create the network in Figure with the host requirements shown.

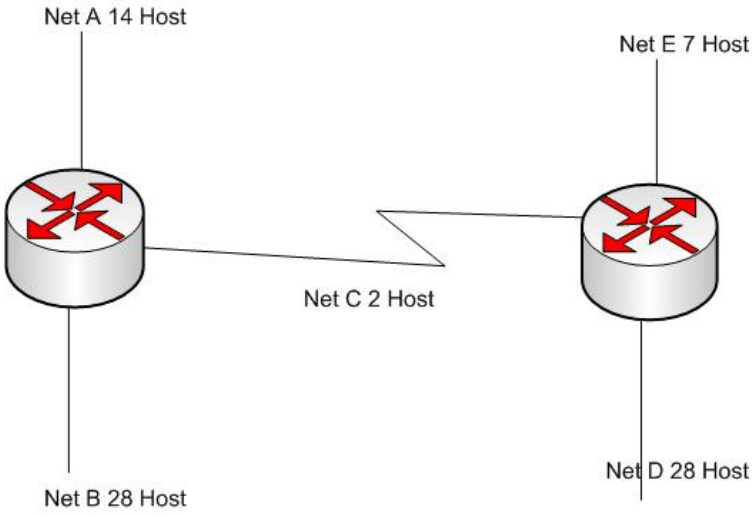

Figure 2.1 Pre Lab question 7 on Subnetting

Looking at the network shown in Figure , you can see that you are required to create five subnets. The largest subnet must support 28 host addresses. Is this possible with a Class C network? and if so, then how?

8. Your router has the following IP address on Eth0: 172.16.112.1/20. How many hosts can be accommodated on the Ethernet segment?
A. 1024
B. 2046

C. 4094
D. 4096
E. 8190

9. You have a /27 subnet mask. Which of the following are valid hosts? (Choose three.)
A. 11.244.18.63
B. 90.10.170.93
C. 143.187.16.56
D. 192.168.15.87
E. 200.45.115.159
F. 216.66.11.192

2.2 Lab Exercise

Problem 1

Assume the figure 2.1 shows a single network of 192.168.X.0/24, where X would be the rack number. Each router needed to be accommodating the number of host mentioned in the figure. The maximum number of address needs to be kept free for future use.

1. Draw a diagram showing the addresses configured in all the interfaces.
2. Configure Static routing protocol. Communicate each host from each other, i.e. ping from a host in Net A to a host in Net E.

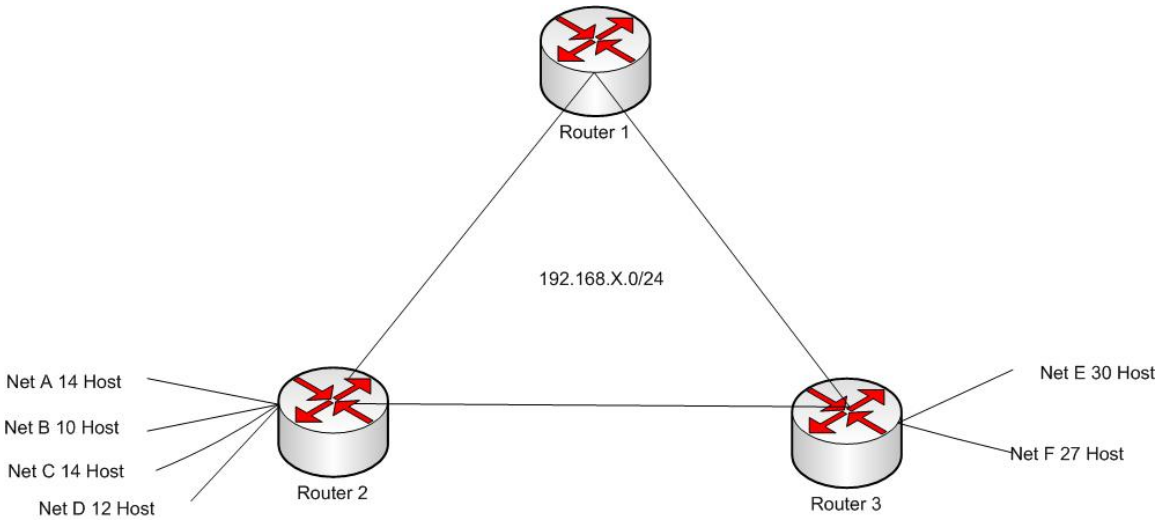

Figure 2.2 Network diagram for IP addressing problem

Problem 2

In the figure 2.2 below we have the same network shown figure 2.1 where a host from outside wishes to connect the hosts inside the network. The ISP assigns you the network 172.1.1.1/29 to connect outside world. Router 1 will be the edge router for the host.

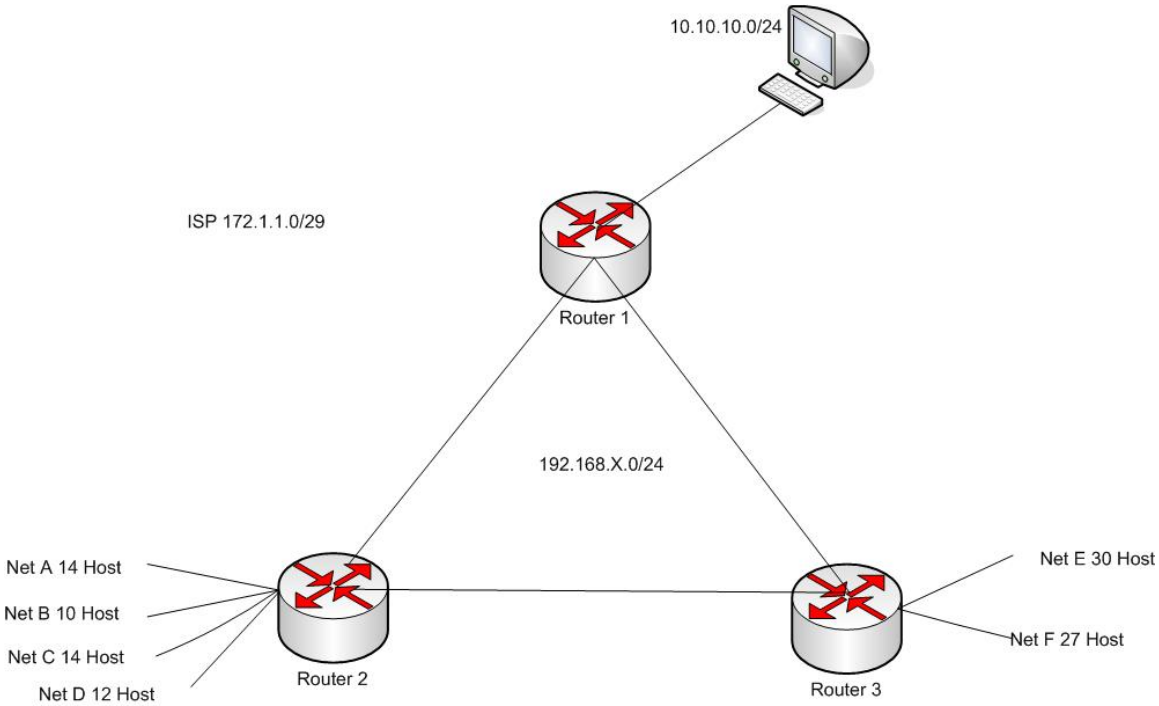

Figure 2.3 Network diagram for NAT resolution

1. Configure the network so that the host on network 10.10.10.0/24 can reach router 1 and all other hosts. You will be using Dynamic NAT.
2. Enable Static routing.

2.2.1 What to hands in

1. Aggregate all the route (subnet and subnetmask).
2. Draw the diagram of the network with IP addresses in each interface. Show the routes that verify all the interfaces are reachable.
3. List of commands for configuring interfaces, routing, NAT.
4. Show NAT translations and statistics.

Instructor Manual

2.3 Pre lab answers

1. What is the subnetwork number of a host with an IP address of 172.16.210.0/22?
A. 172.16.42.0
B. 172.16.107.0
C. 172.16.208.0
D. 172.16.252.0
E. 172.16.254.0

2. What is the subnetwork address for a host with the IP address 200.10.5.68/28?
A. 200.10.5.56
B. 200.10.5.32
C. 200.10.5.64
D. 200.10.5.0

3. The network address of 172.16.0.0/19 provides how many subnets and hosts?
A. 7 subnets, 30 hosts each
B. 7 subnets, 2046 hosts each
C. 7 subnets, 8190 hosts each
D. 8 subnets, 30 hosts each
E. 8 subnets, 2046 hosts each
F. 8 subnets, 8190 hosts each

4. You need 500 subnets, each with about 100 usable host addresses per subnet. What mask will you assign using a Class B network address?
A. 255.255.255.252
B. 255.255.255.128
C. 255.255.255.0
D. 255.255.254.0

5. What mask would you assign to the network ID of 172.16.0.0 if you needed about 100 subnets with about 500 hosts each?
A. 255.255.255.0
B. 255.255.254.0
C. 255.255.252.0
D. 255.255.0.0

6. You are given two address / mask combinations, written with the prefix/length notation, which have been assigned to two devices. Your task is to determine if these devices are on the same subnet or different subnets.

Device A: 172.16.17.30/20
Device B: 172.16.28.15/20

Ans. Both of them are in the same subnet, which is 172.16.16.0.

7. Given the Class C network of 204.15.5.0/24, subnet the network in order to create the network in Figure with the host requirements shown.

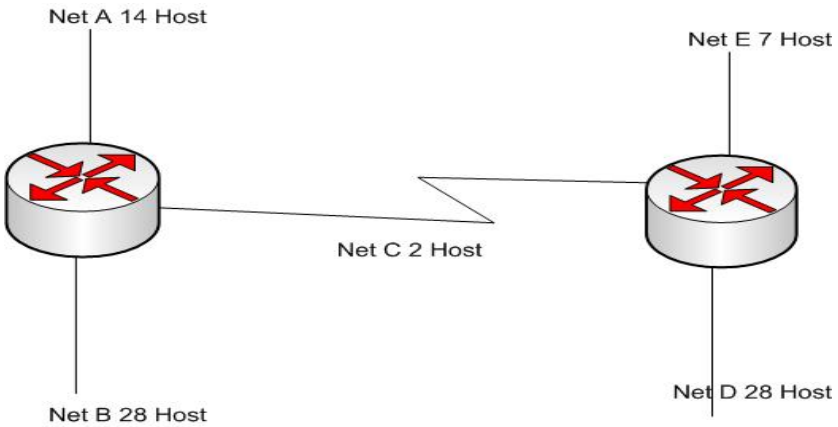

Figure 2.4 Figure 2.1 Pre Lab question 7 solution on Subnetting

Looking at the network shown in Figure , you can see that you are required to create five subnets. The largest subnet must support 28 host addresses. Is this possible with a Class C network? and if so, then how?

Ans. Yes, possible.

netA: 204.15.5.0/27 host address range 1 to 30
netB: 204.15.5.32/27 host address range 33 to 62
netC: 204.15.5.64/27 host address range 65 to 94
netD: 204.15.5.96/27 host address range 97 to 126
netE: 204.15.5.128/27 host address range 129 to 158

8. Your router has the following IP address on Eth0: 172.16.112.1/20. How many hosts can be accommodated on the Ethernet segment?
A. 1024
B. 2046
C. 4094
D. 4096
E. 8190

9. You have a /27 subnet mask. Which of the following are valid hosts? (Choose three.)
A. 11.244.18.63
B. 90.10.170.93
C. 143.187.16.56
D. 192.168.15.87
E. 200.45.115.159
F. 216.66.11.192

2.4 Lab Exercise Solution

Problem 1

Assume the figure 2.1 shows a single network of 192.168.X.0/24, where X would be the rack number. Each router needed to be accommodating the number of host mentioned in the figure. The maximum number of address needs to be kept free for future use.

3. Draw a diagram showing the addresses configured in all the interfaces.
4. Configure Static routing protocol. Communicate each host from each other, i.e. ping from a host in Net A to a host in Net E.

Solution

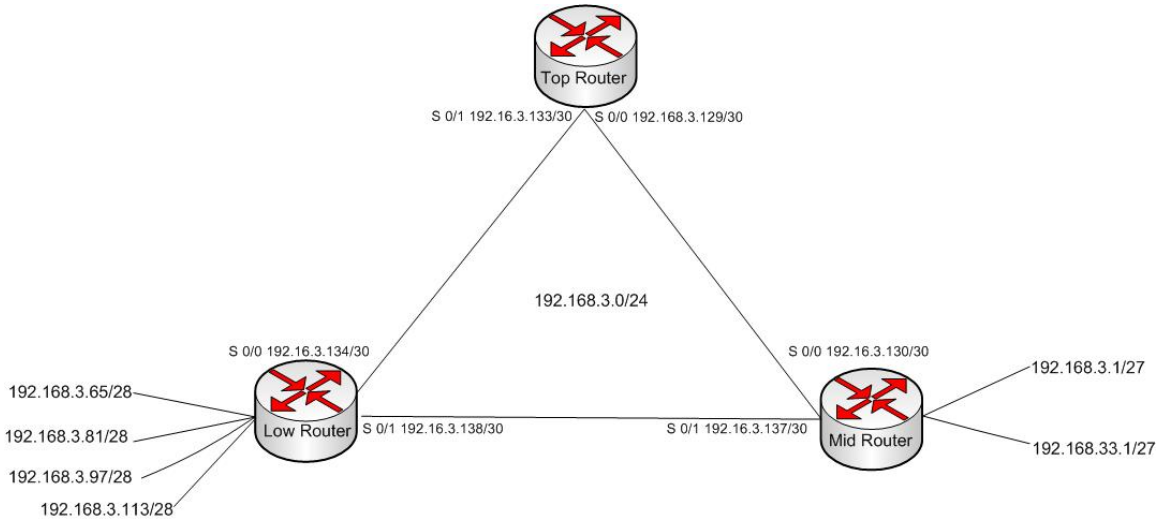

Figure 2.5 Solution network diagram for IP addressing problem

Configuration of static route is same as configured for problem 2.

Problem 2

In the figure 2.2 below we have the same network shown figure 2.5 where a host from outside wishes to connect the hosts inside the network. The ISP assigns you the network 172.1.1.1/29 to connect outside world. Router 1 will be the edge router for the host.

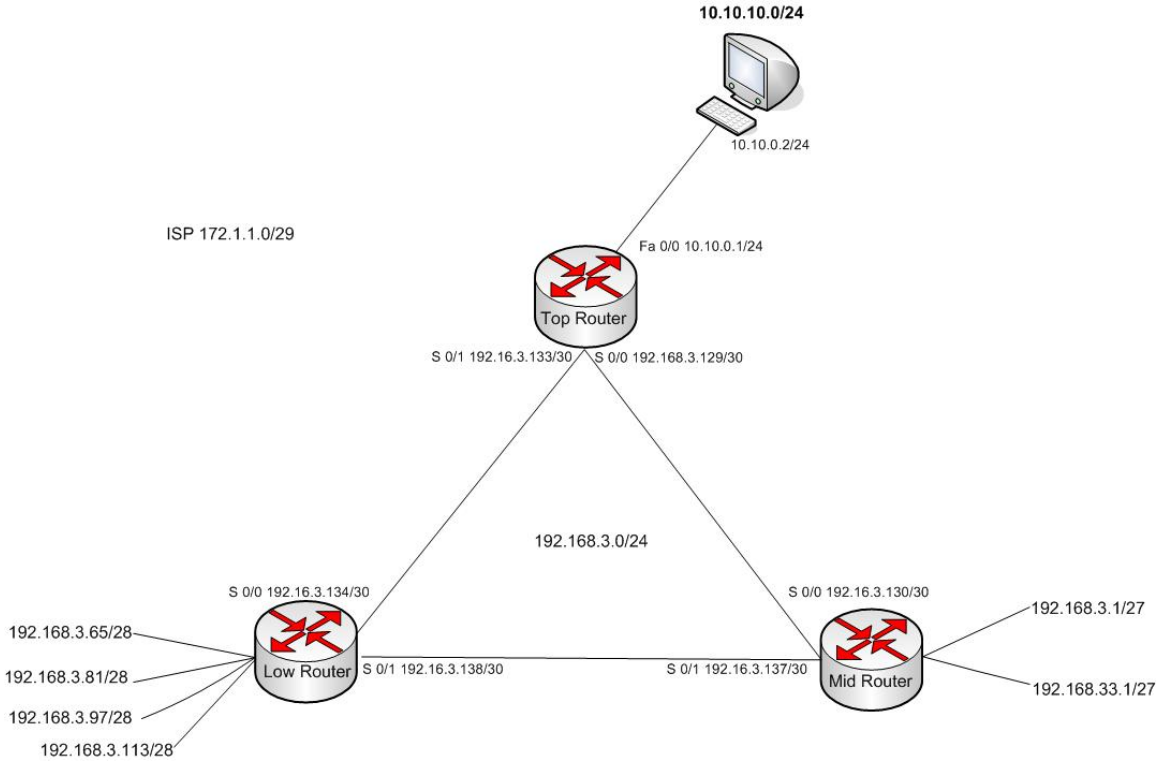

Figure 2.6 Solution network diagram for NAT resolution

3. Configure the network so that the host on network 10.10.10.0/24 can reach router 1 and all other hosts. You will be using Dynamic NAT.
4. Enable Static routing.

What to hands in

1. Aggregate all the route (subnet and subnetmask).
2. Draw the diagram of the network with IP addresses in each interface. Show the routes that verify all the interfaces are reachable.
3. List of commands for configuring interfaces, routing, NAT.
4. Show NAT translations and statistics.

2.5 Configuration

Step 1: Open terminal on the desktop and telnet to the Top router. In this case we are using 3 Cisco 2600 on rack 3, which IP address is 10.3.31.114, 10.3.31.115 and 10.3.31.72 respectively.

Step 2: Follow the Sample configuration example below to configure NAT.

Configuration Top Router 2600

```
mzrahman@menthe:~$ telnet 10.3.31.114
Trying 10.3.31.114...
Connected to 10.3.31.114.
Escape character is '^]'.


User Access Verification

Password:
Password OK
----------------------------------------------
----------------------------------------------
----------------------------------------------
----------------------------------------------

Router(config)#hostname Top_2600
Top_2600(config)#int fastEthernet 0/0
Top_2600(config-if)#ip address 10.10.10.1 255.255.255.0
Top_2600(config-if)#no shutdown
Top_2600(config-if)#ip nat inside
Top_2600(config-if)#exit
Top_2600(config)#int serial 0/0
Top_2600(config-if)#ip address 192.168.3.129 255.255.255.252
Top_2600(config-if)#ip nat outside
Top_2600(config-if)#clock rate 2000000
Top_2600(config-if)#exit
Top_2600(config)#interface Serial0/1
Top_2600(config-if)# ip address 192.168.3.133 255.255.255.252
Top_2600(config-if)# ip nat outside
Top_2600(config-if)#clock rate 2000000
Top_2600(config-if)#exit
Top_2600(config)#ip nat pool team3 172.1.1.1 172.1.1.6 prefix-length 29
Top_2600(config)#ip nat inside source list 1 pool team3 overload
Top_2600(config)#access-list 1 permit 10.10.10.0 0.0.0.255
Top_2600(config)# ip route 192.168.3.0 255.255.255.192 192.168.3.130
Top_2600(config)# ip route 192.168.3.64 255.255.255.192 192.168.3.134
Top_2600(config)# ip route 192.168.3.136 255.255.255.252 192.168.3.134
Top_2600(config)#^Z
```

Configuration Mid Router 2600

```
mzrahman@menthe:~$ telnet 10.3.31.115
Trying 10.3.31.115...
Connected to 10.3.31.115.
Escape character is '^]'.


User Access Verification

Password:
Password OK
----------------------------------------------
----------------------------------------------
----------------------------------------------
----------------------------------------------

Mid_2600#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Mid_2600(config)#interface Loopback1
Mid_2600(config-if)# ip address 192.168.3.1 255.255.255.224
Mid_2600(config-if)#interface Loopback2
Mid_2600(config-if)# ip address 192.168.3.33 255.255.255.224
Mid_2600(config)#interface Serial0/0
Mid_2600(config-if)# ip address 192.168.3.130 255.255.255.252
Mid_2600(config)#int serial 0/1
Mid_2600(config-if)# ip address 192.168.3.137 255.255.255.252
Mid_2600(config-if)# clock rate 2000000
Mid_2600(config-if)# ip route 192.168.3.64 255.255.255.192 192.168.3.138
Mid_2600(config-if)# ip route 192.168.3.128 255.255.255.252 192.168.3.133
Mid_2600(config-if)# ip route 172.1.1.0 255.255.255.248 192.168.3.129
```

Configuration Low Router 2600

```
mzrahman@menthe:~$ telnet 10.3.31.116
Trying 10.3.31.116...
Connected to 10.3.31.116.
Escape character is '^]'.
```

```
User Access Verification

Password:
Password OK
----------------------------------------------
----------------------------------------------
----------------------------------------------
Mid_2600(config)#interface Loopback3
Mid_2600(config-if)# ip address 192.168.3.113 255.255.255.240
Mid_2600(config-if)#interface Loopback4
Mid_2600(config-if)# ip address 192.168.3.65 255.255.255.240
Mid_2600(config-if)#interface Loopback5
Mid_2600(config-if)# ip address 192.168.3.97 255.255.255.240
Mid_2600(config-if)#interface Loopback6
Mid_2600(config-if)# ip address 192.168.3.81 255.255.255.240
Mid_2600(config-if)#exit
Mid_2600(config)#interface Serial0/0
Mid_2600(config-if)# ip address 192.168.3.134 255.255.255.252
Mid_2600(config-if)# clock rate 2000000
Mid_2600(config-if)#interface Serial0/1
Mid_2600(config-if)# ip address 192.168.3.138 255.255.255.252
Mid_2600(config-if)# ip route 192.168.3.0 255.255.255.192 192.168.3.137
Mid_2600(config-if)# ip route 192.168.3.128 255.255.255.252 192.168.3.137
ip route 172.1.1.0 255.255.255.248 192.168.3.133
Mid_2600(config-if)#^Z
```

Chapter 3

Switching and VLAN

Lab Manual

2.1 Pre lab questions
2.2 Lab Exercise

Instructor Manual

2.3 Pre lab answers
2.4 Lab Exercise Solution
2.5 Configuration

Lab Manual

3. Introduction

Introduction

Virtual LAN is a logical group of devices, defined by software. VLANs allow network administrators to resegment their networks without physically rearranging the devices or network connections. A VLAN is a network composed of logical broadcast domains. Configuration VLANs allows network traffic to be separated logically. Network devices on VLAN1 will not be able to communicate devices on VLAN2. It is possible to have devices on VLAN1 of a switch communication with VLAN1 on another switch through a method called VLAN trunking. See the image below:

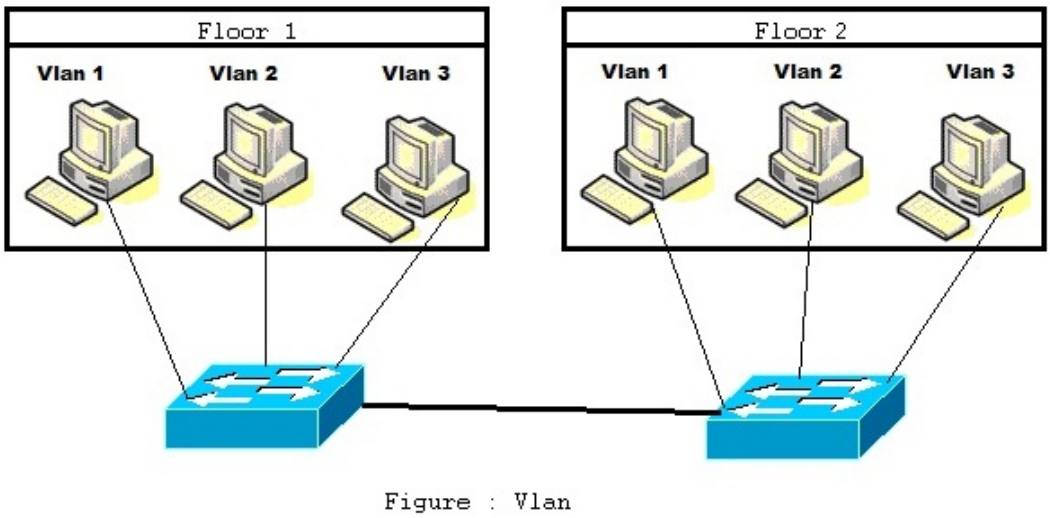

Figure 3.1 Example of a VLAN diagram

There are several different types of memberships associated with VLANs:

- Static VLANs
- Dynamic VLANs

3.1 Pre lab questions

1. Which types of vlan use memory chip inside the switch?

2. Why do we use trunk port?

3. In vlan how many domain information can a switch share at a time?

4. Name the different modes in which VLANs can be configured.

5. Are these VLANs valid? Vlan 1, vlan 4000, vlan 5000?

6. Are these valid vlan names? ***Vlan 2 name THISisTHEvlanUSINGforUSERabcd, vlan 2 name THISisTHEvlanUSINGforUSERabcdINsalesDEPARTMENT?*** Why or why not?

7. In which vlan packets transit untagged along a trunk as normal Ethernet frames?

8. How do you interconnect 2 vlans?

9. Name the different connections in which VLANs can be connected.

3.2 Lab Exercise

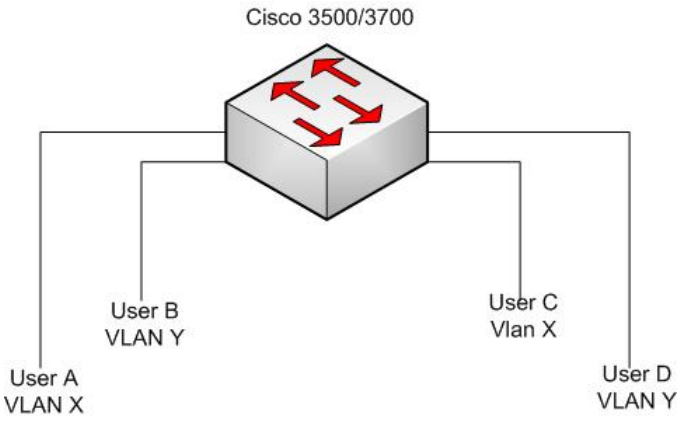

Figure 3.2 Problem 1 on VLAN

1. Create VLANs in both CISCO 3500 and 3700 switches individually where user A, C will be in one VLAN and user B, D will in other.

2. Create VLANs in both CISCO 3500 and 3700 switches where user A dnd B will be in different VLAN in Cisco 3500 and user C and D will in different vlan in Cisco 3700 switch.

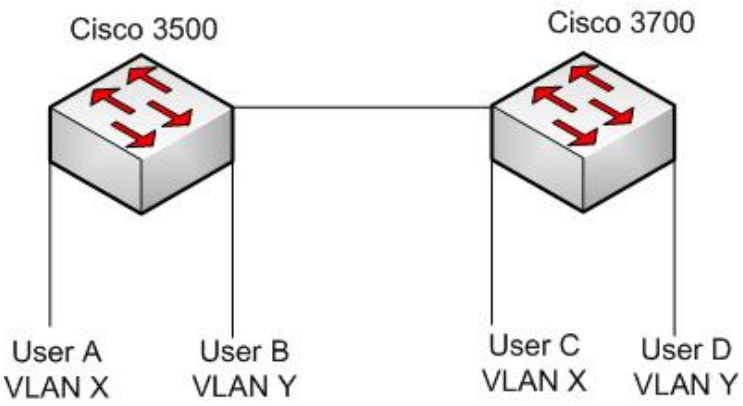

Figure 3.3 Problem 2 on VLAN

3. Inter connect the VLANs in problem 2 so that they can communicate with each other (e.g Host in vlan X can ping a host in vlan Y and vice versa).

(a) You can use router.
(b) You are not allowed to use router

3.2.1What to hand in

1. Show vlan command
2. sh running configuration command
3. Show ping result for problem 3

Instructor Manual

3.3 Pre lab answers

1. Which types of vlan use memory chip inside the switch?
Ans. *Dynamic vlan.*

2. Why do we use trunk port?
Ans. *To interconnect vlans in different switches.*

3. In vlan how many domain information can a switch share at a time?
Ans. *Only one at a time.*

4. Name the different modes in which VLANs can be configured.
Vlan switching mode, Vlan translation mode, Vlan routing mode.

5. Are these VLANs valid? Vlan 1, vlan 4000, vlan 4096?
Vlan 4096 is not valid. valid values are from 1 to 4095. The last VLAN number cannot exceed 4095.

6. Are these valid vlan names? ***vlan 2 name THISisTHEvlanUSINGforUSERabcd, vlan 2 name THISisTHEvlanUSINGforUSERabcdINsalesDEPARTMENT?*** Why or why not?
THISisTHEvlanUSINGforUSERabcdINsalesDEPARTMENT is not valid, because valid vlan name range is 1-32.

7. In which vlan packets transit untagged along a trunk as normal Ethernet frames?
Native vlan.
8. How do you interconnect 2 vlans?
By configuring InterVlan.

9. Name the different connections in which VLANs can be connected.
Trunk link, access link, hybrid link.

3.4 Lab Exercise Solution

Problem 1

Create VLANs in both CISCO 3500 and 3700 switches individually where user A, C will be in one VLAN and user B, D will in other.

Solution:

The configuration in both Cisco 3500 and 3700 are same.

Step 1: Open terminal on the desktop and telnet to the Switch. In this case we are using CISCO 3500 switch on rack 4, which IP address is 10.3.31.73.

Step 2: First of all we need to delete all the existing VLANs in the switch. To do that go to configuration mode by typing ***enable*** then ***delete vlan.dat***

Step 3. Now all the VLANs are deleted but it will still show in the running configuration. Now we need to erase the flash and reload. To do that type ***erase*** then ***reload.***

Step 4: Type ***no*** for all question while reloading.

Step 5: Follow the Sample configuration example below to configure VLAN.

Configure Cisco 3500

mzrahman@menthe:~$ telnet 10.3.31.73
Trying 10.3.31.73...
Connected to 10.3.31.73.
Escape character is '^]'.

User Access Verification

Password:
Password OK

Switch>en
Switch#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
Switch#erase startup-config
Erasing the nvram filesystem will remove all files! Continue? [confirm]
[OK]

Erase of nvram: complete

Switch#reload

System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]

1d10h: %SYS-5-RELOAD: Reload requested

C3500XL Boot Loader (C3500-HBOOT-M) Version 12.0(5.3)WC(1), MAINTENANCE INTERIM SOFTWARE

---------- ------

Switch>en
Switch#conf t
Switch#vlan database
Switch(vlan)#vlan 2 name TEAM1
VLAN 2 added:
Name: TEAM1
Switch(vlan)#vlan 3 name TEAM2
VLAN 3 added:
Name: TEAM2
Switch(vlan)#exit
APPLY completed.
Exiting....

Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#interface fastEthernet0/1
Switch(config-if)#description User A in VLAN 2
Switch(config-if)#switchport access vlan 2
Switch(config-if)#interface fastEthernet0/3
Switch(config-if)#description User C in VLAN 2
Switch(config-if)#switchport access vlan 2
Switch(config-if)#interface fastEthernet0/2
Switch(config-if)#interface fastEthernet0/2
Switch(config-if)#description User B in VLAN 3
Switch(config-if)#switchport access vlan 3
Switch(config-if)#interface fastEthernet0/4
Switch(config-if)#description User D in VLAN 3
Switch(config-if)#switchport access vlan 3
Switch(config-if)#exit

Problem 2

Create VLANs in both CISCO 3500 and 3700 switches where user A and B will be in different VLAN in Cisco 3500 and user C and D will in different vlan in Cisco 3700 switch.

The configuration in both Cisco 3500 and 3700 are same.

Step 1: Open terminal on the desktop and telnet to the Switch. In this case we are using Cisco 3500 and Cisco 3700 switch on rack 4, which IP address is 10.3.31.73 and 10.3.31.72 respectively.

Step 2: Follow the Sample configuration example below to configure VLAN.

Configure Cisco 3500

mzrahman@menthe:~$ telnet 10.3.31.73
Trying 10.3.31.73...
Connected to 10.3.31.73.
Escape character is '^]'.

User Access Verification

Password:
Password OK

Switch>en
Switch#vlan database
Switch(vlan)#vlan 11 na
Switch(vlan)#vlan 11 name Team11
VLAN 11 added:
  Name: Team11
Switch(vlan)#vlan 12 name Team12
VLAN 12 added:
  Name: Team12
Switch(vlan)#exit
APPLY completed.
Exiting....
Switch#
Switch#conf t

Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#int fastEthernet 0/11
Switch(config-if)#description User E in VLAN 11
Switch(config-if)#switchport access vlan 11
Switch(config-if)#int fastEthernet 0/12
Switch(config-if)#description User F in VLAN 12
Switch(config-if)#switchport access vlan 12
Switch(config-if)#int fastEthernet 0/24
Switch(config-if)#description Trunk link to Switch 3700
Switch(config-if)#switchport mode trunk
Switch(config-if)#
01:06:35: %LINK-3-UPDOWN: Interface FastEthernet0/24, changed state to up
01:06:35: %LINK-3-UPDOWN: Interface FastEthernet0/24, changed state to down
Switch(config-if)#switchport trunk encapsulation dot1q
Switch#exit

Configure Cisco 3700

Configuration of Cisco 3700 is same as above.

Problem 3:

Inter connect the vlans in problem 1 and 2 so that they can communicate each other.

To connect vlans among each other we can use either a router or a layer-3 switch.

Connect vlans using a layer-3 switch

Step 1: All the configuration on the switches would be remain same.

Step 2: As a layer-3 switch we will use Cisco 3750 switch itself. We have to configure the vlans on the layer-3 switch by giving ip addresses.

Step 3: Now we have to enable routing on the switch by typing the command ***ip routing***.

Example of the configuration

```
Switch(config)#interface Vlan 11
Switch(config-if)#description VLAN11  192.168.11.0/24
Switch(config-if)#ip address 192.168.11.1 255.255.255.0
Switch(config)#interface Vlan 12
Switch(config-if)#description VLAN12 192.168.12.0/24
Switch(config-if)#ip address 192.168.12.1 255.255.255.0
Switch(config-if)#^Z
Switch(config)#ip routing
Switch(config)#exit
```

Connect vlans using a Router

We can use Cisco 2800 router to inter connect 2 vlans.

Step 1: First of all we have to create two sub interfaces on Router: gig0/1.11 and gig0/1.12. These sub interfaces are assigned to VLANs. To create the first sub interface, enter sub interface configuration mode for Fa0/1.10 by issuing the interface fa0/1.10 command. This gigabyte interface will be connected with the switch trunk port.

Step 2: While in sub interface configuration mode, issue the encapsulation dot1Q 10 command to set the encapsulation type to 802.1Q and assign VLAN 10 to the virtual interface.

Step 3: Now we have to assign ip address on the vlans.

Example of the configuration

```
Router(config)#interface gig 0/1.11
Router(config-subif)# encapsulation dot1Q 11
Router(config-subif)#ip address 192.168.11.1 255.255.255.0
Router(config)#interface gig 0/1.12
Router(config-subif)# encapsulation dot1Q 12
Router(config-subif)#ip address 192.168.12.1 255.255.255.0
Router(config-subif)#^Z
Router#
```

Chapter 4

Vlan and Spanning tree protocol

Lab Manual

Instructor Manual

Lab Manual

4. Introduction

Spanning-Tree Protocol is a link management protocol that provides path redundancy and at the same time prevents creating loops in the network. Multiple active paths between stations cause loops in the network. Spanning Tree Protocol (STP) is a Layer 2 protocol that runs on bridges and switches. The specification for STP is IEEE 802.1D.

There are different types of STP, but 802.1D is the most popular and widely implemented. You implement STP on bridges and switches in order to prevent loops in the network. Use STP in situations where you want redundant links, but not loops. Redundant links are as important as backups in the case of a failover in a network. A failure of your primary activates the backup links so that users can continue to use the network. Without STP on the bridges and switches, such a failure can result in a loop.

4.1 Pre lab questions

1. Which one of these elects a Root Bridge?
a. Bridge Priority
b. Root Path Cost
c. BPDU revision number
d. Path Cost

2. Which one of the following is not true?
a. Lowest MAC address elects the Root bridge.
b. Highest MAC address elects the Root bridge.
c. One or more switches will have a Bridge Priority of 32,768.
d. A secondary Root Bridge will be present on the network.

3. Which switch generates the BPDU Configuration message?
a. All switches in the STP domain
b. Only the Root Bridge switch
c. Only the switch that detects a topology change
d. Only the secondary Root Bridge when it takes over

4. What happens to a port that is neither a Root Port nor a Designated Port?
a. It is available for normal use.
b. It can be used for load balancing.
c. It is put into the Blocking state.
d. It is disabled.

5. What are the STP messages used to communicate between bridges:
a. Advertisement BPDU
b. Configuration BPDU
c. ACK BPDU
d. TCN BPDU

6. What is the different between a root switch and a designated switch?

7. Spanning tree forces redundant data paths into which state?

8. Which protocol switch uses to send and receive spanning tree frame?

9. What does BPDU contains?

10. Which 2 information set the control for a port to be either on forwarding state or blocked state?

11. How does the root switch is elected when their default priority are same?

4.2 Lab Exercise

1. Configure Spanning Tree Protocol for the network below to prevent loops, where SW1 will be the root bridge and both the end user will be in the same vlan.

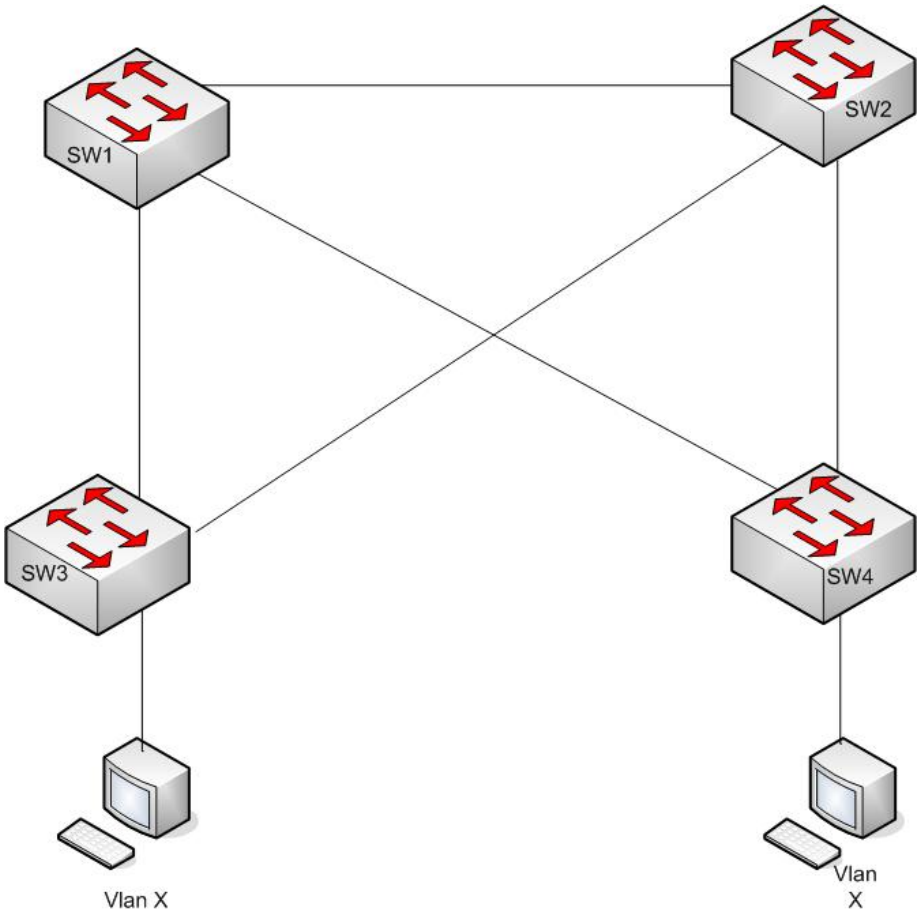

Figure 4.1 Network diagram for configuring STP in a single VLAN

2. Configure Spanning Tree Protocol for the network shown below to prevent loops, where SW1, SW2 and SW3 will be the root bridge for vlan Y, vlan Z and vlan X respectively.

(i) VLAN X should be using path SW3-SW1-Sw4.
(ii) VLAN Y should be using path SW3-SW1-SW2-SW4. Switch 3 should be blocking for VLAN Y on port connecting with SW2.
(iii) VLAN Z should be using path SW3-SW2-SW4. Switch 3 should be blocking for VLAN Z on port connecting with SW1.
(iv) Ping from host in a vlan to another host and break primary link. Your ping should be running.

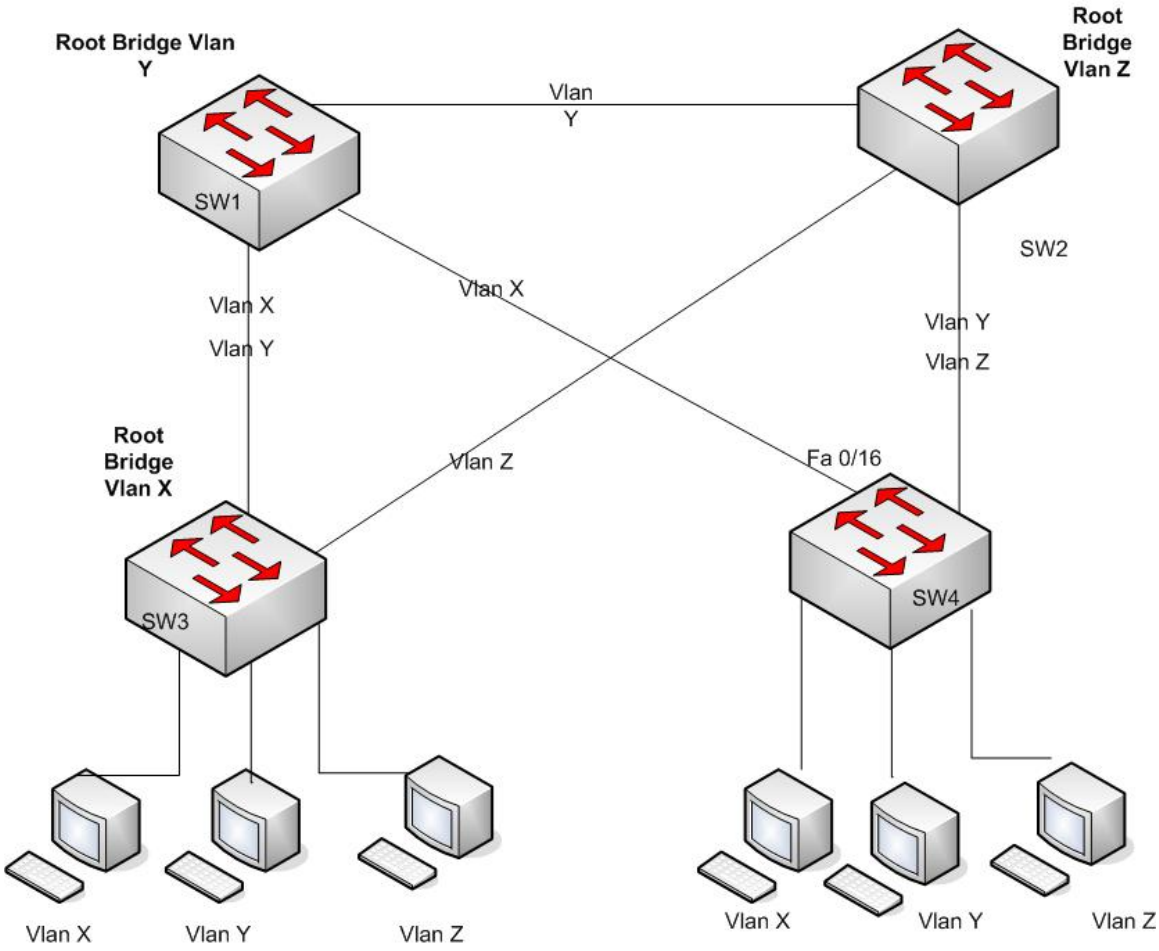

Figure 4.2 Network diagram for configuring STP in multiple VLAN

4.2.1What to hand in

(For problem 1 & 2)

1. ***show vlan*** command.
2. ***show running configuration*** command.
3. Ping between end users in VLAN X and show spanning tree table for all the switches when all links are up. Explain.

(For problem 2)

4. Ping between end users in VLAN X and show spanning tree table for SW1 and SW3 when port in SW1 connecting to SW4 is broken. Explain
5. Ping between end users in VLAN X and show spanning tree table for SW1 and SW3 when port in SW1 connecting to SW4 and port in SW3 connecting to SW2 are broken. Explain

4.3 Pre lab answers

1. Which one of these elects a Root Bridge?
a. Bridge Priority
b. Root Path Cost
c. BPDU revision number
d. Path Cost

2. Which one of the following is not true?
a. Lowest MAC address elects the Root bridge.
b. Highest MAC address elects the Root bridge.
c. One or more switches will have a Bridge Priority of 32,768.
d. A secondary Root Bridge will be present on the network.

3. Which switch generates the BPDU Configuration message?
a. All switches in the STP domain
b. Only the Root Bridge switch
c. Only the switch that detects a topology change
d. Only the secondary Root Bridge when it takes over

4. What happens to a port that is neither a Root Port nor a Designated Port?
a. It is available for normal use.
b. It can be used for load balancing.
c. It is put into the Blocking state.
d. It is disabled.

5. What are the STP messages used to communicate between bridges:
a. Advertisement BPDU
b. Configuration BPDU
c. ACK BPDU
d. TCN BPDU

6. What is the different between a root switch and a designated switch?
Ans: The switch that has *all* of its ports as the designated role or as the backup role is the root switch. The switch that has at least *one* of its ports in the designated role is called the designated switch.

7. Spanning tree forces redundant data paths into which state?

Ans: Spanning tree forces redundant data paths into a standby (blocked) state.

8. Which protocol switch uses to send and receive spanning tree frame?

Ans: Switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs)

9. What does BPDU contains?

Ans: BPDUs contain information about the sending switch and its ports, including switch and MAC addresses, switch priority, port priority, and path cost.

10. Which 2 information set the control for a port to be either on forwarding state or blocked state?

Ans: The spanning-tree port priority and path cost settings control which port is put in the forwarding state and which is put in the blocking state.

11. How does the root switch is elected when their default priority are same?

Ans: If all switches are configured with the default priority (32768), the switch with the lowest MAC address in the VLAN becomes the root switch.

4.4 Lab Exercise Solution

Problem 1

Configure Spanning Tree Protocol for the network below to prevent loops, where SW1 will be the root bridge and both the end user will be in the same vlan.

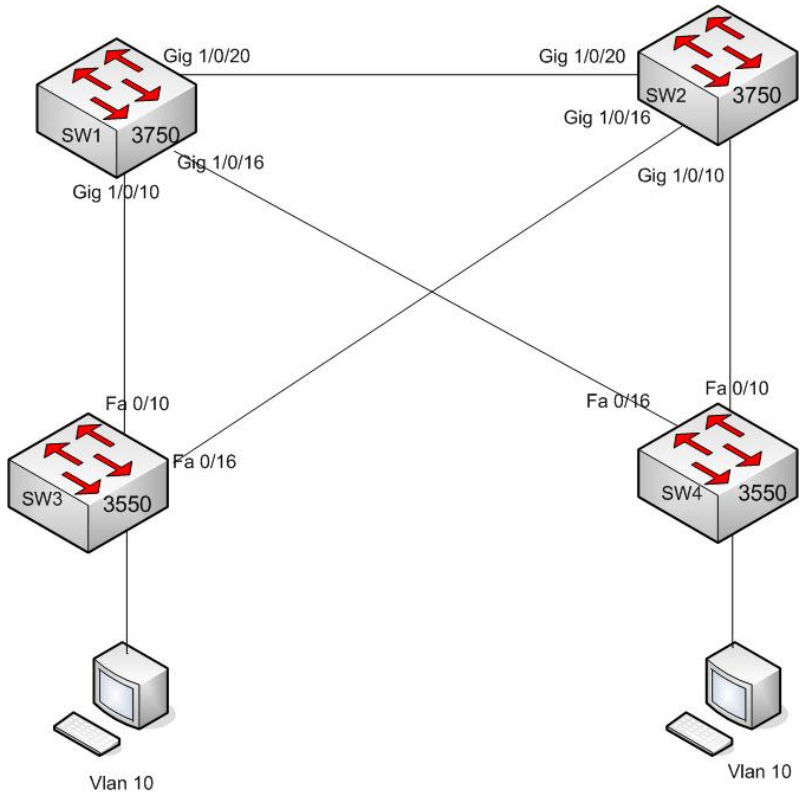

Figure 4.3 Solution network diagram for configuring STP in a single VLAN

Solution

In this lab we are using 2 Cisco 3550 and 2 Cisco 3750 switches in Rack 1 and Rack 2. The correspondent ip addresses of the switches are as follows:

Rack#1 SW1 3750 – 10.3.31.132
Rack#1 SW3 3550 – 10.3.31.133
Rack#2 SW2 3750 – 10.3.31.112
Rack#2 SW4 3550 – 10.3.31.113

Step 1: Connect all the switches as the network diagram above. Telnet the switches with correspondent ip address and configure them.

Step 2: First of all we need to create vlan in all the switches. The commands would be same for all the switches.

Create vlans:

```
Switch#vlan database
Switch(vlan)#vlan 10 name userA
Switch(vlan)#exit
```

Step 3:

Configuration of Sw 1 (Cisco 3750)

```
Rack#1_3750#conf t
Rack#1_3750(config)#spanning-tree vlan 10 root primary
```

Note: To make the switch primary root bridge for vlan 10

Configure trunk port to connect to other switches:

```
Rack#1_3750(config)#interface GigabitEthernet1/0/10
Rack#1_3750(config-if)#switchport trunk encapsulation dot1q
Rack#1_3750(config-if)#switchport mode trunk

Rack#1_3750(config)#interface GigabitEthernet1/0/16
Rack#1_3750(config-if)#switchport trunk encapsulation dot1q
Rack#1_3750(config-if)#switchport mode trunk


Rack#1_3750(config)#interface GigabitEthernet1/0/20
Rack#1_3750(config-if)#switchport trunk encapsulation dot1q
Rack#1_3750(config-if)#switchport mode trunk
```

Configuration of Sw 2 (Cisco 3750)

```
Rack#2_3750#conf t
Rack#2_3750(config)#spanning-tree vlan 10 root secondary
```

Note: To make the switch secondary root bridge for vlan 10

Configure trunk port to connect to other switches:

```
Rack#2_3750(config)#interface GigabitEthernet1/0/10
Rack#2_3750(config-if)#switchport trunk encapsulation dot1q
Rack#2_3750(config-if)#switchport mode trunk
```

```
Rack#2_3750(config)#interface GigabitEthernet1/0/16
Rack#2_3750(config-if)#switchport trunk encapsulation dot1q
Rack#2_3750(config-if)#switchport mode trunk

Rack#2_3750(config)#interface GigabitEthernet1/0/20
Rack#2_3750(config-if)#switchport trunk encapsulation dot1q
Rack#2_3750(config-if)#switchport mode trunk
```

Configuration of Sw 3 (Cisco 3550)

```
Rack#1_3550#conf t

Configure access port for the users:

Rack#1_3550(config)#interface FastEthernet0/1
Rack#1_3550(config)#switchport access vlan 10

Configure trunk port to connect to other switches:

Rack#1_3550(config)#interface FastEthernet0/10
Rack#1_3550(config-if)#switchport trunk encapsulation dot1q
Rack#1_3550(config-if)#switchport mode trunk

Rack#1_3550(config)#interface FastEthernet0/16
Rack#1_3550(config-if)#switchport trunk encapsulation dot1q
Rack#1_3550(config-if)#switchport mode trunk
```

Configuration of Sw 4 (Cisco 3550)

```
Configure access port for the users:

Rack#2_3550(config)#interface FastEthernet0/1
Rack#2_3550(config)#switchport access vlan 10

Configure trunk port to connect to other switches:

Rack#2_3550(config)#interface FastEthernet0/10
Rack#2_3550(config-if)#switchport trunk encapsulation dot1q
Rack#2_3550(config-if)#switchport mode trunk

Rack#2_3550(config)#interface FastEthernet0/16
Rack#2_3550(config-if)#switchport trunk encapsulation dot1q
Rack#2_3550(config-if)#switchport mode trunk
```

Problem 2

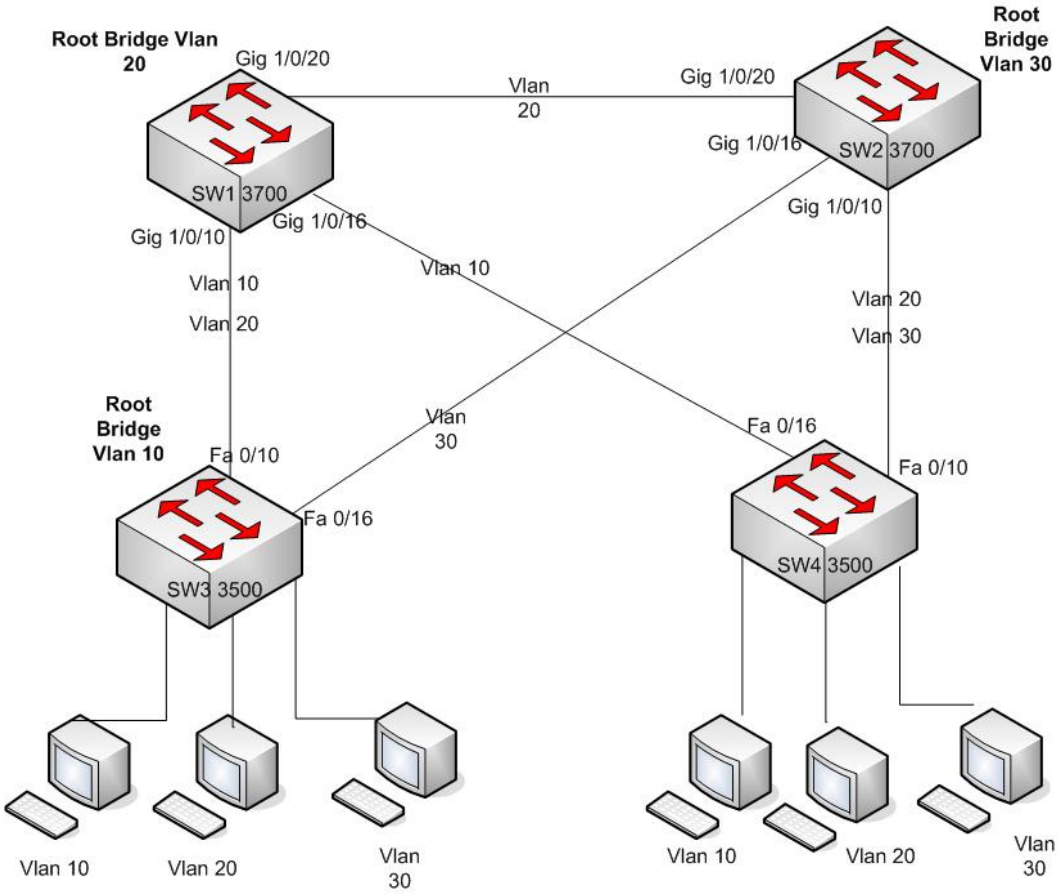

Figure 4.4 Solution network diagram fot configuring STP in multiple VLAN

Solution

In this lab we are using 2 Cisco 3550 and 2 Cisco 3750 switches in Rack 1 and Rack 2. The correspondent ip addresses of the switches are as follows:

Rack#1 SW1 3750 – 10.3.31.132
Rack#1 SW3 3550 – 10.3.31.133
Rack#2 SW2 3750 – 10.3.31.112
Rack#2 SW4 3550 – 10.3.31.113

Step 1: Connect all the switches as the network diagram above. Telnet the switches with correspondent ip address and configure them.

Step 2: First of all we need to create 3 vlans in all the switches. The commands would be same for all the switches.

Create vlans:

```
Switch#vlan database
Switch(vlan)#vlan 10 name userA
Switch(vlan)#vlan 20 name userB
Switch(vlan)#vlan 30 name userC
Switch(vlan)#exit
```

Step 3:

Configuration of Sw 1 (Cisco 3750)

```
Rack#1_3750#conf t
Rack#1_3750(config)#spanning-tree vlan 20 root primary
Rack#1_3750(config)#spanning-tree vlan 30 root secondary
```

Note: To make the switch root bridge for vlan 20 and secondary root bridge for vlan 30

Configure trunk port to connect to other switches:

```
Rack#1_3750(config)#interface GigabitEthernet1/0/10
Rack#1_3750(config-if)#switchport trunk encapsulation dot1q
Rack#1_3750(config-if)#switchport trunk allowed vlan 10,20,30
Rack#1_3750(config-if)#switchport mode trunk

Rack#1_3750(config)#interface GigabitEthernet1/0/16
Rack#1_3750(config-if)#switchport trunk encapsulation dot1q
Rack#1_3750(config-if)#switchport trunk allowed vlan 10,20,30
Rack#1_3750(config-if)#switchport mode trunk

Rack#1_3750(config-if)#spanning-tree vlan 10 cost 1
Rack#1_3750(config-if)#spanning-tree vlan 20 cost 1000
```

Note: Configuring the path cost to send the packet in the selected path as the network diagram.

```
Rack#1_3750(config)#interface GigabitEthernet1/0/20
Rack#1_3750(config-if)#switchport trunk encapsulation dot1q
Rack#1_3750(config-if)#switchport trunk allowed vlan 10,20,30
Rack#1_3750(config-if)#switchport mode trunk
```

Configuration of Sw 2 (Cisco 3750)

```
Rack#2_3750#conf t
Rack#2_3750(config)#spanning-tree vlan 30 root primary
Rack#2_3750(config)#spanning-tree vlan 10 root secondary
Rack#2_3750(config)#spanning-tree vlan 20 root secondary
```

Note: To make the switch root bridge for vlan 30 and secondary root bridge for vlan 10 and vlan 20

Configure trunk port to connect to other switches:

```
Rack#2_3750(config)#interface GigabitEthernet1/0/10
Rack#2_3750(config-if)#switchport trunk encapsulation dot1q
Rack#2_3750(config-if)#switchport trunk allowed vlan 10,20,30
Rack#2_3750(config-if)#switchport mode trunk

Rack#2_3750(config)#interface GigabitEthernet1/0/16
Rack#2_3750(config-if)#switchport trunk encapsulation dot1q
Rack#2_3750(config-if)#switchport trunk allowed vlan 10,20,30
Rack#2_3750(config-if)#switchport mode trunk

Rack#2_3750(config)#interface GigabitEthernet1/0/20
Rack#2_3750(config-if)#switchport trunk encapsulation dot1q
Rack#2_3750(config-if)#switchport trunk allowed vlan 10,20,30
Rack#2_3750(config-if)#switchport mode trunk
```

Configuration of Sw 3 (Cisco 3550)

```
Rack#1_3550#conf t
Rack#1_3550(config)#spanning-tree vlan 10 priority 0
```

Note: To make the switch root bridge for vlan 10

Configure access port for the users:

```
Rack#1_3550(config)#interface FastEthernet0/1
Rack#1_3550(config)#switchport access vlan 10
Rack#1_3550(config)#interface FastEthernet0/2
Rack#1_3550(config)#switchport access vlan 20
Rack#1_3550(config)#interface FastEthernet0/3
Rack#1_3550(config)#switchport access vlan 30
```

Configure trunk port to connect to other switches:

```
Rack#1_3550(config)#interface FastEthernet0/10
Rack#1_3550(config-if)#switchport trunk encapsulation dot1q
Rack#1_3550(config-if)#switchport trunk allowed vlan 10,20,30
Rack#1_3550(config-if)#switchport mode trunk

Rack#1_3550(config)#interface FastEthernet0/16
Rack#1_3550(config-if)#switchport trunk encapsulation dot1q
Rack#1_3550(config-if)#switchport trunk allowed vlan 10,20,30
Rack#1_3550(config-if)#switchport mode trunk
```

Configuration of Sw 4 (Cisco 3550)

Configure access port for the users:

```
Rack#2_3550(config)#interface FastEthernet0/1
Rack#2_3550(config)#switchport access vlan 10
Rack#2_3550(config)#interface FastEthernet0/2
Rack#2_3550(config)#switchport access vlan 20
Rack#2_3550(config)#interface FastEthernet0/3
Rack#2_3550(config)#switchport access vlan 30
```

Configure trunk port to connect to other switches:

```
Rack#2_3550(config)#interface FastEthernet0/10
Rack#2_3550(config-if)#switchport trunk encapsulation dot1q
Rack#2_3550(config-if)#switchport trunk allowed vlan 10,20,30
Rack#2_3550(config-if)#switchport mode trunk

Rack#2_3550(config)#interface FastEthernet0/16
Rack#2_3550(config-if)#switchport trunk encapsulation dot1q
Rack#2_3550(config-if)#switchport trunk allowed vlan 10,20,30
Rack#2_3550(config-if)#switchport mode trunk


Rack#2_3550(config-if)#spanning-tree vlan 10 cost 1
Rack#2_3550(config-if)#spanning-tree vlan 20 cost 1000
```

Note: Configuring the path cost to send the packet in the selected path as the network diagram.

4.4.1 Outputs and Results

Spanning tree table

When all links are up

Rack#1_3750#sh spanning-tree vlan 10-20

```
VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    0
             Address     0007.eb94.7201
             Cost        19
             Port        10 (GigabitEthernet1/0/10)
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext
10)
             Address     0018.186e.7b00
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec
             Aging Time 300

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
------------------
Gi1/0/10         Root FWD 19        128.10   P2p
Gi1/0/20         Altn BLK 4         128.20   P2p

VLAN0020
  Spanning tree enabled protocol ieee
  Root ID    Priority    24596
             Address     0018.186e.7b00
             This bridge is the root
[Note: Confirms that this is Root Bridge for VLAN 20]
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    24596  (priority 24576 sys-id-ext
20)
             Address     0018.186e.7b00
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec
             Aging Time 300
```

```
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
------------------
Gi1/0/10         Desg FWD 19        128.10   P2p
Gi1/0/20         Desg FWD 4         128.20   P2p
```

Rack#1_3550#sh spanning-tree brief

```
VLAN10
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 0
             Address 0007.eb94.7201
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    0
             Address     0007.eb94.7201
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                            Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
Fa0/1   128.13  128  19   FWD  0     0007.eb94.7201 128.13
Fa0/10  128.23  128  1    FWD  0     0007.eb94.7201 128.23
Fa0/16  128.29  128  19   FWD  0     0007.eb94.7201 128.29

VLAN20
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 24596
             Address 0018.186e.7b00
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32768
             Address     0007.eb94.7202
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                            Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
```

```
Fa0/2   128.14  128  19   BLK  19    0007.eb94.7202 128.14
Fa0/10  128.23  128  19   FWD  0     0018.186e.7b00 128.10
Fa0/16  128.29  128  19   BLK  4     0018.186e.9b80 128.16

VLAN30
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 24606
             Address 0018.186e.9b80
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32768
             Address     0007.eb94.7203
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                            Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
Fa0/3   128.15  128  19   BLK  19    0007.eb94.7203 128.15
Fa0/10  128.23  128  19   BLK  4     0018.186e.7b00 128.10
Fa0/16  128.29  128  19   FWD  0     0018.186e.9b80 128.16
```

Rack#2_3750#sh spanning-tree vlan 10-20

```
VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    0
             Address     0007.eb94.7201
             Cost        19
             Port        16 (GigabitEthernet1/0/16)
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    28682  (priority 28672 sys-id-ext
10)
             Address     0018.186e.9b80
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec
             Aging Time 300

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
```

```
------------------
Gi1/0/10         Desg FWD 19        128.10   P2p
Gi1/0/16         Root FWD 19        128.16   P2p
Gi1/0/20         Desg FWD 4         128.20   P2p

VLAN0020
  Spanning tree enabled protocol ieee
  Root ID    Priority    24596
             Address     0018.186e.7b00
             Cost        4
             Port        20 (GigabitEthernet1/0/20)
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    28692  (priority 28672 sys-id-ext
20)
             Address     0018.186e.9b80
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec
             Aging Time 300

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
------------------
Gi1/0/10         Desg FWD 19        128.10   P2p
Gi1/0/16         Desg FWD 19        128.16   P2p
Gi1/0/20         Root FWD 4         128.20   P2p
```

Rack#2_3550#sh spanning-tree brief

```
VLAN10
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 0
             Address 0007.eb94.7201
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32768
             Address     0007.eb94.7241
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                            Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
Fa0/1   128.13  128  19   FWD  38    0007.eb94.7241 128.13
```

```
Fa0/10  128.23  128  19   FWD  19    0018.186e.9b80 128.10
Fa0/16  128.29  128  1    BLK  38    0007.eb94.7241 128.29

VLAN20
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 24596
             Address 0018.186e.7b00
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32768
             Address     0007.eb94.7242
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                             Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
Fa0/2   128.14  128  19   BLK  23    0007.eb94.7242 128.14
Fa0/10  128.23  128  19   FWD  4     0018.186e.9b80 128.10
Fa0/16  128.29  128  1000 BLK  23    0007.eb94.7242 128.29

VLAN30
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 24606
             Address 0018.186e.9b80
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32768
             Address     0007.eb94.7243
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                             Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
Fa0/3   128.15  128  19   BLK  19    0007.eb94.7243 128.15
Fa0/10  128.23  128  19   FWD  0     0018.186e.9b80 128.10
Fa0/16  128.29  128  19   BLK  19    0007.eb94.7243 128.29
```

When port 0/16 in SW1 is shutdown

Spanning tree table for vlan 10 on SW1

Rack#1_3750#sh spanning-tree vlan 10-20

```
VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    0
             Address     0007.eb94.7201
             Cost        19
             Port        10 (GigabitEthernet1/0/10)
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext
10)
             Address     0018.186e.7b00
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec
             Aging Time 300

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
------------------
Gi1/0/10         Root FWD 19        128.10   P2p
Gi1/0/20         Altn BLK 4         128.20   P2p
```

Spanning tree table for vlan 10 on SW3

Rack#1_3550#sh spanning-tree brief

```
VLAN10
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 0
             Address 0007.eb94.7201
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    0
             Address     0007.eb94.7201
             Hello Time   2 sec  Max Age 20 sec  Forward
```

```
Delay 15 sec


Port                            Designated
Name    Port ID Prio Cost Sts   Cost  Bridge ID      Port ID
------- ------- ---- ---- ---   ----  -------------- -------
Fa0/1   128.13  128  19   FWD   0     0007.eb94.7201 128.13
Fa0/10  128.23  128  1    FWD   0     0007.eb94.7201 128.23
Fa0/16  128.29  128  19   FWD   0     0007.eb94.7201 128.29
```

When port 0/16 in SW1 and port 0/16 in SW3 is shutdown

Spanning tree table for vlan 10 on SW1

Rack#1_3750#sh spanning-tree vlan 10-20

```
VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    0
             Address     0007.eb94.7201
             Cost        19
             Port        10 (GigabitEthernet1/0/10)
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext
10)
             Address     0018.186e.7b00
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec
             Aging Time 15

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
------------------
Gi1/0/10         Root FWD 19        128.10   P2p
Gi1/0/20         Desg FWD 4         128.20   P2p
```

Spanning tree table for vlan 10 on SW3

Rack#1_3550#sh spanning-tree brief

```
VLAN10
  Spanning tree enabled protocol IEEE
  ROOT ID    Priority 0
             Address 0007.eb94.7201
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec

  Bridge ID  Priority    0
             Address     0007.eb94.7201
             Hello Time   2 sec  Max Age 20 sec  Forward
Delay 15 sec


Port                            Designated
Name    Port ID Prio Cost Sts  Cost  Bridge ID      Port ID
------- ------- ---- ---- ---  ----  -------------- -------
Fa0/1   128.13  128  19   FWD  0     0007.eb94.7201 128.13
Fa0/10  128.23  128  1    FWD  0     0007.eb94.7201 128.23
Fa0/16  128.29  128  19   BLK  0     0007.eb94.7201 128.29
```

Chapter 5

Static Routing

Lab Manual

Instructor Manual

Lab Manual

5. Introduction

Introduction

Routing is the process of finding a path to a destination host. The network layer uses the ip routing table to send packets from the source network to the destination network. Routing service uses the network topology information when counting network paths.

Routing protocol supports a routed protocol by providing mechanism or sharing routing information. Routing protocol messages move between the routers only.

Advantages

- Static routes are simple and quick to configure.
- Static routing is supported on all routing devices and all routers.
- Static routes are easy to predict and understand in small networks.
- In static routing there is no overhead for routing protocols which is required for dynamic routes.

Disadvantages

- Network using static routes in not fault tolerant.
- Static routes require extensive planning and have high management overhead. The more routers exist in a network, the more routes that need to be configured. If you have 'N' number of routers and a route between each router is needed, then you must configure N x N routes, so, for a network of nine routers, you need 81 routes (9 x 9 = 81).
- Static routes do not dynamically adapt to network topology changes or equipment failures.
- Static routing does not scale well in large networks.

5.1 Pre lab questions

1. What would be the default routing table on a Cisco router interface when is roots?

A. Connected networks only.
B. Connected networks and a single default static route.
C. None - the routing table is empty until a routing protocol populates it.
D. None of these.

2. Which of the following statements will create a static route that will send packets to the destination IP address 2.2.2.2, but no others?

A. ip route 2.2.2.2 255.255.255.255 172.12.123.1
B. ip route 2.2.2.2 0.0.0.0 172.12.123.1
C. ip route 2.2.2.2 172.12.123.1 255.255.255.255
D. ip route 2.2.2.2 172.12.123.1 0.0.0.0
E. ip route 0.0.0.0 0.0.0.0 172.12.123.1
F. ip route 0.0.0.0 172.12.123.1 0.0.0.0

3. Which of the following statements are true regarding the command ip route 172.16.4.0 255.255.255.0 192.168.4.2? (Choose two.)

A. The command is used to establish a static route.
B. The default administrative distance is used.
C. The command is used to configure the default route.
D. The subnet mask for the source address is 255.255.255.0.
E. The command is used to establish a stub network.

4. What information must be stored in the route table?

5. What IOS command is used to examine the IPv4 and IPv6 route table?

6. What is a summary route? In the context of static routing, how are summary routes useful?

7. What does it mean when a route table says that an address is variably subnetted?

5.2 Lab Exercise

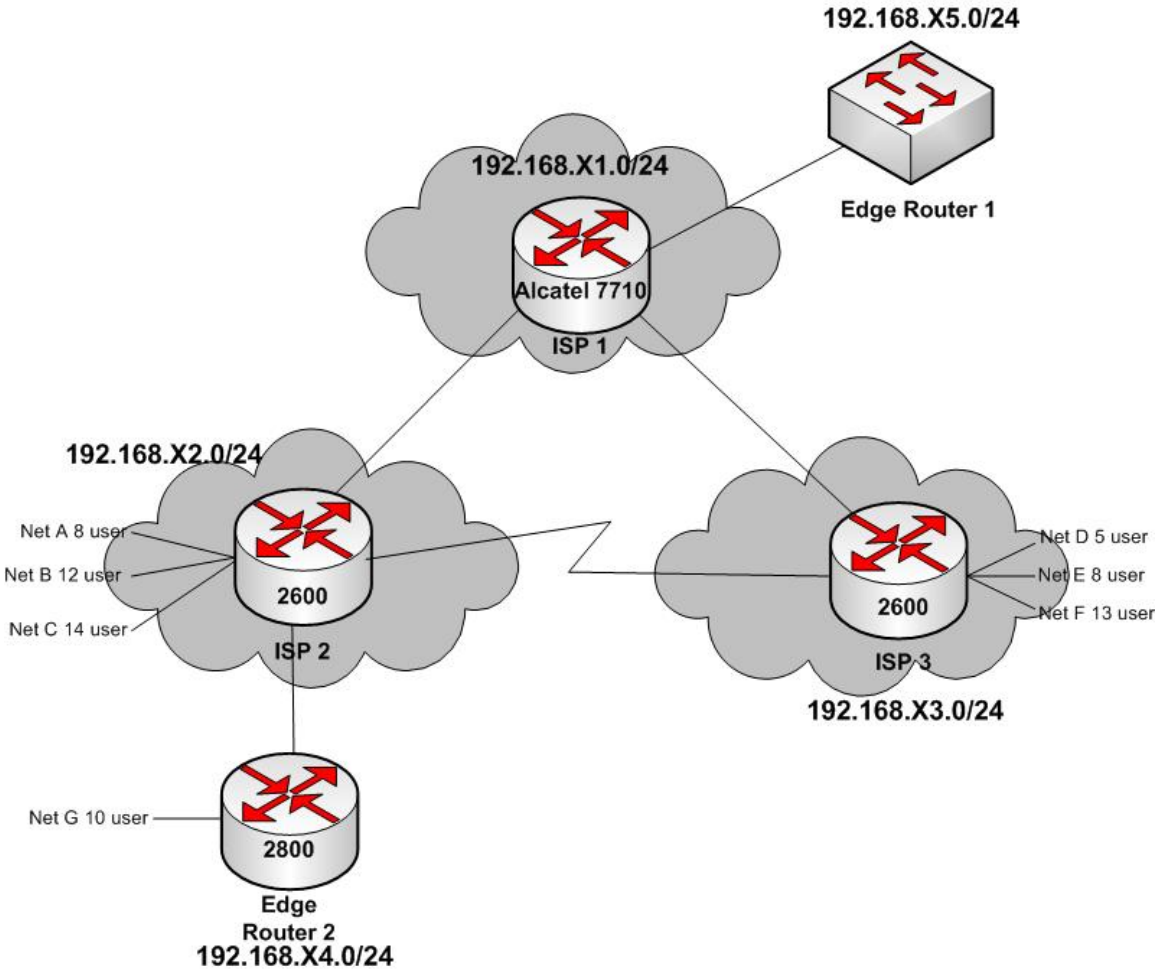

Figure 5.1 Network diagram for configuring Static routing protocol

In this lab, you will configure static routes in all the ISP routers so that the routers can reach all networks.

You have two edge customer devices (Cisco 2800 and Cisco 3750) connected to ISP routers. ISP 1 will provide all the IP address for its connected interface, and ISP 2 will provide IP address for the interfaces connect with ISP 3 and edge router 2.

For edge router 1 you will use a switch as a router which is connected to network 192.168.X5.0/24. It does not know about networks 192.168.X1.0/24, 192.168.X2.0/24, 192.168.X3.0/24, and 192.168.X4.0/24

Here 'X' is the rack number.

- Configure static routes to all ISP routers.
- Configure alternate route in case the primary link break down.
- Verify with the Ping program when complete.

5.2.1What to hand in

1. Draw the network diagram and give all interface ip address. The maximum number of address needs to be kept free for future use.
2. The list of commands issued in the routers configuring interfaces, enable routing.
3. The output of ***show run*** command.
4. Aggregate all ISP routes.
5. Show **ip route** before and after aggregation. What difference do you observe?

Instructor Manual

5.3 Pre lab answers

1. What would be the default routing table on a Cisco router interface when is roots?

A. Connected networks only.
B. Connected networks and a single default static route.
C. None - the routing table is empty until a routing protocol populates it.
D. None of these.

2. Which of the following statements will create a static route that will send packets to the destination IP address 2.2.2.2, but no others?

A. ip route 2.2.2.2 255.255.255.255 172.12.123.1
B. ip route 2.2.2.2 0.0.0.0 172.12.123.1
C. ip route 2.2.2.2 172.12.123.1 255.255.255.255
D. ip route 2.2.2.2 172.12.123.1 0.0.0.0
E. ip route 0.0.0.0 0.0.0.0 172.12.123.1
F. ip route 0.0.0.0 172.12.123.1 0.0.0.0

3. Which of the following statements are true regarding the command ip route 172.16.4.0 255.255.255.0 192.168.4.2? (Choose two.)

A. The command is used to establish a static route.
B. The default administrative distance is used.
C. The command is used to configure the default route.
D. The subnet mask for the source address is 255.255.255.0.
E. The command is used to establish a stub network.

4. What information must be stored in the route table?

Ans. At a minimum, each entry of the routing table must include a destination address and the address of a next-hop router or an indication that the destination address is directly connected.

5. What IOS command is used to examine the IPv4 and IPv6 route table?

Ans *Show ip route* is used to examine the routing table of IPv4 in a Cisco router. For IPv6 the command is ***show ipv6 route.***

6. What is a summary route? In the context of static routing, how are summary routes useful?

Ans. A summary route is a single route entry that points to multiple subnets or major IP addresses. In the context of static routes, summary routes can reduce the number of static routes that must be configured.

7. What does it mean when a route table says that an address is variably subnetted?

Ans. Variably subnetted means that the router knows of more than one subnet mask for subnets of the same major IP address.

5.4 Lab Exercise Solution

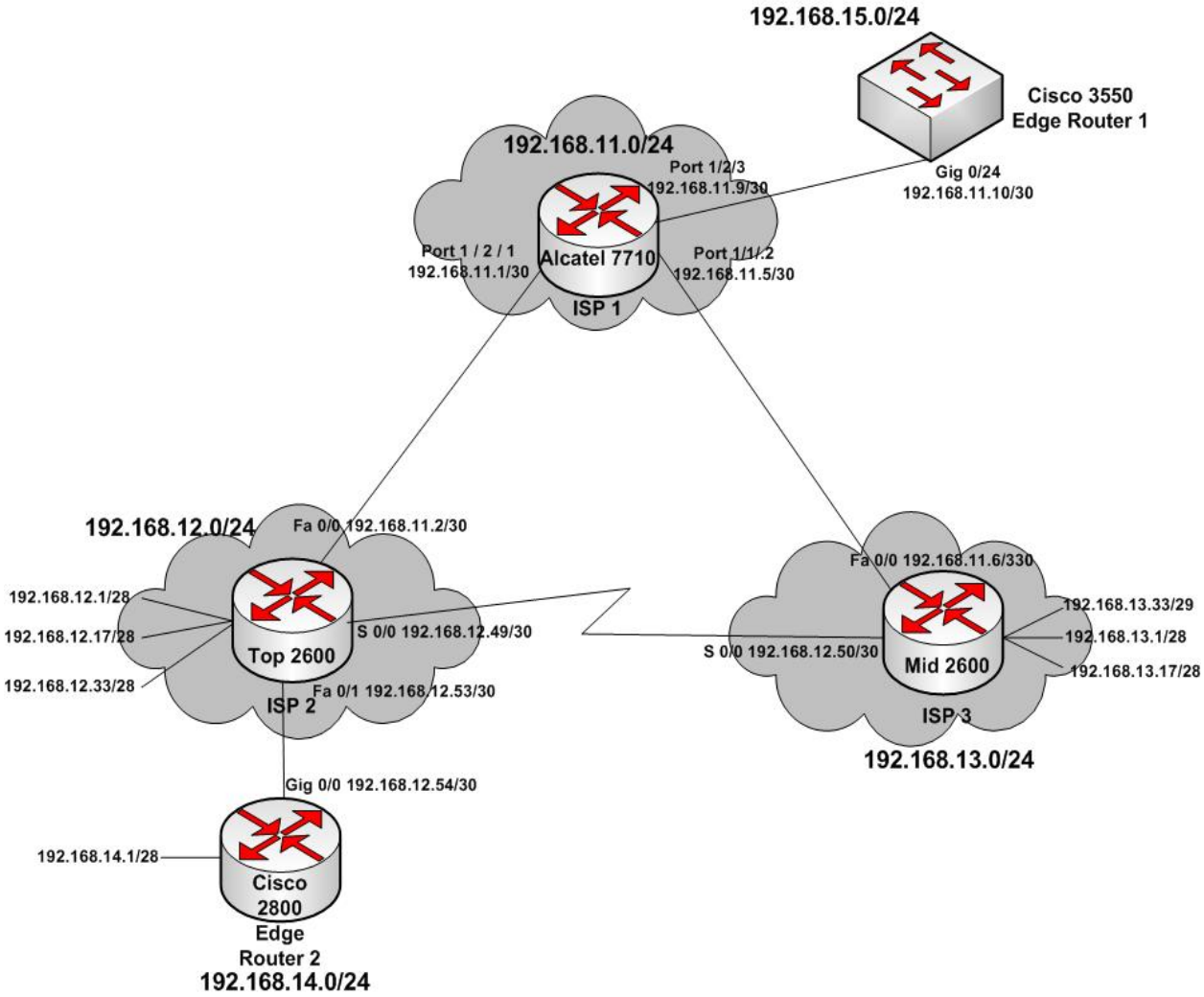

Figure 5.2 Solution network diagram for configuring Static routing protocol

In this lab we will use Cisco 2600 Top router (10.3.31.114), Cisco 2600 Mid router (10.3.31.115), Cisco 2800 router (10.3.31.117), Cisco 3750 Switch (10.3.31.112) and Alcatel Lucent 7710 router (10.3.31.169) in rack# 2.

Step 1: Telnet all the device one by one with the correspondent ip address and configure them as follows.

5.4.1 Configuration

Configuration of Cisco Top 2600 router:

```
mzrahman@team4:~$ telnet 10.3.31.114
Trying 10.3.31.114...
!
interface Loopback4
 ip address 192.168.12.1 255.255.255.240
!
interface Loopback5
 ip address 192.168.12.17 255.255.255.240
!
interface Loopback6
 ip address 192.168.12.33 255.255.255.240
!
interface FastEthernet0/0
 ip address 192.168.11.2 255.255.255.252
 duplex auto
 speed auto
!
interface Serial0/0
 ip address 192.168.12.49 255.255.255.252
 clock rate 2000000
 no fair-queue
!
interface FastEthernet0/1
 ip address 192.168.12.53 255.255.255.252
 duplex auto


Note: Configure Static route

ip route 192.168.11.4 255.255.255.252 192.168.12.50
ip route 192.168.11.8 255.255.255.252 192.168.11.1
ip route 192.168.13.0 255.255.255.240 192.168.12.50
ip route 192.168.13.16 255.255.255.240 192.168.12.50
ip route 192.168.13.32 255.255.255.248 192.168.12.50

Note: Configure Alternate/backup Static route
```

```
ip route 192.168.11.4 255.255.255.252 192.168.11.1 240
ip route 192.168.11.8 255.255.255.252 192.168.12.50 240
ip route 192.168.13.0 255.255.255.240 192.168.11.1 240
ip route 192.168.13.16 255.255.255.240 192.168.11.1 240
ip route 192.168.13.32 255.255.255.248 192.168.11.1 240
!
!
end
```

Configuration of Cisco Mid 2600 router:

```
mzrahman@team4:~$ telnet 10.3.31.115
Trying 10.3.31.115...
Connected to 10.3.31.115.
!
!
interface Loopback1
 ip address 192.168.13.1 255.255.255.240
!
interface Loopback2
 ip address 192.168.13.17 255.255.255.240
!
interface Loopback3
 ip address 192.168.13.33 255.255.255.248
!
interface FastEthernet0/0
 ip address 192.168.11.6 255.255.255.252
 duplex auto
 speed auto
!
interface Serial0/0
 ip address 192.168.12.50 255.255.255.252
 no fair-queue


Note: Configure Static route

ip route 192.168.11.0 255.255.255.252 192.168.12.49
ip route 192.168.11.8 255.255.255.252 192.168.11.5
ip route 192.168.12.0 255.255.255.240 192.168.12.49
ip route 192.168.12.16 255.255.255.240 192.168.12.49
ip route 192.168.12.32 255.255.255.240 192.168.12.49
ip route 192.168.12.52 255.255.255.252 192.168.12.49
!

Note: Configure Alternate/backup Static route

ip route 192.168.11.0 255.255.255.252 192.168.11.5 240
```

```
ip route 192.168.11.8 255.255.255.252 192.168.12.49 240
ip route 192.168.12.0 255.255.255.240 192.168.11.5 240
ip route 192.168.12.16 255.255.255.240 192.168.11.5 240
ip route 192.168.12.32 255.255.255.240 192.168.11.5 240
ip route 192.168.12.52 255.255.255.252 192.168.11.5 240

!
!
end
```

Configuration of Cisco 2800 router:

```
Router#sh run
!
interface Loopback7
 ip address 192.168.14.1 255.255.255.240
!
interface GigabitEthernet0/0
 ip address 192.168.12.54 255.255.255.252
 duplex auto

!
ip route 0.0.0.0 0.0.0.0 192.168.12.53
!
!
end
```

Configuration of Cisco 3750 switch:

```
mzrahman@team4:~$ telnet 10.3.31.112
Trying 10.3.31.112...
!
interface GigabitEthernet1/0/24
 no switchport
 ip address 192.168.11.10 255.255.255.252
!
interface GigabitEthernet1/0/25

Note: Configuring Static route in switch needs an extra
parameter.

ip route 0.0.0.0 0.0.0.0 192.168.11.9 permanent
ip http server
!
end
```

Configuration of Alcatel-Lucent 7710 router:

mzrahman@menthe:~$ **telnet 10.3.31.169**
Trying 10.3.31.169...
Connected to 10.3.31.169.
Escape character is '^]'.
TiMOS-B-6.1.R4 both/hops ALCATEL SR 7710 Copyright (c) 2000-2008 Alcatel-Lucent.
All rights reserved. All use subject to applicable license agreements.
Built on Thu Oct 30 15:49:21 PDT 2008 by builder in /rel6.1/b1/R4/panos/main

Login: admin
Password: admin

*A:RACK-2#

Configure Ports:

```
*A:RACK-2# configure router
*A:RACK-2>config>router# interface toTopRouter
*A:RACK-2>config>router>if$ address 192.168.11.1/30
*A:RACK-2>config>router>if$ port 1/2/1
*A:RACK-2>config>router>if$ exit
*A:RACK-2>config>router# interface toMidRouter
*A:RACK-2>config>router>if$ address 192.168.11.5/30
*A:RACK-2>config>router>if$ port 1/2/2
*A:RACK-2>config>router>if$ exit
*A:RACK-2>config>router# interface toSwitch
*A:RACK-2>config>router>if$ address 192.168.11.9/30
*A:RACK-2>config>router>if$ port 1/2/3
*A:RACK-2>config>router>if$ exit
```

Configure Static Route:

```
A:RACK-2# configure router static-route 192.168.15.0/24 next-hop
192.168.11.10
*A:RACK-2# configure router static-route 192.168.12.48/30 next-
hop 192.168.11.6
*A:RACK-2# configure router static-route 192.168.12.28/30 next-
hop 192.168.11.6
*A:RACK-2# configure router static-route 192.168.13.0/28 next-hop
192.168.11.6
*A:RACK-2# configure router static-route 192.168.13.17/28 next-
hop 192.168.11.6
*A:RACK-2# configure router static-route 192.168.13.16/28 next-
hop 192.168.11.6
```

```
*A:RACK-2# configure router static-route 192.168.13.32/29 next-
hop 192.168.11.6
*A:RACK-2# configure router static-route 192.168.12.0/28 next-hop
192.168.11.2
*A:RACK-2# configure router static-route 192.168.12.16/28 next-
hop 192.168.11.2
*A:RACK-2# configure router static-route 192.168.12.32/28 next-
hop 192.168.11.2
*A:RACK-2# configure router static-route 192.168.12.52/28 next-
hop 192.168.11.2
```

Configure Alternet Route:

```
*A:RACK-2# configure router static-route 192.168.12.48/30 next-
hop 192.168.11.2 metric 240
*A:RACK-2# configure router static-route 192.168.13.0/28 next-hop
192.168.11.2 metric 240
*A:RACK-2# configure router static-route 192.168.13.16/28 next-
hop 192.168.11.2 metric 240
*A:RACK-2# configure router static-route 192.168.13.32/29 next-
hop 192.168.11.2 metric 240
*A:RACK-2# configure router static-route 192.168.12.0/28 next-hop
192.168.11.6 metric 240
*A:RACK-2# configure router static-route 192.168.12.16/28 next-
hop 192.168.11.6 metric 240
*A:RACK-2# configure router static-route 192.168.12.32/28 next-
hop 192.168.11.6 metric 240
*A:RACK-2# configure router static-route 192.168.12.52/30 next-
hop 192.168.11.6 metric 240
*A:RACK-2# configure router static-route 192.168.14.0/24 next-hop
192.168.11.6 metric 240
```

Chapter 6

Dynamic Routing (RIPv2)

Lab Manual

Instructor Manual

Lab Manual

6. Static Vs. Dynamic Routing

There are significant difference between static routing and dynamic routing.

- Static routing sets up the optimal paths manually between source and destination computers. On the contrary, dynamic routing uses dynamic protocols to find the optimal path and update the routing table between the source and the destination computers.

- Static routing doesn't have any controlling mechanism where the routers use static routing if there is any faults in the routing paths. Dynamic routers that use dynamic routing protocols can sense a faulty router in the network. Moreover, they eliminates the faulty router and finds out alternate possible optimal path from the source to the destination. If any of the router is down or faulty for certain reasons, this fault is circulated in the entire network. Because of this quality of the dynamic routers, they are also known as adaptive routers.

- The static routing is the simplest way to route a data packets from a source to a destination in a network whereas, dynamic routing uses complex algorithms for routing the data packets.

- The static routing works very well in small networks but they cannot be used in large networks. On the other hand, dynamic routing is used for larger networks. Manual routing has no specific routing algorithm. The dynamic routers are based on various routing algorithms. OSPF (Open Shortest Path First), IGRP (Interior Gateway Routing Protocol) and RIP (Routing Information Protocol) are some popular dynamic routing protocols.

- The static routing requires minimal amount of memory. On the other hand, dynamic router have quite a few memory overheads, depending on which routing algorithm it is using.

6.1 Pre lab questions

1. Why do routing protocols use metrics?

2. What is load balancing? Name four different types of load balancing.

3. Which three fields are new to the RIPv2 message format?

4. What is the purpose of the Next Hop field?

5. What is the UDP port number used by RIPv2?

6. What are neighbours?

7. Which statement is true regarding classless routing protocols? (Choose two.)

A. The use of discontiguous networks is not allowed.
B. The use of variable length subnet masks is permitted.
C. RIPv1 is a classless routing protocol.
D. IGRP supports classless routing within the same autonomous system.
E. RIPv2 supports classless routing.

8. Which command displays RIP routing updates?
A. show ip route
B. debug ip rip
C. show protocols
D. debug ip route

9. What does RIPv2 use to prevent routing loops? (Choose two.)

A. CIDR
B. Split horizon
C. Authentication
D. Classless masking
E. Holddown timers

10. You type **debug ip rip** on your router console and see that 172.16.10.0 is being advertised to you with a metric of 16. What does this mean?

A. The route is 16 hops away.
B. The route has a delay of 16 microseconds.
C. The route is inaccessible.
D. The route is queued at 16 messages a second.

11. Which of the following is true regarding RIPv2?

A. It has a lower administrative distance than RIPv1.
B. It converges faster than RIPv1.
C. It has the same timers as RIPv1.
D. It is harder to configure than RIPv1.

6.2 Lab Exercise

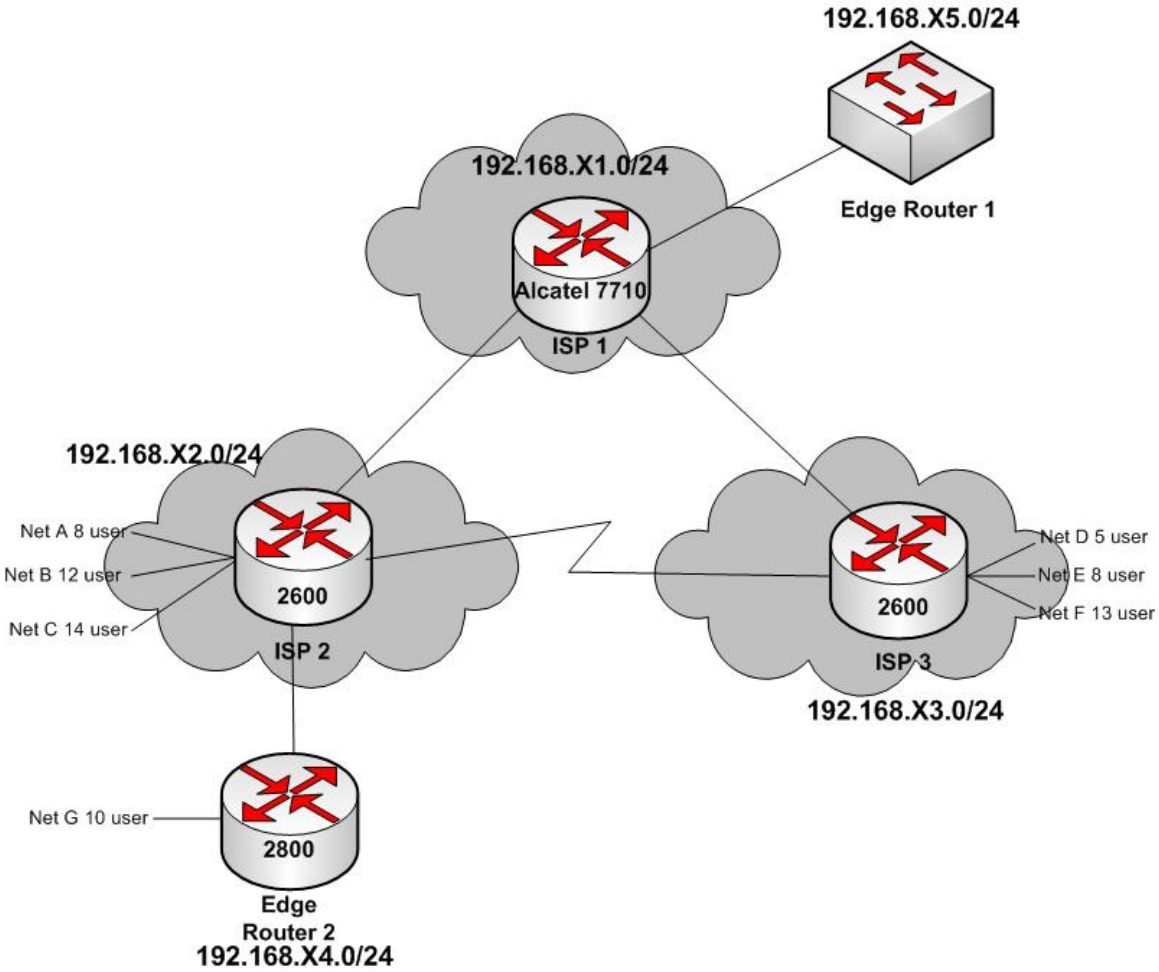

Figure 6.1 Network diagram for RIPV2 protocol

In this lab, you will configure RIPv2 in all the ISP routers so that the routers can reach all networks.

You have two edge customer devices (Cisco 2800 and Cisco 3750) connected to ISP routers. ISP 1 will provide all the IP address for its connected interface, and ISP 2 will provide IP address for the interfaces connect with ISP 3 and edge router 2.

For edge router 1 you will use a switch as a router which is connected to network 192.168.X5.0/24. It does not know about networks 192.168.X1.0/24, 192.168.X2.0/24, 192.168.X3.0/24, and 192.168.X4.0/24

Here ‘X’ is the rack number.

- Configure RIPv2 to all ISP routers.
- Verify with the Ping program when complete.

6.2.1What to hand in

1. Draw the network diagram and give all interface ip address. The maximum number of address needs to be kept free for future use.
2. The list of commands issued in the routers configuring interfaces, enable routing.
3. The output of ***show run*** command.
4. Aggregate all ISP routes.
5. Show **ip route** before and after aggregation. What difference do you observe?

Instructor Manual

6.3 Pre lab answers

1. Why do routing protocols use metrics?

Ans. A route metric, also called a route cost or a route distance, is used to determine the best path to a destination. Best is defined by the type of metric used.

2. What is load balancing? Name four different types of load balancing.

Ans. Load balancing is the process of sending packets over multiple paths to the same destination. Four types of load balancing are

- Equal cost, per packet.
- Equal cost, per destination.
- Unequal cost, per packet.
- Unequal cost, per destination.

3. Which three fields are new to the RIPv2 message format?

Ans. The Route Tag field, the Subnet Mask field, and the Next Hop field are RIPv2 extensions that do not exist in RIPv1 messages. The basic format of the RIP message remains unchanged between the two versions; Version 2 merely uses fields that are unused in Version 1.

4. What is the purpose of the Next Hop field?

Ans. The Next Hop field is used to inform other routers of a next-hop address on the same multi-access network that is metrically closer to the destination than the originating router

5. What is the UDP port number used by RIPv2?
Ans. RIPv2 uses the same UDP port number as RIPv1, port number 520.

6. What are neighbours?

Ans. Neighbours are routers connected to the same data link.

7. Which statement is true regarding classless routing protocols? (Choose two.)

A. The use of discontiguous networks is not allowed.
B. The use of variable length subnet masks is permitted.
C. RIPv1 is a classless routing protocol.
D. IGRP supports classless routing within the same autonomous system.
E. RIPv2 supports classless routing.

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A. It has a lower administrative distance than RIPv1.
B. It converges faster than RIPv1.
C. It has the same timers as RIPv1.
D. It is harder to configure than RIPv1.

6.4 Lab Exercise Solution

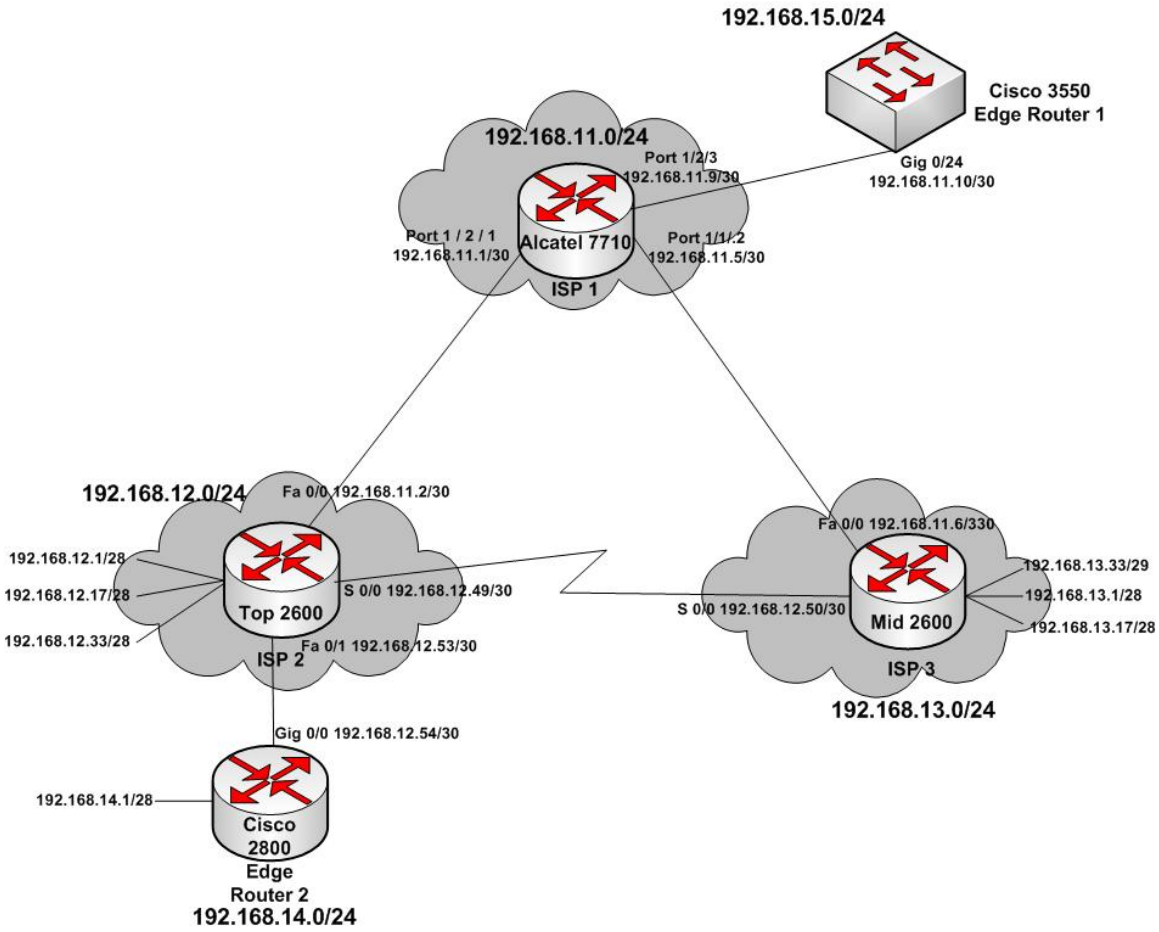

Figure 6.2 Solution network diagram for RIPV2 protocol

Solution:

In this lab we will use Cisco 2600 Top router (10.3.31.114), Cisco 2600 Mid router (10.3.31.115), Cisco 2800 router (10.3.31.117), Cisco 3750 Switch (10.3.31.112) and Alcatel Lucent 7710 router (10.3.31.169) in rack# 2.

Step 1: Telnet all the device one by one with the correspondent ip address and configure them as follows.

6.4.1 Configuration

Configuration of Cisco Top 2600 router:

```
Top_2600#sh run
Building configuration...

Current configuration : 1080 bytes
!
!
interface Loopback4
 ip address 192.168.12.1 255.255.255.240
!
interface Loopback5
 ip address 192.168.12.17 255.255.255.240
!
interface Loopback6
 ip address 192.168.12.33 255.255.255.240
!
interface FastEthernet0/0
 ip address 192.168.11.2 255.255.255.252
!
interface Serial0/0
 ip address 192.168.12.49 255.255.255.252
 clock rate 2000000
!
interface FastEthernet0/1
 ip address 192.168.12.53 255.255.255.252
!
router rip
 version 2
 redistribute static
 network 192.168.11.0
 network 192.168.12.0
 no auto-summary
!
ip route 192.168.14.0 255.255.255.240 192.168.12.54
!
end
```

Configuration of Cisco Mid 2600 router:

```
Mid_2600#sh run
Building configuration...
!
hostname Mid_2600
!
!
interface Loopback1
 ip address 192.168.13.1 255.255.255.240
!
interface Loopback2
 ip address 192.168.13.17 255.255.255.240
!
interface Loopback3
 ip address 192.168.13.33 255.255.255.248
!
interface FastEthernet0/0
 ip address 192.168.11.6 255.255.255.252
!
interface Serial0/0
 ip address 192.168.12.50 255.255.255.252
!
router rip
 version 2
 network 192.168.11.0
 network 192.168.12.0
 network 192.168.13.0
 no auto-summary
!
end
```

Configuration of Cisco 2800 router:

```
Router#sh run
Building configuration...

!
interface Loopback0
 ip address 192.168.14.1 255.255.255.240
!
interface GigabitEthernet0/0
 ip address 192.168.12.54 255.255.255.252
```

```
 no shutdown

ip route 0.0.0.0 0.0.0.0 192.168.12.53
!
!
end
```

Configuration of Cisco 3750 Switch:

```
Switch#sh run
Building configuration...
interface Loopback1
 ip address 192.168.15.1 255.255.255.240
!
interface GigabitEthernet1/0/24
 no switchport
 ip address 192.168.11.10 255.255.255.252
!
ip route 0.0.0.0 0.0.0.0 192.168.11.9
end
```

Configuration of Alcatel-Lucent 7710 Router:

Configuring RIP in Alcatel-Lucent router is different then Cisco router. For configuring RIP we need to do the following steps one by one.

1. Configure ports (interfaces)
2. Create policy
3. Configure Static Route (if needed)
4. Configure RIP (Create group, Create neighbor, Apply policy)

Configure ports:

```
*A:RACK-2# configure router
*A:RACK-2>config>router# interface toTopRouter
*A:RACK-2>config>router>if$ address 192.168.11.1/30
*A:RACK-2>config>router>if$ port 1/2/1
*A:RACK-2>config>router>if$ exit
*A:RACK-2>config>router# interface toMidRouter
```

```
*A:RACK-2>config>router>if$ address 192.168.11.5/30
*A:RACK-2>config>router>if$ port 1/2/2
*A:RACK-2>config>router>if$ exit
*A:RACK-2>config>router# interface toSwitch
*A:RACK-2>config>router>if$ address 192.168.11.9/30
*A:RACK-2>config>router>if$ port 1/2/3
*A:RACK-2>config>router>if$ exit
```

Create Policy:

Create prefix-list (to exclude system IP (10.3.31.169) from routing table):

```
A:RACK-2# configure router policy-options
A:RACK-2>config>router>policy-options# begin
A:RACK-2>config>router>policy-options# prefix-list system
A:RACK-2>config>router>policy-options>prefix-list# prefix 10.3.31.169/32 exact
```

Create Policy:

```
A:RACK-2# configure router policy-options
A:RACK-2>config>router>policy-options# begin
A:RACK-2>config>router>policy-options# policy-statement Rip-policy
A:RACK-2>config>router>policy-options>policy-statement$ entry 1
A:RACK-2>config>router>policy-options>policy-statement>entry$ from prefix-list
system
A:RACK-2>config>router>policy-options>policy-statement>entry# action reject
```
Note: This command will exclude system IP from the routing table

```
A:RACK-2>config>router>policy-options>policy-statement>entry# back
A:RACK-2>config>router>policy-options>policy-statement# entry 2
A:RACK-2>config>router>policy-options>policy-statement>entry$ action accept
```

Note: This command will enable RIP policy

```
A:RACK-2>config>router>policy-options>policy-statement>entry>action$ exit
A:RACK-2>config>router>policy-options>policy-statement>entry$ exit
A:RACK-2>config>router>policy-options>policy-statement# default-action reject
A:RACK-2>config>router>policy-options>policy-statement# exit
A:RACK-2>config>router>policy-options# commit   (to save the policy)
*A:RACK-2>config>router>policy-options# exit all
*A:RACK-2#
```

Configure Static Route:

```
A:RACK-2# configure router static-route 192.168.15.0/24 next-hop 192.168.11.10
```

Configure RIP:

```
*A:RACK-2#configure router rip
*A:RACK-2>config>router>rip# no shutdown

Export Policy:

*A:RACK-2>config>router>rip# export Rip-policy
*A:RACK-2>config>router>rip# timers 30 180 240

Create Group:

*A:RACK-2>config>router>rip# group toAll
*A:RACK-2>config>router>rip>group# neighbor toTopRouter
*A:RACK-2>config>router>rip>group>neighbor$ message-size 255
*A:RACK-2>config>router>rip>group>neighbor$ preference 255
*A:RACK-2>config>router>rip>group>neighbor$ send multicast
*A:RACK-2>config>router>rip>group>neighbor$ back
*A:RACK-2>config>router>rip>group# neighbor toMidRouter
*A:RACK-2>config>router>rip>group>neighbor$ message-size 255
*A:RACK-2>config>router>rip>group>neighbor$ preference 255
*A:RACK-2>config>router>rip>group>neighbor$ send multicast
*A:RACK-2>config>router>rip>group>neighbor$ ^Z
*A:RACK-2#
```

Chapter 7

OSPF Routing Protocol

Lab Manual

Instructor Manual

Lab Manual

7. Introduction

OSPF is a hierarchical link state protocol, created in the middle of 1980. OSPF uses Shortest Path Fast (SPF) and several other techniques to ensure each router has a loop-free topology. It provides fast convergence updates via Link State Advertisement (LSA). OSPF is a classless protocol and uses cost as a metric. OSPF begins the process of building a topological view of the network by sending ***Hello*** packets. OSPF ***Hello***s are generated in every 10 seconds and send it to the connected networks. The ***Hello*** packets include a list of all the other OSPF routers. OSPF routers share information about their connected routers with the **DR**. If the neighbor is not seen any LSA from his neighbor after 40 second, the neighbor is declared as dead.

7.1 Pre lab questions

1. In ***show ip ospf interface*** command output what do the states DR, BDR, and DROTHER mean?

2. How often does OSPF send out link-state advertisements (LSAs)?

3. Which of the following routers support OSPF? Cisco 800, Cisco 1600, Cisco 2600, Cisco 2800.

4. What is the difference between the ip default-gateway, ip default-network, and ip route 0.0.0.0/0 commands?

5. What would be the router ID if you do not configure it?

6. In how many ways OSPF route summarization can be configured?

7. Find the error in following commands

```
R1(config)#router ospf 1
R1(config-router)#network 192.168.0.0 255.255.0.0 area 0
```

8. R1(config)#router ospf 1
R1(config-router)#network 192.168.0.1 0 0.0.0.0 area 0

In the above commands what does 0.0.0.0 means?

9. What is the default Router Dead Interval?

10. What are the four OSPF router types, path type and network type?

11. What is a Designated Router?

7.2 Lab Exercise

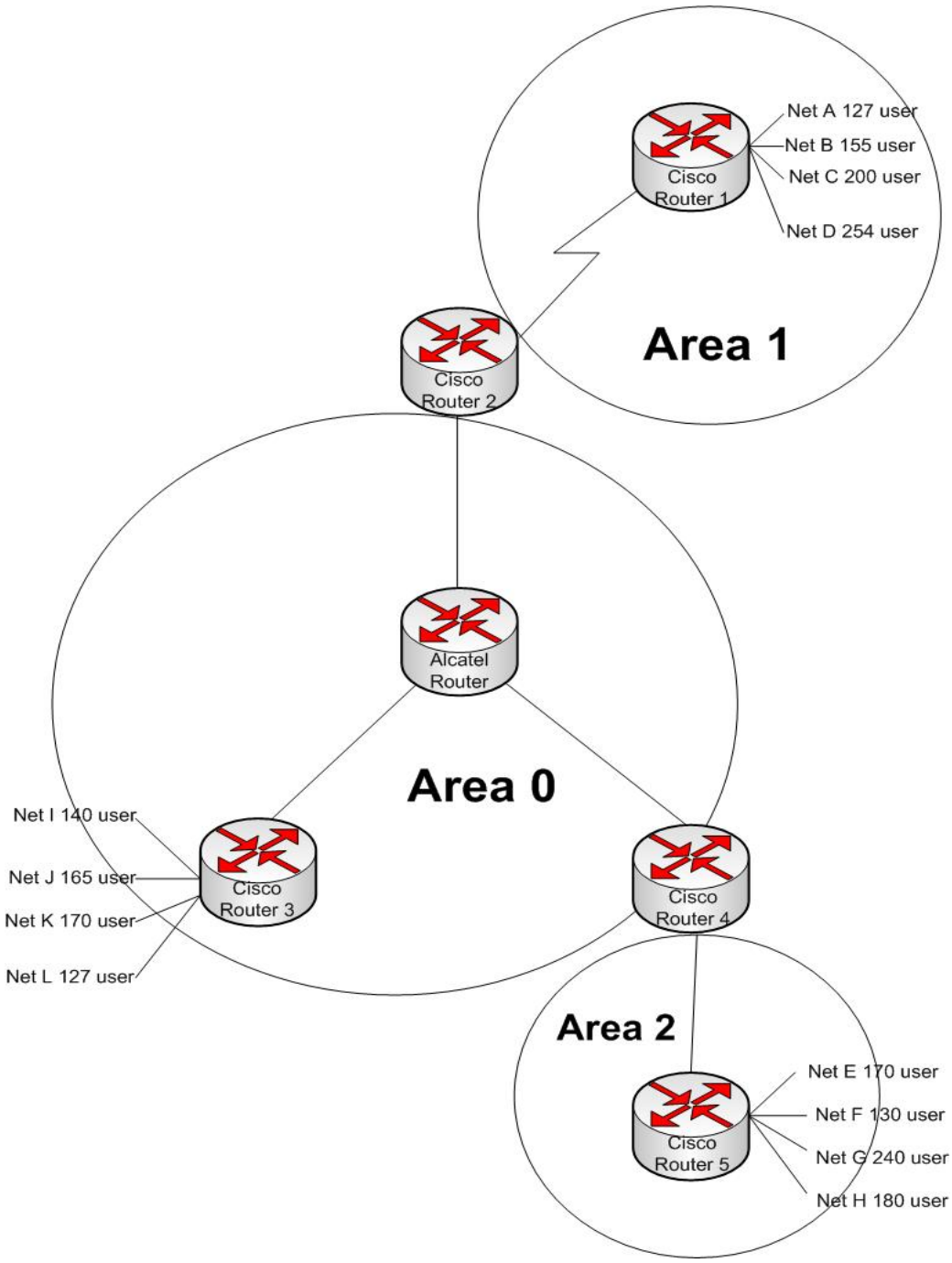

Figure 7.1 Network diagram for OSPF protocol

In this lab you will configure **OSPF** routing protocol in all the routers for 3 different areas. For the above network you are given **172.16.X.0/18** ip range. Use all your IP's from this range. Here '**X'** refers the Rack number.

- Configure OSPF in all the routers.
- Verify with the Ping program when complete.

7.2.1What to hand in

1. Draw the network diagram and assign ip addresses to all hosts and interfaces. The maximum number of address needs to be kept free for future use.
2. The list of commands issued in the routers configuring interfaces, enable routing.
3. Output of ***show run*** command for all routers.
4. Output of ***show ip route*** command.
5. Why does loopback ip shows **/32** in ***show ip route*** command output. How to fix it?
6. What does it mean (**110/1062**) in ***show ip route*** command output. Is it a problem? If yes, how would you fix it?
7. Summarise all the subnets in router 1, 3 and 5. Show the ip route output command for Alcatel router. Show the difference before and after summarization.

Instructor Manual

7.3 Pre lab answers

1. In ***show ip ospf interface*** command output what do the states DR, BDR, and DROTHER mean?

Ans. In the output command DR means designated router. BDR means backup designated router. DROTHER indicates a router that is neither the DR nor the BDR. The DR generates a Network Link-State Advertisement, which lists all the routers on that network.

2. How often does OSPF send out link-state advertisements (LSAs)?

Ans. OSPF sends out its self-originated LSAs when the LSA age reaches the link-state refresh time, which is 1800 seconds.

3. Which of the following routers support OSPF? Cisco 800, Cisco 1600, Cisco 2600, Cisco 2800.

Ans. Cisco 800 does not support OSPF, Cisco 1600 routers require the Plus feature set image of Cisco IOS Software to run OSPF. Cisco 2600 and 2800 both run OSPF.

4. What is the difference between the ip default-gateway, ip default-network, and ip route 0.0.0.0/0 commands?

Ans. The ip default-gateway command is used when IP routing is disabled on the router. However, ip default-network and ip route 0.0.0.0/0 are effective when IP routing is enabled on the router and they are used to route any packets which do not have an exact route match in the routing table. Refer to Configuring a Gateway of Last Resort Using IP Command for more information.

5. What would be the router ID if you do not configure it?

Ans. It takes the higher ip address of its interface as the router id.

6. In how many ways OSPF route summarization can be configured?

Ans. Inter-Area route summarization and External Route summarization. Inter-Area route summarization can only be done on the Area Boarder Router (ABR) and summarize routes from a particular area into the backbone area. External Route summarization can only be done on an ASBR and summarizes routes to an external destination

7. Find the error in following commands

R1(config)#router ospf 1

R1(config-router)#network 192.168.0.0 255.255.0.0 area 0

Ans. It's the mask. OSPF uses wildcard mask, not the subnet mask. A wildcard mask is the exact opposite if a subnet mask.

8. R1(config)#router ospf 1
R1(config-router)#network 192.168.0.1 0 0.0.0.0 area 0

In the above commands what does 0.0.0.0 means?

Ans. It means that every bit within the IP address of the host must match. A wildcard mask for a host would be - 0.0.0.0.

9. What is the default Router Dead Interval?

Ans. 40 Second.

10. What are the four OSPF router types, path type and network type?

Ans. The four OSPF router types are

- Internal Routers, whose OSPF interfaces all belong to the same area
- Backbone Routers, which are Internal Routers in Area 0
- Area Border Routers, which have OSPF interfaces in more than one area
- Autonomous System Boundary Routers, which advertise external routes into the OSPF domain

The four OSPF path types are

- Intra-area paths
- Inter-area paths
- Type 1 external paths
- Type 2 external paths

The five OSPF network types are

- Point-to-point networks
- Broadcast networks
- Non-broadcast multiaccess (NBMA) networks
- Point-to-multipoint networks
- Virtual link

11. What is a Designated Router?

Ans. A Designated Router is a router that represents a multiaccess network, and the routers connected to the network, to the rest of the OSPF domain.

7.4 Lab Exercise Solution

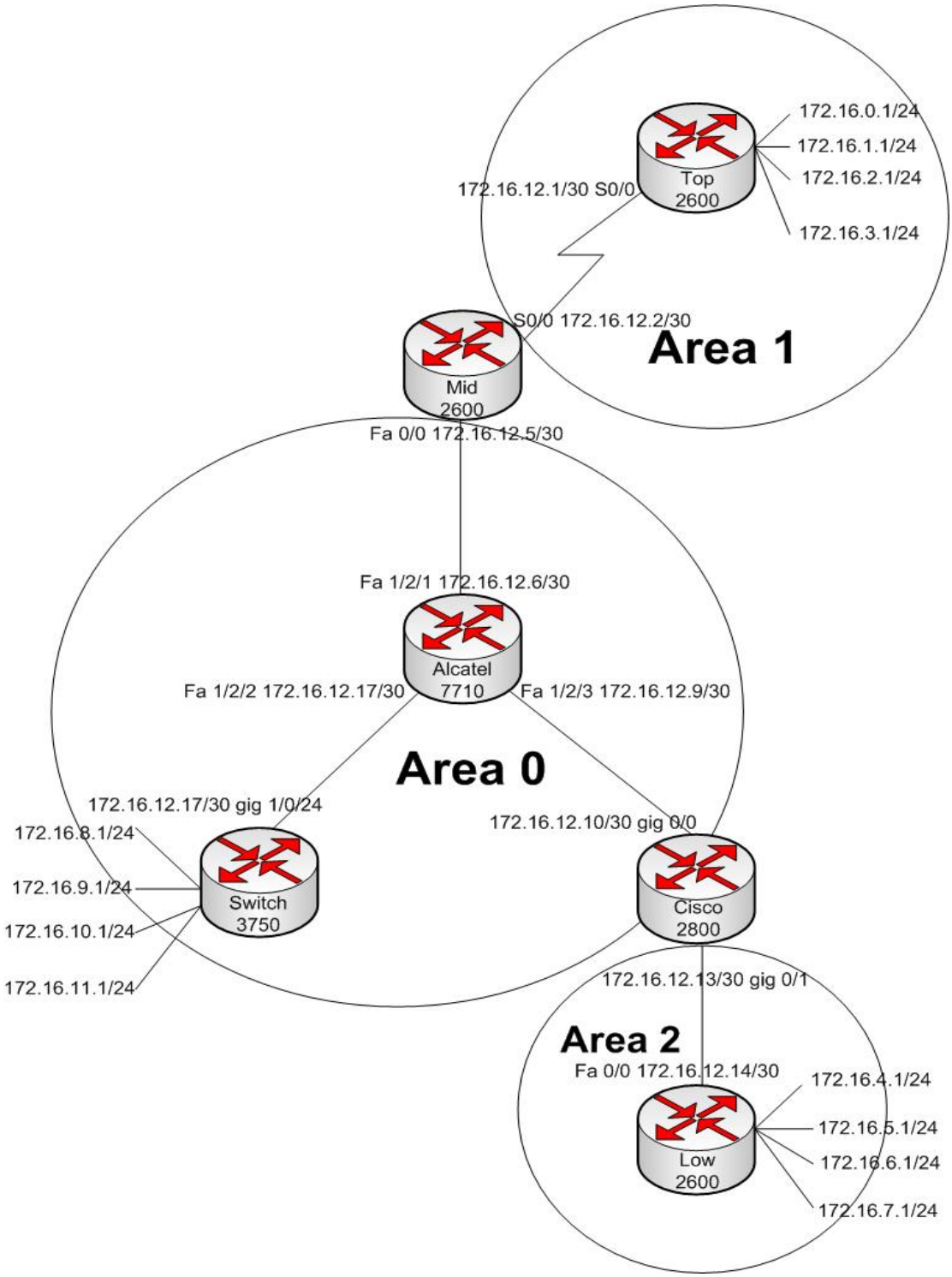

Figure 7.2 Solution network diagram for OSPF protocol

In this lab we will use Cisco 2600 Top router (10.3.31.74), Cisco 2600 Mid router (10.3.31.75), Cisco 2800 router (10.3.31.77), Cisco 3750 Switch (10.3.31.72) and Alcatel Lucent 7710 router (10.3.31.171) in rack# 4.

Step 1: Telnet all the device one by one with the correspondent ip address and configure them as follows.

7.4.1 Configuration

Configuration of Cisco Top 2600 router:

```
Top_2600#sh run
Building configuration...

!
interface Loopback0
 ip address 172.16.0.1 255.255.255.0
 ip ospf network point-to-point

Note: With this command OSPF advertises the loopback subnet as the actual subnet configured on
loopbacks, otherwise Loopbacks are considered host routes in OSPF, and they are advertised as /32.
!
interface Loopback1
 ip address 172.16.1.1 255.255.255.0
 ip ospf network point-to-point
!
interface Loopback2
 ip address 172.16.2.1 255.255.255.0
 ip ospf network point-to-point
!
interface Loopback3
 ip address 172.16.3.1 255.255.255.0
 ip ospf network point-to-point
!
!
interface Serial0/0
 ip address 172.16.12.246 255.255.255.252
 no fair-queue
!
!
router ospf 1
 log-adjacency-changes
 area 1 stub

Note: This command will make area 1 as a stub area, it is important to make configure this command in
all the router in the same stub area.

redistribute connected subnets
```

Note: We need to redistribute the connected subnets as we are not configuring any static route.

network 172.16.0.0 0.0.3.255 area 1
network 172.16.12.244 0.0.0.3 area 1

Note: This command will add the above 2 networks into area 1.
!
!
end

Configuration of Cisco Mid 2600 router:

Mid_2600#sh run
Building configuration...
!
interface FastEthernet0/0
ip address 172.16.12.249 255.255.255.252
duplex auto
speed auto
!
interface Serial0/0
ip address 172.16.12.245 255.255.255.252
clock rate 2000000
no fair-queue
!
interface Serial0/1
no ip address
shutdown
!
router ospf 1
log-adjacency-changes
area 1 stub

area 1 range 172.16.0.0 255.255.252.0 ***[Note: This command will summarise the subnets connected with Top router. This type of summarization is called Inter-Area route summarization that can only be done on the Area Boarder Router (ABR).***

network 172.16.12.244 0.0.0.3 area 1
network 172.16.12.248 0.0.0.3 area 0
!
end

Configuration of Cisco Low 2600 router:

```
Low_2600#sh run
Building configuration...
hostname Low_2600
!
!
interface Loopback4
 ip address 172.16.4.1 255.255.255.0
 ip ospf network point-to-point
!
interface Loopback5
 ip address 172.16.5.1 255.255.255.0
 ip ospf network point-to-point
!
interface Loopback6
 ip address 172.16.6.1 255.255.255.0
 ip ospf network point-to-point
!
interface Loopback7
 ip address 172.16.7.1 255.255.255.0
 ip ospf network point-to-point
!
interface FastEthernet0/0
 ip address 172.16.12.233 255.255.255.252
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 area 2 stub
 redistribute connected subnets
 network 172.16.4.0 0.0.3.255 area 2
 network 172.16.12.232 0.0.0.3 area 2
!
end
```

Configuration of Cisco 2800 router:

```
Router_2800#sh run
Building configuration...

!
hostname Router_2800
```

```
!
interface GigabitEthernet0/0
 ip address 172.16.12.237 255.255.255.252
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 172.16.12.234 255.255.255.252
 duplex auto
 speed auto
!
!
router ospf 1
area 2 stub
area 2 range 172.16.4.0 255.255.252.0
network 172.16.12.236 0.0.0.3 area 0
network 172.16.12.232 0.0.0.3 area 2
!
end
```

Configuration of Cisco 3750 Switch:

```
Switch_3700#sh run
Building configuration...

interface Loopback8
 ip address 172.16.8.1 255.255.255.0
!
interface Loopback9
 ip address 172.16.9.1 255.255.255.0
!
interface Loopback10
 ip address 172.16.10.1 255.255.255.0
!
interface Loopback11
 ip address 172.16.11.1 255.255.255.0
!
interface GigabitEthernet1/0/24
 no switchport
 ip address 172.16.12.241 255.255.255.252
!
router ospf 1
```

summary-address 172.16.8.0 255.255.252.0

Note: summary-address command will summarize all the subnet connected to Switch in area 0. This type of summarization is called External Route summarization that can only be done on an ASBR and summarizes routes to an external destination.

redistribute connected subnets
network 172.16.12.16 0.0.0.3 area 0
network 172.16.12.240 0.0.0.3 area 0
!
end

Configuration of Alcatel-Lucent Router:

Configure ports:

```
*A:RACK-4# configure router
*A:RACK-4>config>router# interface system
*A:RACK-4>config>router>if$ address 172.16.12.253/32
*A:RACK-4>config>router# interface toMidRouter
*A:RACK-4>config>router>if$ address 172.16.12.250/30
*A:RACK-4>config>router>if$ port 1/2/1
*A:RACK-4>config>router>if$ exit
*A:RACK-4>config>router# interface toSwitch
*A:RACK-4>config>router>if$ address 172.16.12.242/30
*A:RACK-4>config>router>if$ port 1/2/2
*A:RACK-4>config>router>if$ exit
*A:RACK-4>config>router# interface to2800
*A:RACK-4>config>router>if$ address 172.16.12.238/32
*A:RACK-4>config>router>if$ port 1/2/3
*A:RACK-4>config>router>if$ exit
```

Configure OSPF:

```
*A:RACK-4#configure router ospf
*A:RACK-4>config>router>ospf# no shutdown
*A:RACK-4>config>router>ospf# router-id 172.16.12. 253
*A:RACK-4>config>router>ospf# reference-bandwidth 100000
```

Note: Default Reference Bandwidth for OSPF is 100000 that should be same in all routers. In Cisco routers it is 100000.

```
*A:RACK-4>config>router>ospf$ area 0
*A:RACK-4>config>router>ospf>area$ interface system
```

```
*A:RACK-4>config>router>ospf>area>if$ exit
*A:RACK-4>config>router>ospf>area# interface toMidRouter
*A:RACK-4>config>router>ospf>area>if$ exit
*A:RACK-4>config>router>ospf>area# interface toSwitch
*A:RACK-4>config>router>ospf>area>if$ exit
*A:RACK-4>config>router>ospf>area# interface to2800
*A:RACK-4>config>router>ospf>area>if$ exit
```

7.4.2 Outputs and Results

Summarization:

Routing table in Alcatel Router before aggregation on Top, 3750 and low router

```
*A:RACK-4# show router route-table

===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix                                     Type    Proto    Age         Pref
       Next Hop[Interface Name]                                       Metric
-------------------------------------------------------------------------------
172.16.0.0/24                                   Remote  OSPF     00h00m23s   10
       172.16.12.249                                                  66
172.16.1.0/24                                   Remote  OSPF     00h00m28s   10
       172.16.12.249                                                  66
172.16.2.0/24                                   Remote  OSPF     00h00m28s   10
       172.16.12.249                                                  66
172.16.3.0/24                                   Remote  OSPF     00h00m28s   10
       172.16.12.249                                                  66
172.16.4.0/24                                   Remote  OSPF     00h03m13s   10
       172.16.12.237                                                  3
172.16.5.0/24                                   Remote  OSPF     00h03m18s   10
       172.16.12.237                                                  3
172.16.6.0/24                                   Remote  OSPF     00h03m18s   10
       172.16.12.237                                                  3
172.16.7.0/24                                   Remote  OSPF     00h03m18s   10
       172.16.12.237                                                  3
172.16.8.0/24                                   Remote  OSPF     00h01m33s   150
       172.16.12.241                                                  20
172.16.9.0/24                                   Remote  OSPF     00h01m33s   150
       172.16.12.241                                                  20
172.16.10.0/24                                  Remote  OSPF     00h01m33s   150
       172.16.12.241                                                  20
172.16.11.0/24                                  Remote  OSPF     00h01m33s   150
       172.16.12.241                                                  20
172.16.12.232/30                                Remote  OSPF     00h18m06s   10
       172.16.12.237                                                  2
172.16.12.236/30                                Local   Local    01h22m05s   0
```

```
       to2800                                                          0
172.16.12.240/30                          Local   Local    01h21m47s   0
       toSwitch                                                        0
172.16.12.244/30                          Remote  OSPF     00h18m12s   10
       172.16.12.249                                                   65
172.16.12.248/30                          Local   Local    00h40m09s   0
       toMidRouter                                                     0
172.16.12.253/32                          Local   Local    01h22m59s   0
       system                                                          0
------------------------------------------------------------------------------
No. of Routes: 18
==============================================================
```

Routing table in Alcatel Router after aggregation on Top, 3750 and low router

```
*A:RACK-4# show router route-table

===============================================================================
=
Route Table (Router: Base)
===============================================================================
=
Dest Prefix                               Type    Proto    Age
Pref
       Next Hop[Interface Name]                                      Metric
-------------------------------------------------------------------------------
-
172.16.0.0/22                             Remote  OSPF     00h14m02s   10
       172.16.12.249                                                   66
172.16.4.0/22                             Remote  OSPF     00h13m57s   10
       172.16.12.237                                                   3
172.16.8.0/22                             Remote  OSPF     00h13m57s   150
       172.16.12.241                                                   20
172.16.12.232/30                          Remote  OSPF     00h13m57s   10
       172.16.12.237                                                   2
172.16.12.236/30                          Local   Local    01h17m55s   0
       to2800                                                          0
172.16.12.240/30                          Local   Local    01h17m37s   0
       toSwitch                                                        0
172.16.12.244/30                          Remote  OSPF     00h14m02s   10
       172.16.12.249                                                   65
172.16.12.248/30                          Local   Local    00h35m59s   0
       toMidRouter                                                     0
172.16.12.253/32                          Local   Local    01h18m50s   0
       system                                                          0
-------------------------------------------------------------------------------
No. of Routes: 9
```

Routes in Low Router before Changing Reference Bandwidth in Alcatel

```
Low_2600#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 172.16.12.234 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 18 subnets, 3 masks
O IA    172.16.12.240/30
           [110/1002] via 172.16.12.234, 00:00:39, FastEthernet0/0
O IA    172.16.12.244/30
           [110/1066] via 172.16.12.234, 00:00:49, FastEthernet0/0
O IA    172.16.12.248/30
           [110/1002] via 172.16.12.234, 00:00:49, FastEthernet0/0
O IA    172.16.12.253/32 [110/2] via 172.16.12.234, 00:30:59, FastEthernet0/0
C       172.16.12.232/30 is directly connected, FastEthernet0/0
O IA    172.16.12.236/30 [110/2] via 172.16.12.234, 00:42:50, FastEthernet0/0
O IA    172.16.9.1/32 [110/1003] via 172.16.12.234, 00:00:40, FastEthernet0/0
O IA    172.16.8.1/32 [110/1003] via 172.16.12.234, 00:00:40, FastEthernet0/0
O IA    172.16.11.1/32 [110/1003] via 172.16.12.234, 00:00:40, FastEthernet0/0
O IA    172.16.10.1/32 [110/1003] via 172.16.12.234, 00:00:42, FastEthernet0/0
C       172.16.4.0/24 is directly connected, Loopback4
C       172.16.5.0/24 is directly connected, Loopback5
C       172.16.6.0/24 is directly connected, Loopback6
C       172.16.7.0/24 is directly connected, Loopback7
O IA    172.16.0.0/24 [110/1067] via 172.16.12.234, 00:00:52, FastEthernet0/0
O IA    172.16.1.0/24 [110/1067] via 172.16.12.234, 00:00:52, FastEthernet0/0
O IA    172.16.2.0/24 [110/1067] via 172.16.12.234, 00:00:52, FastEthernet0/0
O IA    172.16.3.0/24 [110/1067] via 172.16.12.234, 00:00:52, FastEthernet0/0
O*IA 0.0.0.0/0 [110/2] via 172.16.12.234, 00:42:51, FastEthernet0/0
```

Routes in Low Router after Changing Reference Bandwidth in Alcatel

```
Low_2600#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
```

```
Gateway of last resort is 172.16.12.234 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 18 subnets, 3 masks
O IA    172.16.12.240/30 [110/3] via 172.16.12.234, 00:27:52, FastEthernet0/0
O IA    172.16.12.244/30 [110/67] via 172.16.12.234, 00:27:52, FastEthernet0/0
O IA    172.16.12.248/30 [110/3] via 172.16.12.234, 00:27:52, FastEthernet0/0
O IA    172.16.12.253/32 [110/2] via 172.16.12.234, 00:27:52, FastEthernet0/0
C       172.16.12.232/30 is directly connected, FastEthernet0/0
O IA    172.16.12.236/30 [110/2] via 172.16.12.234, 00:39:43, FastEthernet0/0
O IA    172.16.9.1/32 [110/4] via 172.16.12.234, 00:00:49, FastEthernet0/0
O IA    172.16.8.1/32 [110/4] via 172.16.12.234, 00:00:49, FastEthernet0/0
O IA    172.16.11.1/32 [110/4] via 172.16.12.234, 00:00:49, FastEthernet0/0
O IA    172.16.10.1/32 [110/4] via 172.16.12.234, 00:00:49, FastEthernet0/0
C       172.16.4.0/24 is directly connected, Loopback4
C       172.16.5.0/24 is directly connected, Loopback5
C       172.16.6.0/24 is directly connected, Loopback6
C       172.16.7.0/24 is directly connected, Loopback7
O IA    172.16.0.0/24 [110/68] via 172.16.12.234, 00:10:07, FastEthernet0/0
O IA    172.16.1.0/24 [110/68] via 172.16.12.234, 00:10:17, FastEthernet0/0
O IA    172.16.2.0/24 [110/68] via 172.16.12.234, 00:10:17, FastEthernet0/0
O IA    172.16.3.0/24 [110/68] via 172.16.12.234, 00:10:17, FastEthernet0/0
O*IA 0.0.0.0/0 [110/2] via 172.16.12.234, 00:39:44, FastEthernet0/0
```

Chapter 8

IS-IS (Intermediate System to Intermediate System)

Lab Manual

8. Introduction
    8.1 Pre lab questions
    8.2 Lab Exercise

Instructor Manual

    8.3 Pre lab answers
    8.4 Lab Exercise Solution

Lab Manual

8. Introduction

The IS-IS routing protocol is a link-state protocol, that offers several advantages over distance-vector protocols. It is faster converging, supports much larger internet works, and is less susceptible to routing loops. In IS-IS a router is an Intermediate System, and a host is an End System. Accordingly, a protocol that provides communication between a host and a router is known as ES-IS, and a protocol that routers use to speak to each other (a routing protocol) is IS-IS. Both IS-IS and OSPF use areas to create a two-level hierarchical topology, but the fundamental difference between the two protocols is who they define their areas. OSPF area borders are marked by routers. Some interfaces are in one area, and other interfaces are in another area. When an OSPF router has interfaces in more than one area, it is an Area Border Router (ABR). But in IS-IS all the routers are completely within an area, and the area borders are on links, not on routers.

8.1 Pre lab questions

1. What is the default level of a Cisco router?

2. What is the difference between an L1, an L2, and an L1/L2 router?

3. What is the basic difference between an IS-IS area and an OSPF area.

4. How often does an IS-IS router refresh its LSPs?

5. How would you restart IS-IS?

6. In this NSAP Address 49.0001.0000.0000.0001.00
a. What is the Area ID?
b. What is the SysID?
c. What is the NSEL?

7. In this NSAP Address 49.0003.23bc.0008.0000.2060.c9a5.00
a. What is the Area ID?
b. What is the SysID?
c. What is the NSEL?

8. Which of the following is true about an IS (Intermediate System)?

a. An IS can only be a level 1 router.
b. An IS can be either level 1 or Level 2 router but not both at the same time.
c. An IS can be both Level 1 and Level 2 router at the same time.

d. An IS can neither be Level 1 nor Level 2 router. Only ES (End System) can assume Level 1/ Level 2 function.

9. Which one is true about OSPF and IS-IS?

a. Both OSPF and IS-IS use Area 0 as backbone network.
b. Both OSPF and IS-IS use Distance Vector to determine shortest path.
c. Both OSPF and IS-IS have authentication capability.
d. Both use Shortest Path First algorithm to compute shortest path.

10. In OSI hierarchical routing terminology, what are the following terms referred to?

a. ES
b. IS
c. IS-IS
d. CSNP

8.2 Lab Exercise

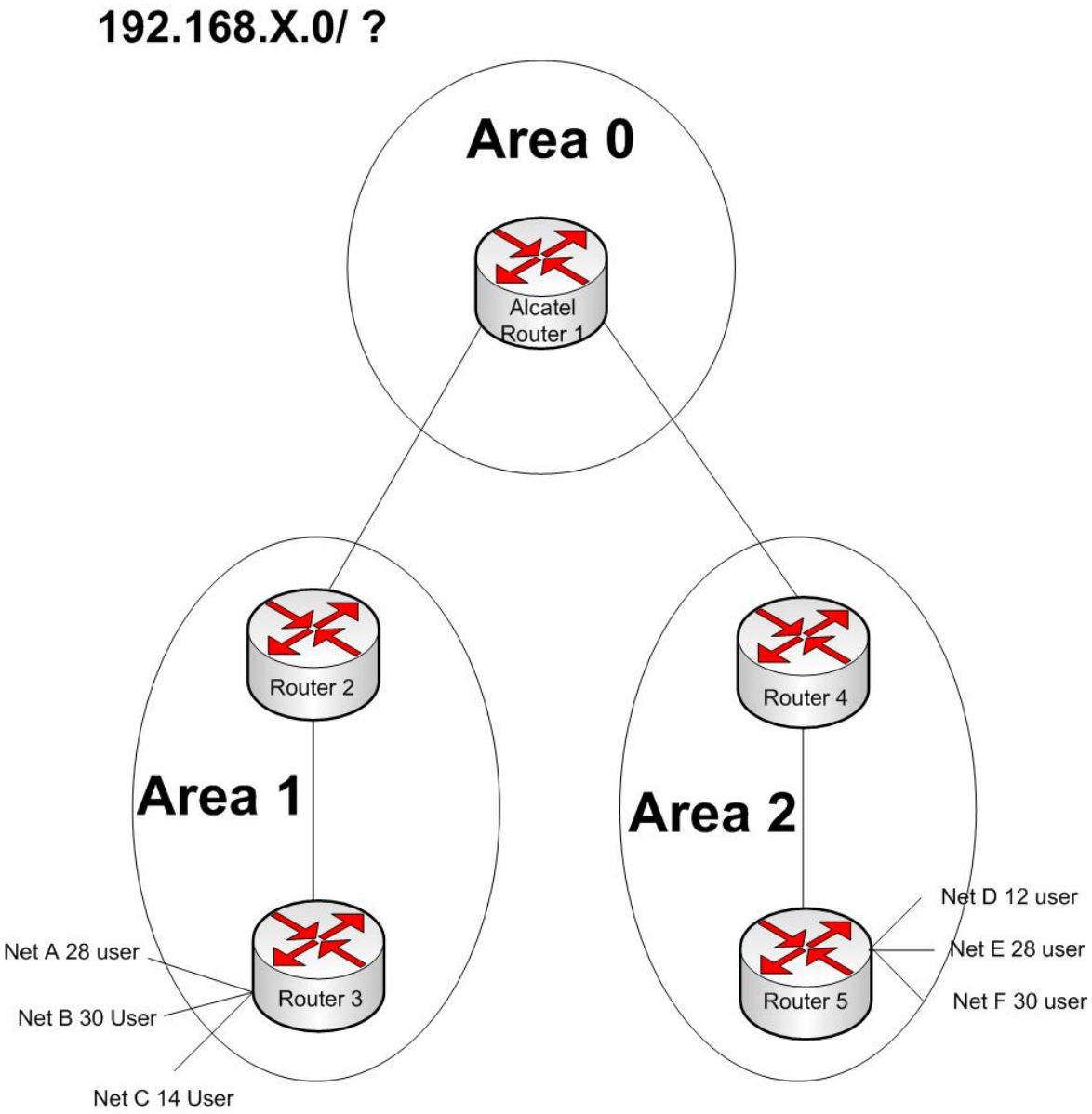

Figure 8.1 Network diagram for IS-IS protocol

In this lab you will configure **IS-IS** routing protocol in all the routers for 3 different areas. For the above network you are given **172.16.X.0** ip range. Use all your IP's from this Class.

Here '**X'** refers the Rack number.

- You are asked to use least number of IPs as required. Find out how many subnets you will require and what would be the range or subnet mask.
- Configure IS-IS in all the routers.

- Show output command of ***show ip route*** and ***show ip isis topology*** for all router. Explain.
- Configure all the routers as L1, L2, L1/L2 router as appropriate.
- Now show output command of ***show ip route*** and ***show ip isis topology*** for all router. Explain the difference you find from last time.
- Configure authentication between all routers in **area 1** using password **CISCO** in plain text.
- Configure level 1 authentication using encrypted password **MINT**. Use md5 authentication.
- Configure the L1/L2 routers in areas 0, 1, and 3 to summarize their L1 addresses.
- Verify with the Ping program when completed.

8.2.1What to hand in

1. Draw the network diagram and assign ip addresses to all hosts and interfaces. The maximum number of address needs to be kept free for future use.
2. The list of commands issued in the routers configuring interfaces, enable routing, configuring level routers and summarization.
3. Output of ***show run*** command for all routers.
4. Output of ***show ip route*** and ***show isis topology*** command for L1/L2 Router before summarization and after summarization.

Instructor Manual

8.3 Pre lab answers

1. What is the default level of a Cisco router?

Ans. Cisco routers by default are L1/L2.

2. What is the difference between an L1, an L2, and an L1/L2 router?

Ans. An L1 router has no direct connections to another area. An L2 router has no adjacencies with L1 routers. An L1/L2 router routes both inter-area and intra-area traffic and acts as an inter-area gateway for L1 routers.

3. What is the basic difference between an IS-IS area and an OSPF area.

Ans. The borders of IS-IS areas are between routers, on links. The borders of OSPF areas are defined by the routers themselves.

4. How often does an IS-IS router refresh its LSPs?

Ans. The refresh rate of an IS-IS router is 900 seconds (15 minutes).

5. How would you restart IS-IS?

Ans. The Command for restart IS-IS is clear ip isis *.

6. In this NSAP Address 49.0001.0000.0000.0001.00

a. What is the Area ID?
b. What is the SysID?
c. What is the NSEL?

Ans.
a. Area ID – 49.0001
b. SysID - 0000.0000.0001
c. NSEL – 00

7. In this NSAP Address 49.0003.23bc.0008.0000.2060.c9a5.00

a. What is the Area ID?
b. What is the SysID?
c. What is the NSEL?

Ans.
a. Area ID – 0008

b. SysID - 0000.2060.c9a5
c. NSEL – 00

Here 49.0003.23bc is Domain.

8. Which of the following is true about an IS (Intermediate System)?

a. An IS can only be a level 1 router.
b. An IS can be either level 1 or Level 2 router but not both at the same time.
c. An IS can be both Level 1 and Level 2 router at the same time.
d. An IS can neither be Level 1 nor Level 2 router. Only ES (End System) can assume Level 1/ Level 2 function.

Ans. C. Level 1 routers are used within an area. They can not connect between two different areas. To connect two different areas in IS-IS routing domain, we need Level 2 router. Level 2 routers form the backbone of IS-IS routing domain connecting different areas.

9. Which one is true about OSPF and IS-IS?

a. Both OSPF and IS-IS use Area 0 as backbone network.
b. Both OSPF and IS-IS use Distance Vector to determine shortest path.
c. Both OSPF and IS-IS have authentication capability.
d. Both use Shortest Path First algorithm to compute shortest path.

Ans. C & D

10. In OSI hierarchical routing terminology, what are the following terms referred to?

a. ES
b. IS
c. IS-IS
d. CSNP

Ans.
a. **ES** - End System, like any node that does not take part in the routing process, such as a work station.
b. **IS** - Intermediate System, refers to any network node that takes part in the routing process.
c. **IS-IS** - Intermediate System-to-Intermediate System, a routing protocol defined for OSI environment.
d. **CSNP** - Connectionless Network Protocol, protocol used by IS-IS for routing in OSI environment.

8.4 Lab Exercise Solution

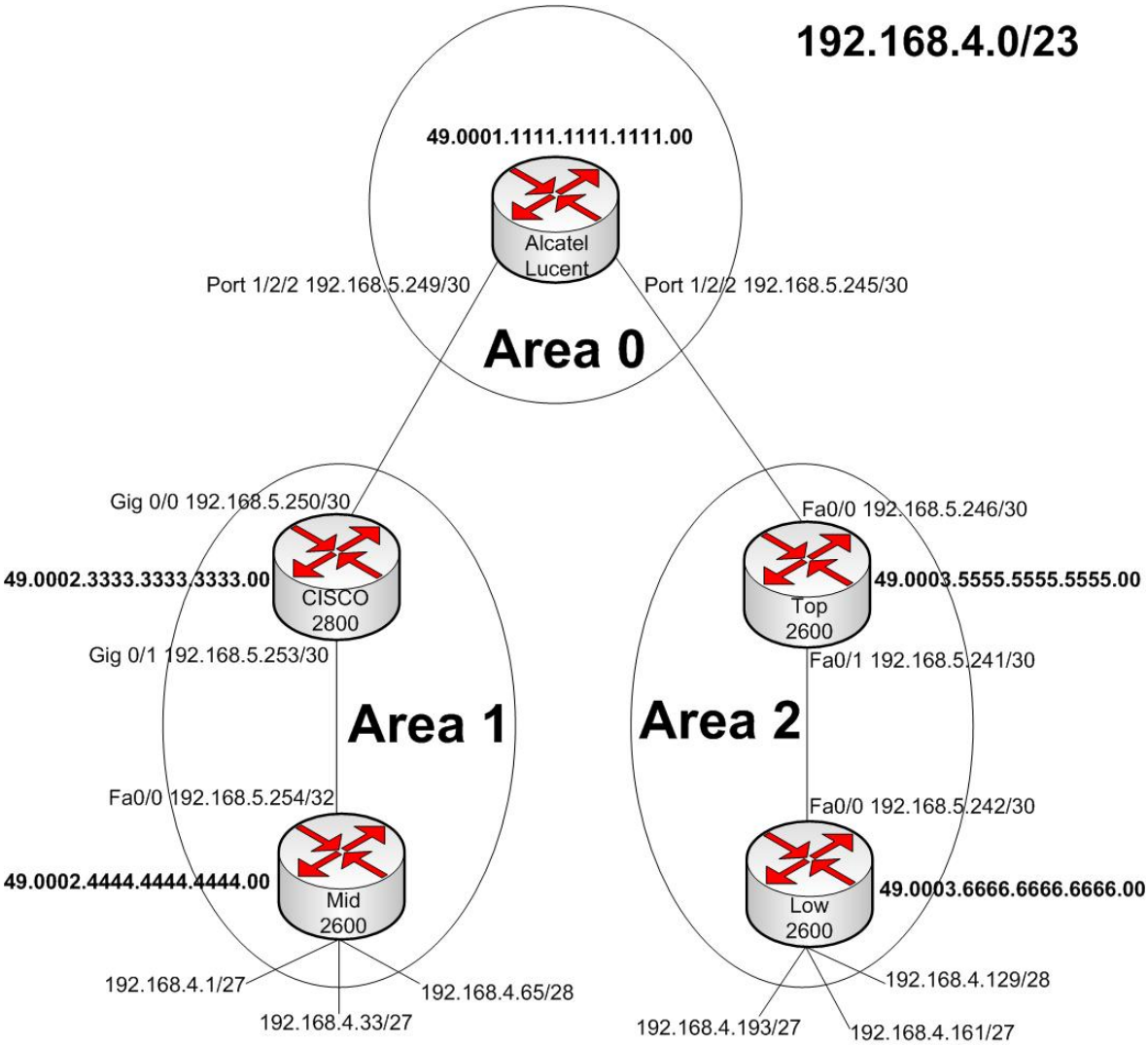

Figure 8.2 Solution network diagram for IS-IS protocol

In this lab we will use Cisco 2600 Top router (10.3.31.74), Cisco 2600 Mid router (10.3.31.75), Cisco 2800 router (10.3.31.77) and Alcatel Lucent 7710 router (10.3.31.171) in rack# 4.

According to the network diagram we need to assign ip address in 10 different networks. Using the network address 192.168.4.0 as a Class-C ip will not cover all the ip required for the subnets. To meet the requirement will need to use CIDR. For this network we will use 192.168.4.0/**23** address range.

Step 1: Telnet all the device one by one with the correspondent ip address and configure them as follows.

8.4.1 Configuration

Configuration of Alcatel 7710 router:

```
#------------------------------------------------
Configure Interfaces
#------------------------------------------------
*A:RACK-4# config>router#
        interface "system"
            shutdown
        exit
        interface "to2800"
            address 192.168.5.249/30
            port 1/2/1
        exit
        interface "toTop"
            address 192.168.5.245/30
            port 1/2/2
        exit



#------------------------------------------------
ISIS Configuration
#------------------------------------------------
  *A:RACK-4#configure router isis
  *A:RACK-4#config> router>isis#
            level-capability level-2    Note: Configure as a L2 Router Only
            area-id 49.0001.1111.1111.1111.00
            interface "to2800"     Note: Enable IS-IS in the interfaces
            exit
            interface "toTop"      Note: Enable IS-IS in the interfaces
            exit
        exit
    exit
```

Configuration of Cisco 2800 router:

```
Router_2800#
!
interface GigabitEthernet0/0
 ip address 192.168.5.250 255.255.255.252
 ip router isis
!
```

```
interface GigabitEthernet0/1
 ip address 192.168.5.253 255.255.255.252
 ip router isis
!
router isis
 net 49.0002.3333.3333.3333.00
 area-password cisco
Note: Command for area password in plain test
 summary-address 192.168.4.0 255.255.255.128
 summary-address 192.168.4.128 255.255.255.128
Note: Command in L1/L2 router for summarize the subnets of L1 router.
!
end
```

Configuration of Cisco Top 2600 router:

```
Top_2600#
!
key chain Top_2600
 key 1
  key-string 7 05060F0135
Note: Encrypted key string MINT
!
!
interface FastEthernet0/0
 ip address 192.168.5.246 255.255.255.252
 ip router isis
!
interface FastEthernet0/1
 ip address 192.168.5.241 255.255.255.252
 ip router isis
!
router isis
 net 49.0003.5555.5555.5555.00
 authentication mode md5
 authentication key-chain Top_2600 level-1
Note: Configure md5 authentication and implement level 1 authentication
 summary-address 192.168.4.0 255.255.255.128
 summary-address 192.168.4.128 255.255.255.128
end
```

Configuration of Cisco Mid 2600 router:

```
Mid_2600#
!
interface Loopback1
 ip address 192.168.4.1 255.255.255.224
 ip router isis
!
interface Loopback2
 ip address 192.168.4.33 255.255.255.224
 ip router isis
!
interface Loopback3
 ip address 192.168.4.65 255.255.255.240
 ip router isis
!
interface FastEthernet0/0
 ip address 192.168.5.254 255.255.255.252
 ip router isis
!
!
router isis
 net 49.0002.4444.4444.4444.00
 is-type level-1
Note: Command for comfiguring as a L1 router
 area-password cisco
!
End
```

Configuration of Cisco Low 2600 router:

```
Low_2600#
!
key chain Low_2600
 key 1
  key-string 7 060B062F58
!
interface Loopback4
 ip address 192.168.4.129 255.255.255.240
 ip router isis
!
interface Loopback5
 ip address 192.168.4.161 255.255.255.224
 ip router isis
!
```

```
interface Loopback6
 ip address 192.168.4.193 255.255.255.240
 ip router isis
!
interface FastEthernet0/0
 ip address 192.168.5.242 255.255.255.252
 ip router isis
!
router isis
 net 49.0003.6666.6666.6666.00
 is-type level-1
 authentication mode md5
 authentication key-chain Low_2600 level-1
!
end
```

8.4.2 Outputs and Results

sh ip route when all are L1/L2 router

```
Mid_2600#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.4.0/24 is variably subnetted, 8 subnets, 3 masks
C       192.168.4.64/28 is directly connected, Loopback3
C       192.168.4.32/27 is directly connected, Loopback2
C       192.168.4.0/27 is directly connected, Loopback1
i L2    192.168.4.0/25 [115/30] via 192.168.5.253, FastEthernet0/0
i L2    192.168.4.192/28 [115/50] via 192.168.5.253, FastEthernet0/0
i L2    192.168.4.160/27 [115/50] via 192.168.5.253, FastEthernet0/0
i L2    192.168.4.128/28 [115/50] via 192.168.5.253, FastEthernet0/0
i L2    192.168.4.128/25 [115/50] via 192.168.5.253, FastEthernet0/0
     192.168.5.0/30 is subnetted, 4 subnets
C       192.168.5.252 is directly connected, FastEthernet0/0
i L1    192.168.5.248 [115/20] via 192.168.5.253, FastEthernet0/0
i L2    192.168.5.244 [115/30] via 192.168.5.253, FastEthernet0/0
i L2    192.168.5.240 [115/40] via 192.168.5.253, FastEthernet0/0
```

sh ip route when all are appropriate level router

```
Mid_2600#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.5.253 to network 0.0.0.0

     192.168.4.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.4.64/28 is directly connected, Loopback3
C       192.168.4.32/27 is directly connected, Loopback2
C       192.168.4.0/27 is directly connected, Loopback1
     192.168.5.0/30 is subnetted, 2 subnets
C       192.168.5.252 is directly connected, FastEthernet0/0
i L1    192.168.5.248 [115/20] via 192.168.5.253, FastEthernet0/0
i*L1 0.0.0.0/0 [115/10] via 192.168.5.253, FastEthernet0/0
```

sh ip topology when all are L1/L2 router

```
Mid_2600#sh isis topology

IS-IS paths to level-1 routers
System Id            Metric     Next-Hop             Interface   SNPA
Router_2800          10         Router_2800          Fa0/0
0017.e0c0.17c1
Mid_2600             --

IS-IS paths to level-2 routers
System Id            Metric     Next-Hop             Interface   SNPA
RACK-4               20         Router_2800          Fa0/0
0017.e0c0.17c1
Router_2800          10         Router_2800          Fa0/0
0017.e0c0.17c1
Mid_2600             --
Top_2600             30         Router_2800          Fa0/0
0017.e0c0.17c1
Low_2600             40         Router_2800          Fa0/0
0017.e0c0.17c1
```

sh ip topology when all are appropriate level router

```
Mid_2600#sh isis topology

IS-IS paths to level-1 routers
System Id            Metric     Next-Hop             Interface   SNPA
Router_2800          10         Router_2800          Fa0/0
0017.e0c0.17c1
Mid_2600             --
```

Note: No level 2 Route

sh ip route before Summary address in L1/L2 router

```
Router_2800#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.4.0/24 is variably subnetted, 6 subnets, 2 masks
i L1    192.168.4.64/28 [115/20] via 192.168.5.254, GigabitEthernet0/1
i L1    192.168.4.32/27 [115/20] via 192.168.5.254, GigabitEthernet0/1
i L1    192.168.4.0/27 [115/20] via 192.168.5.254, GigabitEthernet0/1
i L2    192.168.4.192/28 [115/40] via 192.168.5.249, GigabitEthernet0/0
i L2    192.168.4.160/27 [115/40] via 192.168.5.249, GigabitEthernet0/0
i L2    192.168.4.128/28 [115/40] via 192.168.5.249, GigabitEthernet0/0
     192.168.5.0/30 is subnetted, 4 subnets
C       192.168.5.252 is directly connected, GigabitEthernet0/1
C       192.168.5.248 is directly connected, GigabitEthernet0/0
i L2    192.168.5.244 [115/20] via 192.168.5.249, GigabitEthernet0/0
i L2    192.168.5.240 [115/30] via 192.168.5.249, GigabitEthernet0/0




Top_2600#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
```

```
level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.4.0/24 is variably subnetted, 6 subnets, 2 masks
i L2    192.168.4.64/28 [115/40] via 192.168.5.245, FastEthernet0/0
i L2    192.168.4.32/27 [115/40] via 192.168.5.245, FastEthernet0/0
i L2    192.168.4.0/27 [115/40] via 192.168.5.245, FastEthernet0/0
i L1    192.168.4.192/28 [115/20] via 192.168.5.242, FastEthernet0/1
i L1    192.168.4.160/27 [115/20] via 192.168.5.242, FastEthernet0/1
i L1    192.168.4.128/28 [115/20] via 192.168.5.242, FastEthernet0/1
     192.168.5.0/30 is subnetted, 4 subnets
i L2    192.168.5.252 [115/30] via 192.168.5.245, FastEthernet0/0
i L2    192.168.5.248 [115/20] via 192.168.5.245, FastEthernet0/0
C       192.168.5.244 is directly connected, FastEthernet0/0
C       192.168.5.240 is directly connected, FastEthernet0/1
```

sh ip route After Summary address in L1/L2 router

```
Router_2800#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.4.0/24 is variably subnetted, 5 subnets, 3 masks
i L1    192.168.4.64/28 [115/20] via 192.168.5.254, GigabitEthernet0/1
i L1    192.168.4.32/27 [115/20] via 192.168.5.254, GigabitEthernet0/1
i L1    192.168.4.0/27 [115/20] via 192.168.5.254, GigabitEthernet0/1
i su     192.168.4.0/25 [115/20] via 0.0.0.0, Null0
i L2    192.168.4.128/25 [115/40] via 192.168.5.249, GigabitEthernet0/0
     192.168.5.0/30 is subnetted, 4 subnets
C       192.168.5.252 is directly connected, GigabitEthernet0/1
C       192.168.5.248 is directly connected, GigabitEthernet0/0
i L2    192.168.5.244 [115/20] via 192.168.5.249, GigabitEthernet0/0
i L2    192.168.5.240 [115/30] via 192.168.5.249, GigabitEthernet0/0
```

```
Top_2600#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.4.0/24 is variably subnetted, 5 subnets, 3 masks
i L2    192.168.4.0/25 [115/40] via 192.168.5.245, FastEthernet0/0
i L1    192.168.4.192/28 [115/20] via 192.168.5.242, FastEthernet0/1
i L1    192.168.4.160/27 [115/20] via 192.168.5.242, FastEthernet0/1
i L1    192.168.4.128/28 [115/20] via 192.168.5.242, FastEthernet0/1
i su    192.168.4.128/25 [115/20] via 0.0.0.0, Null0
     192.168.5.0/30 is subnetted, 4 subnets
i L2    192.168.5.252 [115/30] via 192.168.5.245, FastEthernet0/0
i L2    192.168.5.248 [115/20] via 192.168.5.245, FastEthernet0/0
C       192.168.5.244 is directly connected, FastEthernet0/0
C       192.168.5.240 is directly connected, FastEthernet0/1
```

Chapter 9

BGP (Border Gateway Protocol)

Lab Manual

Instructor Manual

Lab Manual

9. Introduction

Border Gateway Protocol (BGP) is an exterior gateway protocol (EGP) that is used to exchange routing information with all the routers in different autonomous systems (ASs). BGP routing information contains the complete route to each destination. BGP exchanges the routing information with other BGP systems to maintain a network reachability information database.

BGP allows policy-based routing. Routing policies can be used to choose among multiple paths to a destination and to control the routing information redistribution. BGP uses the Transmission Control Protocol (TCP) as its transport protocol. BGP use port 179 for establishing connections

BGP supports two types of exchanges of routing information. One is exchange between different ASs and the other, exchange within a single AS. When used between ASs, BGP is called external BGP or EBGP. When used within an AS, BGP is called internal BGP or IBGP.

9.1 Pre lab questions

Q1. What are the BGP message types?

Q2. What does an Open message type contains

a. Version number
b. Hold time
c. Withdrawn routes
d. Path attributes

Q3. If a BGP Router Sees Its Own AS Number in the AS_PATH of a Route from another AS,

a. It Rejects the Update
b. Update routing table
c. Hold the update for 30 Second then update

Q4. What is the advantage of using loopback address as a router ID?

Q5. Load balancing works only with IBGP.

a. True
b. False

Explain why?

Q6. Before establishing a BGP peer connection, the two neighbors must

a. Perform the standard TCP three-way handshake
b. Open a UDP connection to port 179
c. Open a TCP connection to port 197

Q7. What does “incomplete” means in ***show router bgp route*** command in Alcatel router?

a. The NLRI was learned by some other means.
b. Incomplete is the lowest-preferred ORIGIN value.
c. Incomplete does not imply that the route is in any way faulty
d. The information for determining the origin of the route is incomplete.

Q8. What does a next hop of 0.0.0.0 mean in the show ip bgp command output?

Q9. What is a BGP peer group?

Q10. What is NLRI?

9.2 Lab Exercise

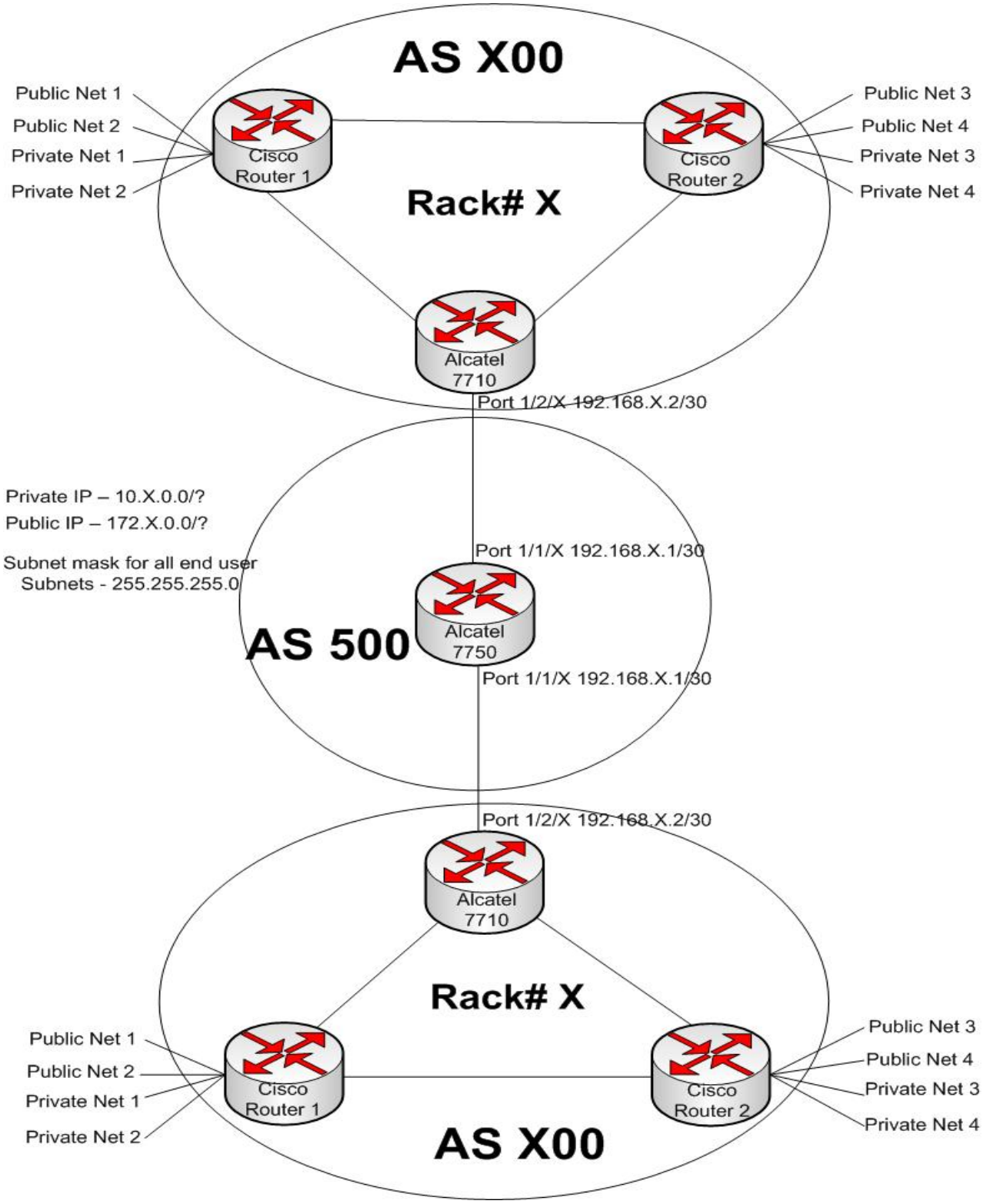

Figure 9.1 Network diagram for BGP protocol

In this lab you will configure **BGP** routing protocol in all the routers for correspondent autonomous system (AS) for your team. Each team will be working in one AS. Your AS will be "X00". Your AS has two different subnets, where public and private subnet range is 172.X.0.0 and 10.X.0.0 respectively.

Here '**X'** refers the Rack number.

- You are asked to use least number of IPs as required. Find out how many subnets you will require and what would be the range or subnet mask.
- Configure BGP in all the routers in your AS.
- You will configure the connecting interface to other routers from your public IP range.
- While you are connecting to the other AS, you will use the IP address and the ports as shown in the network diagram correspondent to your rack number.
- Configure EBGP and IBGP as required.
- Configure policy/prefix list/community list if required.
- Advertise all of your subnets without redistribution.
    - You will advertise all of your subnets with in your AS.
    - You will advertise only your public subnets outside your AS.
- Explain ***show ip bgp*** and ***show ip route*** in Cisco router 2.
- Show the routing table in Alcatel 7710 before and after filtering your advertisement.

9.2.1What to hand in

1. Draw the network diagram and assign ip addresses to all hosts and interfaces. The maximum number of address needs to be kept free for future use.
2. The list of commands issued in the routers configuring interfaces, enable routing, configuring policy etc.
3. Output of ***show run*** command for all routers.
4. ***show ip bgp*** and ***show ip route*** in Cisco router 2.
5. The routing table of Alcatel 7710 before and after filtering your advertisement.
6. Verify connectivity with a ping program.

Instructor Manual

9.3 Pre lab answers

Q1. What are the BGP message types?

Ans. The four BGP message types are:

1. Open
2. Keepalive
3. Update
4. Notification

Q2. What does an Open message type contains

a. Version number
b. Hold time
c. Withdrawn routes
d. Path attributes

Q3. If a BGP Router Sees Its Own AS Number in the AS_PATH of a Route from another AS,

a. It Rejects the Update
b. Update routing table
c. Hold the update for 30 Second then update

Q4. What is the advantage of using loopback address as a router ID?

Ans. Using addresses associated with loopback interfaces has two advantages:

a. The loopback interface is more stable than any physical interface. It is active when the router boots up, and it fails only if the entire router fails.

b. The network administrator has more scope in assigning predictable or recognizable addresses as the router IDs.

Q5. Load balancing works only with IBGP.
a. True
b. False

Ans. Load balancing works only with EBGP. IBGP can use only one link.

Q6. Before establishing a BGP peer connection, the two neighbors must

a. Perform the standard TCP three-way handshake
b. Open a UDP connection to port 179
c. Open a TCP connection to port 197

Q7. What does "incomplete" means in *show router bgp route* command in Alcatel router?

a. The NLRI was learned by some other means.
b. Incomplete is the lowest-preferred ORIGIN value.
c. Incomplete does not imply that the route is in any way faulty
d. The information for determining the origin of the route is incomplete.

Ans. All of them.

Q8. What does a next hop of 0.0.0.0 mean in the show ip bgp command output?

Ans. It means that the network is locally originated via redistribution of Interior Gateway Protocol (IGP) into BGP, or via a network or aggregate command in the BGP configuration.

Q9. What is a BGP peer group?

Ans. A BGP peer group is a group of BGP peers that have been identified on a single router to share common routing policies. Peer groups simplify configuration by allowing route policies to be applied to the group rather than to each individual member.

Q10. What is NLRI?

Ans. Network Layer Reachability Information is the IP address prefix or prefixes advertised in a BGP Update.

9.4 Lab Exercise Solution

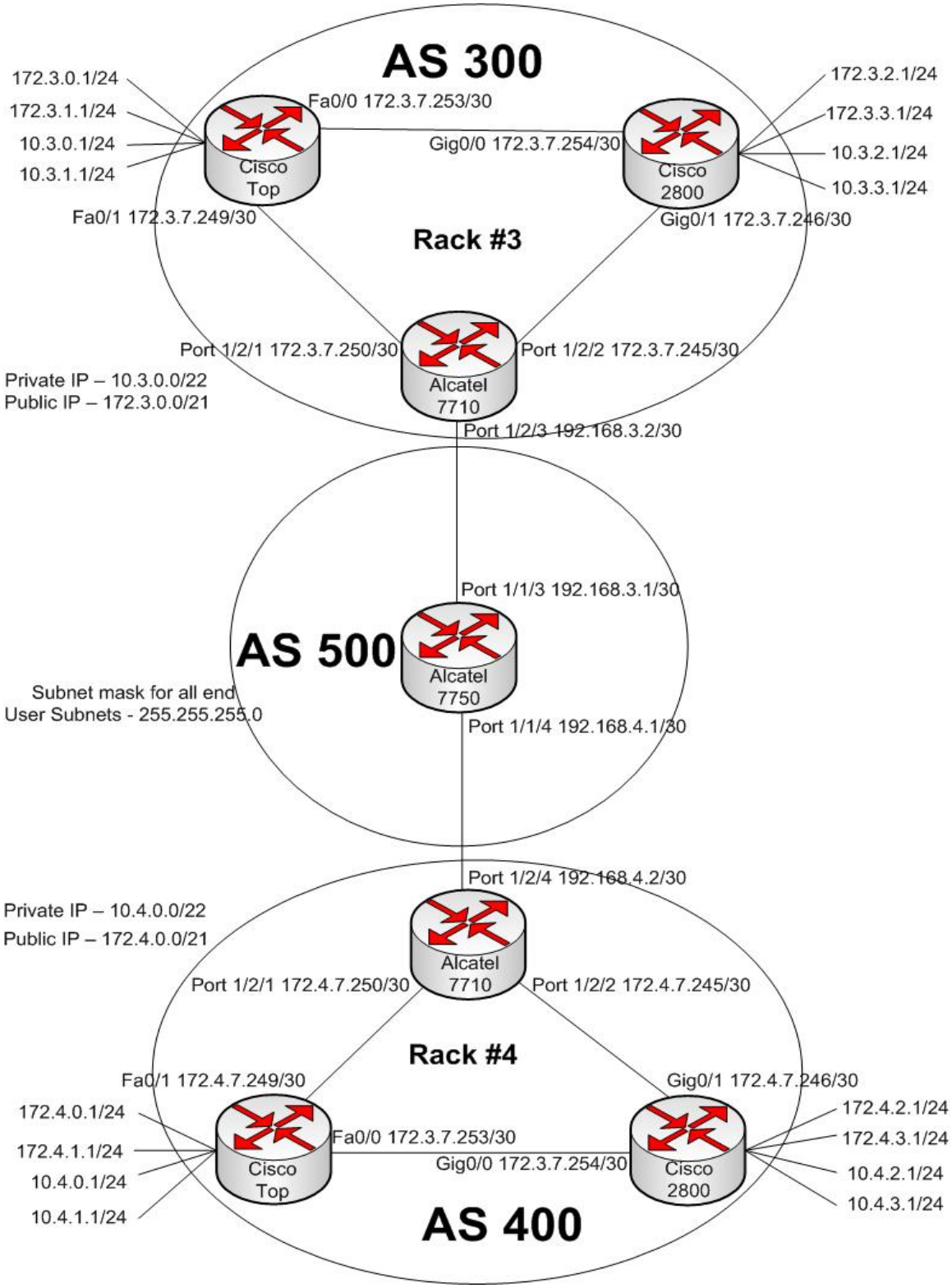

Figure 9.2 Solution network diagram for BGP protocol

In this lab we will use Cisco 2600 Top router (10.3.31.94), Cisco 2800 router (10.3.31.97) and Alcatel Lucent 7710 router (10.3.31.170) in rack# 3 for AS 300 and Cisco 2600 Top router (10.3.31.74), Cisco 2800 router (10.3.31.77) and Alcatel Lucent 7710 router (10.3.31.171) in rack# 4 for AS 400. The Lab instructor will monitor the network traffic from Alcatel 7500 (10.3.31.172) which will be in AS 500.

According to the network requirement the public IP range would be 172.3.0.0/21 and for private IP range would be 10.3.0.0/22 for AS 300 in rack #3. And same as in rack#4. The subnets connected to the Instructor's monitoring router would be 192.168.3.0/30 and 192.168.4.0/30 for AS 300 and AS 400 respectively.

9.4.1 Configuration

Step 1: Telnet all the device one by one with the correspondent ip address and configure them as follows.

Configuration of Cisco Top 2600 router in Rack#3:

```
Top_R3#sh run
!
hostname Top_R3
!
interface Loopback0
 ip address 172.3.0.1 255.255.255.0
!
interface Loopback1
 ip address 172.3.1.1 255.255.255.0
!
interface Loopback2
 ip address 10.3.0.1 255.255.255.0
!
interface Loopback3
 ip address 10.3.1.1 255.255.255.0
!
interface Loopback8
 no ip address
!
interface FastEthernet0/0
 ip address 172.3.7.253 255.255.255.252
!
interface FastEthernet0/1
 ip address 172.3.7.249 255.255.255.252
!
```

```
router bgp 300
 network 10.3.0.0 mask 255.255.255.0
 network 10.3.1.0 mask 255.255.255.0
 network 172.3.0.0 mask 255.255.255.0
 network 172.3.1.0 mask 255.255.255.0
 network 172.3.7.252 mask 255.255.255.252
 neighbour 172.3.7.250 remote-as 300
 neighbour 172.3.7.254 remote-as 300
 !
 ip route 3.3.3.3 255.255.255.0 172.3.7.250
 ip route 3.3.3.3 255.255.255.0 172.3.7.254 2
 ip route 172.3.2.1 255.255.255.0 172.3.7.254
 ip route 172.3.2.1 255.255.255.0 172.3.7.250 2
!
end
```

Configuration of Cisco 2800 router in Rack#3:

```
Router-2800-R3#sh run
!
hostname Router-2800-R3
!
interface Loopback4
 ip address 172.3.2.1 255.255.255.0
!
interface Loopback5
 ip address 172.3.3.1 255.255.255.0
!
interface Loopback6
 ip address 10.3.2.1 255.255.255.0
!
interface Loopback7
 ip address 10.3.3.1 255.255.255.0
!
interface GigabitEthernet0/0
 ip address 172.3.7.254 255.255.255.252
!
interface GigabitEthernet0/1
 ip address 172.3.7.246 255.255.255.252
!
router bgp 300
 network 10.3.2.0 mask 255.255.255.0
 network 10.3.3.0 mask 255.255.255.0
 network 172.3.2.0 mask 255.255.255.0
 network 172.3.3.0 mask 255.255.255.0
 network 172.3.7.252 mask 255.255.255.252
 neighbour 172.3.7.245 remote-as 300
 neighbour 172.3.7.253 remote-as 300
 !
```

```
 ip route 3.3.3.3 255.255.255.0 172.3.7.245
 ip route 3.3.3.3 255.255.255.0 172.3.7.253 2
 ip route 172.3.0.1 255.255.255.0 172.3.7.253
 ip route 172.3.0.1 255.255.255.0 172.3.7.253 2
!
end
```

Configuration of Alcatel 7710 router in Rack#3:

```
A:RACK-3# admin display-config

#--------------------------------------------------
echo "Router (Network Side) Configuration"
#--------------------------------------------------
    router
        interface "system"
            shutdown
            address 3.3.3.3/32
        exit
        interface "to2800"
            address 172.3.7.245/30
            port 1/2/2
        exit
        interface "to7750"
            address 192.168.3.2/30
            port 1/2/3
        exit
        interface "toTop"
            address 172.3.7.250/30
            port 1/2/1
        exit
        autonomous-system 300
    exit

#--------------------------------------------------
echo "Static Route Configuration"
#--------------------------------------------------

static-route 172.3.1.0/24 next-hop 172.3.7.246 metric 2
static-route 172.3.1.0/24 next-hop 172.3.7.249
static-route 172.3.3.0/24 next-hop 172.3.7.249 metric 2
static-route 172.3.3.0/24 next-hop 172.3.7.246

#--------------------------------------------------
echo "Policy Configuration"
#--------------------------------------------------
        policy-options
```

```
            begin
            prefix-list "deny"
                prefix 10.3.0.0/24 exact
                prefix 10.3.1.0/24 exact
                prefix 10.3.2.0/24 exact
                prefix 10.3.3.0/24 exact
            exit
            policy-statement "filter_local"
                entry 1
                    from
                        prefix-list "deny"
                    exit
                    to
                        protocol bgp
                    exit
                    action reject
                exit
                entry 2
                    from
                        protocol direct
                    exit
                    action accept
                    exit
                exit
            exit
            commit
        exit
#--------------------------------------------------
echo "BGP Configuration"
#--------------------------------------------------
        bgp
            hold-time 180
            keepalive 60
            export "filter_local"
            group "eBGP"
                neighbor 192.168.3.1
                    peer-as 500
                exit
            exit
            group "iBGP"
                next-hop-self
                neighbor 172.3.7.246
                    peer-as 300
                exit
                neighbor 172.3.7.249
                    peer-as 300
                exit
            exit
        exit
    exit
```

```
exit all
```

Configuration of Alcatel 7710 router in Rack#4:

```
A:RACK-4# admin display-config
#--------------------------------------------------
echo "Router (Network Side) Configuration"
#--------------------------------------------------
    router
        interface "system"
            shutdown
            address 4.4.4.4/32
        exit
        interface "to2800"
            address 172.4.7.245/30
            port 1/2/2
        exit
        interface "to7750"
            address 192.168.4.2/30
            port 1/2/4
        exit
        interface "toTop"
            address 172.4.7.250/30
            port 1/2/1
        exit
        autonomous-system 400
    exit
#--------------------------------------------------
echo "Static Route Configuration"
#--------------------------------------------------

static-route 172.4.1.0/24 next-hop 172.4.7.246 metric 2
static-route 172.4.1.0/24 next-hop 172.4.7.249
static-route 172.4.3.0/24 next-hop 172.4.7.249 metric 2
static-route 172.4.3.0/24 next-hop 172.4.7.246


#--------------------------------------------------
echo "Policy Configuration"
#--------------------------------------------------
        policy-options
            begin
            prefix-list "deny"
                prefix 10.4.0.0/24 exact
                prefix 10.4.1.0/24 exact
                prefix 10.4.2.0/24 exact
                prefix 10.4.3.0/24 exact
            exit
            policy-statement "filter_local"
```

```
                entry 1
                    from
                        prefix-list "deny"
                    exit
                    to
                        protocol bgp
                    exit
                    action reject
                exit
                entry 2
                    from
                        protocol direct
                    exit
                    action accept
                    exit
                exit
            exit
            commit
        exit
#--------------------------------------------------
echo "BGP Configuration"
#--------------------------------------------------
        bgp
            hold-time 180
            keepalive 60
            export "filter_local"
            group "eBGP"
                neighbor 192.168.4.1
                    peer-as 500
                exit
            exit
            group "iBGP"
                next-hop-self
                neighbor 172.4.7.246
                    peer-as 400
                exit
                neighbor 172.4.7.249
                    peer-as 400
                exit
            exit
        exit
    exit


exit all
```

Configuration of Cisco Top 2600 router in Rack#4:

```
Top_R4#sh run
!
hostname Top_R4
!
```

```
interface Loopback0
 ip address 172.4.0.1 255.255.255.0
!
interface Loopback1
 ip address 172.4.1.1 255.255.255.0
!
interface Loopback2
 ip address 10.4.0.1 255.255.255.0
!
interface Loopback3
 ip address 10.4.1.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 172.4.7.253 255.255.255.252
!
interface FastEthernet0/1
 ip address 172.4.7.249 255.255.255.252
!
router bgp 400
 network 10.4.0.0 mask 255.255.255.0
 network 10.4.1.0 mask 255.255.255.0
 network 172.4.0.0 mask 255.255.255.0
 network 172.4.1.0 mask 255.255.255.0
 network 172.4.7.252 mask 255.255.255.252
 neighbor 172.4.7.250 remote-as 400
 neighbor 172.4.7.254 remote-as 400
 !
 ip route 4.4.4.4 255.255.255.0 172.4.7.250
 ip route 4.4.4.4 255.255.255.0 172.4.7.254 2
 ip route 172.4.2.1 255.255.255.0 172.4.7.254
 ip route 172.4.2.1 255.255.255.0 172.4.7.250 2
!
end
```

Configuration of Cisco 2800 router in Rack#4:

```
Router-2800-R4#sh run
!
hostname Router-2800-R4
!
interface Loopback4
 ip address 172.4.2.1 255.255.255.0
!
interface Loopback5
 ip address 172.4.3.1 255.255.255.0
!
interface Loopback6
 ip address 10.4.2.1 255.255.255.0
!
interface Loopback7
 ip address 10.4.3.1 255.255.255.0
!
```

```
interface GigabitEthernet0/0
 ip address 172.4.7.254 255.255.255.252
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 172.4.7.246 255.255.255.252
!
router bgp 400
 network 10.4.2.0 mask 255.255.255.0
 network 10.4.3.0 mask 255.255.255.0
 network 172.4.2.0 mask 255.255.255.0
 network 172.4.3.0 mask 255.255.255.0
 network 172.4.7.252 mask 255.255.255.252
 neighbor 172.4.7.245 remote-as 400
 neighbor 172.4.7.253 remote-as 400
 !
 ip route 4.4.4.4 255.255.255.0 172.4.7.245
 ip route 4.4.4.4 255.255.255.0 172.4.7.253 2
 ip route 172.4.0.1 255.255.255.0 172.4.7.253
 ip route 172.4.0.1 255.255.255.0 172.4.7.253 2
!
End
```

Configuration of Alcatel 7750 router:

```
A:Alcatel-7750# admin display-config
#--------------------------------------------------
"Interface Configuration"
#--------------------------------------------------
    router
        interface "system"
            address 5.5.5.5/32
        exit
        interface "to-R1-7710"
            address 192.168.1.1/30
            port 1/1/1
        exit
        interface "to-R2-7710"
            address 192.168.2.1/30
            port 1/1/2
        exit
        interface "to-R3-7710"
            address 192.168.3.1/30
            port 1/1/3
        exit
        interface "to-R4-7710"
            address 192.168.4.1/30
            port 1/1/4
        exit
```

```
        autonomous-system 500
        router-id 5.5.5.5
    exit

#--------------------------------------------------
"Policy Configuration"
#--------------------------------------------------
        policy-options
            begin
            policy-statement "direct"
                entry 1
                    from
                        protocol direct
                    exit
                    action accept
                    exit
                exit
            exit
            commit
        exit
#--------------------------------------------------
"BGP Configuration"
#--------------------------------------------------
        bgp
            hold-time 180
            keepalive 60
            export "direct"
            router-id 5.5.5.5
            group "eBGP"
                neighbor 192.168.1.2
                    peer-as 100
                exit
                neighbor 192.168.2.2
                    peer-as 200
                exit
                neighbor 192.168.3.2
                    peer-as 300
                exit
                neighbor 192.168.4.2
                    peer-as 400
                exit
            exit
        exit
    exit


exit all
```

9.4.2 Outputs and Results

Show ip bgp in Router 2800 in Rack#4

```
Router-2800-R4#sh ip bgp
BGP table version is 364, local router ID is 172.4.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i5.5.5.5/32       172.4.7.245                 100      0 500 ?
*>i10.4.0.0/24      172.4.7.253              0  100      0 i
*>i10.4.1.0/24      172.4.7.253              0  100      0 i
*> 10.4.2.0/24      0.0.0.0                  0         32768 i
*> 10.4.3.0/24      0.0.0.0                  0         32768 i
*>i172.3.0.0/24     172.4.7.245                 100      0 500 300 i
*>i172.3.1.0/24     172.4.7.245                 100      0 500 300 i
*>i172.3.2.0/24     172.4.7.245                 100      0 500 300 i
*>i172.3.3.0/24     172.4.7.245                 100      0 500 300 i
*>i172.3.7.244/30   172.4.7.245                 100      0 500 300 ?
*>i172.3.7.248/30   172.4.7.245                 100      0 500 300 ?
*>i172.3.7.252/30   172.4.7.245                 100      0 500 300 i
*>i172.4.0.0/24     172.4.7.253              0  100      0 i
*>i172.4.1.0/24     172.4.7.253              0  100      0 i
*> 172.4.2.0/24     0.0.0.0                  0         32768 i
*> 172.4.3.0/24     0.0.0.0                  0         32768 i
r>i172.4.7.244/30   172.4.7.245                 100      0 ?
*>i172.4.7.248/30   172.4.7.245                 100      0 ?
*> 172.4.7.252/30   0.0.0.0                  0         32768 i
* i                 172.4.7.253              0  100      0 i
   Network          Next Hop            Metric LocPrf Weight Path
*>i192.168.3.0/30   172.4.7.245                 100      0 500 ?
*>i192.168.4.0/30   172.4.7.245                 100      0 ?
```

Show ip route in Router 2800 in Rack#4

```
Router-2800-R4#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set
```

```
     5.0.0.0/32 is subnetted, 1 subnets
B       5.5.5.5 [200/0] via 172.4.7.245, 00:25:08
     172.3.0.0/16 is variably subnetted, 7 subnets, 2 masks
B       172.3.7.248/30 [200/0] via 172.4.7.245, 00:25:08
B       172.3.7.252/30 [200/0] via 172.4.7.245, 00:15:08
B       172.3.7.244/30 [200/0] via 172.4.7.245, 00:25:08
B       172.3.3.0/24 [200/0] via 172.4.7.245, 00:25:08
B       172.3.2.0/24 [200/0] via 172.4.7.245, 00:25:08
B       172.3.1.0/24 [200/0] via 172.4.7.245, 00:25:08
B       172.3.0.0/24 [200/0] via 172.4.7.245, 00:25:09
     172.4.0.0/16 is variably subnetted, 7 subnets, 2 masks
C       172.4.7.252/30 is directly connected, GigabitEthernet0/0
B       172.4.7.248/30 [200/0] via 172.4.7.245, 01:04:32
C       172.4.7.244/30 is directly connected, GigabitEthernet0/1
B       172.4.0.0/24 [200/0] via 172.4.7.253, 1d18h
B       172.4.1.0/24 [200/0] via 172.4.7.253, 1d18h
C       172.4.2.0/24 is directly connected, Loopback4
C       172.4.3.0/24 is directly connected, Loopback5
     192.168.4.0/30 is subnetted, 1 subnets
B       192.168.4.0 [200/0] via 172.4.7.245, 01:04:33
     10.0.0.0/24 is subnetted, 4 subnets
C       10.4.2.0 is directly connected, Loopback6
C       10.4.3.0 is directly connected, Loopback7
B       10.4.0.0 [200/0] via 172.4.7.253, 1d18h
B       10.4.1.0 [200/0] via 172.4.7.253, 1d18h
     192.168.3.0/30 is subnetted, 1 subnets
B       192.168.3.0 [200/0] via 172.4.7.245, 00:25:10
```

Routing Table in Alcatel 7710 in Rack#4 before filtering route

```
A:RACK-4# show router route-table
===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix                                     Type    Proto    Age
Pref
       Next Hop[Interface Name]                                      Metric
-------------------------------------------------------------------------------
5.5.5.5/32                                      Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0

Note: These routes need to be filtered
10.3.0.0/24                                     Remote  BGP      00h00m15s   170
       192.168.4.1                                                    0
10.3.1.0/24                                     Remote  BGP      00h00m15s   170
       192.168.4.1                                                    0
10.3.2.0/24                                     Remote  BGP      00h00m15s   170
       192.168.4.1                                                    0
10.3.3.0/24                                     Remote  BGP      00h00m15s   170
       192.168.4.1                                                    0
10.4.0.0/24                                     Remote  BGP      01h06m45s   170
```

```
       172.4.7.249                                                    0
10.4.1.0/24                                 Remote  BGP      01h06m45s   170
       172.4.7.249                                                    0
10.4.2.0/24                                 Remote  BGP      01h06m45s   170
       172.4.7.246                                                    0
10.4.3.0/24                                 Remote  BGP      01h06m45s   170
       172.4.7.246                                                    0
172.3.0.0/24                                Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0
172.3.1.0/24                                Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0
172.3.2.0/24                                Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0
172.3.3.0/24                                Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0
172.3.7.244/30                              Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0
172.3.7.248/30                              Remote  BGP      00h27m15s   170
       192.168.4.1                                                    0
172.3.7.252/30                              Remote  BGP      00h17m10s   170
       192.168.4.1                                                    0
172.4.0.0/24                                Remote  BGP      01h06m45s   170
       172.4.7.249                                                    0
172.4.1.0/24                                Remote  BGP      01h06m45s   170
       172.4.7.249                                                    0
172.4.2.0/24                                Remote  BGP      01h06m45s   170
       172.4.7.246                                                    0
172.4.3.0/24                                Remote  BGP      01h06m45s   170
       172.4.7.246                                                    0
172.4.7.244/30                              Local   Local    01d11h03m   0
       to2800                                                         0
172.4.7.248/30                              Local   Local    01d11h03m   0
       toTop                                                          0
172.4.7.252/30                              Remote  BGP      00h18m12s   170
       172.4.7.249                                                    0
192.168.3.0/30                              Remote  BGP      00h27m16s   170
       192.168.4.1                                                    0
192.168.4.0/30                              Local   Local    01d11h03m   0
       to7750                                                         0
-------------------------------------------------------------------------------
No. of Routes: 25
===============================================================
```

Routing Table in Alcatel 7710 in Rack#4 after filtering route

```
A:RACK-4# show router route-table
===============================================================================
Route Table (Router: Base)
===============================================================================
```

```
Dest Prefix                                     Type    Proto    Age          Pref
       Next Hop[Interface Name]                                       Metric
-------------------------------------------------------------------------------
5.5.5.5/32                                      Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
10.4.0.0/24                                     Remote  BGP      01h08m04s    170
       172.4.7.249                                                    0
10.4.1.0/24                                     Remote  BGP      01h08m04s    170
       172.4.7.249                                                    0
10.4.2.0/24                                     Remote  BGP      01h08m04s    170
       172.4.7.246                                                    0
10.4.3.0/24                                     Remote  BGP      01h08m04s    170
       172.4.7.246                                                    0
172.3.0.0/24                                    Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
172.3.1.0/24                                    Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
172.3.2.0/24                                    Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
172.3.3.0/24                                    Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
172.3.7.244/30                                  Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
172.3.7.248/30                                  Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
172.3.7.252/30                                  Remote  BGP      00h18m29s    170
       192.168.4.1                                                    0
172.4.0.0/24                                    Remote  BGP      01h08m04s    170
       172.4.7.249                                                    0
172.4.1.0/24                                    Remote  BGP      01h08m04s    170
       172.4.7.249                                                    0
172.4.2.0/24                                    Remote  BGP      01h08m04s    170
       172.4.7.246                                                    0
172.4.3.0/24                                    Remote  BGP      01h08m04s    170
       172.4.7.246                                                    0
172.4.7.244/30                                  Local   Local    01d11h04m    0
       to2800                                                         0
172.4.7.248/30                                  Local   Local    01d11h04m    0
       toTop                                                          0
172.4.7.252/30                                  Remote  BGP      00h19m31s    170
       172.4.7.249                                                    0
192.168.3.0/30                                  Remote  BGP      00h28m34s    170
       192.168.4.1                                                    0
192.168.4.0/30                                  Local   Local    01d11h04m    0
       to7750                                                         0
-------------------------------------------------------------------------------
No. of Routes: 21
===============================================================
```

Routing Table in Alcatel 7750 before filtering route

```
A:Alcatel-7750# show router route-table

===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix                                       Type    Proto    Age         Pref
       Next Hop[Interface Name]                                        Metric
-------------------------------------------------------------------------------
5.5.5.5/32                                        Local   Local    04d20h12m   0
       system                                                          0
Note: These routes need to be filtered

10.3.0.0/24                                       Remote  BGP      00h02m15s   170
       192.168.3.2                                                     0
10.3.1.0/24                                       Remote  BGP      00h02m15s   170
       192.168.3.2                                                     0
10.3.2.0/24                                       Remote  BGP      00h02m15s   170
       192.168.3.2                                                     0
10.3.3.0/24                                       Remote  BGP      00h02m15s   170
       192.168.3.2                                                     0
10.4.0.0/24                                       Remote  BGP      00h00m01s   170
       192.168.4.2                                                     0
10.4.1.0/24                                       Remote  BGP      00h00m01s   170
       192.168.4.2                                                     0
10.4.2.0/24                                       Remote  BGP      00h00m01s   170
       192.168.4.2                                                     0
10.4.3.0/24                                       Remote  BGP      00h00m01s   170
       192.168.4.2                                                     0
172.3.0.0/24                                      Remote  BGP      00h31m50s   170
       192.168.3.2                                                     0
172.3.1.0/24                                      Remote  BGP      00h31m50s   170
       192.168.3.2                                                     0
172.3.2.0/24                                      Remote  BGP      00h31m50s   170
       192.168.3.2                                                     0
172.3.3.0/24                                      Remote  BGP      00h31m50s   170
       192.168.3.2                                                     0
172.3.7.244/30                                    Remote  BGP      00h31m50s   170
       192.168.3.2                                                     0
172.3.7.248/30                                    Remote  BGP      00h31m50s   170
       192.168.3.2                                                     0
172.3.7.252/30                                    Remote  BGP      00h21m51s   170
       192.168.3.2                                                     0
172.4.0.0/24                                      Remote  BGP      00h31m52s   170
       192.168.4.2                                                     0
172.4.1.0/24                                      Remote  BGP      00h31m52s   170
       192.168.4.2                                                     0
172.4.2.0/24                                      Remote  BGP      00h31m52s   170
       192.168.4.2                                                     0
172.4.3.0/24                                      Remote  BGP      00h31m52s   170
```

```
       192.168.4.2                                                    0
172.4.7.244/30                              Remote  BGP      00h31m52s   170
       192.168.4.2                                                    0
172.4.7.248/30                              Remote  BGP      00h31m52s   170
       192.168.4.2                                                    0
172.4.7.252/30                              Remote  BGP      00h22m31s   170
       192.168.4.2                                                    0
192.168.3.0/30                              Local   Local    01h45m36s   0
       to-R3-7710                                                     0
192.168.4.0/30                              Local   Local    01d11h07m   0
       to-R4-7710                                                     0
-------------------------------------------------------------------------------
No. of Routes: 25
===============================================================
```

Routing Table in Alcatel 7750 after filtering route

```
A:Alcatel-7750# show router route-table

===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix                                 Type    Proto    Age         Pref
       Next Hop[Interface Name]                                    Metric
-------------------------------------------------------------------------------
5.5.5.5/32                                  Local   Local    04d20h10m   0
       system                                                         0
172.3.0.0/24                                Remote  BGP      00h29m25s   170
       192.168.3.2                                                    0
172.3.1.0/24                                Remote  BGP      00h29m25s   170
       192.168.3.2                                                    0
172.3.2.0/24                                Remote  BGP      00h29m25s   170
       192.168.3.2                                                    0
172.3.3.0/24                                Remote  BGP      00h29m25s   170
       192.168.3.2                                                    0
172.3.7.244/30                              Remote  BGP      00h29m25s   170
       192.168.3.2                                                    0
172.3.7.248/30                              Remote  BGP      00h29m25s   170
       192.168.3.2                                                    0
172.3.7.252/30                              Remote  BGP      00h19m26s   170
       192.168.3.2                                                    0
172.4.0.0/24                                Remote  BGP      00h29m27s   170
       192.168.4.2                                                    0
172.4.1.0/24                                Remote  BGP      00h29m27s   170
       192.168.4.2                                                    0
172.4.2.0/24                                Remote  BGP      00h29m27s   170
       192.168.4.2                                                    0
172.4.3.0/24                                Remote  BGP      00h29m27s   170
       192.168.4.2                                                    0
```

```
172.4.7.244/30                                  Remote  BGP      00h29m27s   170
       192.168.4.2                                                   0
172.4.7.248/30                                  Remote  BGP      00h29m27s   170
       192.168.4.2                                                   0
172.4.7.252/30                                  Remote  BGP      00h20m06s   170
       192.168.4.2                                                   0
192.168.3.0/30                                  Local   Local    01h43m10s   0
       to-R3-7710                                                    0
192.168.4.0/30                                  Local   Local    01d11h05m   0
       to-R4-7710                                                    0
-------------------------------------------------------------------------------
No. of Routes: 17
===============================================================
```

Chapter 10

IP Multicast

Lab Manual

Instructor Manual

Lab Manual

10.1 Pre lab questions

1. Explain the different modes of PIM. Under which conditions should each one be used? Can you mix different modes in the same network and have them work together? Do all routers between the server and the edge router need to be multicast-enabled?

2. Explain when and where CGMP is required.

3. What is IGMP snooping? When is it necessary?

4. Is it necessary to configure a unicast routing protocol in addition to a multicast routing protocol in order for multicast to succeed? Why or why not?

10.2 Lab Exercise

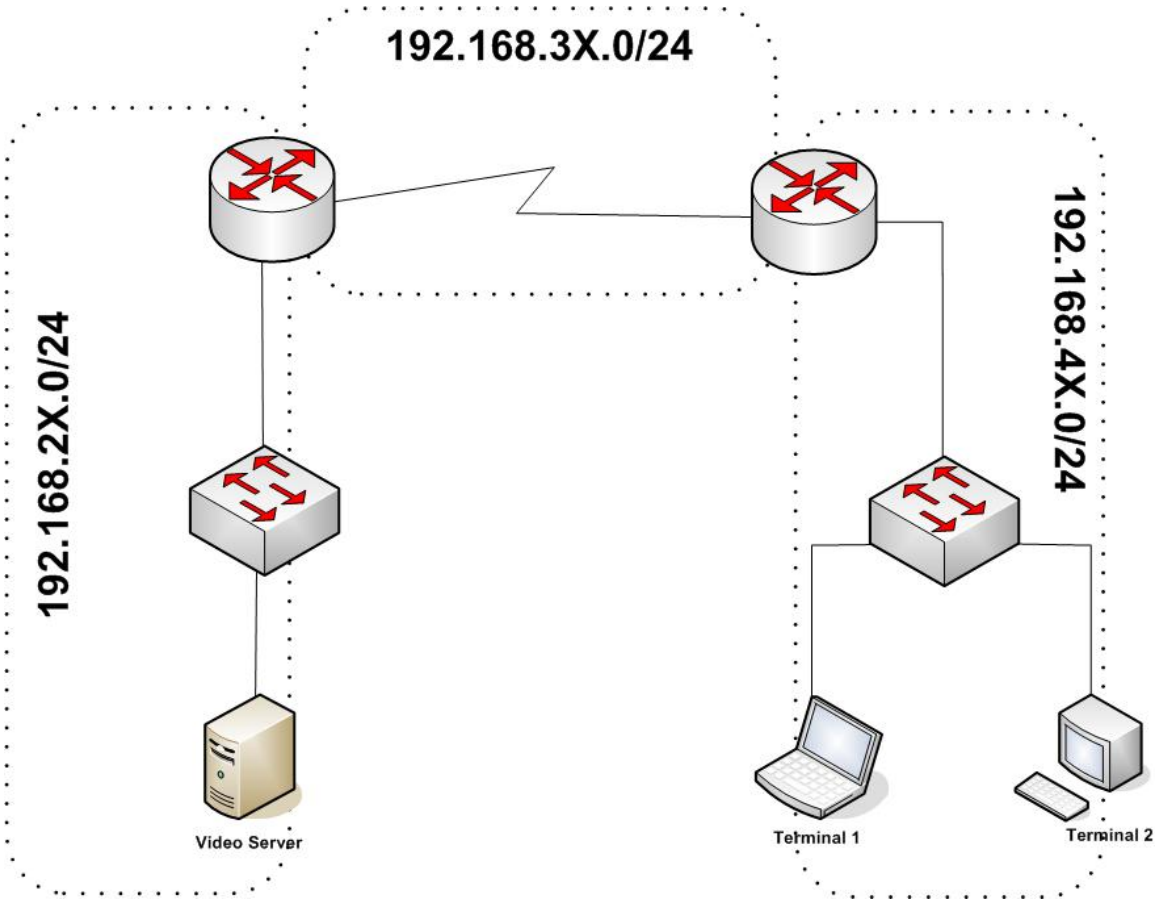

Figure 10.1 Network diagram for IP Multicast

In this lab you will be configuring IP Multicast. Each team will configure their own video server for streaming video.

- you are asked to configure unicast routing if you think it is required
- enable multicast routing on the routers
- configure Protocol Independent Multicast (PIM)
- define a Rendezvous Point(RP) in your network
- configure the LAN switches for multicast
- Use “show ip mroute” to watch the routers in your system and see if and when they add entries to their multicast routing table.

10.2.1What to hand in

1. Relevant configurations for the switches and routers.
2. Demonstrate multicast by scheduling a video stream and watching it, at Terminal 1.
3. Screenshot of both terminal 1 and terminal 2 with wireshark running and only Terminal 1 is interested in joining group.
4. Use “show ip mroute” to find out what the routers are thinking. Capture some traces if necessary to find out what the client is doing.

Instructor Manual

10.3 Pre lab answers

1. Explain the different modes of PIM. Under which conditions should each one be used? Can you mix different modes in the same network and have them work together? Do all routers between the server and the edge router need to be multicast-enabled?

Ans
PIM can operate in two modes, depending on the density of the recipients in a multicast group. Cisco has developed a third hybrid mode, as well. The PIM modes are as follows:

a. PIM Dense Mode
b. PIM Sparse Mode
c. PIM Sparse-Dense Mode

PIM Dense Mode:
PIM routers can be configured for Dense Mode (also called PIM-DM) if it is safe to assume that a multicast group's recipients are located on every subnet. The multicast traffic's source becomes the root of the tree, and the multicast tree is known from the source to each of the recipients. This is also termed (S,G) multicast traffic, where the path between the source and group members is unique and well-defined.

PIM Sparse Mode:
In PIM Sparse the multicast tree isn't extended to a router unless a host there has already joined the group. The multicast tree is built by beginning with the group members at the end leaf nodes and extending back toward a central root point. The tree is built from the bottom up.

Sparse Mode also works on the idea of a shared tree structure, where the root is not necessarily the multicast source. Instead, the root is a PIM-SM router that is centrally located in the network. This root router is called the Rendezvous Point (RP).

PIM Sparse-Dense Mode:
PIM has the potential to support both Dense and Sparse Modes, because they exist on different multicast groups in a network. Cisco offers the hybrid Sparse-Dense Mode, allowing a PIM router to use Sparse or Dense Mode on a per-group basis. If a group has an RP defined, Sparse Mode is used; otherwise, Dense Mode is used.

We can mix two different modes by using sparse-dense mode in one network. Let's assume that we have extended our network by adding a third router(connected to mid router) which is having a multicast source that functions in a different group. If the dense mode is configured in the WAN link of mid router and third router(assume sparse mode

is still active between top and mid router), then the f0/0 should be configured as sparse-dense mode in order to the clients(in 192.168.41.0/24) get connected to the source beyond third router.

In our scenario, yes, all the routers should be enabled with multicasting as the clients have one path to reach the RP. Lets assume that there are many routers meshed together and only one router has the source and another router has the multicast interested client/s. In this case, the unicast protocol will be defining the best path to source(or RP) so it's enough to enable multicast only along the best path.

2. Explain when and where CGMP is required.
Ans
CGMP will be running between router and L2 switch. CGMP is required when there are L2 switches exist in multicast network. As the L2 switches cannot distinguish between IGMP report messages and IP multicast data packets, there should be a mechanism to forward the all the packets from L2 switches towards the local multicast router, so the router will translate the IGMP messages and will be sending CGMP signals accordingly to the switches they are connected to. So CGMP should be globally enabled in L2 switches and the router interfaces which are connected to L2 switches.

3. What is IGMP snooping? When is it necessary?
Ans
IGMP snooping is a methodology used to control and constrain multicast traffic to only the ports that have receivers attached. IGMP snooping, as implied by the name, is a feature that allows a layer 2 switch to listen on the IGMP conversation between hosts and routers by processing the layer IGMP packets sent in a multicast network.

When IGMP snooping is enabled in a switch it analyzes all IGMP packets between hosts connected to the switch and multicast routers in the network. When a switch hears an IGMP report from a host for a given multicast group, the switch adds the host's port number to the multicast list for that group. And, when the switch hears an IGMP Leave, it removes the host's port from the table entry.

4. Is it necessary to configure a unicast routing protocol in addition to a multicast routing protocol in order for multicast to succeed? Why or why not?
Ans
As we configured above, unicast routing should be enabled in addition to the multicast routing in order for multicast is to succeed. When the RP is configured, usually it will be configured with the unicast address. When there are multiple routers with different networks it(PIM) needs a mechanism in order to build the tree towards the RP. So there should be unicast routing protocol enabled. Multicast routing protocol will be running along with unicast routing protocol in multicast networks.

10.4 Lab Exercise Solution

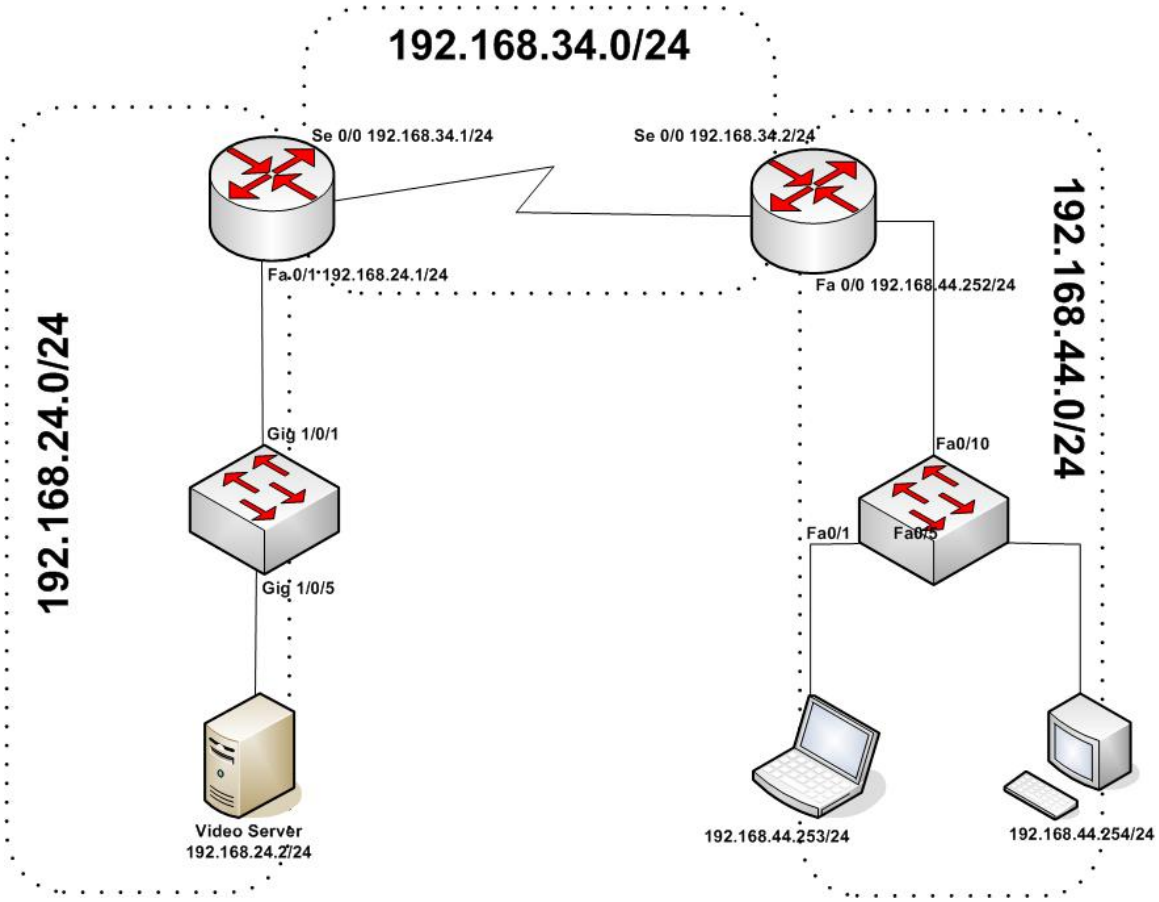

Figure 10.2 Solution network diagram for IP Multicast

In this lab we will use Cisco Top router (10.3.31.94), Cisco Mid router (10.3.31.95), Cisco 3750 switch(10.3.31.72), Cisco 3550 switch(10.3.31.73), a video server for multicast and two desktop pc.

After connecting all the devices as the above diagram, ip multicast routing is enabled, A PIM is enabled and the interfaces are enabled in sparse mode. CGMP is enabled to the interfaces connected to the switches. The configurations are as follows:

10.4.1 Configuration

Configuration of Cisco Top Router

```
Top_2600#sh run
!
hostname Top_2600
!
ip multicast-routing
!
interface Serial0/0
 ip address 192.168.34.1 255.255.255.0
 ip pim sparse-mode
 clock rate 2000000
!
interface FastEthernet0/1
 ip address 192.168.24.1 255.255.255.0
 ip pim sparse-mode
 ip cgmp
!
router rip
 version 2
 network 192.168.24.0
 network 192.168.34.0
!
ip pim rp-address 192.168.34.1
!
End
```

Configuration of Cisco Mid Router

```
Mid_2600#
!
hostname Mid_2600
!
!
ip multicast-routing
!
interface FastEthernet0/0
 ip address 192.168.44.252 255.255.255.0
 ip pim sparse-mode
 ip cgmp
!
interface Serial0/0
 ip address 192.168.34.2 255.255.255.0
 ip pim sparse-mode
```

```
!
router rip
 version 2
 network 192.168.34.0
 network 192.168.44.0
!
ip pim rp-address 192.168.34.1
!
End
```

Configuration of Cisco Switch 3550

```
SW_3550#
hostname SW_3550
!
interface FastEthernet0/1
 switchport access vlan 10
!
interface FastEthernet0/5
 switchport access vlan 10
!
interface FastEthernet0/10
 switchport access vlan 10
!
end
```

10.4.2 Outputs and Results

Show ip mroute in Mid router

```
Mid_2600#sh ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report,
       Z - Multicast Tunnel, z - MDT-data group sender,
       Y - Joined MDT-data group, y - Sending to MDT-data group
Outgoing interface flags: H - Hardware switched, A - Assert winner
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 239.255.0.1), 00:01:54/stopped, RP 192.168.34.1, flags: SJC
  Incoming interface: Serial0/0, RPF nbr 192.168.34.1
  Outgoing interface list:
    FastEthernet0/0, Forward/Sparse, 00:01:32/00:02:43

(192.168.24.2, 239.255.0.1), 00:00:13/00:02:50, flags: JT
```

```
  Incoming interface: Serial0/0, RPF nbr 192.168.34.1
  Outgoing interface list:
    FastEthernet0/0, Forward/Sparse, 00:00:13/00:02:46

(*, 224.0.1.40), 1w0d/stopped, RP 192.168.34.1, flags: SJPCL
  Incoming interface: Serial0/0, RPF nbr 192.168.34.1
  Outgoing interface list: Null

(*, 239.255.255.250), 00:32:37/00:02:33, RP 192.168.34.1, flags: SJC
  Incoming interface: Serial0/0, RPF nbr 192.168.34.1
  Outgoing interface list:
    FastEthernet0/0, Forward/Sparse, 00:32:37/00:02:33
```

Show IP Multicast in Mid Router

```
Mid_2600#sh ip multicast interface fa0/0
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.44.252/24
  Multicast routing: enabled
  Multicast switching: fast
  Multicast packets in/out: 0/498587
  Multicast boundary: not set
  Multicast TTL threshold: 0
  Multicast Tagswitching: disabled
```

sh ip igmp groups

```
Mid_2600#sh ip igmp groups
IGMP Connected Group Membership
Group Address    Interface                Uptime    Expires   Last Reporter
239.255.0.1      FastEthernet0/0          00:02:12  00:02:50  192.168.44.253
224.0.1.40       Serial0/0                1w0d      stopped   192.168.34.2
239.255.255.250  FastEthernet0/0          00:33:16  00:02:50  192.168.44.254
```

Show cgpm state in the Switch 3550

```
SW_3550#sh cgmp state
CGMP is running.
CGMP Fast Leave is not running.
CGMP Allow reserved address to join GDA .
Default router timeout is 300 sec.
```

When CGMP leaving is enabled in the switch

```
In this scenario, switch was enabled with CGMP fast leaving using “cgmp leave-
processing” in global configuration mode. Router configuration remained same.

Switch(config)#cgmp leave-processing
Switch#sh cgmp group
1d23h: %SYS-5-CONFIG_I: Configured from console by state
```

```
CGMP is running.
CGMP Fast Leave is running.
CGMP Allow reserved address to join GDA .
Default router timeout is 300 sec.
```

Wireshark capture files

Case:1 Before Enabling CGMP leaving

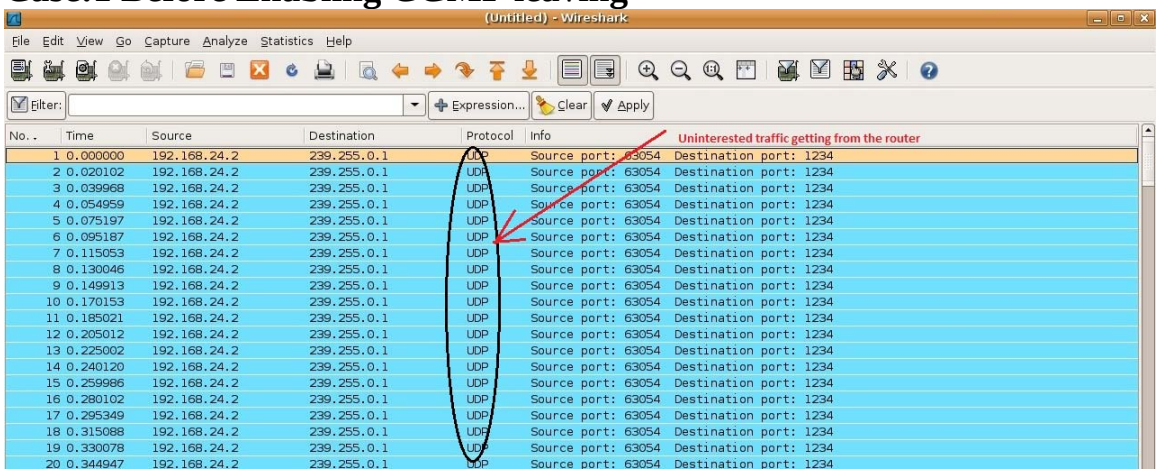

Figure 10.3: Traffic pattern received at multicast uninterested client with CGMP leaving disabled

Case:2 After Enabling CGMP leaving

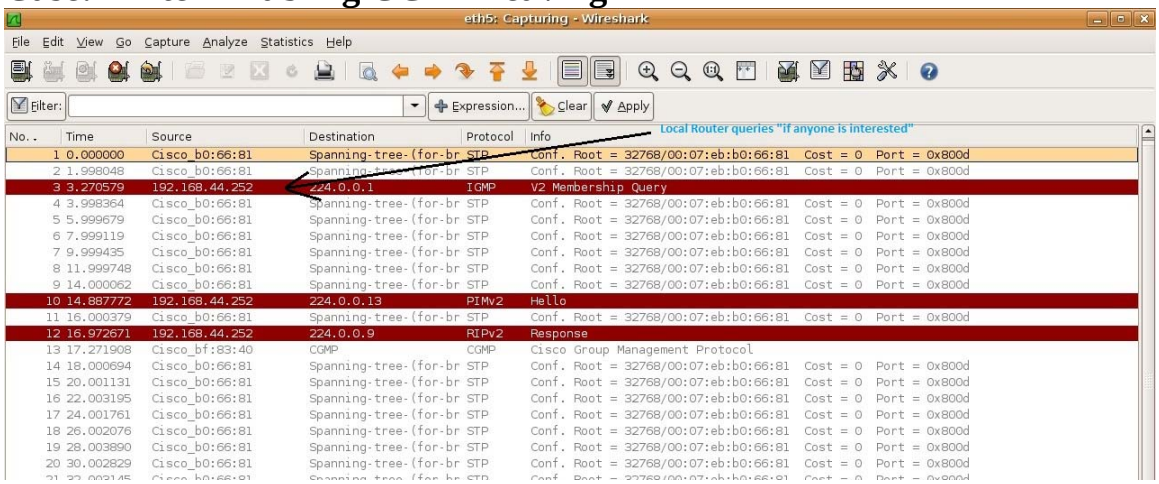

Figure 10.4: Traffic pattern received at multicast uninterested client with CGMP leaving enabled

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Chapter 5

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Chapter 10

1. MINT 708 Lab-4 Lab report 05/01/2009 prepared by Muhammad Rahman (myself) and Kirupakaran Pirasath.