



CISCO NETWORKING ACADEMY PROGRAM



CCNP 1:

Advanced Routing v3.1

Student Lab Manual

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Lab 1.4.1 Introductory Lab 1 – Getting Started and Building Start.txt

Objective

This lab may introduce new CCNP lab equipment and certain IOS features. This introductory activity also describes how to use a simple text editor to create all or part of a router configuration and apply that configuration to a router.

Equipment Requirements

- A single router, preferably a 2600 series router (however, the 1700 series routers will also work), and a workstation running Windows 2000 operating system
- One 3 1/2-inch floppy disk with label

Preliminary

Modular interfaces. Cisco routers can come with a variety of interface configurations. Some models have only fixed interfaces. This means that users cannot change or replace the interfaces. Other models have one or more modular interfaces. This allows the user to add, remove, or replace interfaces as needed.

Fixed interface identification, such as Serial 0, S0, and Ethernet 0, E0, may already be familiar. Modular routers use notation such as Serial 0/0 or S0/1, where the first number refers to the module and the second number refers to the interface. Both notations use 0 as their starting reference, so S0/1 indicates that there is another serial interface S0/0.

FastEthernet. Many routers today are equipped with FastEthernet interfaces. FastEthernet has 10/100 Mbps autosensing. FastEthernet 0/0 or Fa0/0 notation must be used on routers with FastEthernet interfaces.

The `ip subnet-zero` command. The `ip subnet-zero` command is enabled by default in IOS 12. This command allows IP addresses to be assigned in the first subnet, called subnet 0. Because subnet 0 uses only binary zeros in the subnet field, its subnet address can potentially be confused with the major network address. With the advent of classless IP, the use of subnet 0 has become more common. The labs in this manual assume that addresses can be assigned to the router interfaces using subnet 0. If any routers are used that have an IOS earlier than 12.0, the global configuration command `ip subnet-zero` must be added to the router configuration.

The `no shutdown` command. Interfaces are shut down by default. Remember to type a `no shutdown` command in interface configuration mode when the interface is ready to be brought up. The command `no shutdown` will not appear in the output of the `show running-config` command.

Passwords. The `login` command is applied to virtual terminals by default. This means that in order for the router to accept Telnet connections, a password must be configured. Otherwise, the router will not allow a Telnet connection, replying with the error message `password required, but none set`.

Step 1

Take a few moments to examine the router. Become familiar with any serial, BRI (ISDN), PRI (ISDN), and DSU/CSU interfaces on the router. Look closely at any connectors or cables that are not familiar.

Step 2

Establish a HyperTerminal session to the router.
Enter privileged EXEC mode.

Step 3

To clear the configuration, issue the `erase startup-config` command.

Confirm the objective when prompted, and answer 'no' if asked to save changes. The result should look something like this:

```
Router#erase startup-config
Erasing the nvram filesystem will remove all files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#
```

When the prompt returns, issue the `reload` command.

Confirm the objective when prompted. After the router finishes the boot process, choose not to use the AutoInstall facility, as shown:

```
Would you like to enter the initial configuration dialog? [yes/no]: no
Would you like to terminate autoinstall? [yes]: ← Press Enter to accept default.
Press RETURN to get started!
```

Step 4

In privileged mode, issue the `show run` command.

Note the following default configurations while scrolling through the running configuration:

- The version number of the IOS
- The `ip subnet-zero` command, which allows the use of subnet 0
- Each available interface and its name.
Note: Each interface has the `shutdown` command applied to its configuration.
- The `no ip http server` command, which prevents the router from being accessed by a Web browser
- No passwords are set for CON, AUX, and VTY sessions, as shown here:

```
line con 0
transport input none          (not applicable in IOS 12.2)
line aux 0
line vty 0 4
```

Using Copy and Paste with Notepad

In the next steps, use the copy and paste feature to edit router configurations. A text file needs to be created that can be pasted into the labs and used as a starting point for the router configuration. Specifically, a login configuration must be built that can be used with every lab included in this manual.

Step 5

If necessary, issue the `show run` command again so that **line con** and **line vty** are showing on the screen:

```
line con 0
transport input none      (not applicable in IOS 12.2)
line aux 0
line vty 0 4
!
end
```

Select the text as shown in this step and choose the `copy` command from HyperTerminal Edit menu.

Next, open Notepad. Notepad is typically found on the Start menu under Programs, Accessories. After Notepad opens, select **Paste** from the Notepad Edit menu.

Edit the lines in Notepad to look like the following lines. The one space indent is optional:

```
enable secret class
line con 0
  transport input none      (not applicable in IOS 12.2)
  password cisco
  login

line aux 0
  password cisco
  login

line vty 0 4
  password cisco
  login
```

This configuration sets the enable secret to **class** and requires a login for all console, AUX port, and virtual terminal connections. The AUX port is usually a modem. The password for these connections is set to **cisco**.

Note: Each of the passwords can be set to something else if so desired.

Step 6

Save the open file in Notepad to a floppy disk as **start.txt**.

Select all the lines in the Notepad document and choose **Edit > Copy**.

Step 7

Use the Windows taskbar to return to the HyperTerminal session, and enter global configuration mode.

From the HyperTerminal Edit menu, choose **Paste to Host**.

Issue the `show run` command to see if the configuration looks okay.

As a shortcut, the contents of the **start.txt** file can now be pasted to any router before getting started with a lab.

Other Useful Commands

To enhance the **start.txt** file, consider adding one of the following commands:

- `ip subnet-zero` ensures that an older IOS allows IP addresses from subnet 0.
- `ip http server` allows access to the router using a Web browser. Although this configuration might not be desirable on a production router, it does enable an HTTP server for testing purposes in the lab.
- `no ip domain-lookup` prevents the router from attempting to query a DNS when a word is input that is not recognized as a command or a host table entry. This saves time when making a typo or misspelling a command.
- `logging synchronous` in the **line con 0** configuration returns to a fresh line when the input is interrupted by a console logging message.
- `configure terminal` (`config t`) can be used in a file so that a command does not have to be typed before pasting the contents of the file to the router.

Step 8

Use the Windows taskbar to return to Notepad and edit the lines so that they read as shown:

```

config t
!
enable secret class
ip subnet-zero
ip http server
no ip domain-lookup
line con 0
  logging synchronous
  password cisco
  login

  transport input none          (not applicable in IOS 12.2)
line aux 0
password cisco
login
line vty 0 4
password cisco
login
!
end
copy run start

```

Save the file to the floppy disk so the work is not lost.

Select and copy all the lines, and return to the HyperTerminal session.

Because the `config t` command was included in the script, entering global configuration mode before pasting is no longer necessary.

If necessary, return to privileged EXEC mode. From the Edit menu, select **Paste to Host**.

After the paste is complete, confirm the copy operation.

Use `show run` to see if the configuration looks okay.

Using Notepad to Assist in Editing

Understanding how to use Notepad can reduce typing and typos during editing sessions. Another major benefit is that an entire router configuration can be done in Notepad when at home or at the office and then paste it to the router console when access is available. In the next steps, a simple editing example will be looked at.

Step 9

Configure the router with the following commands:

```
Router#config t
Router(config)#router rip
Router(config)#network 192.168.1.0
Router(config)#network 192.168.2.0
Router(config)#network 192.168.3.0
Router(config)#network 192.168.4.0
Router(config)#network 192.168.5.0
```

Press **Ctrl+Z**, and verify the configuration with **show run**. RIP was just set up to advertise a series of networks. However, the routing protocol is to be changed to IGRP. With the **no router rip** command, the RIP process is completely removed. The **network** commands would still need to be retyped. The next steps show an alternative method.

Step 10

Issue the **show run** command and hold the output so that the **router rip** commands are displayed. Using the keyboard or mouse, select the **router rip** command and all **network** statements.

Copy the selection.

Use the taskbar to return to Notepad.

Open a new document and paste the selection onto the blank page.

Step 11

In the new document, type the word **no** and a space in front of the word **router**.

Press the **End** key, and press **Enter**.

Type **router igrp 100**, but do not press **Enter**. The result should look like as follows:

```
no router rip
router igrp 100
network 192.168.1.0
network 192.168.2.0
network 192.168.3.0
network 192.168.4.0
network 192.168.5.0
```

Step 12

Select the results and copy them.

Use the taskbar to return to the HyperTerminal session.

While in global configuration mode, paste the results.

Use the **show run** command to verify the configuration.

Reflection

How could using copy and paste with Notepad be helpful in other editing situations?



Lab 1.4.2 Introductory Lab 2 – Capturing HyperTerminal and Telnet Sessions

Objective

This activity describes how to capture HyperTerminal and Telnet sessions.

Note: Mastering these techniques will reduce the amount of typing in later labs and while working in the field. These techniques are useful when perusing and testing on a production router while troubleshooting a problem.

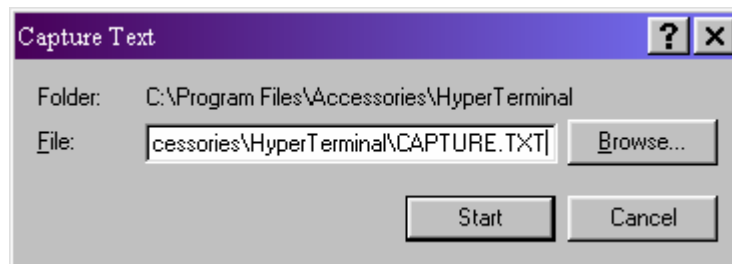
Step 1

Log in to a router using HyperTerminal.

It is possible to capture the results of the HyperTerminal session in a text file, which can be viewed and/or printed using Notepad, WordPad, or Microsoft Word.

Note: This feature captures future screens, not what is currently onscreen. Basically this is turning on a recording session.

To start a capture session, choose the menu option **Transfer > Capture Text**. The Capture Text dialog box appears, as shown in the following figure.



The default filename for a HyperTerminal capture is **CAPTURE.TXT**, and the default location of this file is C:\Program Files\Accessories\HyperTerminal.

Note: When using Telnet, the command to begin a capture or log, is **Terminal > Start Logging**. The document that was created has LOG as the extension. Other than the name and path of the capture file, the logging procedures are the same for both Telnet and HyperTerminal.

Make sure that the floppy disk is in the A: drive. When the Capture Text dialog box appears, change the File path to **A:\TestRun.txt**.

Click the **Start** button. Anything that appears onscreen after this point is copied to the file.

Step 2

Go to the User privileged configuration mode. Then issue the **show running config** command and view the entire configuration file.

From the **Transfer** menu, choose **Capture Text > Stop**.

Telnet users should select **Stop Logging** from the Terminal menu to end the session.

Step 3

Using the Start menu, launch Windows Explorer. Windows Explorer might be found under Programs or Accessories, depending on which version of Windows is used.

In the left pane, select the **3½ floppy (A:)** drive. On the right side, the file that was just created should be now seen.

Double-click the **TestRun.txt** document icon. The result should look something like the following:

```
Router# show running configuration
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Router
!
enable secret 5 $1$HD2B$6iXb.h6QEJJjtn/NnwUHO.
!
!
ip subnet-zero
no ip domain-lookup
!
interface FastEthernet0/0
--More-- [ ] [ ] no ip address
no ip directed-broadcast
shutdown
```

Unrecognizable characters may be seen near the word “More”. This happened because the spacebar was pressed to see the rest of the list. Basic word processing techniques can be used to clean that up.

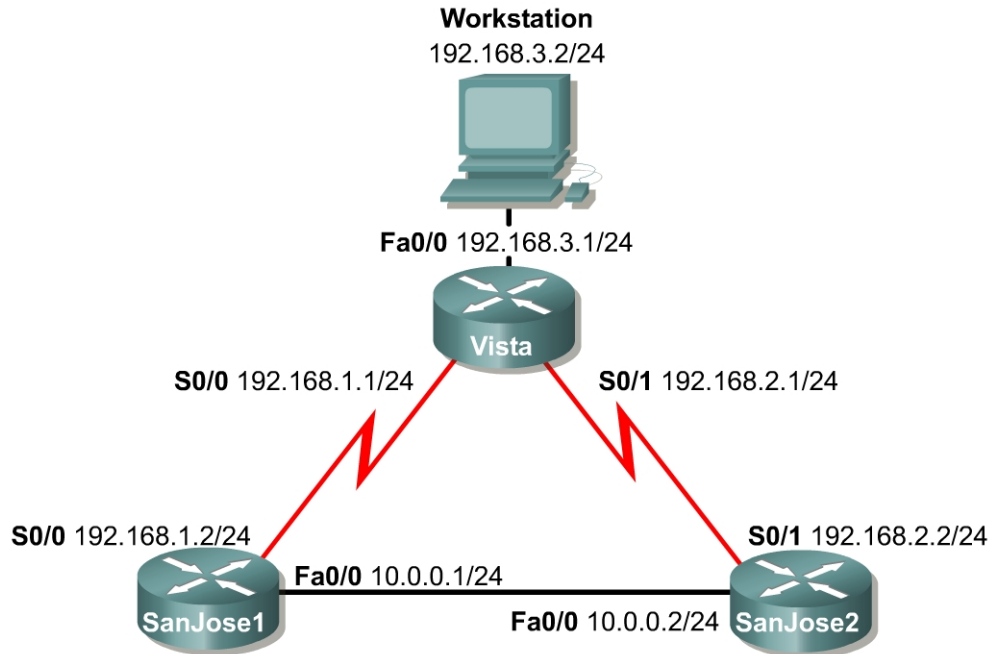
Suggestion

Consider capturing each router configuration for every lab that is done. Capture files can be useful as configuration features are reviewed and while preparing for certification exams.

Reflection

Could the capture techniques be useful if a member of the lab team misses a lab session? Can capture techniques be used to configure an off site lab?

Lab 1.4.3 Introductory Lab 3 – Access Control List Basics and Extended Ping



Objective

This lab activity reviews the basics of standard and extended access lists, which are used extensively in the CCNP curriculum.

Scenario

The LAN users connected to the Vista router are concerned about access to their network from hosts on network 10.0.0.0. Use a standard access list to block all access to Vista's LAN from network 10.0.0.0/24.

After removing the standard access list, use an extended ACL to block network 192.168.3.0 host access to Web servers on the 10.0.0.0/24 network.

Step 1

Build and configure the network according to the diagram. Use RIP v1 and enable updates on all active interfaces with the appropriate **network** commands. The commands necessary to configure RIP v1 are as follows:

```
SanJose1(config)#router rip
SanJose1(config-router)#network 192.168.1.0
SanJose1(config-router)#network 10.0.0.0

Vista(config)#router rip
Vista(config-router)#network 192.168.1.0
Vista(config-router)#network 192.168.2.0
```

```
SanJose2(config)#router rip
SanJose2(config-router)#network 192.168.2.0
SanJose2(config-router)#network 10.0.0.0
```

Use the `ping` command to verify the work and test connectivity between all interfaces. Once you have verified connectivity, save your configurations for reuse in Labs 1.5.1 and 1.5.2.

Step 2

Check the routing table on Vista using the `show ip route` command. Vista should have all four networks in its table. Troubleshoot, if necessary.

Access Control List Basics

Access Control Lists (ACLs) are simple but powerful tools. When the access list is configured, each statement in the list is processed by the router in the order in which it was created. If an individual packet meets the criteria of a statement, the permit or deny is applied to that packet, and no further list entries are checked. The next packet to be checked starts again at the top of the list.

It is not possible to reorder statements, skip statements, edit statements, or delete statements from a numbered access list. With numbered access lists, any attempt to delete a single statement results in the deletion of the entire list. Named ACLs (NACLs) do allow for the deletion of individual statements.

The following concepts apply to both standard and extended access lists:

Two step process. First, the access list is created with one or more `access-list` commands while in global configuration mode. Second, the access list is applied to or referenced by other commands, such as the `access-group` command, to apply an ACL to an interface. An example would be the following:

```
Vista#config t
Vista(config)#access-list 50 deny 10.0.0.0 0.0.0.255
Vista(config)#access-list 50 permit any
Vista(config)#interface fastethernet 0/0
Vista(config-if)#ip access-group 50 out
Vista(config-if)#^Z
```

Syntax and Keywords

The basic syntax for creating an access list entry is as follows:

```
router(config)#access-list acl-number {permit | deny}...
```

The `permit` command allows packets matching the specified criteria to be accepted for whatever application the access list is being used. The `deny` command discards packets matching the criteria on that line.

Two important keywords that can be used with IP addresses and the `access list` command are `any` and `host`. The keyword `any` matches all hosts on all networks, equivalent to `0.0.0.0 255.255.255.255`. The keyword `host` can be used with an IP address to indicate a single host address. The syntax is `host ip-address`, such as `host 192.168.1.10`. This is treated exactly the same as `192.168.1.10 0.0.0.0`.

Implicit deny statement. Every access list contains a final 'deny' statement that matches all packets. This is called the implicit deny. Because the implicit deny statement is not visible in `show` command output, it is often overlooked, with serious consequences. As an example, consider the following single line access list:

```
Router(config)#access-list 75 deny host 192.168.1.10
```

Access-list 75 clearly denies all traffic sourced from the host, 192.168.1.10. What might not be obvious is that all other traffic will be discarded as well, because the **deny any** is the final statement in any access list.

At least one permit statement is required. There is no requirement that an ACL contain a **deny** statement. If nothing else, the **deny any** statement takes care of that. But if there are no **permit** statements, the effect will be the same as if there were only a single **deny any** statement.

Wildcard mask. In identifying IP addresses, ACLs use a wildcard mask instead of a subnet mask. Initially, they might look like the same thing, but closer observation reveals that they are very different. Remember that a binary 0 in a wildcard bitmask instructs the router to match the corresponding bit in the IP address.

In/out. When deciding whether an ACL should be applied to inbound or outbound traffic, always view things from the perspective of the router. Determine whether traffic is coming into the router, inbound, or leaving the router, outbound.

Applying ACLs. Extended ACLs should be applied as close to the source as possible, thereby conserving network resources. It is necessary for standard ACLs to be applied as close to the destination as possible, because the standard ACL can match only at the source address of a packet.

Step 3

On the Vista router, create the following standard ACL and apply it to the LAN interface:

```
Vista#config t
Vista(config)#access-list 50 deny 10.0.0.0 0.0.0.255
Vista(config)#access-list 50 permit any
Vista(config)#interface fastethernet 0/0
Vista(config-if)#ip access-group 50 out
Vista(config-if)#^Z
```

Try **pinging** 192.168.3.2 from SanJose1.

The ping should be successful. This result might be unexpected, because all traffic from the 10.0.0.0/8 network was blocked. The ping is successful because, even though it came from SanJose1, it is not sourced from the 10.0.0.0/8 network. A **ping** or **traceroute** from a router uses the closest interface to the destination as the source address. Therefore, the **ping** is coming from the 192.168.1.0/24, SanJose1's Serial 0/0.

In order to test the ACL from SanJose1, use the extended **ping** command to specify a specific source interface.

Step 4

On SanJose1, issue the following commands. Remember that the extended **ping** works only in privileged mode.

```
SanJose1#ping 192.168.3.2
Sending 5, 100-byte ICMP Echos to 192.168.3.2, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms
SanJose1#
SanJose1#ping
Protocol [ip]:
Target IP address: 192.168.3.2
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
```

```
Source address or interface: 10.0.0.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

Step 5

Standard ACLs are numbered 1-99. IOS Release 12.0 also allows standard lists to be numbered 1300–1699. Extended ACLs are numbered 100-199. IOS Release 12.0 allows lists to be numbered 2000-2699. Extended ACLs can be used to enforce highly specific criteria for filtering packets. In this step, configure an extended ACL to block access to a Web server.

Before proceeding, issue the `no access-list 50` and `no ip access-group 50` commands on the Vista router to remove the ACL configured previously.

Now, configure both SanJose1 and SanJose 2 to act as Web servers, by using the `ip http server` command, shown as follows:

```
SanJose1(config)#ip http server
SanJose2(config)#ip http server
```

From the workstation at 192.168.3.2, use a Web browser to view the Web servers on both routers at 10.0.0.1 and 10.0.0.2. The Web login requires that the enable secret password for the router be entered as the password.

After verifying the Web connectivity between the workstation and the routers, proceed to Step 6.

Step 6

On the Vista router, enter the following commands:

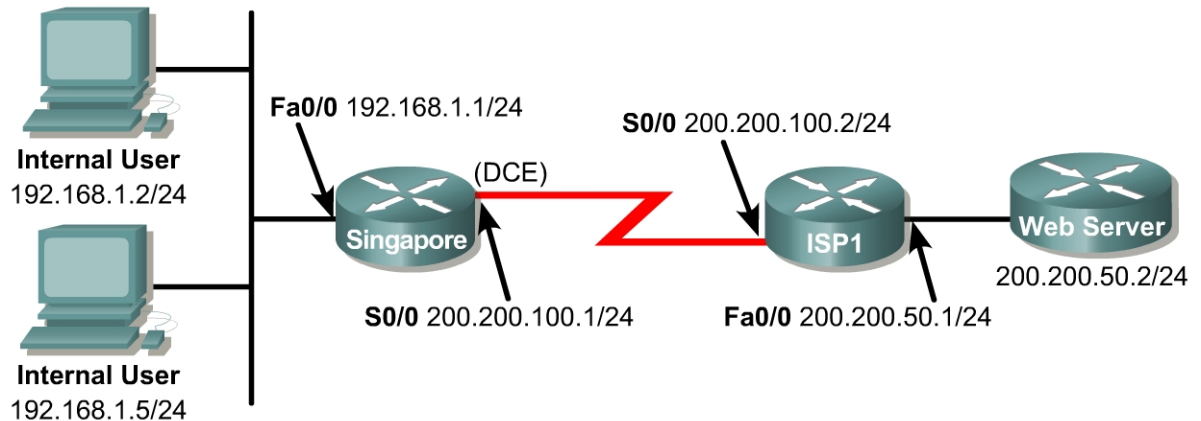
```
Vista(config)#access-list 101 deny tcp 192.168.3.0 0.0.0.255 10.0.0.0
0.0.0.255 eq www
Vista(config)#access-list 101 deny tcp 192.168.3.0 0.0.0.255 any eq ftp
Vista(config)#access-list 101 permit ip any any
Vista(config)#interface fastethernet 0/0
Vista(config-if)#ip access-group 101 in
```

From the workstation at 192.168.3.2, again attempt to view the Web servers at 10.0.0.1 and 10.0.0.2. Both attempts should fail.

Note: It may be necessary to click on the browser REFRESH button so that the screen display will not come from the browsers cache.

Next, browse SanJose1 at 192.168.1.2. Why is this not blocked?

Lab 1.4.4 Implementing Quality of Service with Priority Queuing



Objective

In this lab, the student will implement quality of service by replacing the default queuing method with priority queuing based upon protocol type.

Scenario

The International Travel Agency is planning to launch an informational web site on a local web server for the general public. You have been hired to configure the network so all Internet user traffic to the web server is given the highest priority. Other traffic such as Telnet and e-mail are to be allowed over the WAN link, but are not as important as traffic to the web server. Internet access to the web server is through the standard http port. You decide to use priority queuing.

Step 1

Build and configure the network according to the diagram. If a web server is not available, use a Cisco router with the configuration below to simulate a web server.

```
Router(config)#hostname WebServer
WebServer(config)#ip http server
WebServer(config)#ip route 0.0.0.0 0.0.0.0 200.200.50.1
WebServer(config)#interface fastethernet 0/0
WebServer(config-if)#ip address 200.200.50.2 255.255.255.0
WebServer(config-if)#no shutdown
```

A default route is configured since no routing protocol will be enabled. Use the `ping` command to test connectivity between the Singapore and ISP1 routers and between the workstations and their respective gateways.

Step 2

Since no routing protocol will be enabled, configure a default route to the Internet from the Singapore router and a static route from the ISP1 router to the WebServer network.

```
Singapore(config)#ip route 0.0.0.0 0.0.0.0 200.200.100.2
ISP1(config)#ip route 192.168.1.0 255.255.255.0 200.200.100.1
```

Now, check that the WebServer is accessible by connecting from an Internal User workstation with a browser using the WebServer IP address of 200.200.50.2.

Step 3

Determine which queuing mode is enabled on the Singapore router using the **show interface serial 0/0**. A sample output is shown below.

```
ISP1#show interface s0/0
Serial0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 200.200.100.2/24
  MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:05, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: weighted fair
  Output queue: 0/1000/64/0 (size/max total/threshold/drops)
    Conversations 0/1/32 (active/max active/max total)
    Reserved Conversations 0/0 (allocated/max allocated)
    Available Bandwidth 96 kilobits/sec
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    13041 packets input, 877578 bytes, 0 no buffer
    Received 11437 broadcasts, 0 runts, 0 giants, 0 throttles
    3 input errors, 0 CRC, 3 frame, 0 overrun, 0 ignored, 0 abort
    12200 packets output, 808601 bytes, 0 underruns
    0 output errors, 0 collisions, 10 interface resets
    0 output buffer failures, 0 output buffers swapped out
    9 carrier transitions
  DCD=up DSR=up DTR=up RTS=up CTS=up
```

Weighted Fair Queuing (WFQ) is the default queuing mode on interfaces that run at or below E1 speeds (2.048 Mbps or less) and First In, First Out (FIFO) is the default if the bandwidth is greater than E1 speeds.

1. What is the queuing mode on the Serial 0/0 interface of the Singapore router?

If the bandwidth of your serial interface is 128 K bit and the queuing mode is FIFO (contrary to the statement above) as shown below, it is probably because **no fair-queue** was automatically configured on the interface with the IOS version that is being used. You can use the **show running-config** command to check if fair queuing was disabled by default. (See the partial sample output below.)

```
ISP1#show interface s0/0
Serial0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 200.200.100.2/24
  MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:06, output 00:00:09, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
```

```
---output omitted---
```

```
ISP1#show running-config
```

```
---output omitted---
```

```
interface Serial0/0
 ip address 200.200.100.2 255.255.255.0
 no fair-queue
 clockrate 128000
```

```
---output omitted---
```

Step 4

Priority queuing allows traffic types to be associated with one of four priorities: high, medium, normal, and low. Priority queuing will transmit all packets in the high queue first. When the high queue is empty, then packets in the medium queue will be transmitted. When the medium queue is empty, the high queue is again checked for buffered packets. Because the higher priority queue is always checked before lower priority queued packets are sent, it is possible that lower priority packets will never get transmitted causing their sessions to time out.

You will configure priority queuing based on protocol type by designating http traffic as high priority with all other IP traffic as medium priority on both the ISP1 and Singapore routers. The first step is to define a priority list.

```
Singapore(config)#access-list 101 permit tcp any any eq 80
Singapore(config)#priority-list 1 protocol ip high list 101

Singapore(config)#access-list 102 permit ip any any
Singapore(config)#priority-list 1 protocol ip medium list 102

ISP1(config)#access-list 101 permit tcp any any eq 80
ISP1(config)#priority-list 1 protocol ip high list 101

ISP1(config)#access-list 102 permit ip any any
ISP1(config)#priority-list 1 protocol ip medium list 102
```

Step 5

You must now assign the priority list to the appropriate interface. Only one list can be assigned per interface.

```
Singapore(config)#interface serial 0/0
Singapore(config-if)#priority-group 1

ISP1(config)#interface serial 0/0
ISP1(config-if)#priority-group 1
```

Step 6

Verify the queuing mode with the **show interface serial 0/0** command on both the ISP1 and Singapore routers. The output should both show: Queuing strategy: priority-list 1.

There are other **show** commands that can be used to verify the queuing mode: **show queueing priority** and **show queueing interface serial 0/0**. Sample outputs for the commands on the Singapore router are shown below.

```
ISP1#show queueing priority
Current DLCI priority queue configuration:
Current priority queue configuration:

List   Queue  Args
1      high   protocol ip          list 101
1      medium protocol ip          list 102

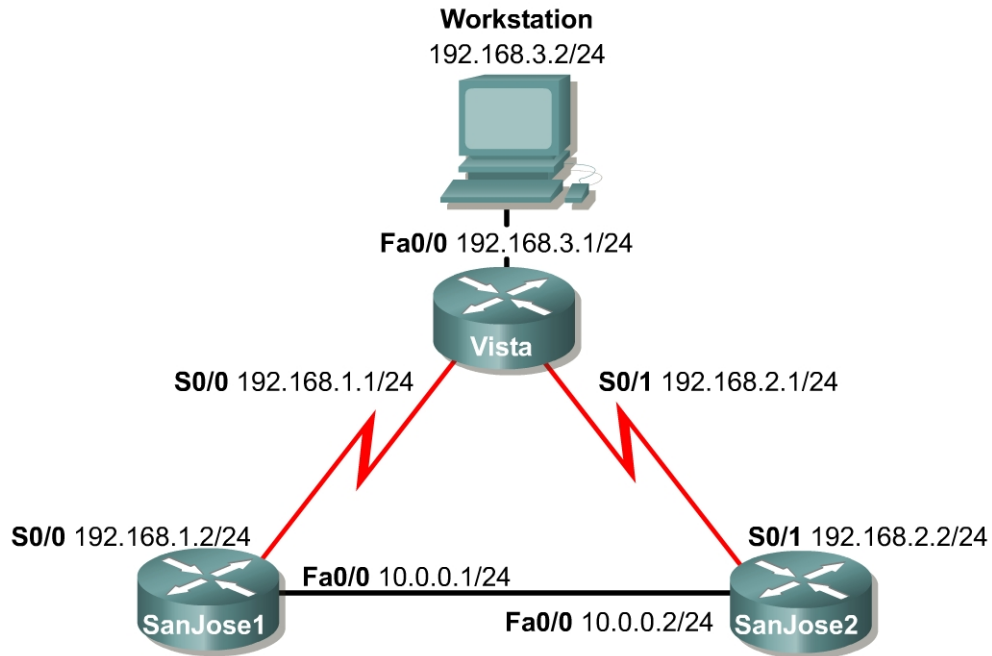
ISP1#show queueing interface s0/0
Interface Serial0/0 queuing strategy: priority

Output queue utilization (queue/count)
      high/25 medium/0 normal/12248 low/0
```

You have now successfully configured priority queuing based upon protocol type. All traffic destined for WebServer will now be given the highest priority over all other IP traffic. Unfortunately, it is very difficult to test priority queuing in a lab environment since it would be difficult to generate enough non-http traffic from one Internet User workstation to see the effects of priority queuing if the other Internet User is accessing the web server.

Save your configuration files for Singapore, ISP1, and WebServer.

Lab 1.5.1 Equal-Cost Load Balancing with RIP



Objective

In this lab, the student will observe equal-cost load balancing on a per packet and per destination basis by using advanced `debug` commands.

Scenario

Vista has two paths to network 10.0.0.0. Use advanced `debug` features to verify that both paths are being used to load balance traffic to 10.0.0.0 and to test both per packet and per destination load balancing.

Step 1

Build and configure the network according to the diagram. If continuing from the previous lab, remove any configured ACLs. Use RIP v1 and enable updates on all active interfaces with network commands similar to the following:

```
SanJose1(config)#router rip
SanJose1(config-router)#network 192.168.1.0
SanJose1(config-router)#network 10.0.0.0
```

Use the `ping` command to verify the work and test connectivity between all interfaces.

Step 2

Check the routing table on Vista using the `show ip route` command. Vista should have two routes to network 10.0.0.0 in its table. Troubleshoot, if necessary.

RIP automatically performs load balancing using equal-cost routes. Notice that both routes have a metric of 1. In this case, it is a hop count. RIP cannot perform unequal-cost load balancing. In the next lab it will be seen that IGRP can perform unequal-cost load balancing.

Step 3

To configure Vista to load balance on a per packet basis, both S0/0 and S0/1 must use process switching. Process switching forces the router to look in the routing table for the destination network of each routed packet. In contrast, fast switching performs a table lookup for the first packet only. The router then stores the result in a high speed cache and uses the cached information to forward all additional packets to the same destination. Fast switching is the default setting.

Enable process switching on both of Vista serial interfaces with the following interface configuration command:

```
Vista(config-if)#no ip route-cache
Verify that fast switching is disabled by using the show ip interface
command:
Vista#show ip interface s0/0
Serial0 is up, line protocol is up
  Internet address is 192.168.1.1 255.255.255.0
  Broadcast address is 255.255.255.255
  Address determined by non-volatile memory
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is enabled
  Outgoing access list is not set
  Inbound access list is not set
  Proxy ARP is enabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachable are always sent
  ICMP mask replies are never sent
  IP fast switching is disabled
<output omitted>
```

Step 4

Because there are two routes to the destination network in the table, half the packets will be sent along one path, and half will travel over the other. The path selection alternates with each packet received. Observe this process by using the `debug ip packet` command, which outputs information about IP packets sent and received by the router:

```
Vista#debug ip packet
```

With the `debug` running, send a few `ping` packets to 10.0.0.1 from the workstation at 192.168.3.2, and then return to Vista's console. As the `ping` packets are sent, the router outputs IP packet information. Stop the `debug` after a successful `ping` using the following command:

```
Vista#undebug all (the shortcut u all can be used here)
```

Note: The `debug` output will not be seen if accessing Vista via `telnet`. To display the `debug` results during a Telnet session, issue the `terminal monitor` command from privileged mode.

Examine the `debug` output. The `debug` output can be a little confusing. This is because the `ping` requests and replies are mixed together, as well as the routing updates. Look for a line of output that includes `d=10.0.0.1`, the destination address. On those lines, look for the interface that the packet was sent out on. The output interface should alternate between Serial0 and Serial1:

```
IP: s=192.168.3.2 (FastEthernet0/0), d=10.0.0.1 (Serial0/1), g=192.168.2.2, len 100, forward
IP: s=192.168.3.2 (FastEthernet0/0), d=10.0.0.1 (Serial0/0), g=192.168.1.2, len 100, forward
IP: s=192.168.3.2 (FastEthernet0/0), d=10.0.0.1 (Serial0/1), g=192.168.2.2, len 100, forward
IP: s=192.168.3.2 (FastEthernet0/0), d=10.0.0.1 (Serial0/0), g=192.168.1.2, len 100, forward
IP: s=192.168.3.2 (FastEthernet0/0), d=10.0.0.1 (Serial0/1), g=192.168.2.2, len 100, forward
```

Step 5

Configure `debug` to output strictly information of interest. To do this, configure an access control list (ACL) that `debug` will use to match packets against. Because the `ping` requests to the 10.0.0.0 network are the only packets of interest, create a list that filters everything else:

```
Vista(config)#access-list 101 permit icmp any 10.0.0.0 0.255.255.255
```

Apply the access list filter for the `debug` output with the following command:

```
Vista#debug ip packet 101
```

IP packet `debugging` is on for access list 101

Repeat the `ping` to 10.0.0.1 from the workstation, and return to Vista console to view the output.

Step 6

After verifying per packet load balancing, configure Vista to use per destination load balancing. Both of Vista's serial interfaces must be configured to use fast switching so that the route cache can be used after the initial table lookup:

```
Vista(config-if)#ip route-cache
```

With fast switching, the relevant information contained in the first packet of a flow is cached so that the CPU need not process subsequent packets in the flow. Use the `show ip interface` command to verify that fast switching is enabled.

Step 7

Because the routing table is consulted only once per destination, packets that are part of a train to a specific host all follow the same path. Only when a second destination forces another table lookup or when the cached entry expires, is the alternate path used.

Use the `debug ip packet 101` command, and `ping 10.0.0.1` from the workstation. Since fast switching is enabled, only one packet will be reflected in the output.

1. Which serial interface was the packet sent out on?

Now **ping** 10.0.0.2.

2. Which serial interface was the packet sent out on?

Although there will not be a reply, send **ping** packets to the phantom addresses 10.0.0.3 and 10.0.0.4 to see what path the router selects.

Finally, issue the **show ip cache** command to view the contents of the route cache. Notice that mappings exist for 10.0.0.1 and 10.0.0.2, as well as for any other IP addresses on the 10.0.0.0 network for which a **ping** was executed:

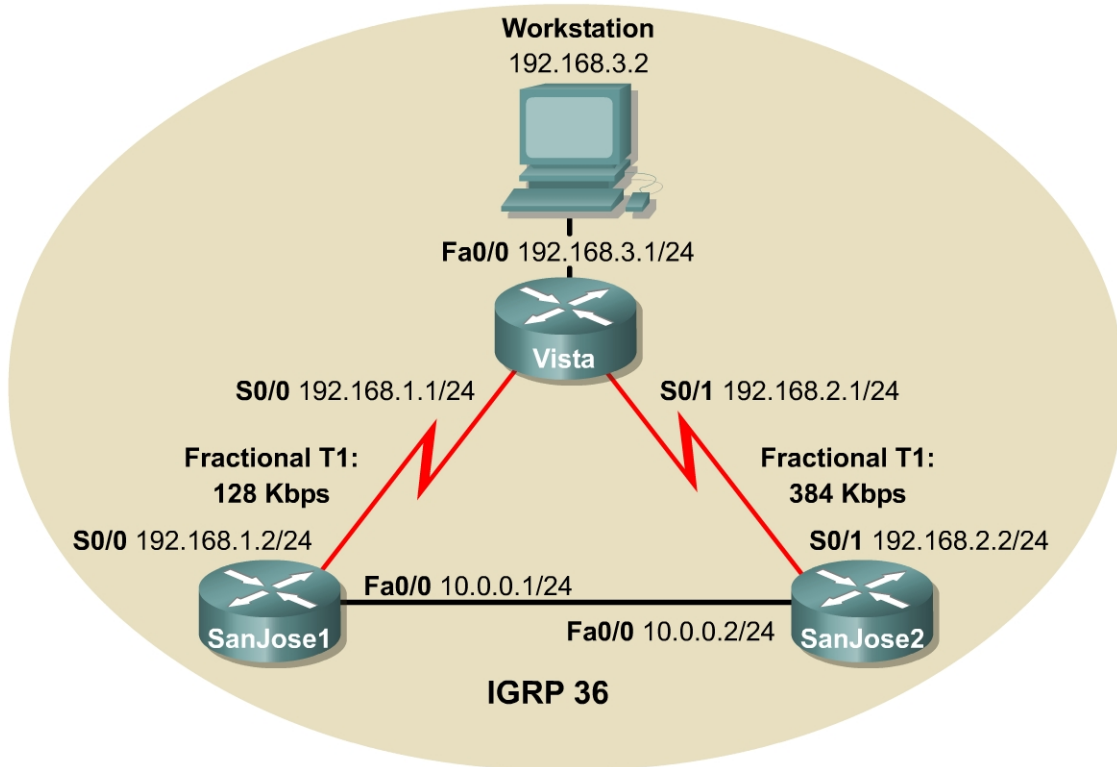
```
Vista#show ip cache
IP routing cache 5 entries, 848 bytes
  14 adds, 9 invalidates, 0 refcounts
Minimum invalidation interval 2 seconds, maximum interval 5 seconds,
  quiet interval 3 seconds, threshold 0 requests
Invalidation rate 0 in last second, 0 in last 3 seconds
Last full cache invalidation occurred 01:40:00 ago
```

Prefix/Length	Age	Interface	Next Hop
10.0.0.1/32	00:00:15	Serial0/0	192.168.1.2
10.0.0.2/32	00:03:19	Serial0/1	192.168.2.2
10.0.0.3/32	00:00:57	Serial0/0	192.168.1.2
10.0.0.4/32	00:00:43	Serial0/1	192.168.2.2
192.168.3.2/32	00:03:37	FastEthernet0/0	192.168.3.2

3. Briefly explain the meaning of this output.

Note: Save the configuration. It can be used with the next lab.

Lab 1.5.2 Unequal-Cost Load Balancing with IGRP



Objective

In this lab, the student will observe unequal-cost load balancing on an IGRP network by using advanced **debug** commands.

Scenario

Vista has two paths to network 10.0.0.0, but they have unequal IGRP metrics. Configure unequal-cost load balancing and use advanced **debug** features to verify the work.

Step 1

Build and configure the network according to the diagram. If continuing from the previous lab, remove the RIP process (and networks advertised by RIP) with the single command **no router rip**. Configure IGRP with an autonomous system number of 36, and enable updates on all active interfaces with **network** commands similar to the following:

```
SanJose2 (config)#router igrp 36
SanJose2 (config-router)#network 192.168.2.0
SanJose2 (config-router)#network 10.0.0.0
```

Use **ping** to verify the configuration and test connectivity between all interfaces.

Also, because the metric for IGRP includes bandwidth in its calculation, manually configure the bandwidth of serial interfaces in order to ensure accuracy. For the purposes of this lab, Vista alternative paths to network 10.0.0.0 are not of unequal-cost until the appropriate bandwidths are set. Use the following commands to further configure Vista for the correct bandwidth and process switching:

```
Vista(config)#interface s0/0
Vista(config-if)#bandwidth 128
Vista(config-if)#no ip route-cache
Vista(config-if)#interface s0/1
Vista(config-if)#bandwidth 384
Vista(config-if)#no ip route-cache
```

Use the **show interface** command output to verify the correct bandwidth settings and the **show ip interface** command to ensure that fast switching is disabled.

1. Can you set the bandwidth of Ethernet interfaces manually?
-

Note: The **bandwidth** command can be entered in interface configuration mode, but it only effects metric computations; in this case, it only affects routing protocols that use bandwidth in their metric computations.

2. Can an Ethernet interface be placed in fast switching mode?
-

Step 2

Check the routing table on Vista by using the **show ip route** command. Vista should have only one route to network 10.0.0.0 in its table. Troubleshoot if necessary.

Step 3

The variance value determines whether IGRP will accept unequal-cost routes. An IGRP router will only accept routes equal to the local best metric for the destination multiplied by the variance value. So, if a router using IGRP has a local best metric for Network A is 10476, and the variance is three, the router will accept unequal-cost routes with any metric up to 31428 or $10,476 \times 3$. This is as long as the advertising router is closer to the destination. An IGRP router accepts only up to four paths to the same network.

Note: An alternate route is added to the route table only if the next hop router in that path is closer to the destination by having a lower metric value than the current route.

By default, the variance of IGRP is set to one (1), which means that only routes that are exactly one (1) times the local best metric are installed. Therefore, a variance of one (1) disables unequal-cost load balancing.

Configure Vista to enable unequal-cost load balancing using the following commands:

```
Vista(config)#router igrp 36
Vista(config-router)#variance 10
```

1. According to the help feature, what is the maximum variance multiplier value?
-

Step 4

Check Vista routing table again. Vista should have two routes to network 10.0.0.0 with unequal metrics.

1. What is the IGRP metric for the route to 10.0.0.0 via SanJose1?

2. What is the IGRP metric for the route to 10.0.0.0 via SanJose2?

Step 5

Now test unequal-cost load balancing by sending a `ping` packet to network 10.0.0.0 from Vista while debugging. Remove any existing access lists on Vista. First, configure an access list to restrict `debug` output to the `ping` requests from Vista to network 10.0.0.0:

```
Vista(config)#access-list 101 permit icmp any 10.0.0.0 0.255.255.255
```

Then, enable `debug` using the access list to filter output:

```
Vista#debug ip packet 101
```

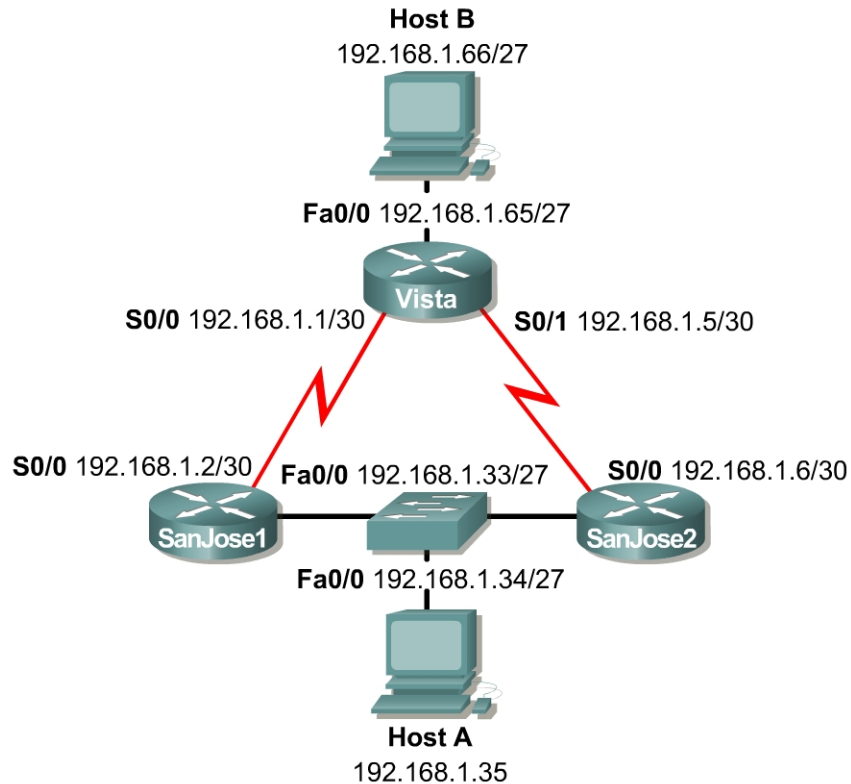
Finally, execute the command `ping -t 10.0.0.1`. This continuous ping can be stopped by typing **Ctrl-C**.

1. Are the packets load balanced per destination or per packet?

2. How is unequal-cost load balancing different from equal-cost load balancing?

Note: If using a named ACL, any line can be selectively deleted from the access list. In a numbered ACL, lines cannot be selectively deleted, but lines can be added to the end of the list. In a named ACL, lines can be added after the list has already been created, but their appearance in the list cannot be controlled (interestingly, they are not always appended to the end). Therefore, with either a named or numbered ACL, making changes that require adding lines to middle of a list should only be done by deleting the entire ACL and reconstructing it. Cisco recommends using a TFTP server (or a cut-and-paste) so that edited ACLs can be implemented with ease. In this case, the first line of the edited ACL should begin with a line that explicitly deletes the existing ACL (if applicable). Otherwise, the downloaded ACL is appended to the existing ACL.

Lab 2.10.1 Configuring VLSM and IP Unnumbered



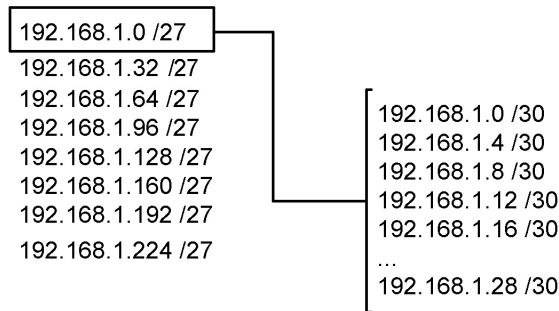
Objective

In this lab, the student will configure VLSM and test its functionality with two different routing protocols, RIP v1 and RIP v2. Finally, the student will use IP unnumbered in place of VLSM to further conserve addresses.

Scenario

When International Travel Agency was much smaller, it wanted to configure its network using a single Class C address, 192.168.1.0, as shown in the following table. The routers need to be configured with the appropriate addresses. The company requires that at least 25 host addresses be available on each LAN, but it also demands that the maximum number of addresses be conserved for future growth.

To support 25 hosts on each subnet, a minimum of five (5) bits is needed in the host portion of the address. Five (5) bits will yield 30 possible host addresses ($2^5 = 32 - 2$). If five (5) bits must be used for hosts, the other three (3) bits in the last octet can be added to the default 24-bit Class C mask. Therefore, a 27-bit mask can be used to create the following subnets:



To maximize this address space, the 192.168.1.0 /27 subnet is subnetted further using a 30-bit mask. This creates subnets that can be used on point-to-point links with minimal waste, because each subnet can contain only two possible host addresses.

Step 1

Build and configure the network according to the diagram. This configuration requires the use of subnet 0, so the `ip subnet-zero` command may be required. This will depend on which IOS version is being used.

Note: Host A and Host B are not required to complete this lab.

On all three routers, configure RIP v1 and enable updates on all active interfaces with this network command:

```
SanJose1(config)#router rip
SanJose1(config-router)#network 192.168.1.0
```

Use `ping` to verify that each router can `ping` its directly connected neighbor.

Note: Some remote networks might be unreachable. Proceed to Step 2 anyway.

Step 2

Issue the `show ip route` command on Vista, as shown in the following example:

```
Vista#show ip route
<output omitted>
Gateway of last resort is not set
      192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.1.64/27 is directly connected, Ethernet0
C       192.168.1.0/30 is directly connected, Serial0
C       192.168.1.4/30 is directly connected, Serial1
```

The 192.168.1.32 /27 subnet is clearly absent from the routing table of Vista.

1. The other routers also have incomplete tables. Why is this so?

Because RIP v1 with VLSM is being used, routing has broken down on the network. Remember that VLSM is not supported by classful routing protocols such as RIP v1 and IGRP. These protocols do not send subnet masks in their routing updates. In order for routing to work, RIP v2 must be configured, which does support VLSM.

Step 3

At each of three router consoles, enable RIP v2 updates and turn off automatic route summarization, as shown in the following example:

```
SanJose1(config)#router rip
SanJose1(config)#network 192.168.1.0           (in case RIP was removed)
SanJose1(config-router)#version 2
SanJose1(config-router)#no auto-summary
```

Configuring **no auto-summary** disables the automatic summarization of subnet routes into network-level routes. This allows subnet information to be sent across classful network boundaries. Note that RIP v1 does not support this feature because it requires VLSM support.

When all three routers are running RIP v2, return to Vista and examine its routing table. It should now be complete, shown as follows:

```
Vista#show ip route
<output omitted>
Gateway of last resort is not set

    192.168.1.0/24 is variably subnetted, 4 subnets, 2 masks
C       192.168.1.64/27 is directly connected, Ethernet0
R       192.168.1.32/27 [120/1] via 192.168.1.6, 00:00:12, Serial1
        [120/1] via 192.168.1.2, 00:00:13, Serial0
C       192.168.1.0/30 is directly connected, Serial0
C       192.168.1.4/30 is directly connected, Serial1
```

Notice that Vista has received equal cost routes to 192.168.1.32 /27 from both SanJose1 and SanJose2.

Step 4

Although VLSM has reduced address waste by creating very small subnets for point-to-point links, the IP unnumbered feature can make it unnecessary to address these links altogether. Further maximize address use by configuring IP unnumbered on every serial interface in the WAN. To configure IP unnumbered, use the following commands:

```
SanJose1(config)#interface serial 0/0
SanJose1(config-if)#ip unnumbered fastethernet 0/0

Vista(config)#interface serial 0/0
Vista(config-if)#ip unnumbered fastethernet 0/0
Vista(config-if)#interface serial 0/1
Vista(config-if)#ip unnumbered fastethernet 0/0

SanJose2(config)#interface serial 0/0
SanJose2(config-if)#ip unnumbered fastethernet 0/0
```

After the IP unnumbered configuration is complete, each serial interface borrows the address of the local LAN interface. Check the routing table on the Vista router again:

```
Vista#show ip route
```

```
<output omitted>
```

```
Gateway of last resort is not set
```

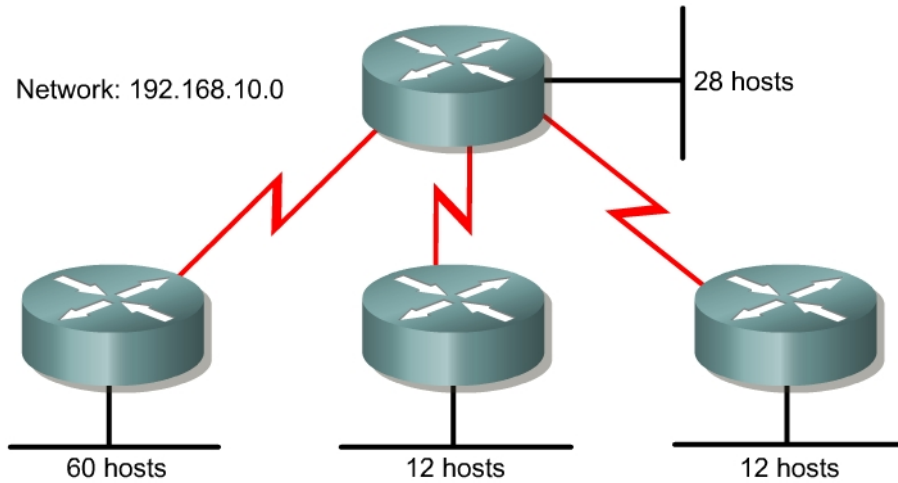
```
192.168.1.0/27 is subnetted, 2 subnets
```

```
C      192.168.1.64 is directly connected, Ethernet0
```

```
R      192.168.1.32 [120/1] via 192.168.1.34, 00:00:00, Serial1  
                    [120/1] via 192.168.1.33, 00:00:08, Serial0
```

If IP unnumbered were configured on the point-to-point serial links, only the LANs would require addresses in this topology. Because each LAN uses the same 27-bit mask, VLSM would not be required in this case. This would make classful routing protocols, such as RIP v1 and IGRP, viable options.

Lab 2.10.2a VLSM 1



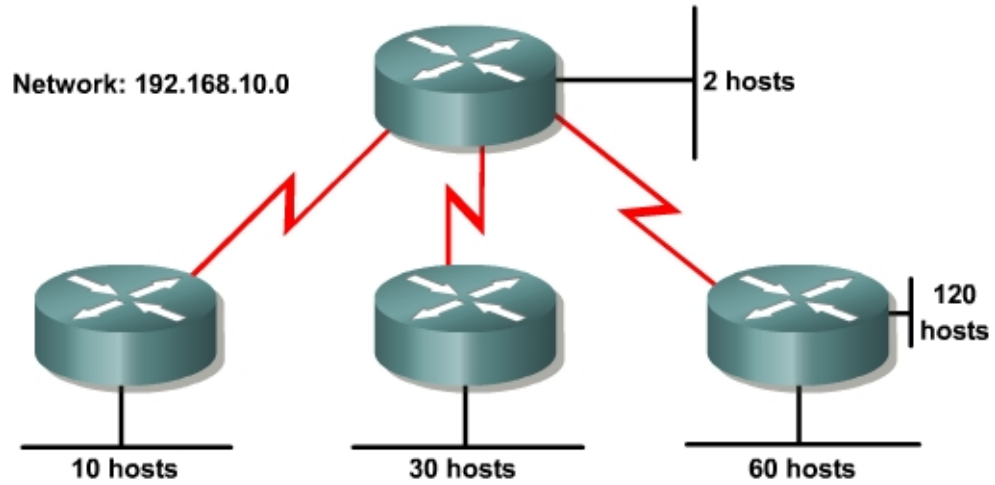
Objective

Create an addressing scheme using variable length subnet masking (VLSM).

Scenario

The assignment is the Class C address 192.168.10.0 and it must support the network shown in the diagram. The use of IP unnumbered or NAT is not permitted on this network. Create an addressing scheme that meets the requirements shown in the diagram.

Lab 2.10.2b VLSM 2



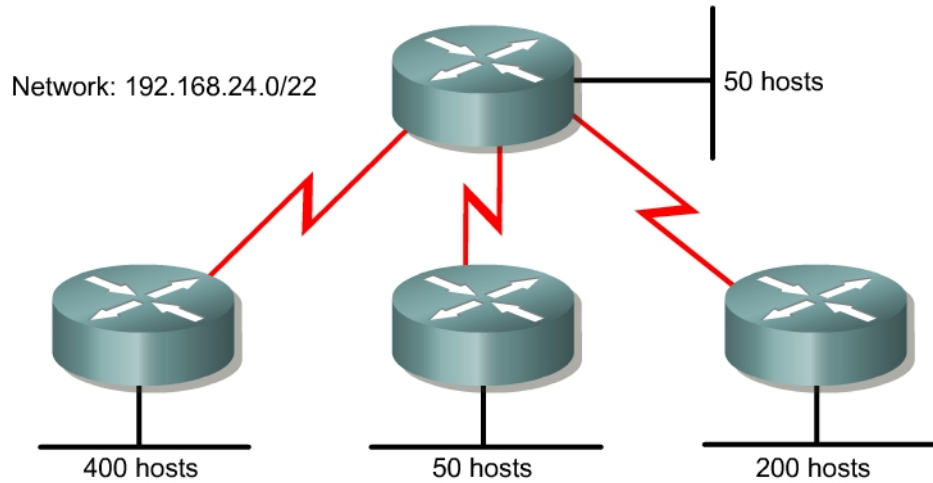
Objective

Create an addressing scheme using subnetting and/or variable length subnet masking (VLSM).

Scenario

The assignment is the Class C address 192.168.10.0 and it must support the network shown in the diagram. The use of IP unnumbered, NAT, or /31 subnets (available on point-to-point networks with IOS Release 12.2) are not permitted on this network. Create an addressing scheme that meets the requirements shown in the diagram. First, attempt an IP addressing scheme using traditional subnetting. If that proves to be impossible, use VLSM.

Lab 2.10.2c VLSM 3



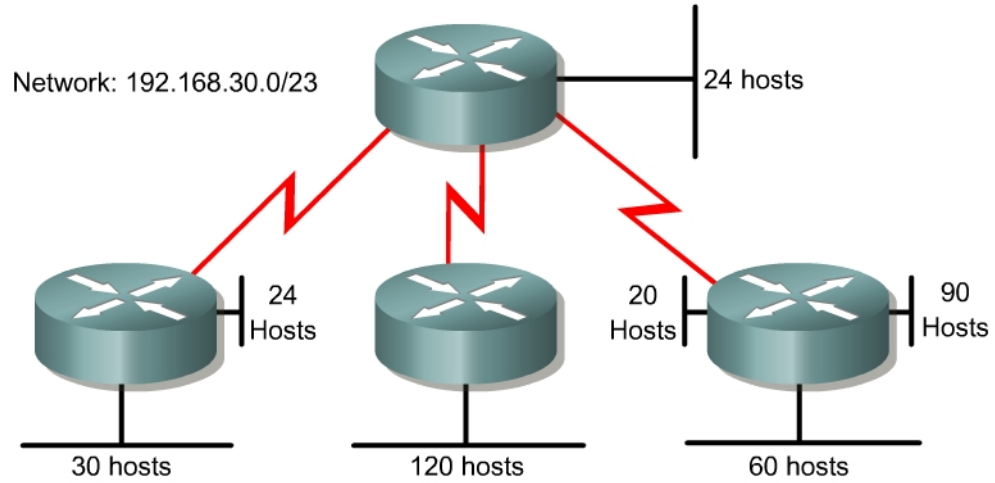
Objective

Create an addressing scheme using VLSM.

Scenario

The assignment is the CIDR address 192.168.24.0/22, and it must support the network shown in the diagram. The use of IP unnumbered or NAT is not permitted on this network. Create an addressing scheme that meets the requirements shown in the diagram.

Lab 2.10.2d VLSM 4



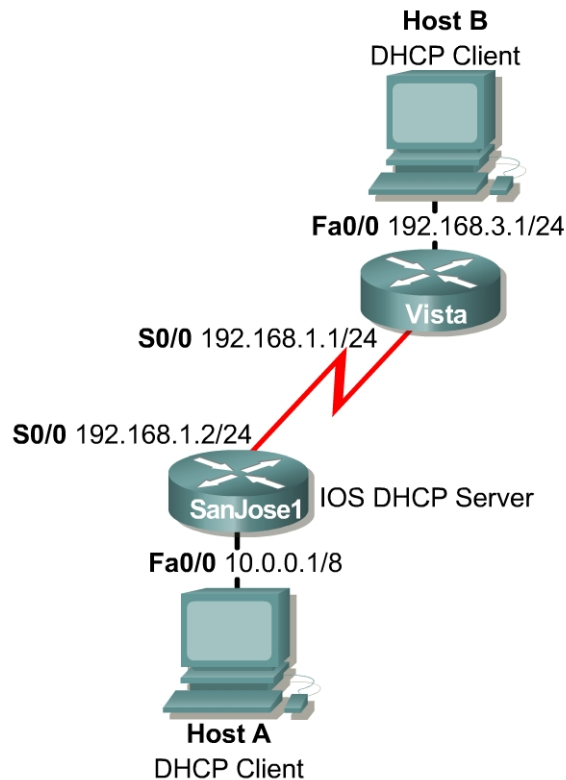
Objective

Create an addressing scheme using VLSM.

Scenario

The assignment is the CIDR address 192.168.30.0/23, and it must support the network shown in the diagram. The use of IP unnumbered or NAT is not permitted on this network. Create an addressing scheme that meets the requirements shown in the diagram.

Lab 2.10.3 Using DHCP and IP Helper Addresses



Objective

In this lab, configure a Cisco router to act as a DHCP server for clients on two separate subnets. The IP helper address feature will also be used to forward DHCP requests from a remote subnet.

Scenario

Clients on the 192.168.3.0/24 network and the 10.0.0.0/8 network require the services of DHCP for automatic IP configuration. Configure SanJose1 to serve both subnets by creating two separate address pools. Finally, configure the FastEthernet interface of the Vista router to forward UDP broadcasts, including DHCP requests, to SanJose1.

Step 1

Build and configure the network according to the diagram. Connect Host A and Host B as shown, but configure these clients to obtain their IP addresses automatically. Because these hosts rely on DHCP, they cannot be tested using `ping` until Step 5.

Configure RIP v2 on SanJose1 and Vista. Be sure to enable updates on all active interfaces with the `network` command:


```
SanJose1(config)#router rip
SanJose1(config)#version 2
SanJose1(config-router)#network 192.168.1.0
SanJose1(config-router)#network 10.0.0.0
```

```
Vista(config)#router rip
Vista(config-router)#version 2
Vista(config-router)#network 192.168.1.0
Vista(config-router)#network 192.168.3.0
```

Use **ping** and **show ip route** to verify the work and test connectivity between SanJose1 and Vista.

Step 2

Configure SanJose1 to act as a DHCP server for clients on the 10.0.0.0/8 network.

First, verify that SanJose1 can use DHCP services and that it is enabled:

```
SanJose1(config)#service dhcp
```

Next, configure the DHCP address pool for the 10.0.0.0 network. Name the pool **10-net**:

```
SanJose1(config)#ip dhcp pool 10-net
SanJose1(dhcp-config)#network 10.0.0.0 255.0.0.0
```

Step 3

International Travel Agency uses the first ten addresses in this address range to statically address servers and routers. From global configuration mode, exclude addresses from the DHCP pool so that the server does not attempt to assign them to clients. Configure SanJose1 to dynamically assign addresses from the 10-net pool, starting with 10.0.0.11:

```
SanJose1(config)#ip dhcp excluded-address 10.0.0.1 10.0.0.10
```

Step 4

Return to DHCP configuration mode and assign the IP options of the default gateway address, DNS server address, WINS server address, and domain name:

```
SanJose1(dhcp-config)#default-router 10.0.0.1
SanJose1(dhcp-config)#dns-server 10.0.0.3
SanJose1(dhcp-config)#netbios-name-server 10.0.0.4
SanJose1(dhcp-config)#domain-name xyz.net
```

Step 5

The DHCP server is now ready to be tested. Release and renew the IP configuration for Host A.

Host A should be dynamically assigned the first available address in the pool, which is 10.0.0.11. Check the configuration of Host A with **wiipcfg** to verify that it received the proper IP address, subnet mask, default gateway, DNS server address, and WINS server address. Check the configuration of Host A with **ipconfig /all** for Windows NT and Windows 2000 users. Troubleshoot, if necessary.

Step 6

Because Host B also requires dynamic IP configuration, create a second DHCP pool with address and gateway options appropriate to its network, 192.168.3.0/24:

```
SanJose1(config)#ip dhcp pool 192.168.3-net
SanJose1(dhcp-config)#network 192.168.3.0 255.255.255.0
SanJose1(dhcp-config)#default-router 192.168.3.1
SanJose1(dhcp-config)#dns-server 10.0.0.3
```

```
SanJose1(dhcp-config)#netbios-name-server 10.0.0.4
SanJose1(dhcp-config)#domain-name xyz.net
```

ITA has recently installed IP phones on the 192.168.3.0 network. These phones require a DHCP server to provide a TFTP server address, 10.0.0.5. The Cisco IOS DHCP server configuration does not provide a keyword for TFTP servers, so configure this option using its raw option number:

```
SanJose1(dhcp-config)#option 150 ip 10.0.0.5
```

Note: When a Cisco IP phone is turned on, it automatically queries for a DHCP server. Then the DHCP server responds by assigning an IP address to the Cisco IP phone. The IP address of the TFTP server is provided through DHCP option 150.

Step 7

The configuration of the DHCP server is now complete. However, Host B uses a UDP broadcast to find an IP address, and Vista is not configured to forward broadcasts. In order for DHCP to work, configure the FastEthernet interface of the Vista router to forward UDP broadcasts to SanJose1:

```
Vista(config)#interface fastethernet 0/0
Vista(config-if)#ip helper-address 192.168.1.2
```

Step 8

Release and renew the IP configuration of Host B while simultaneously logged into the console of SanJose1. Use a second host, if necessary.

Verify, using `winipcfg` or `ipconfig /all`, that Host B received the correct IP configuration, and troubleshoot if necessary.

1. An `ip dhcp excluded-address` command was not issued. The DHCP server did not assign Host B 192.168.3.1. Why not?

Issue `show ip dhcp ?` and note the choices.

```
SanJose1#show ip dhcp ?
binding    DHCP address bindings
conflict   DHCP address conflicts
database   DHCP database agents
import     Show Imported Parameters
relay      Miscellaneous DHCP relay information
server     Miscellaneous DHCP server information
```

Try the **conflict** and **binding** options.

```
SanJose1#show ip dhcp binding
IP address      Client-ID/      Lease expiration  Type
                Hardware address
10.0.0.11       0063.6973.636f.2d30.  Mar 02 1993 02:28 AM  Automatic
                3030.342e.3961.6432.
                2e64.3063.302d.4661.
                302f.30
192.168.3.2     0063.6973.636f.2d30.  Mar 02 1993 03:11 AM  Automatic
                3030.392e.3433.3566.
                2e39.6362.312d.4661.
                302f.30
```

```
SanJose1#show ip dhcp conflict
IP address      Detection method  Detection time
192.168.3.1     Ping              Mar 01 1993 03:11 AM
```

2. How did SanJose1 know to assign Host B an address from the 3-net pool and not the 10-net pool?

Issue the **show ip dhcp server statistics** command. Sample output follows:

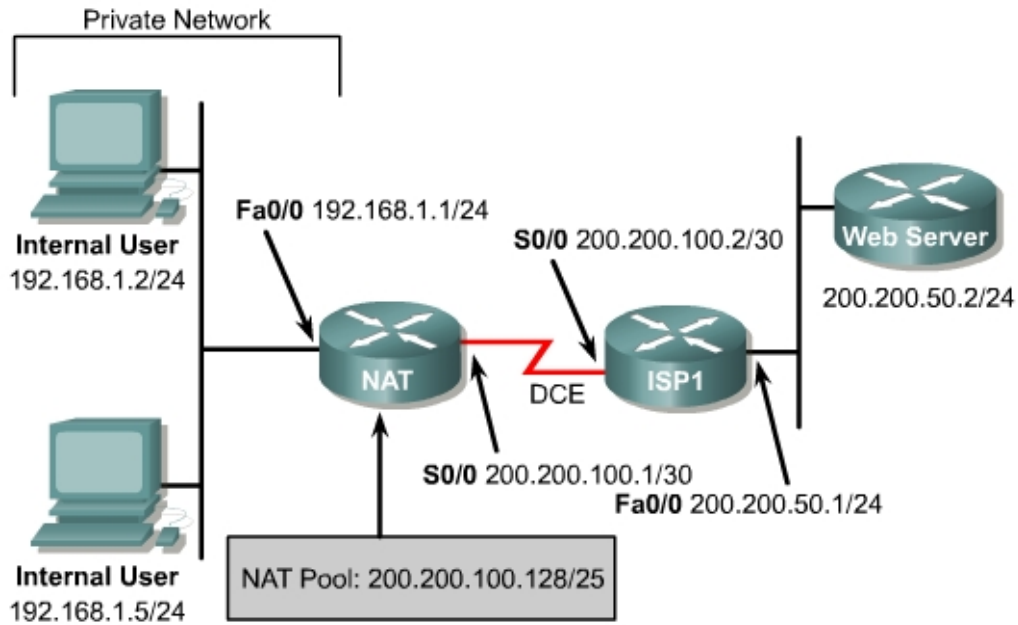
```
SanJose1#show ip dhcp server statistics
Memory usage      15650
Address pools     2
Database agents   0
Automatic bindings 2
Manual bindings   0
Expired bindings  0
Malformed messages 0

Message           Received
BOOTREQUEST       0
DHCPDISCOVER      31
DHCPREQUEST       3
DHCPDECLINE       0
DHCPRELEASE       3
DHCPIFORM         0

Message           Sent
BOOTREPLY         0
DHCPOFFER         4
DHCPACK           3
DHCNPAK           0
```

3. How many DHCPOFFER messages were sent on your network?

Lab 2.10.4a Network Address Translation – Static NAT and Dynamic NAT



Objective

In this lab, static Network Address Translation (NAT) and dynamic NAT are configured.

Scenario

The International Travel Agency needs approximately 100 private IP addresses translated in a one-to-one fashion with a pool of public IP addresses. To do this, ITA will use NAT translation with a portion of its class C address space allocated by ISP1.

Step 1

Build and configure the network according to the diagram.

Use **ping** to test connectivity between the NAT and ISP1 routers, between the workstations and the default gateway, and between WebServer and ISP1.

Step 2

Since no routing protocol will be enabled, configure a default route to the Internet on the NAT router:

```
NAT(config)#ip route 0.0.0.0 0.0.0.0 200.200.100.2
```

ISP1 needs to be able to reach hosts on the 192.168.1.0/24 network. But these hosts will have their IP addresses translated to public IP addresses in the 200.200.100.128/25 network, so a static route to the 200.200.100.128/25 network is required:

```
ISP1(config)#ip route 200.200.100.128 255.255.255.128 200.200.100.1
```

Step 3

Create a standard Access Control List that defines all Internal Users:

```
NAT(config)#access-list 1 permit 192.168.1.0 0.0.0.255
```

Step 4

In this step, configure private and public address spaces to be used for NAT and configure the translation:

The public address space 200.200.100.128/25 will be used as a pool to provide NAT translation for the private IP addresses. To statically map the Internal User with IP address 192.168.1.2 pictured in the diagram, enter the following command

```
NAT(config)#ip nat inside source static 192.168.1.2 200.200.100.252
```

This static mapping has the advantage of allowing “external” users to always access the host 192.168.1.2 by way of the fixed IP address 200.200.100.252 (in addition to letting the 192.168.1.2 Internal User access the Internet). On the down side, this external accessibility is also viewed as a security vulnerability. To allow the other hosts on the internal (private) network to reach the Internet, translations will need to be made for those hosts as well. A list of static translations could be made one by one, but a simpler alternative is to configure a pool of addresses and let the router make one-to-one dynamic NAT translations for these hosts. For example, to map the non-statically mapped hosts in the 192.168.1.0/24 network to public IP addresses in the range 200.200.100.129 to 200.200.100.250, proceed as follows:

```
NAT(config)#ip nat pool public 200.200.100.129 200.200.100.250 netmask  
255.255.255.128  
NAT(config)#ip nat inside source list 1 pool public
```

This provides a dynamic one-to-one NAT translation between public IP addresses in the “public” pool and private IP addresses specified by access list 1. The Internal Users IP addresses are configured independently of the NAT translation. Dynamic NAT translations are made for any internal hosts for which no static translation has been defined. The configuration above reserves IP addresses 200.200.100.251 to 200.200.100.254 for use in further static NAT mappings. Static translations are often used with an internal server to enable external access to it by way of a fixed external IP.

Note: If there are more than 128 active hosts on the private network, static NAT translation and/or dynamic one-to-one NAT translations will prevent more than 128 hosts from accessing the Internet. For these additional hosts to get on the Internet, “NAT overloading” must be configured (see Lab 2.10.4b).

Step 5

Now, designate the inside NAT interface and the outside NAT interface. In more complex topologies, it is possible to have more than one inside NAT interface.

```
NAT(config)#interface fastethernet 0/0  
NAT(config-if)#ip nat inside  
NAT(config-if)#interface serial 0/0  
NAT(config-if)#ip nat outside
```

There are several **show** commands that can be used to see if NAT is working: **show ip nat translations**, **show ip nat statistics**, and **show ip nat translations verbose**.

From the two Internal User workstations, ping WebServer (200.200.50.2). Then check that WebServer is accessible by connecting from an Internal User workstation using a browser with the WebServer IP address, 200.200.50.2. Issue the three NAT show commands listed above on the NAT router. Sample outputs are shown below.

```
NAT#show ip nat translations
Pro Inside global      Inside local      Outside local      Outside global
--- 200.200.100.129    192.168.1.5      ---                ---
--- 200.200.100.252    192.168.1.2      ---                ---
```

```
NAT#show ip nat statistics
Total active translations: 2 (1 static, 1 dynamic; 0 extended)
Outside interfaces:
  Serial0/0
Inside interfaces:
  FastEthernet0/0
Hits: 131 Misses: 9
Expired translations: 0
Dynamic mappings:
-- Inside Source
[Id: 2] access-list 1 pool public refcount 1
  pool public: netmask 255.255.255.128
    start 200.200.100.129 end 200.200.100.250
    type generic, total addresses 122, allocated 1 (0%), misses 0
```

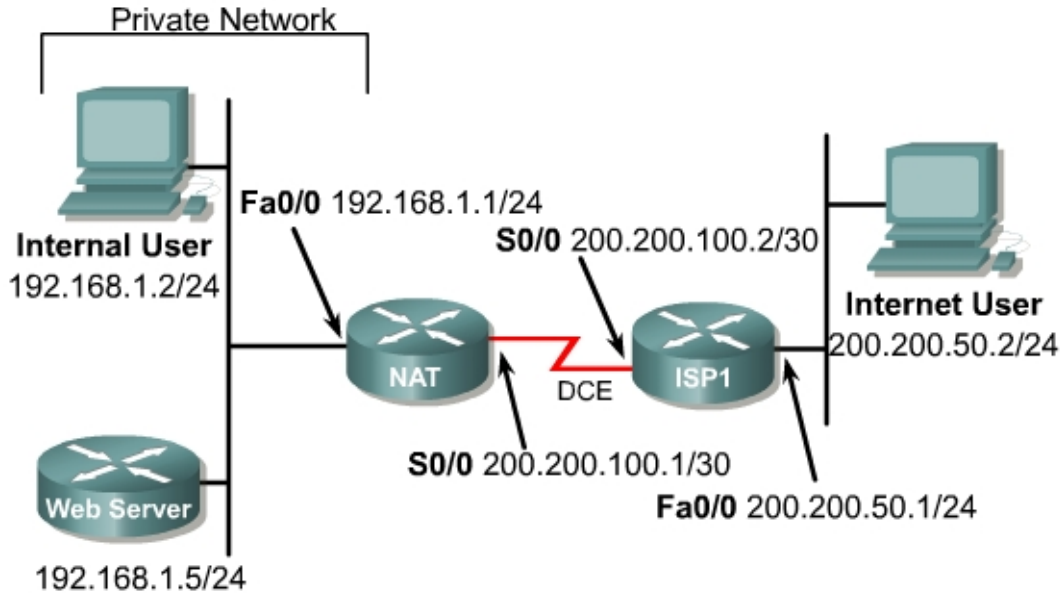
```
NAT#show ip nat translations verbose
Pro Inside global      Inside local      Outside local      Outside global
--- 200.200.100.129    192.168.1.5      ---                ---
    create 00:02:55, use 00:02:55, left 23:57:04, Map-Id(In): 2,
    flags:
none, use count: 0
--- 200.200.100.252    192.168.1.2      ---                ---
    create 00:40:36, use 00:02:59,
    flags:
static, use_count: 0
```

Notice that the Internal User with IP address 192.168.1.5 had its address dynamically translated to 200.200.100.129, the first available address in the “public” pool. The command **clear ip nat translation *** can be used to clear all dynamic NAT translations:

```
NAT#clear ip nat translation *
NAT#show ip nat translations
Pro Inside global      Inside local      Outside local      Outside global
--- 200.200.100.252    192.168.1.2      ---                ---
```

Save the configurations for NAT and ISP1.

Lab 2.10.4b Network Address Translation – Port Address Translation and Port Forwarding



Objective

In this lab, Port Address Translation (PAT) and port forwarding are configured.

Scenario

The International Travel Agency is planning to launch an informational Web site on a local Web server for the general public. However, the one Class C address that has been allocated will not be sufficient for the users and devices the company has on this network. Therefore, a network is configured that will allow all internal company users access to the Internet and all Internet users access to the company's informational Web server through static NAT and PAT. Internal user addresses must be translated to one legal global address and all Internet Users must access the informational Web server through the one legal global address as well.

Step 1

Build and configure the network according to the diagram. If you are using the configuration files from the previous lab, remove the NAT pool (public) and the static and dynamic NAT configurations. Use a Cisco router as WebServer if another Web server is not available.

Use **ping** to test connectivity between the NAT and ISP1 routers, between the Internal User and the NAT router, and between the Internet User and ISP1.

Also check that WebServer server is accessible by connecting to it from the Internal User workstation with a browser using the WebServer IP address, 192.168.1.5.

Step 2

Since no routing protocol will be enabled, configure a default route to the Internet from the NAT router.

```
NAT(config)#ip route 0.0.0.0 0.0.0.0 200.200.100.2
```

Step 3

Create a standard Access Control List that would enable all Internal Users access to the Internet.

```
NAT(config)#access-list 1 permit 192.168.1.0 0.0.0.255
```

Step 4

Because a single inside global address, 200.200.100.1, will be used to represent multiple inside local addresses, 192.168.1.x, simultaneously, apply the access list and configure NAT overload on the serial 0/0 interface of the NAT router. In general, NAT can be used to overload a pool of public addresses, when a single external address is overloaded. This is referred to as port address translation (PAT).

```
NAT(config)#ip nat inside source list 1 interface s0/0 overload
```

This configuration allows Internal Users to access the Internet, but blocks external users from accessing internal hosts.

Step 5

Now specify the inside and outside NAT interfaces.

```
NAT(config)#interface fastethernet 0/0
NAT(config-if)#ip nat inside
```

```
NAT(config-if)#interface serial 0/0
NAT(config-if)#ip nat outside
```

Enter the command `ping 200.200.50.2` from the Internal User workstation. Then, on the NAT router, enter the commands `show ip nat translations`, `show ip nat statistics`, and `show ip nat translations verbose`. Sample output follows.

```
NAT#show ip nat translations
Pro Inside global      Inside local      Outside local      Outside global
icmp 200.200.100.1:516 192.168.1.5:516  200.200.50.2:516  200.200.50.2:516
icmp 200.200.100.1:517 192.168.1.5:517  200.200.50.2:517  200.200.50.2:517
icmp 200.200.100.1:518 192.168.1.5:518  200.200.50.2:518  200.200.50.2:518
icmp 200.200.100.1:519 192.168.1.5:519  200.200.50.2:519  200.200.50.2:519
icmp 200.200.100.1:520 192.168.1.5:520  200.200.50.2:520  200.200.50.2:520
```

```
NAT#show ip nat statistics
Total active translations: 5 (0 static, 5 dynamic; 5 extended)
Outside interfaces:
  Serial0/0
Inside interfaces:
  FastEthernet0/0
Hits: 25 Misses: 30
Expired translations: 20
Dynamic mappings:
-- Inside Source
[Id: 1] access-list 1 interface Serial0/0 refcount 5
NAT#show ip nat translations verbose
```



```

Pro Inside global      Inside local      Outside local      Outside global
icmp 200.200.100.1:516 192.168.1.5:516   200.200.50.2:516   200.200.50.2:516
      create 00:00:15, use 00:00:15, left 00:00:44, Map-Id(In): 1,
      flags:
      extended, use_count: 0
icmp 200.200.100.1:517 192.168.1.5:517   200.200.50.2:517   200.200.50.2:517
      create 00:00:15, use 00:00:15, left 00:00:44, Map-Id(In): 1,
      flags:
      extended, use_count: 0
icmp 200.200.100.1:518 192.168.1.5:518   200.200.50.2:518   200.200.50.2:518
      create 00:00:15, use 00:00:15, left 00:00:44, Map-Id(In): 1,
      flags:
      extended, use_count: 0
icmp 200.200.100.1:519 192.168.1.5:519   200.200.50.2:519   200.200.50.2:519
      create 00:00:15, use 00:00:15, left 00:00:44, Map-Id(In): 1,
      flags:
      extended, use_count: 0
icmp 200.200.100.1:520 192.168.1.5:520   200.200.50.2:520   200.200.50.2:520
      create 00:00:15, use 00:00:15, left 00:00:44, Map-Id(In): 1,
      flags:
      extended, use_count: 0

```

Step 6

Internet users need access to the informational Web server through 200.200.100.1 through port 80. Configure PAT so that Internet users are directed to the informational Web server, 192.168.1.5, when they connect to the IP address 200.200.100.1 through a web browser.

```

NAT(config)#ip nat inside source static tcp 192.168.1.5 80 200.200.100.1 80
extendable

```

The **extendable** keyword at the end of this static NAT command causes the router to reuse the global address of an active translation and save enough information to distinguish it from another translation entry. This command has the effect of translating external attempts to connect to port 80/IP address 200.200.100.1 to internal attempts to connect to port 80/IP address 192.168.1.5. The process of performing NAT translations based on the value of the incoming port number of an IP packet is called *port forwarding*.

Step 7

Successful configuration of port forwarding is indicated by being able to reach the informational Web server from the Internet User workstation with a Web browser using the inside global address of 200.200.100.1.

After successful connection to the web server with a browser from the Internet User workstation, issue the same three **show** commands from Step 5 on the NAT router to view the translations. Sample outputs are shown below.

```

NAT#show ip nat translations
Pro Inside global      Inside local      Outside local      Outside global
tcp 200.200.100.1:80   192.168.1.5:80   200.200.50.2:4806 200.200.50.2:4806
tcp 200.200.100.1:80   192.168.1.5:80   200.200.50.2:4809 200.200.50.2:4809
tcp 200.200.100.1:80   192.168.1.5:80   200.200.50.2:4814 200.200.50.2:4814
tcp 200.200.100.1:80   192.168.1.5:80   ---                ---

NAT#show ip nat statistics
Total active translations: 4 (1 static, 3 dynamic; 4 extended)
Outside interfaces:
  Serial0/0
Inside interfaces:
  FastEthernet0/0
Hits: 243 Misses: 30
Expired translations: 34
Dynamic mappings:
-- Inside Source
 [Id: 1] access-list 1 interface Serial0/0 refcount 0
NAT#show ip nat translations verbose

```

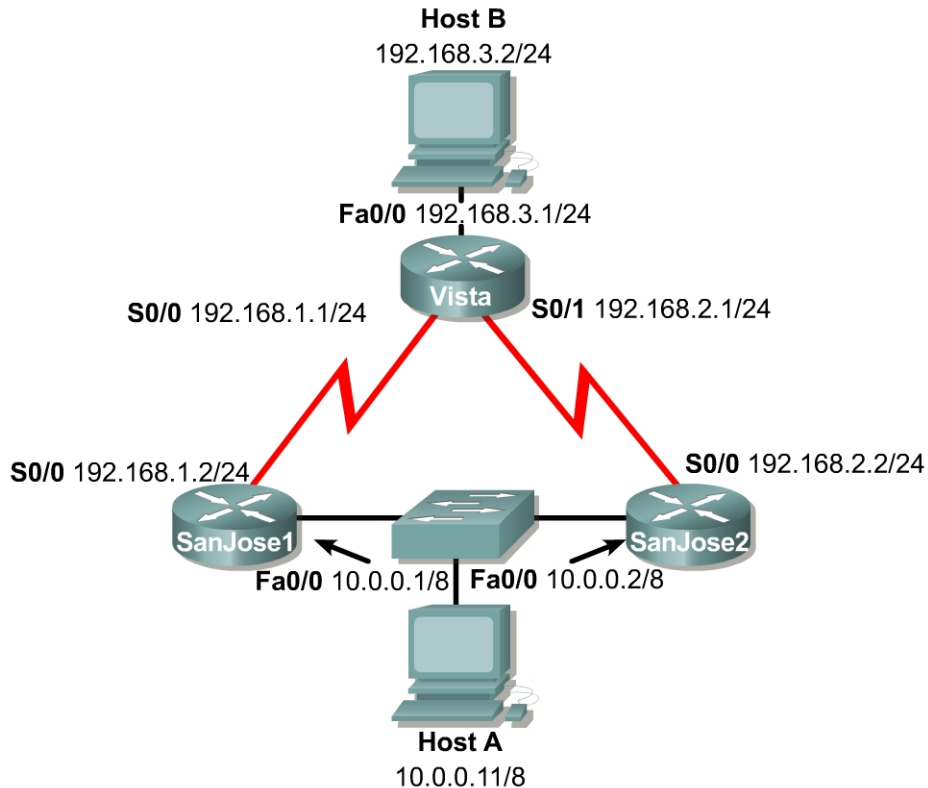
```

Pro Inside global      Inside local      Outside local      Outside global
tcp 200.200.100.1:80   192.168.1.5:80   200.200.50.2:4806 200.200.50.2:4806
  create 00:01:00, use 00:00:59, left 00:00:00,
  flags:
  extended, timing-out, use_count: 0
tcp 200.200.100.1:80   192.168.1.5:80   200.200.50.2:4809 200.200.50.2:4809
  create 00:00:59, use 00:00:59, left 00:00:00,
  flags:
  extended, timing-out, use_count: 0
tcp 200.200.100.1:80   192.168.1.5:80   200.200.50.2:4814 200.200.50.2:4814
  create 00:00:41, use 00:00:40, left 00:00:19,
  flags:
  extended, timing-out, use_count: 0
tcp 200.200.100.1:80   192.168.1.5:80   ---                ---
  create 00:11:23, use 00:00:41,
  flags:
  static, extended, extendable, use_count: 3

```

PAT and port address translation have now been successfully configured.

Lab 3.7.1 Migrating from RIP to EIGRP



Objective

In this lab, configure RIP v2 and then EIGRP so that their metric calculations can be compared.

Scenario

International Travel Agency (ITA) currently uses RIP v2 as its interior gateway protocol. Migrate its network to EIGRP.

Step 1

Build and configure the network according to the diagram.

Note: Host A and Host B are not required to complete this lab, but they might be used in testing or as Telnet clients. If used, the Host A gateway may be either SanJose1 router or the SanJose2 router.

On all three routers, configure RIP v2 and enable updates on all active interfaces with the `network` command. The following are sample commands for SanJose1:

```
SanJose1(config)#router rip
SanJose1(config-router)#version 2
SanJose1(config-router)#network 192.168.1.0
SanJose1(config-router)#network 10.0.0.0
```

Use **ping** and **show ip route** to verify full connectivity within the network.

Step 2

While migrating to EIGRP, leave RIP running on all the routers to avoid a loss of connectivity. On SanJose1 and SanJose2, configure EIGRP for Autonomous System 24. Do not configure Vista for EIGRP yet.

```
SanJose1(config)#router eigrp 24
SanJose1(config-router)#network 192.168.1.0
SanJose1(config-router)#network 10.0.0.0
```

and

```
SanJose2(config)#router eigrp 24
SanJose2(config-router)#network 192.168.2.0
SanJose2(config-router)#network 10.0.0.0
```

Step 3

From the Vista console, issue the **show ip route** command. The EIGRP has not be configured on this router yet. Therefore, a route has been established to the 10.0.0.0 /8 network through the RIP.

1. What is the administrative distance of this route?

2. What is the metric of this route?

Enable **debug** so that changes to the routing table will be reported to the console.

```
Vista#debug ip routing
```

If the connection is through Telnet, enter the **terminal monitor** command so that the logging output can be seen.

Now enable EIGRP on Vista.

```
Vista(config)#router eigrp 24
Vista(config-router)#network 192.168.1.0
Vista(config-router)#network 192.168.2.0
Vista(config-router)#network 192.168.3.0
```

3. After this configuration is made, did **debug** report any changes to the routing table? If so, what were they?

Issue the **show ip route** command again from Vista. There should now be an EIGRP route to network 10.0.0.0 /8.

4. What is the metric of this route?

5. Because this metric is higher than the metric of the RIP route, why did Vista choose the EIGRP route over the RIP route?

Step 4

To see more with the `debug ip routing` command, force the routing table to rebuild with this command:

```
Vista#clear ip route *
```

1. According to the `debug` output, what are the administrative distances of Vista connected routes?

2. What is the metric for each of the connected routes?

Step 5

To complete the migration from RIP to EIGRP, disable RIP on all three routers using the command `no router rip`.

Next, enter the command `show ip route`:

```
Vista#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

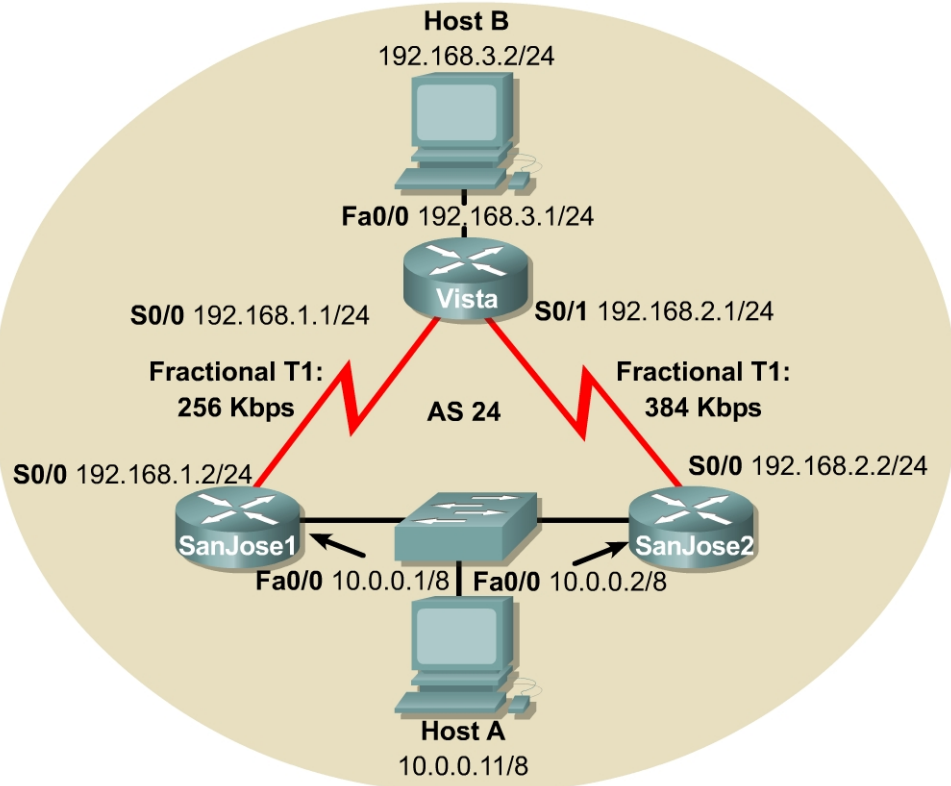
D    10.0.0.0/8 [90/20514560] via 192.168.1.2, 00:00:59, Serial0/0
      [90/20514560] via 192.168.2.2, 00:00:59, Serial0/1
C    192.168.1.0/24 is directly connected, Serial0/0
C    192.168.2.0/24 is directly connected, Serial0/1
C    192.168.3.0/24 is directly connected, FastEthernet0/0
```

Turn off debug before exiting the Vista router.

```
Vista#no debug all
```

Save the configuration files for the next lab.

Lab 3.7.2 Configuring IGRP



Objective

In this lab, configure IGRP for unequal cost load balancing and tune IGRP timers to improve performance.

Scenario

International Travel Agency (ITA) has asked for IGRP to be implemented in its WAN.

Step 1

Build and configure the network according to the diagram. If the configuration files are used from the previous lab, remove all routing protocols.

Note: Host A and Host B are not required to complete this lab, but they might be used in testing or as Telnet clients. If used, the Host A gateway may be either SanJose1 router or the SanJose2 router.

On all three routers, configure IGRP for Autonomous System 24, and enable updates on all active interfaces with the `network` command.

The IGRP metric includes bandwidth in its calculation. Manually configure the bandwidth of serial interfaces in order for metrics to be accurate. Use the following commands to configure the correct bandwidth settings for each serial interface:

```
SanJose1(config)#interface serial 0/0
```

```
SanJose1(config-if)#bandwidth 256

Vista(config)#interface serial 0/0
Vista(config-if)#bandwidth 256
Vista(config-if)#interface serial 0/1
Vista(config-if)#bandwidth 384

SanJose2(config-if)#interface serial 0/0
SanJose2(config-if)#bandwidth 384
```

Use the output from the `show interface` command to verify the correct bandwidth settings. Use `ping` and `show ip route` to verify full connectivity within the network.

Step 2

On Vista, configure unequal cost load balancing using the `variance 5` command.

Note: A default value of 1 is used for equal cost load balancing. The following are sample commands for Vista:

```
Vista(config)#router igrp 24
Vista(config-router)#variance 5
```

Use the `show ip route` command to verify that the routers are installing two unequal cost routes to the same destination:

```
Vista#show ip route
<output omitted>
I    10.0.0.0/8 [100/41072] via 192.168.1.2, 00:00:01, Serial0/0
      [100/28051] via 192.168.2.2, 00:00:00, Serial0/1
C    192.168.1.0/24 is directly connected, Serial0/0
C    192.168.2.0/24 is directly connected, Serial0/1
C    192.168.3.0/24 is directly connected, FastEthernet0/0
```

1. What has changed in the output of the `show ip route` command? How does the metric of the new route compare with that of the original route?

Step 3

On any router, issue the `show ip protocols` command and check the IGRP invalid, holddown, and flush timers for IGRP.

Note: A route does not become invalid until after 270 seconds and is not flushed from the table until after more than 10 minutes or 630 seconds. Also, the maximum hop count is set at 100 by default.

In small networks, it is advised that the timers for IGRP be adjusted to speed up the convergence process.

Fast IGRP is a specific set of timer settings that result in improved convergence. To configure Fast IGRP, change the IGRP timers as follows:

- 15 seconds between updates
- 45 seconds for route expiration
- 0 seconds for holddown
- 60 seconds for flushing the route from the table

As part of this configuration disable the holddown timers completely. This is done so that after the route for a given network has been removed, a new route for that destination network will be accepted immediately. Finally, reduce the IGRP maximum hop count to a number appropriate to the ITA network.

Configure Fast IGRP by issuing the following commands on all three routers:

```
SanJose1(config-router)#timers basic 15 45 0 60
SanJose1(config-router)#no metric holddown
SanJose1(config-router)#metric maximum-hops 10
```

Verify the settings with the `show ip protocols` command.

Step 4

In this step, test the IGRP timer settings by simulating a link failure.

On SanJose1, enable `debug` so that any changes to the routing table will be reported to the console:

```
SanJose1#debug ip routing
```

If the connection is through Telnet, enter the `terminal monitor` so that the logging output is to the Telnet session.

With the connection to SanJose1 open, log into Vista. Do this on a separate workstation if necessary. On Vista, shut down the Fast Ethernet interface. This will cause the removal of 192.168.3.0 /24 from the Vista routing table.

```
Vista(config)#interface fastethernet 0/0
Vista(config-if)#shutdown
```

Use the `show ip route` command to verify that Vista no longer possesses a valid route to 192.168.3.0 /24.

Return to SanJose1 and issue the `show ip route` command.

Note: The route to 192.168.3.0 is still in the SanJose1 table, but it is flagged as possibly down.

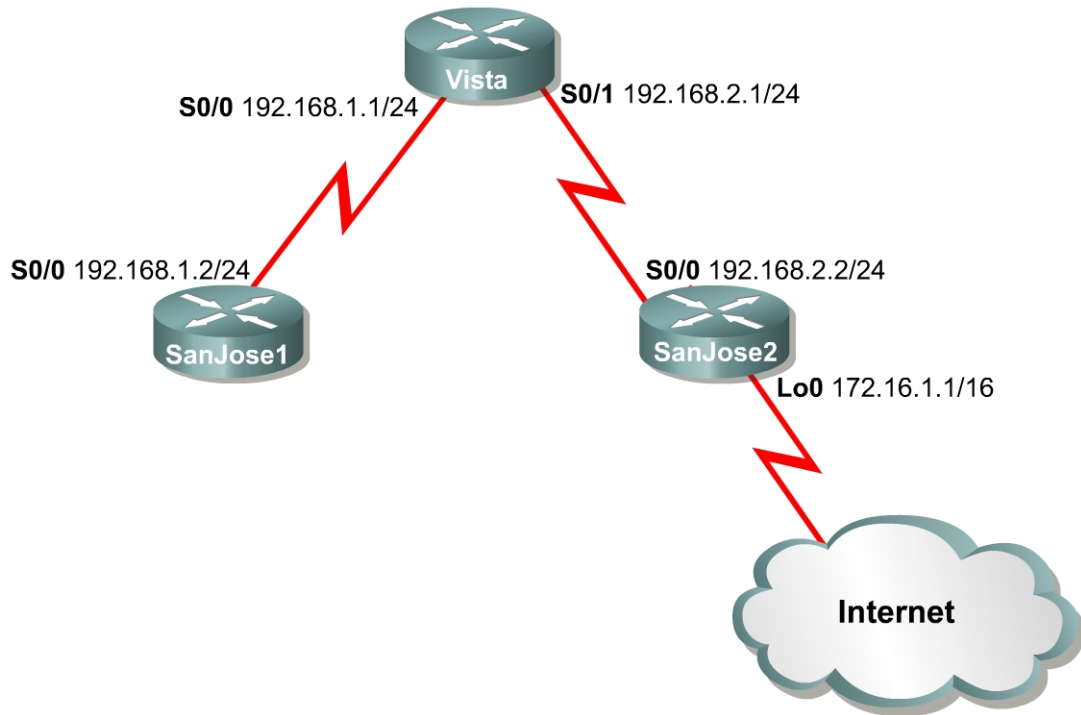
1. How long will the wait be before this route is removed?

To check the answer, wait for the `debug` output on SanJose1 to report that the route to 192.168.3.0 has been flushed.

2. If SanJose1 had been configured with default timers, how long would it have taken for the route to be flushed?

Save the configuration files for the next lab.

Lab 3.7.3 Configuring Default Routing with RIP and IGRP



Objective

In this lab, configure a default route and use RIP to propagate this default information to other routers. When this configuration has reached convergence, migrate the network from RIP to IGRP and configure default routing to work with that protocol as well.

Scenario

International Travel Agency (ITA) asked for default routing to be configured for its network, which currently uses RIP. The company connects to the Internet through SanJose2. It has been decided to configure a static default route on that router. To aid scalability, SanJose2 will propagate the default route to all other RIP routers.

ITA also asked that the possibility of migrating all routers to IGRP be explored. As a test, configure the three routers in this scenario for IGRP and configure default routing for that protocol as well.

Procedures

Before beginning this lab, it is recommended that each router be reloaded after erasing its startup configuration. This prevents problems caused by residual configurations. After the equipment is prepared, proceed with Step 1.

Step 1

Build and configure the network according to the diagram. If the configuration are used from the previous lab, remove all routing protocols. Do not configure the 172.16.1.1/16 address on SanJose2 yet. This network connects ITA to its ISP and the Internet.

Configure RIP on all three routers. However, be sure not to configure the SanJose2 RIP process to include the 172.16.0.0/16 network.

Use **ping** and **show ip route** to verify full connectivity within the network, excluding 172.16.0.0/16.

Step 2

Configure SanJose2 to simulate the existence of an outside network. For this scenario, the link between ITA and its provider needs to be simulated by configuring a loopback interface with an IP address. Enter the following commands on SanJose2:

```
SanJose2(config)#interface loopback0
SanJose2(config-if)#ip address 172.16.1.1 255.255.0.0
```

Note: If 172.16.1.1 is **pinged** from the SanJose2 console, the loopback interface replies.

From the Vista console, attempt to **ping** 172.16.1.1. This **ping** should fail because the 172.16.0.0/17 network is not in the Vista table.

1. If no default route exists, what does a router do with a packet destined for a network that is not in its table?
-

Step 3

Next, configure SanJose2 with a 0.0.0.0/0 default route pointed at the simulated ISP. Issue the following command on SanJose2:

```
SanJose2(config)#ip route 0.0.0.0 0.0.0.0 loopback0
```

This command statically configures the default route. The default route directs traffic destined for networks that are not in the routing table to the simulated WAN link loopback 0.

Depending on the IOS version, RIP might need to be specifically configured to propagate this 0.0.0.0/0 route. Enter the following commands on SanJose2:

```
SanJose2(config)#router rip
SanJose2(config-router)#default-information originate
```

Step 4

Now check the routing tables of SanJose1 and Vista using the **show ip route** command. Verify that they both have received and installed a route to 0.0.0.0/0 in their tables.

1. On Vista, what is the metric of this route?
-

2. On SanJose1, what is the metric of this route?
-

SanJose1 and Vista still do not have routes to 172.16.0.0/16 in their tables. From Vista, **ping** 172.16.1.1. This **ping** should be successful.

3. Why does the **ping** to 172.16.1.1 work, even though there is no route to 172.16.0.0/16 in the Vista table?
-

Check to be sure that SanJose1 can also **ping** 172.16.1.1. Troubleshoot, if necessary.

Note: If default route propagation does not occur as expected, two options are available as a last resort:

- (1) Save the configuration files and reboot the routers.
- (2) Remove the RIP process on each router with the `no router rip` command and reconfigure the RIP.

Step 5

With default routing now working, migrate the network from RIP to IGRP for testing purposes. Issue the following command on all three routers:

```
SanJose1(config)#no router rip
```

With the RIP removed from each router configuration, configure IGRP on all three routers using AS 24, as follows:

```
SanJose1(config)#router igrp 24
SanJose1(config-router)#network 192.168.1.0

Vista(config)#router igrp 24
Vista(config-router)#network 192.168.1.0
Vista(config-router)#network 192.168.2.0

SanJose2(config)#router igrp 24
SanJose2(config-router)#network 192.168.2.0
```

Use `ping` and `show ip route` to verify that IGRP is working properly. Do not worry about the 172.16.1.1 loopback address on SanJose2 yet.

Step 6

Check SanJose2 routing table. The static default route to 0.0.0.0/0 should still be there. The `default-information originate` command may have been required to propagate this route with RIP, based on the IOS version. The `default-information originate` command is not available in an IGRP configuration. Therefore, use the `ip default-network` method to propagate default information in IGRP.

On SanJose2, issue the following commands:

```
SanJose2(config)#router igrp 24
SanJose2(config-router)#network 172.16.0.0
SanJose2(config-router)#exit
SanJose2(config)#ip default-network 172.16.0.0
```

These commands configure IGRP to update neighbor routers about the network 172.16.0.0/16, which includes the simulated ISP link, loopback 0. Not only will IGRP advertise this network, but the `ip default-network` command also will flag this network as a candidate default route. A candidate default route is flagged with an asterisk in the routing table. When a network is flagged as a default, that flag will stay with the route as it passes from neighbor to neighbor by IGRP.

Check the routing tables of SanJose1 and Vista. If they do not yet have the 172.16.0.0/16 route with an asterisk, wait for another IGRP update. This could take 90 seconds. The `clear ip route *` command could also be issued on all three routers to force them to immediately send new updates.

When the 172.16.0.0/16 route appears as a candidate default in all three routing tables, proceed to the next step.

Note: If default route propagation does not occur as expected, two options are available as a last resort:

- (1) Save the configuration files and reboot the routers.

- (2) Remove the RIP process on each router with the `no router igrp 24` command and reconfigure the RIP.

Step 7

The 172.16.0.0/16 network is known explicitly by SanJose1 and Vista. To test our default route, a second loopback interface needs to be created on SanJose2. Issue the following commands on SanJose2:

```
SanJose2(config)#interface loopback1
SanJose2(config-if)#ip address 10.0.0.1 255.0.0.0
```

This loopback interface simulates another external network, but one that is not explicitly identified in the routing table for SanJose1 or Vista.

Return to SanJose1 and check its routing table using the `show ip route` command.

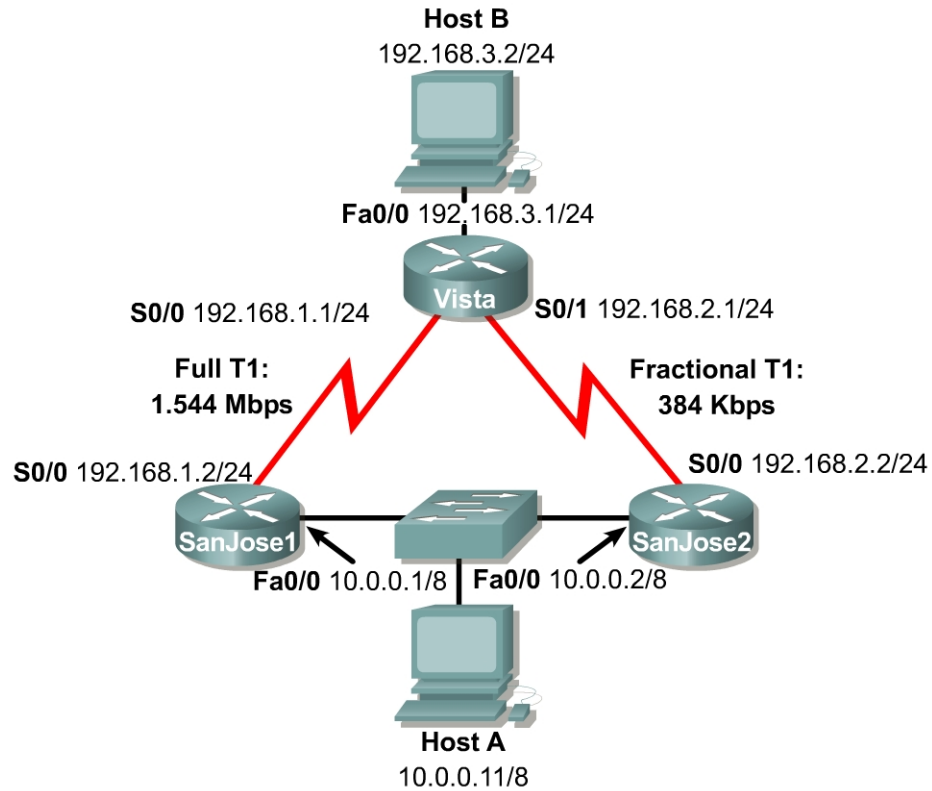
1. Is there a route to the 10.0.0.0/8 network?

From SanJose1, `ping 10.0.0.1`. This `ping` should be successful.

2. If there is no route to 10.0.0.0/8 and no route to 0.0.0.0/0, why does this `ping` succeed?
-

Save the configuration files for the next lab.

Lab 3.7.4 Configuring Floating Static Routes



Objective

In this lab, configure a floating static route.

Scenario

International Travel Agency (ITA) uses a combination of static routing and RIP in the core of its network. One of ITA key boundary routers, Vista, has two routes to the 10.0.0.0/8 network. Only one of these routes is advertised by RIP. If the other path is configured statically using the default administrative distance, the static route will be preferred over the RIP route. The lower administrative distance is preferred. However, ITA wants the RIP route to be preferred. This is because the RIP route has a higher bandwidth. Therefore, the default administrative distance of the static route must be overridden to create a floating static route.

Procedures

Before beginning this lab, it is recommended that each router be reloaded after erasing its startup configuration. This prevents problems caused by residual configurations. After the equipment is prepared, proceed with Step 1.

Step 1

Build and configure the network according to the diagram. Be sure to configure Host B. Do not configure a routing protocol. If the configuration files are used from the previous lab, remove all routing protocols and static routes.

Use **ping** to verify that directly connected devices can reach each other.

Step 2

Configure routing on the three routers. SanJose1 and Vista will run RIP, so issue the following commands on the appropriate router:

```
SanJose1(config)#router rip
SanJose1(config-router)#network 192.168.1.0
SanJose1(config-router)#network 10.0.0.0
...
Vista(config)#router rip
Vista(config-router)#network 192.168.1.0
Vista(config-router)#network 192.168.3.0
```

SanJose2 will reach Vista using a static route. Enter the following command on SanJose2:

```
SanJose2(config)#ip route 192.168.3.0 255.255.255.0 192.168.2.1
```

Verify that Host B can **ping** the serial interfaces of both SanJose1, 192.168.1.2, and SanJose2, 192.168.2.2. Troubleshoot, if necessary.

Step 3

Check Vista routing table. It should have a route to the 10.0.0.0/8 network.

1. Which interface will Vista use to reach the 10.0.0.0/8 network?

Now that the RIP route to the 10.0.0.0/8 network is verified as operational, configure a static route on Vista that will use SanJose2 to get to 10.0.0.0/8, using the following command:

```
Vista(config)#ip route 10.0.0.0 255.0.0.0 192.168.2.2
```

When Vista has been configured with this static route, check its routing table using the **show ip route** command. Only the static route to the 10.0.0.0/8 network should be in Vista routing table.

2. What happened to the RIP route?

Remember that ITA wants Vista configured to use the SanJose2 link to 10.0.0.0/8 only if the other route goes down. Therefore, the static route on Vista must be configured so that it floats. Floating means that it remains in the configuration but is not installed in the routing table until a route with a better metric is lost.

Before a floating static route can be configured on Vista, remove the first static route using the following command:

```
Vista(config)#no ip route 10.0.0.0 255.0.0.0 192.168.2.2
```

When it has been verified that this static route is no longer part of Vista configuration, issue the following command to create a floating static route:

```
Vista(config)#ip route 10.0.0.0 255.0.0.0 192.168.2.2 130
```

The integer 130 at the end of this command overrides the default administrative distance for the static route. By default, a static route has an administrative distance of 1. In this scenario, the administrative distance must be increased so that it is higher than the RIP administrative distance of 120. Only by increasing the default route administrative distance above 120 will the RIP route be preferred. Vista will install the static route only if the RIP route fails.

Add the following floating static route to SanJose1 in case the link between SanJose1 and Vista should fail:

```
SanJose1(config)#ip route 192.168.3.0 255.255.255.0 10.0.0.2 130
```

Step 4

After reconfiguring the static route to be a floating static route, check the Vista routing table again. Only the RIP route to 10.0.0.0/8 should be in the table. Verify that routing is working by **pinging** Host A 10.0.0.11 from Host B. Troubleshoot, if necessary.

Although the floating static route cannot be seen in the Vista table, it remains in the configuration file. Observe how Vista reacts to a link failure by issuing the following command:

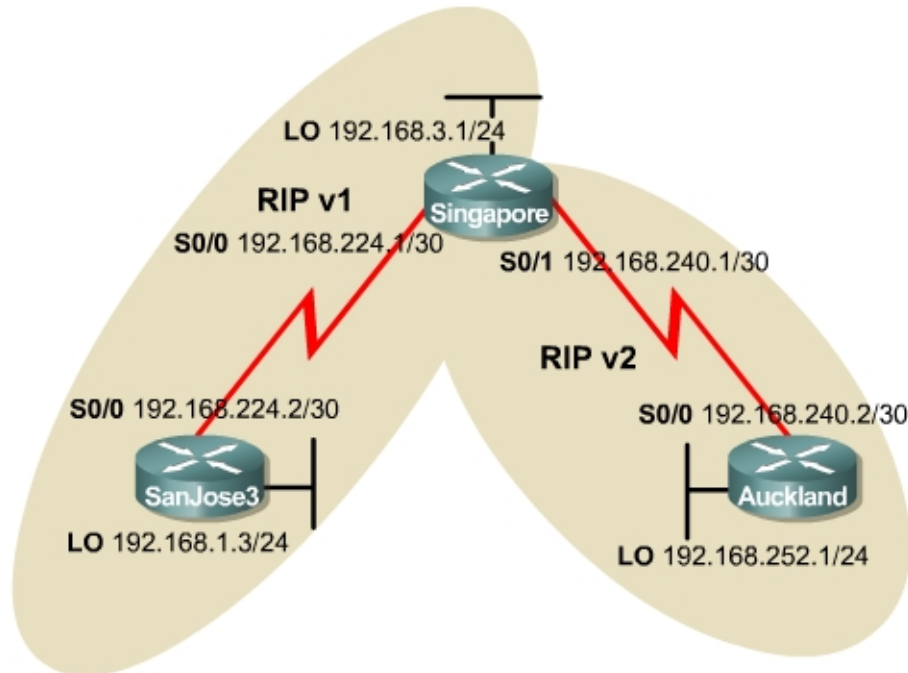
```
Vista#debug ip routing
```

Verify that the routers are configured correctly, and disconnect the SanJose1 Ethernet connection to the 10.0.0.0/8 network. The **debug** output on Vista should send a change notification after a few seconds.

```
RT: del 10.0.0.0 via 192.168.1.2, rip metric [120/1]
RT: delete network route to 10.0.0.0
RT: add 10.0.0.0/8 via 192.168.2.2, static metric [130/0]
```

Check the Vista routing table to ensure that the static route has been installed. As a final test, **ping** 10.0.0.1 and 10.0.0.2 from Host B. The **ping** to 10.0.0.2 should be successful. Why is the **ping** to 10.0.0.1 not successful?

Lab 4.4.1 Routing between RIP v1 and RIP v2



Objective

In this lab, configure RIP v1 and RIP v2 routing protocols. RIP v2 will be configured to accept RIP v1 updates.

Scenario

RIP v1 is presently running between SanJose3, Singapore, and Auckland. New routers that support RIP v2 and variable-length subnet mask (VLSM) have been installed at the Singapore and Auckland headquarters. However, an upgrade of the SanJose3 router, which presently does not support RIP v2 will be installed at a later time. RIP v2 will have to be configured between Auckland and Singapore. Singapore will then need to be configured to receive RIP v1 updates so the SanJose3 router will be able to communicate with Auckland.

Step 1

Build the network according to the diagram and configure all routers with RIP v1. Test connectivity between the routers and troubleshoot as necessary. A `ping` should be successful from one end of the network to the other.

Step 2

Verify that RIP v1 is running. There are several commands that could be used to verify RIP v1 is enabled and running. Two of the commands are shown below:


```

SanJose3#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 14 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  Redistributing: rip
  Default version control: send version 1, receive any version
    Interface          Send Recv Triggered RIP Key-chain
    Serial0/0          1     1  2
Routing for Networks:
  192.168.1.0
  192.168.224.0
Routing Information Sources:
  Gateway             Distance      Last Update
  192.168.224.2       120           00:00:22
Distance: (default is 120)

```

The `debug ip rip` command can be used to check the type of updates the router is receiving and sending.

```

SanJose3#debug ip rip
RIP protocol debugging is on
00:21:28: RIP: sending v1 update to 255.255.255.255 via Serial0/0 (192.168.224.1)
00:21:28: RIP: sending v1 update to 255.255.255.255 via Loopback0 (192.168.1.3)
00:21:28: RIP: build update entries
00:21:28:     network 192.168.3.0 metric 2
00:21:28:     network 192.168.224.0 metric 1
00:21:28:     network 192.168.240.0 metric 2
00:21:28:     network 192.168.252.0 metric 3
00:21:41: RIP: received v1 update from 192.168.224.2 on Serial0/0
00:21:41:     192.168.3.0 in 1 hops
00:21:41:     192.168.240.0 in 1 hops
00:21:41:     192.168.252.0 in 2 hops

```

Notice that all RIP v1 updates are sent using broadcast addresses through all the interfaces. The advertisements are also classful. That is, no mask information is carried in a RIP v1 update. RIP v1 does not support classless interdomain routing (CIDR) and VLSM.

Turn `debug` off if it is enabled and check that a route to 192.168.1.0 exists in the routing tables of the Singapore and Auckland routers.

Step 3

The next step is to configure RIP v2 on the Singapore and Auckland routers.

```

Singapore(config)#router rip
Singapore(config-router)#version 2

Auckland(config)#router rip
Auckland(config-router)#version 2

```

Issue a `show running-config` command on either Singapore or Auckland and notice that RIP version 1 was replaced by RIP version 2. Issue the `clear ip route *` command to flush the routing table.

Check the routing table of the Singapore and Auckland routers.

1. Is there still a route to 192.168.1.0 on either router?

By default, RIP v1 will accept RIP v2 updates. However, RIP v2 will not accept RIP v1 updates. Therefore, RIP v2 must be configured to accept RIP v1 updates.

When `debug ip rip` is issued on the SanJose3 and Singapore routers, it is possible to view RIP v1 accepting RIP v2 updates and RIP v2 ignoring RIP v1 updates. A sample output is shown below.

```

SanJose3#debug ip rip
RIP protocol debugging is on
01:12:28: RIP: received v2 update from 192.168.224.2 on Serial0/0
01:12:28:     192.168.3.0/24 via 0.0.0.0 in 1 hops
01:12:28:     192.168.240.0/24 via 0.0.0.0 in 1 hops
01:12:28:     192.168.252.0/24 via 0.0.0.0 in 2 hops
01:12:32: RIP: sending v1 update to 255.255.255.255 via Serial0/0 (192.168.224.1)
01:12:32: RIP: build update entries
01:12:32:     network 192.168.1.0 metric 1
01:12:32: RIP: sending v1 update to 255.255.255.255 via Loopback0 (192.168.1.3)
01:12:32: RIP: build update entries
01:12:32:     network 192.168.3.0 metric 2
01:12:32:     network 192.168.224.0 metric 1
01:12:32:     network 192.168.240.0 metric 2
01:12:32:     network 192.168.252.0 metric 3

```

```

Singapore#debug ip rip
RIP protocol debugging is on
01:49:40: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (192.168.224.2)
01:49:40: RIP: build update entries
01:49:40:     192.168.3.0/24 via 0.0.0.0, metric 1, tag 0
01:49:40:     192.168.240.0/24 via 0.0.0.0, metric 1, tag 0
01:49:40:     192.168.252.0/24 via 0.0.0.0, metric 2, tag 0
01:49:40: RIP: sending v2 update to 224.0.0.9 via Serial0/1 (192.168.240.1)
01:49:40: RIP: build update entries
01:49:40:     192.168.3.0/24 via 0.0.0.0, metric 1, tag 0
01:49:40:     192.168.224.0/24 via 0.0.0.0, metric 1, tag 0
01:49:40: RIP: sending v2 update to 224.0.0.9 via Loopback0 (192.168.3.1)
01:49:40: RIP: build update entries
01:49:40:     192.168.224.0/24 via 0.0.0.0, metric 1, tag 0
01:49:40:     192.168.240.0/24 via 0.0.0.0, metric 1, tag 0
01:49:40:     192.168.252.0/24 via 0.0.0.0, metric 2, tag 0
01:49:40: RIP: ignored v2 packet from 192.168.3.1 (sourced from one of our addresses)
01:49:45: RIP: received v2 update from 192.168.240.2 on Serial0/1
01:49:45:     192.168.252.0/24 via 0.0.0.0 in 1 hops
01:40:45: RIP: ignored v1 packet from 192.168.224.1 (illegal version)

```

Step 4

Configure RIP v2 to accept RIP v1 updates.

```

Singapore(config-if)#interface serial 0/0
Singapore(config-if)#ip rip receive version 1

```

Issue the `clear ip route *` command to flush the routing table. Check the Singapore and Auckland routing tables again.

1. Is there a route for network 192.168.1.0?
-

Enable the `debug ip rip` command on Singapore to see RIP v2 now accepting RIP v1 updates. A sample output is shown below.

```

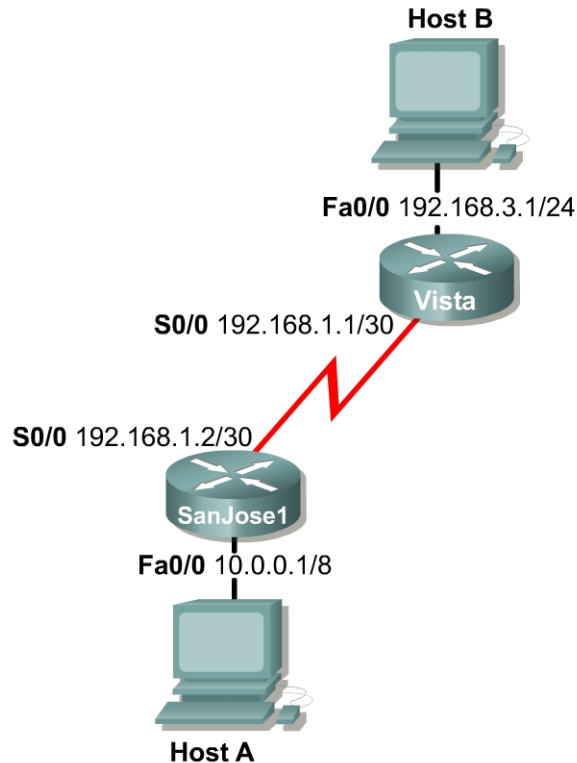
Singapore#debug ip rip
RIP protocol debugging is on
02:05:09: RIP: received v1 update from 192.168.224.1 on Serial0/0
02:05:09:     192.168.1.0 in 1 hops
02:05:22: RIP: received v2 update from 192.168.240.2 on Serial0/1
02:05:22:     192.168.252.0/24 via 0.0.0.0 in 1 hops
02:05:33: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (192.168.224.2)

```

2. Remember that RIP v1 updates are sent through a broadcast. How are RIP v2 updates sent?
-

3. What are the steps to verify that RIP v2 supports CIDR/VLSM by examining the `debug ip rip` output?
-

Lab 4.4.2 RIP v2 MD5 Authentication



Objective

In this lab configure RIP v2 authentication.

Scenario

RIP v1 is running between SanJose1 and Vista. Currently, there is no authentication between the two routers. RIP v2 must be used to provide authentication. The default authentication in every RIP v2 packet is plain text authentication. However, the Cisco IOS implementation of RIP v2 provides a higher level of security with MD5 authentication. After viewing the default authentication, the routers will be upgraded to MD5 authentication.

Step 1

Build the network according to the diagram. Configure the routers with RIP v1 and advertise all networks. Test connectivity and routing between the routers. Troubleshoot the network if required.

Step 2

Verify that RIP v1 is running. Debug commands can be very useful when verifying RIP operation. Type in the `debug ip rip` command on each router. The following is sample output of the `debug ip rip` on Vista.

```
00:30:58: RIP: sending v1 update to 255.255.255.255 via Serial0/0 (192.168.1.1)
```

```
00:30:58: RIP: build update entries
00:30:58:      network 192.168.3.0 metric 1
00:30:58: RIP: sending v1 update to 255.255.255.255 via Loopback0 (192.168.3.1)
00:30:58: RIP: build update entries
00:30:58:      network 10.0.0.0 metric 2
00:30:58:      network 192.168.1.0 metric 1
00:30:58: RIP: received v1 update from 192.168.1.2 on Serial0/0
00:30:58:      10.0.0.0 in 1 hops
00:31:24: RIP: received v1 update from 192.168.1.2 on Serial0/0
00:31:24:      10.0.0.0 in 1 hops
```

Stop all previous debugs.

1. What version of RIP are the routers running?

2. Which show command could be used to verify the version of RIP running?

Step 3

Configure RIP v2 on SanJose1 and Vista.

```
Vista(config)#router rip
Vista(config-router)#version 2

SanJose1(config)#router rip
SanJose1(config-router)#version 2
```

Again, use the `debug ip rip` command to verify that RIP v2 is running on SanJose1.

```
00:42:03: RIP: received v2 update from 192.168.1.1 on Serial0/0
00:42:03:      192.168.3.0/24 via 0.0.0.0 in 1 hops
00:42:04: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (192.168.1.2)
00:42:04: RIP: build update entries
00:42:04:      10.0.0.0/8 via 0.0.0.0, metric 1, tag 0
00:42:04: RIP: sending v2 update to 224.0.0.9 via Loopback0 (10.0.0.1)
00:42:04: RIP: build update entries
00:42:04:      192.168.1.0/24 via 0.0.0.0, metric 1, tag 0
00:42:04:      192.168.3.0/24 via 0.0.0.0, metric 2, tag 0
00:42:04: RIP: ignored v2 packet from 10.0.0.1 (sourced from one of our address
```

1. What version of RIP updates are being sent and received?

Notice that RIP is no longer using broadcasts on 255.255.255.255 to send updates. RIP v2 uses the multicast address 224.0.0.9 for sending routing messages. RIP v2 also supports classless interdomain routing/variable-length subnet mask (CIDR/VLSM) by providing the subnet mask information to its neighbors.

Turn off debugging.

Step 4

Authentication will be configured on SanJose1 and Vista. The key is defined first.

```
Vista(config)#key chain private
Vista(config-keychain)#key 1
```

```
Vista(config-keychain-key)#key-string 234

SanJose1(config)#key chain private
SanJose1(config-keychain)#key 1
SanJose1(config-keychain-key)#key-string 234
```

Enable the authentication on the interfaces.

```
Vista(config)#interface serial 0/0
Vista(config-if)#ip rip authentication key-chain private

SanJose1(config)#interface serial 0/0
SanJose1(config-if)#ip rip authentication key-chain private
```

Execute the `debug ip rip` command again on Vista and examine the output.

```
01:10:31: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (192.168.1.1)
01:10:31: RIP: build update entries
01:10:31:      192.168.3.0/24 via 0.0.0.0, metric 1, tag 0
01:10:31: RIP: sending v2 update to 224.0.0.9 via Loopback0 (192.168.3.1)
01:10:31: RIP: build update entries
01:10:31:      10.0.0.0/8 via 0.0.0.0, metric 2, tag 0
01:10:31:      192.168.1.0/24 via 0.0.0.0, metric 1, tag 0
01:10:31: RIP: ignored v2 packet from 192.168.3.1 (sourced from one of our addresses)
01:10:35: RIP: received packet with text authentication 234
01:10:35: RIP: received v2 update from 192.168.1.2 on Serial0/0
01:10:35:      10.0.0.0/8 via 0.0.0.0 in 1 hops
```

Step 5

The Cisco implementation of RIP v2 supports MD5 authentication. This provides a higher level of security over clear text. Both router interfaces need to be configured with MD5 authentication. The key number and key string must match on both sides, or authentication will fail.

```
Vista(config)#interface serial0/0
Vista(config-if)#ip rip authentication mode md5
```

Examine the debug output on Vista before applying the MD5 authentication on the SanJose1 router.

```
1:21:11: RIP: ignored v2 packet from 192.168.1.2 (invalid authentication)
01:21:28: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (192.168.1.1)
01:21:28: RIP: build update entries
01:21:28:      192.168.3.0/24 via 0.0.0.0, metric 1, tag 0
01:21:28: RIP: sending v2 update to 224.0.0.9 via Loopback0 (192.168.3.1)
01:21:28: RIP: build update entries
01:21:28:      10.0.0.0/8 via 0.0.0.0, metric 2, tag 0
01:21:28:      192.168.1.0/24 via 0.0.0.0, metric 1, tag 0
```

Clear the routing table on Vista. Type the command `show ip route`.

1. Is the RIP route still there? Why or why not? **Note:** It may take several moments for the correct result to be displayed.

Enable MD5 authentication on SanJose1.

```
SanJose1(config)#interface serial0/0
SanJose1(config-if)#ip rip authentication mode md5
```

Examine the `debug` output:

```
01:30:06: RIP: sending v2 update to 224.0.0.9 via Loopback0 (10.0.0.1)
01:30:06: RIP: build update entries
01:30:06:      192.168.1.0/24 via 0.0.0.0, metric 1, tag 0
01:30:06:      192.168.3.0/24 via 0.0.0.0, metric 2, tag 0
01:30:06: RIP: ignored v2 packet from 10.0.0.1 (sourced from one of our addresses)
01:30:11: RIP: received packet with MD5 authentication
01:30:11: RIP: received v2 update from 192.168.1.1 on Serial0/0
01:30:11:      192.168.3.0/24 via 0.0.0.0 in 1 hops
```

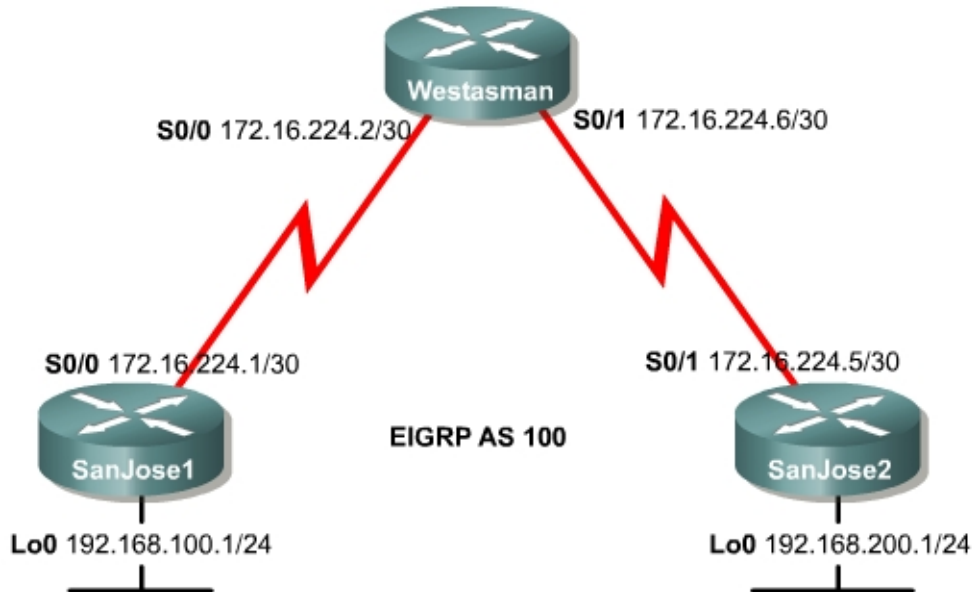
Display the routing table.

2. Is the RIP route there?

If a route is missing, troubleshoot.

3. Use the **show ip rip database** command to verify that RIP v2 is being routed. List three other commands used in this context.

Lab 5.7.1 Configuring EIGRP



Objective

In this lab EIGRP will be configured on three Cisco routers within the International Travel Agency WAN and the basic behaviors of the protocol will be observed.

Scenario

The International Travel Agency is implementing EIGRP between its overseas headquarters and its North American headquarters. EIGRP must be configured at all three locations before the SanJose1 headquarters can connect to the SanJose2 headquarters.

Step 1

Build and configure the network according to the diagram, but do not configure EIGRP yet.

Use `ping` to test connectivity between serial interfaces. SanJose1 and SanJose2 will not be able to ping each other until EIGRP is enabled.

Step 2

Configure EIGRP for AS 100 on all routers as the following shows:

```
SanJose1(config)#router eigrp 100
SanJose1(config-router)#network 192.168.100.0
SanJose1(config-router)#network 172.16.0.0

Westasman(config)#router eigrp 100
Westasman(config-router)#network 172.16.0.0

SanJose2(config)#router eigrp 100
```



```
SanJose2(config-router)#network 192.168.200.0
SanJose2(config-router)#network 172.16.0.0
```

Step 3

After enabling EIGRP on each of the three routers, verify the operation using the `show ip route` command on the Westasman router. The Westasman router should have routes to all networks.

1. Based on the output of this command, which routes were learned by way of EIGRP?

The Westasman router received EIGRP routes that are internal to the EIGRP domain, 192.168.100.0 and 192.168.200.0. Internally learned EIGRP routes are denoted by a D.

2. The administrative distance of an external EIGRP route is 170. What is the administrative distance of an internal EIGRP route?

Step 4

Now that EIGRP is configured, use `show` commands to view EIGRP neighbors and topology tables on the Westasman router.

From the Westasman router, issue the `show` command to view the neighbor table:

```
Westasman#show ip eigrp neighbors
```

1. How many EIGRP neighbors are listed in the output?

To view the topology table, issue the `show ip eigrp topology all-links` command.

2. A passive route is one that is stable and available for use. How many routes are in passive mode?

3. What is the feasible distance and the reported distance for the LANs (loopback addresses) on the SanJose1 and SanJose2 routers?

To view more specific information about a topology table entry, use an IP address with the `show ip eigrp topology` command:

```
Westasman#show ip eigrp topology 192.168.200.0
```

4. Does it show which router originated the route?

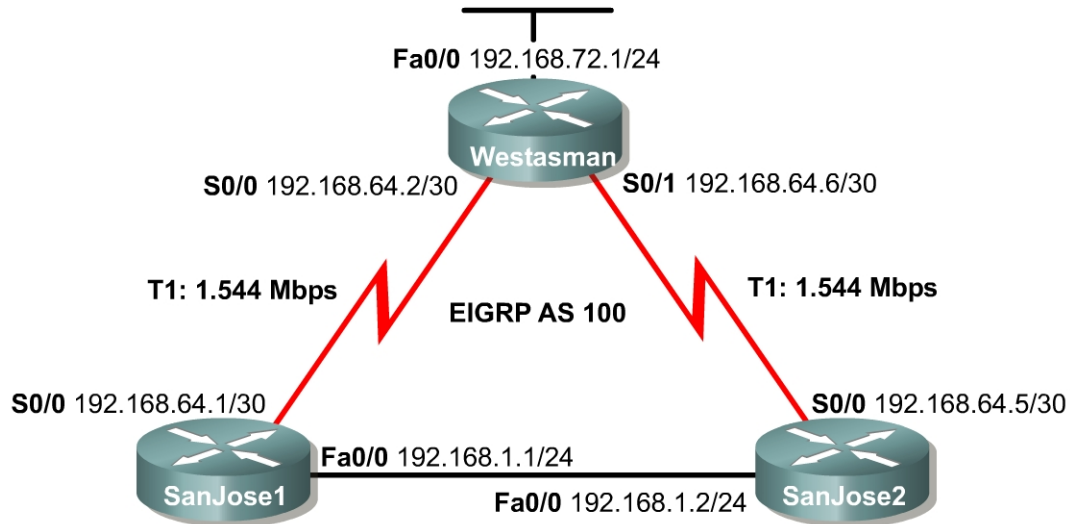
Finally, use `show` commands to view key EIGRP statistics. On the Westasman router, issue the `show ip eigrp traffic` command to see the EIGRP packet types. Then enter the `show ip eigrp interfaces` command.

5. List the five EIGRP packet types and the number sent and received for each.

6. Which interfaces are participating in the EIGRP routing process?

Save the configuration files for the routers.

Lab 5.7.2 Configuring EIGRP Fault Tolerance



Objective

In this lab EIGRP will be configured over a full mesh topology and then tested to observe DUAL replace a successor with a feasible successor after a link failure.

Scenario

The International Travel Agency wants to run EIGRP on its core, branch, and regional routers. EIGRP is to be configured and tested for its ability to install alternate routes in the event of link failure.

Step 1

Build and configure the network according to the diagram, configuring EIGRP as indicated for AS 100. If using the configuration files from the previous lab, be sure to change IP addresses according to the diagram. Also, remove all loopback interfaces.

Set the bandwidth for each serial interface to reflect the diagram. Use the `show interface` command to verify the configuration.

Use `ping` and `show ip route` to verify the configuration and test connectivity between all routers.

Step 2

Verify that EIGRP maintains all routes to destination networks in its topology table.

From the SanJose2 router, issue the `show ip eigrp topology all-links` command:

```
SanJose2#show ip eigrp topology all-links
IP-EIGRP Topology Table for AS(100)/ID(192.168.64.5)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 192.168.72.0/24, 1 successors, FD is 1889792, serno 53
```

```

    via 192.168.64.6 (2297856/128256), Serial0/0
    via 192.168.1.1 (2300416/2297856), FastEthernet0/0
P 192.168.64.0/30, 1 successors, FD is 2273792, serno 50
    via 192.168.64.6 (2681856/2169856), Serial0/0
P 192.168.64.0/24, 1 successors, FD is 1761792, serno 52
    via Summary (2169856/0), Null0
    via 192.168.1.1 (2172416/2169856), FastEthernet0/0, serno 48
P 192.168.64.4/30, 1 successors, FD is 2169856, serno 51
    via Connected, Serial0/0
P 192.168.1.0/24, 1 successors, FD is 28160, serno 2
    via Connected, FastEthernet0/0

```

The router topology table for SanJose2 includes two paths to the 192.168.72.0 network. Use the **show ip route** to determine which path is installed in the SanJose2 routing table.

1. Which route is installed?

2. According to the output of the **show ip eigrp topology all-links** command, what is the feasible distance (FD) for the route 192.168.72.0?

Both paths to 192.168.72.0 are listed in the topology table with their computed distance and reported distance in parentheses. The computed distance is listed first.

3. What is the reported distance (RD) of the route to 192.168.72.0 by way of 192.168.1.1?

4. Is this RD greater than, less than, or equal to the FD of the route?

Step 3

To display debugging information about EIGRP feasible successor metrics (FSM) and to observe how EIGRP deals with the loss of a successor to a route, use the **debug eigrp fsm** command.

On the SanJose2 router, issue the command **debug eigrp fsm**.

Next, shut down or unplug the router serial connection to SanJose2. This will cause the SanJose2 router to lose its preferred route to 192.168.72.0 by way of 192.168.64.6.

Examine the **debug eigrp fsm** output for information regarding the route to 192.168.72.0, as shown in the following example:

```

<output omitted>
11:15:55: DUAL: Destination 192.168.72.0/24
11:15:55: DUAL: Find FS for dest 192.168.72.0/24. FD is 1889792, RD is
2297856
11:15:55: DUAL: 192.168.64.6 metric 4294967295/4294967295
11:15:55: DUAL: 192.168.1.1 metric 2300416/2297856 not found Dmin is
2300416
11:15:55: DUAL: Dest 192.168.72.0/24 entering active state.
11:15:55: DUAL: Set reply-status table. Count is 1.
<output omitted>
11:15:55: DUAL: rcvreply: 192.168.72.0/24 via 192.168.1.1 metric
2300416/2297856
11:15:55: DUAL: reply count is 1

```

```
11:15:55: DUAL: Clearing handle 1, count now 0
11:15:55: DUAL: Freeing reply status table
11:15:55: DUAL: Find FS for dest 192.168.72.0/24. FD is 4294967295, RD is
4294967295 found
11:15:55: DUAL: Removing dest 192.168.72.0/24, nexthop 192.168.64.6
11:15:55: DUAL: RT installed 192.168.72.0/24 via 192.168.1.1
11:15:55: DUAL: Send update about 192.168.72.0/24. Reason: metric chg
11:15:55: DUAL: Send update about 192.168.72.0/24. Reason: new if
<output omitted>
```

The highlighted portion of the sample output shows DUAL attempting to locate a feasible successor (FS) for 192.168.72.0. In this case, DUAL failed to find a feasible successor, and the router entered the active state. After querying its EIGRP neighbors, SanJose2 locates and installs a route to 192.168.72.0/24 by way of 192.168.1.1.

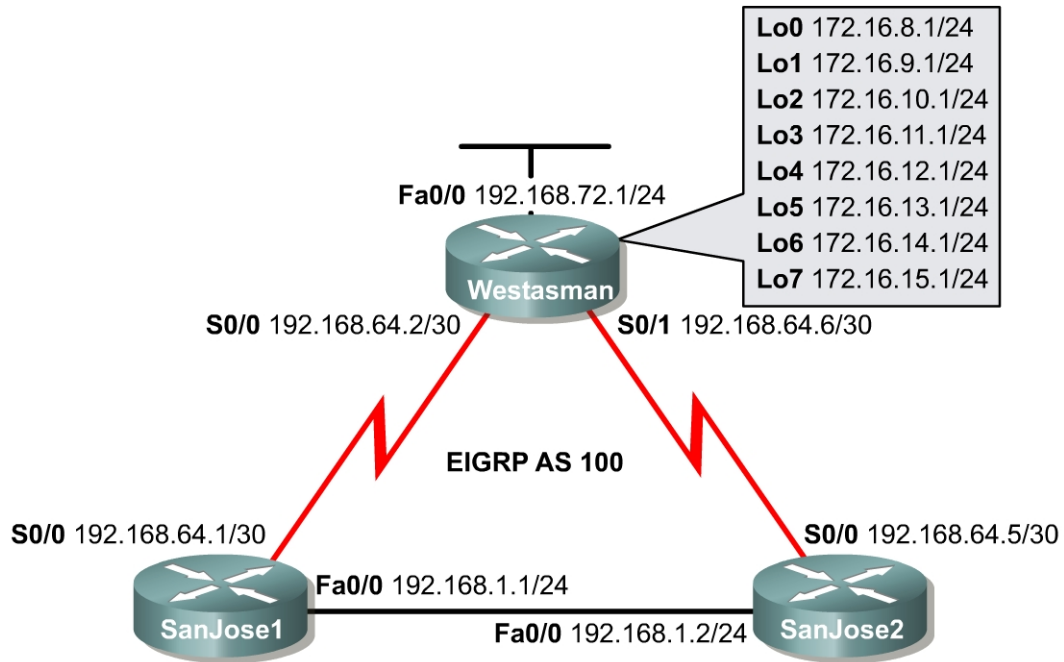
Step 4

Verify that the new route has been installed by using the `show ip route` command.

Bring the SanJose2 router serial interface back up. 192.168.64.6 will be restored as the preferred route to the 192.168.72.0 network.

Save the configuration files for the routers.

Lab 5.7.3 Configuring EIGRP Summarization



Objective

In this lab EIGRP will be configured and the operation will be tested over discontinuous subnets by disabling automatic route summarization. Discontinuous subnets are subnets that are out of order. Finally, EIGRP will be manually configured to use specific summary routes.

Scenario

The International Travel Agency uses VLSM to conserve IP addresses. All LANs are addressed using contiguous subnets, but the company would like to examine the effects of discontinuous subnets using EIGRP for future reference. The existence of multiple networks is simulated by loopback interfaces on the Westasman router. The WAN links are addressed using 192.168.0 with a 30-bit mask.

Because this scheme creates discontinuous subnets, the default summarization behavior of EIGRP should result in incomplete routing tables. The problem should be resolved by disabling the default summarization in EIGRP while maintaining a route summary at the Westasman router with manual route summarization.

Step 1

Build and configure the network according to the diagram. Add the loopback interfaces if the configuration files from the previous lab are used. This configuration requires the use of subnet 0. Therefore, check if this is enabled or enter the `ip subnet-zero` command, depending on which IOS version is used. Configure the Westasman router with eight loopback interfaces using the IP addresses from the diagram. These interfaces simulate the existence of multiple networks behind the Westasman router. Configure EIGRP as indicated for AS 100.

Use `ping` to verify that all serial interfaces can ping each other.

Note: Until the additional configurations are complete, not all networks will appear in the routing table for each router.

Step 2

Use `show ip route` to check the routing table for SanJose1 and SanJose2.

1. Are any routes missing? If so, which ones?

SanJose1 and SanJose2 will install a summary route to 192.168.64.0/24 by way of Null0. EIGRP routers create these summary routes automatically. Because the local router has generated the summary, there is no next hop for the route. Therefore, the router maps this summary route to its null interface.

2. Look again at the routing tables for SanJose1 and SanJose2. What subnet masks appear on each router for the route 192.168.64.0? What are the corresponding next hop interfaces?

Examine the routing table on Westasman.

3. Are any routes missing? If so, which ones?

In order for all subnets to appear in the routing table, the default behavior of EIGRP that automatically summarizes routes must be disabled.

Step 3

Disable the automatic summarization feature on EIGRP.

On each router, issue the following commands:

```
Westasman(config)#router eigrp 100
Westasman(config-router)#no auto-summary
```

After issuing these commands on all three routers, return to the SanJose1 router and type the `show ip route` command.

1. Has anything changed in the SanJose1 routing table?

Finally, to provide the most prescriptive routing updates, use the wildcard mask option for advertising networks in EIGRP. For a given classful network, all subnets need to be advertised with their exact subnet masks. This is completed through the wildcard mask. If just one subnet is advertised without the mask option then all other subnets will be advertised. To illustrate this, on Westasman enter the following commands:

```
Westasman(config)#router eigrp 100
Westasman(config-router)#no network 172.16.0.0
Westasman(config-router)#network 172.16.8.0 0.0.0.255
```

Now, enter **show ip route** on SanJose1:

```
SanJose1#show ip route

<output omitted>

Gateway of last resort is not set

D    192.168.72.0/24 [90/2297856] via 192.168.64.2, 00:02:27, Serial0/0
     172.16.0.0/24 is subnetted, 1 subnets
D    172.16.8.0 [90/2297856] via 192.168.64.2, 00:02:27, Serial0/0
     192.168.64.0/30 is subnetted, 2 subnets
C    192.168.64.0 is directly connected, Serial0/0
D    192.168.64.4 [90/2172416] via 192.168.1.2, 00:03:31,
FastEthernet0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

Next, enter the command **network 172.16.9.0** in EIGRP 100 configuration mode on Westasman. Then enter **show ip route** again on SanJose1:

```
SanJose1#show ip route

<output omitted>

Gateway of last resort is not set

D    192.168.72.0/24 [90/2297856] via 192.168.64.2, 00:05:55, Serial0/0
     172.16.0.0/24 is subnetted, 8 subnets
D    172.16.12.0 [90/2297856] via 192.168.64.2, 00:00:06, Serial0/0
D    172.16.13.0 [90/2297856] via 192.168.64.2, 00:00:06, Serial0/0
D    172.16.14.0 [90/2297856] via 192.168.64.2, 00:00:06, Serial0/0
D    172.16.15.0 [90/2297856] via 192.168.64.2, 00:00:06, Serial0/0
D    172.16.8.0 [90/2297856] via 192.168.64.2, 00:05:55, Serial0/0
D    172.16.9.0 [90/2297856] via 192.168.64.2, 00:00:07, Serial0/0
D    172.16.10.0 [90/2297856] via 192.168.64.2, 00:00:07, Serial0/0
D    172.16.11.0 [90/2297856] via 192.168.64.2, 00:00:07, Serial0/0
     192.168.64.0/30 is subnetted, 2 subnets
C    192.168.64.0 is directly connected, Serial0/0
D    192.168.64.4 [90/2172416] via 192.168.1.2, 00:07:00,
FastEthernet0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

The wildcard mask option in EIGRP allows prescriptive subnet advertisements, as long as each advertised subnet has the mask applied in the configuration.

Before proceeding to Step 4, remove the **network 172.16.8.0 0.0.0.255** and **network 172.16.9.0** commands on Westasman and apply the **network 172.16.0.0** command.

Step 4

Now that auto summarization is disabled, the International Travel Agency's routers should build complete routing tables. Unfortunately, this means that the Westasman router is advertising eight routes that should be summarized for efficiency. Use the manual summarization feature of EIGRP to summarize these addresses.

The Westasman router should be advertising eight subnets:

- 172.16.8.0
- 172.16.9.0
- 172.16.10.0
- 172.16.11.0

- 172.16.12.0
- 172.16.13.0
- 172.16.14.0
- 172.16.15.0

The first 21 bits of these addresses are the same. Therefore, a summary route for all subnets can be created using a /21 prefix which is 255.255.248.0 in dotted-decimal notation.

Because the Westasman router must advertise the summary route to the SanJose1 and SanJose2 routers, enter the following commands on the Westasman router:

```
Westasman(config)#interface s0/0
Westasman(config-if)#ip summary-address eigrp 100 172.16.8.0
255.255.248.0
Westasman(config-if)#interface s0/1
Westasman(config-if)#ip summary-address eigrp 100 172.16.8.0
255.255.248.0
```

These commands configure EIGRP to advertise summary routes for AS 100 through the serial 0/0 and 0/1 interfaces. Verify this configuration by issuing the `show ip protocols` command.

1. Which metric is the Westasman router using for its address summarization?

After verifying manual address summarization on the Westasman router, check the routing tables on SanJose1 and SanJose2.

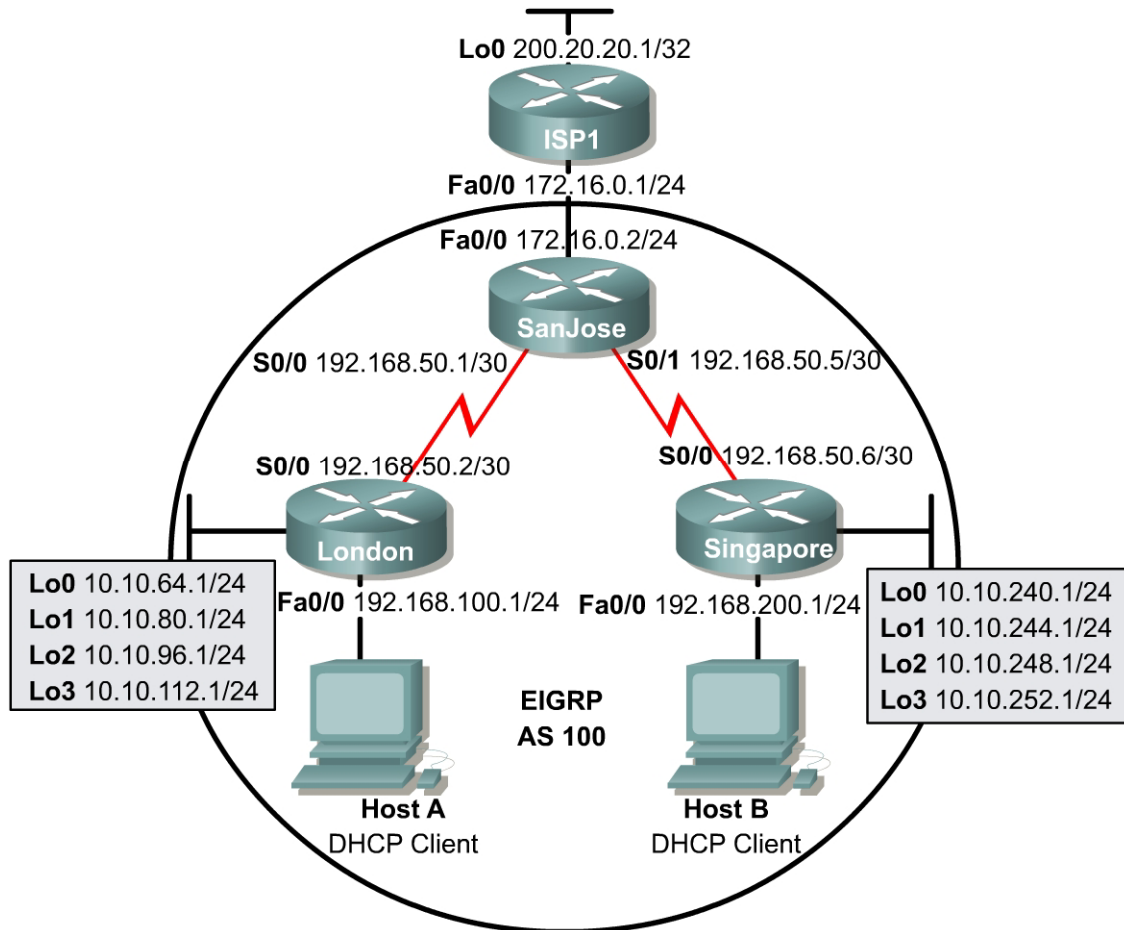
2. What has happened in the SanJose1 and SanJose2 routing tables since they were looked at in Step 3?

From the SanJose1 or SanJose2 router, verify that 192.168.72.1 can be pinged.

It should be possible to ping 172.16.15.1 from the SanJose1 router.

3. Is there a route to 172.16.15.0 in the SanJose1 routing table? Explain.

Lab 5.8.1 EIGRP Challenge Lab



Objective

In this lab an EIGRP network will be configured with Network Address Translation (NAT) and Dynamic Host Configuration Protocol (DHCP) services provided by the routers. EIGRP interface address summarization will be configured to reduce the number of routes in the EIGRP routing tables.

Scenario

The International Travel Agency is currently running EIGRP between its overseas and North American headquarters. The ISP recently raised the price on the static IP addresses. In order to alleviate costs, the task of the network engineer is to implement address conservation technologies such as NAT and DHCP. It is also necessary to implement interface address summarization in order to reduce routing table size. To simplify default routing procedures, SanJose should propagate a persistent default route to both overseas headquarters.

Design Considerations

Before beginning this lab, it is recommended that each router be reloaded after erasing its startup configuration. This prevents problems caused by residual configurations. It is also recommended that the network be built and configured according to the diagram, but do not configure EIGRP until the connectivity between directly connected networks has been confirmed. The respective loopback addresses simulate local networks, so no physical connections need to be made.

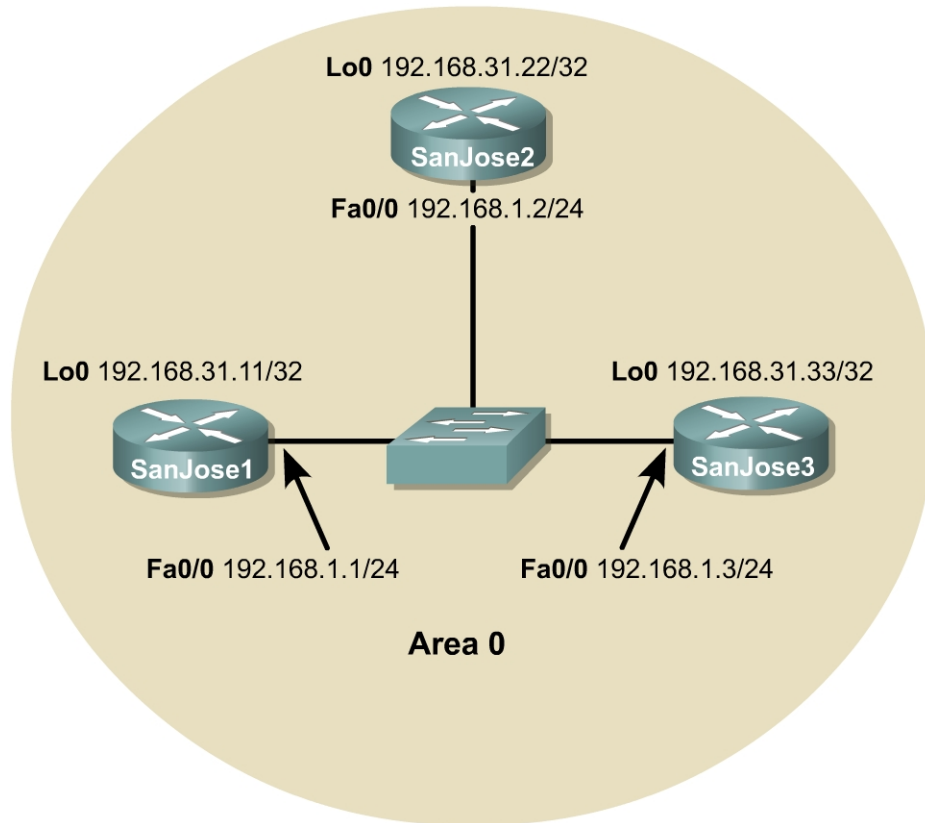
Implementation Requirements

- A successful `ping` to every interface from every router.
- Advertise a persistent default route from SanJose through EIGRP.
- Configure Network Address Translation (NAT) on SanJose.
- Configure Dynamic Host Configuration Protocol (DHCP) service on London and Singapore routers.
- Configure EIGRP interface address summarization on London and Singapore.

Implementation Completion Tests

- Successful `pings` to the loopback interface of ISP1 from Host A and Host B.
- `show run` and `show ip route` for each router.
- `show ip eigrp neighbor` of the SanJose router.
- `show ip eigrp topology all-links` of the SanJose router.
- `show ip dhcp binding` and `show ip dhcp server statistics` of the London and Singapore routers.
- `show ip nat translations` and `show ip nat statistics` of the SanJose router.

Lab 6.9.1 Configuring OSPF



Objective

In this lab, OSPF will be configured on three Cisco routers. First, configure loopback interfaces to provide stable OSPF Router IDs. Then configure the OSPF process and enable OSPF on the appropriate interfaces. After OSPF is enabled, tune the update timers and configure authentication.

Scenario

The backbone of International Travel Agency's (ITA) WAN, located in San Jose, consists of three routers connected using an Ethernet core. Configure these core routers as members of OSPF Area 0. Because the core routers are connected to the Internet, it is decided to implement security, preventing unauthorized routers from joining Area 0. Also, within the core, the network failures need to be realized quickly.

Step 1

Build and configure the network according to the diagram, but do not configure OSPF yet. A switch or hub is required to connect the three routers through Ethernet.

Use `ping` to verify the work and test connectivity between the FastEthernet interfaces.

Step 2

On each router, configure a loopback interface with a unique IP address. Cisco routers use the highest loopback IP address as the OSPF Router ID. In the absence of a loopback interface, the router uses the highest IP address among its active interfaces, which might force a router to change router IDs if an interface goes down. Because loopback interfaces are immune to physical and data link problems, they should be used to derive the router ID. To avoid conflicts with registered network addresses, use private network ranges for the loopback interfaces. Configure the core routers using the following commands:

```
SanJose1(config)#interface loopback 0
SanJose1(config-if)#ip address 192.168.31.11 255.255.255.255

SanJose2(config)#interface loopback 0
SanJose2(config-if)#ip address 192.168.31.22 255.255.255.255

SanJose3(config)#interface loopback 0
SanJose3(config-if)#ip address 192.168.31.33 255.255.255.255
```

Step 3

Now that loopback interfaces are configured, configure OSPF. Use the following commands as an example to configure each router:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#network 192.168.1.0 0.0.0.255 area 0
```

Note: An OSPF process ID is locally significant. It does not need to match neighboring routers. The ID is needed to identify a unique instance of an OSPF database, because multiple processes can run concurrently on a single router.

Step 4

After enabling OSPF routing on each of the three routers, verify its operation using `show` commands. Several important `show` commands can be used to gather OSPF information. First, issue the `show ip protocols` command on any of the three routers, as follows:

```
SanJose1#show ip protocols
Routing Protocol is "ospf 1"
  Sending updates every 0 seconds
  Invalid after 0 seconds, hold down 0, flushed after 0
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  Redistributing: ospf 1
  Routing for Networks:
    192.168.1.0
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: (default is 110)
```

Note: The update timers are set to 0. Updates are not sent at regular intervals. Updates are event driven.

Next, use the `show ip ospf` command, as follows, to get more details about the OSPF process, including the router ID:

```

SanJose1#show ip ospf
Routing Process "ospf 1" with ID 192.168.31.11
Supports only single TOS(TOS0) routes
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x0
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 1
    Area has no authentication
    SPF algorithm executed 5 times
    Area ranges are
    Number of LSA 4. Checksum Sum 0x1CAC4
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0

```

1. What address is the router using as its router ID?

The loopback interface should be seen as the router ID. To see the OSPF neighbors, use the **show ip ospf neighbor** command. The output of this command displays all known OSPF neighbors, including their router IDs, their interface addresses, and their adjacency status. Also issue the **show ip ospf neighbor detail** command, which outputs even more information as follows:

```

SanJose1#show ip ospf neighbor
Neighbor ID   Pri  State           Dead Time   Address
Interface
192.168.31.22  1   FULL/BDR        00:00:36   192.168.1.2
FastEthernet0/0
192.168.31.33  1   FULL/DR         00:00:33   192.168.1.3
FastEthernet0/0

```

```

SanJose1#show ip ospf neighbor detail
Neighbor 192.168.31.22, interface address 192.168.1.2
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.1.3 BDR is 192.168.1.2
  Options 2
  Dead timer due in 00:00:34
  Index 2/2, retransmission queue length 0, number of
retransmission 2
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 192.168.31.33, interface address 192.168.1.3
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.1.3 BDR is 192.168.1.2
  Options 2
  Dead timer due in 00:00:30
  Index 1/1, retransmission queue length 0, number of
retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec

```

2. Based on the output of this command, which router is the Designated Router (DR) on this network?

3. Which router is the Backup Designated Router (BDR)?

Most likely, the router with the highest router ID is the DR, the router with the second-highest router ID is the BDR, and the other router is a DROTHER.

Because each interface on a given router is connected to a different network, some of the key OSPF information is interface specific. Issue the `show ip ospf interface` command for the FastEthernet interface on the router as follows:

```
SanJose1#show ip ospf interface fa0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0
    Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST,
Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
    Designated Router (ID) 192.168.31.33, Interface address
192.168.1.3
    Backup Designated router (ID) 192.168.31.22, Interface address
192.168.1.2
    Timer intervals configured, Hello 10, Dead 40, Wait 40,
Retransmit 5
      Hello due in 00:00:09
      Index 1/1, flood queue length 0
      Next 0x0(0)/0x0(0)
      Last flood scan length is 0, maximum is 1
      Last flood scan time is 0 msec, maximum is 0 msec
      Neighbor Count is 2, Adjacent neighbor count is 2
        Adjacent with neighbor 192.168.31.22 (Backup Designated
Router)
        Adjacent with neighbor 192.168.31.33 (Designated Router)
      Suppress hello for 0 neighbor(s)
```

4. Based on the output of this command, what OSPF network type is the Ethernet interface on the router connected to?

5. What is the Hello update timer set to?

6. What is the Dead timer set to?

Ethernet networks are known to OSPF as broadcast networks. The default timer values are ten (10) second hello updates and 40 second dead intervals.

Step 5

It is decided to adjust OSPF timers so that the core routers will detect network failures in less time. This will increase traffic, but this is less of a concern on the high speed core Ethernet segment than on a busy WAN link. It is also decided that the need for quick convergence at the core outweighs the extra traffic. Manually change the Hello and Dead intervals on SanJose1 as follows:

```
SanJose1(config)#interface fastethernet 0/0
SanJose1(config-if)#ip ospf hello-interval 5
SanJose1(config-if)#ip ospf dead-interval 20
```

These commands set the Hello update timer to five (5) seconds and the Dead interval to 20 seconds. Although the Cisco IOS does not require it, configure the Dead interval to four times the Hello interval. This ensures that routers experiencing temporary link problems can recover and are not declared dead unnecessarily, causing a ripple of updates and recalculations throughout the internetwork.

After the timers are changed on SanJose1, issue the `show ip ospf neighbor` command.

1. Does SanJose1 still show that it has OSPF neighbors?
-

To find out what happened to SanJose1's neighbors, use the IOS `debug` feature by entering the command `debug ip ospf events` as follows:

```
SanJose1#debug ip ospf events
OSPF events debugging is on
SanJose1#
00:08:25: OSPF: Rcv hello from 192.168.31.22 area 0 from
FastEthernet0/0 192.168.1.2
00:08:25: OSPF: Mismatched hello parameters from 192.168.1.2
00:08:25: Dead R 40 C 20, Hello R 10 C 5 Mask R 255.255.255.0
C 255.255.255.0
SanJose1#
00:08:32: OSPF: Rcv hello from 192.168.31.33 area 0 from
FastEthernet0/0 192.168.1.3
00:08:32: OSPF: Mismatched hello parameters from 192.168.1.3
00:08:32: Dead R 40 C 20, Hello R 10 C 5 Mask R 255.255.255.0
C 255.255.255.0
```

2. According to the `debug` output, what is preventing SanJose1 from forming relationships with the other two OSPF routers in Area 0?
-

The Hello and Dead intervals must be the same before routers within an area can form neighbor adjacencies.

Turn off `debug` using `undebug all`, or just `u all`.

```
SanJose1#undebug all
All possible debugging has been turned off
```

The Hello and Dead intervals are declared in Hello packet headers. In order for OSPF routers to establish a relationship, their Hello and Dead intervals must match.

Configure the SanJose2 and SanJose3 Hello and Dead timers to match the timers on SanJose1. Before continuing, verify that these routers can now communicate by checking the OSPF neighbor table.

Step 6

Whether intentional, or by accident, no unauthorized routers exchanging updates within Area 0 are wanted. This is accomplished by adding encrypted authentication to each OSPF packet header. Select message digest (MD5) authentication. This mode of authentication sends a message digest, or hash, in place of the password. OSPF neighbors must be configured with the same message digest key number, encryption type, and password in order to authenticate using the hash.

To configure a message digest password for SanJose1 to use on its Ethernet interface, use the following commands:

```
SanJose1(config)#interface fastethernet 0/0
SanJose1(config-if)#ip ospf message-digest-key 1 md5 7 itsasecret
SanJose1(config-if)#router ospf 1
SanJose1(config-router)#area 0 authentication message-digest
```

After entering these commands, wait 20 seconds, and then issue the `show ip ospf neighbor` command on SanJose1.

1. Does SanJose1 still show that it has OSPF neighbors?

Use the `debug ip ospf events` command to determine why SanJose1 does not see its neighbors:

```
SanJose1#debug ip ospf events
OSPF events debugging is on
SanJose1#
00:49:32: OSPF: Send with youngest Key 1
SanJose1#
00:49:33: OSPF: Rcv pkt from 192.168.31.33, FastEthernet0/0 :
Mismatch Authentication type. Input packet specified type
0, we use type 2
00:49:33: OSPF: Rcv pkt from 192.168.31.22, FastEthernet0/0 :
Mismatch Authentication type. Input packet specified type , we use type 2
SanJose1#u all
All possible debugging has been turned off
```

Again, it is seen that OSPF routers will not communicate unless certain configurations match. In this case, the routers are not communicating because the authentication fields in the OSPF packet header are different.

Correct this problem by configuring authentication on the other two routers. Remember that the same key number, encryption type, and password must be used on each router.

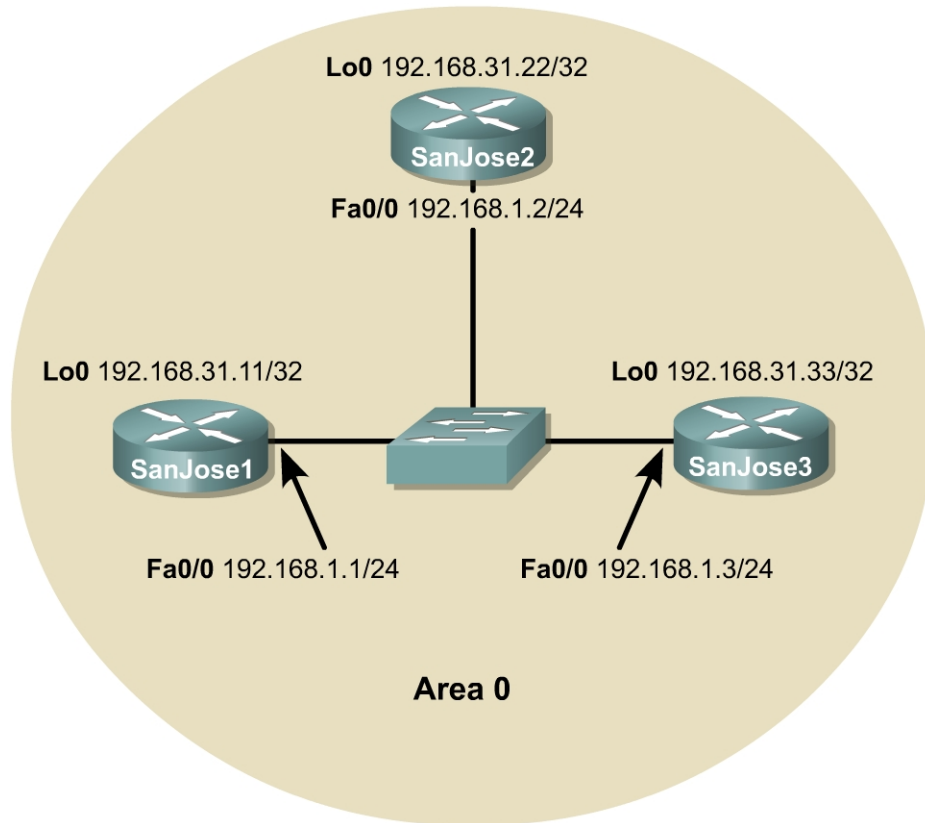
After the configurations are complete, verify that the routers can communicate by using the `show ip ospf neighbors` command.

```
SanJose1#show ip ospf neighbors
Neighbor ID      Pri   State           Dead Time   Address
Interface
192.168.31.33    1     FULL/DR         00:00:16   192.168.1.3
FastEthernet0/0
192.168.31.22    1     FULL/BDR        00:00:15   192.168.1.2
FastEthernet0/0
```

Step 7

Save the configuration files for each router. These configurations will be used to begin the next lab. At the conclusion of each lab, it is recommended that the configuration file for each router is copied and saved for future reference.

Lab 6.9.2a Examining the DR/BDR Election Process



Objective

In this lab, observe the OSPF DR and BDR election processing using `debug` commands. Then assign each OSPF interface a priority value to force the election of a specific router as a DR.

Scenario

The backbone of International Travel Agency's enterprise network consists of three routers connected using an Ethernet core. SanJose1 has more memory and processing power than the other core routers. Unfortunately, other core routers are continually elected as the DR under the default settings. In the interest of optimization, ensure that SanJose1 is elected the DR, because it is best suited to handle associated extra duties, including management of Link State Advertisements (LSA) for Area 0. Investigate and correct this situation.

Step 1

Build and configure the network according to the diagram. Use the configuration files from the previous lab if available. Configure OSPF on all Ethernet interfaces. A switch or hub is required to connect the three routers through Ethernet. Be sure to configure each router with the loopback interface and IP address shown in the diagram.

Use `ping` to verify the work and test connectivity between the Ethernet interfaces.

Step 2

Use the `show ip ospf neighbor detail` command as follows to verify that the OSPF routers have formed adjacencies:

Note: The routers are still using authentication for the previous lab setup.

```
SanJose3#show ip ospf neighbor detail
Neighbor 192.168.31.11, interface address 192.168.1.1
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 1, State is FULL, 12 state changes
  DR is 192.168.1.3 BDR is 192.168.1.2
  Options 2
  Dead timer due in 00:00:17
  Index 2/2, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 192.168.31.22, interface address 192.168.1.2
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.1.3 BDR is 192.168.1.2
  Options 2
  Dead timer due in 00:00:15
  Index 1/1, retransmission queue length 0, number of retransmission 5
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

1. Which router is the DR? Why?

2. Which router is the BDR? Why?

Recall that router IDs determine the DR and BDR.

Step 3

If the network is configured according to the diagram, SanJose1 will not be the DR. Temporarily shut down SanJose3, which has the highest router ID, 192.168.31.33, and observe the DR/BDR election process. To observe the election, issue the following `debug` command on SanJose1:

```
SanJose1#debug ip ospf adj
```

Now that OSPF adjacency events will be logged to SanJose1 console, remove SanJose3 from the OSPF network by shutting down its FastEthernet interface as follows:

```
SanJose3(config)#interface fastethernet 0/0
SanJose3(config-if)#shutdown
Watch the debug output on SanJose1:
SanJose1#
00:48:47: OSPF: Rcv hello from 192.168.31.22 area 0 from
FastEthernet0/0 192.168.1.2
00:48:47: OSPF: Neighbor change Event on interface FastEthernet0/0
00:48:47: OSPF: DR/BDR election on FastEthernet0/0
00:48:47: OSPF: Elect BDR 192.168.31.11
00:48:47: OSPF: Elect DR 192.168.31.22
00:48:47: OSPF: Elect BDR 192.168.31.11
00:48:47: OSPF: Elect DR 192.168.31.22
00:48:47: DR: 192.168.31.22 (Id) BDR: 192.168.31.11 (Id)
00:48:47: OSPF: Remember old DR 192.168.31.33 (id)
00:48:47: OSPF: End of hello processing
```

1. Who is elected DR? Why?

The former BDR is promoted to DR.

In the `debug` output, look for a statement about remembering the “old DR”. Unless SanJose1 and SanJose2 are powered off, they will remember that SanJose3 was the old DR. When SanJose3 comes back online, these routers will allow SanJose3 to reassume its role as DR.

```
SanJose1#
00:51:32: OSPF: Rcv hello from 192.168.31.22 area 0 from
FastEthernet0/0 192.168.1.2
00:51:32: OSPF: End of hello processing
00:51:33: OSPF: Rcv hello from 192.168.31.33 area 0 from
FastEthernet0/0 192.168.1.3
00:51:33: OSPF: 2 Way Communication to 192.168.31.33 on
FastEthernet0/0, state 2WAY
00:51:33: OSPF: Neighbor change Event on interface FastEthernet0/0
00:51:33: OSPF: DR/BDR election on FastEthernet0/0
00:51:33: OSPF: Elect BDR 192.168.31.11
00:51:33: OSPF: Elect DR 192.168.31.33
00:51:33: DR: 192.168.31.33 (Id) BDR: 192.168.31.11 (Id)
00:51:33: OSPF: Send DBD to 192.168.31.33 on FastEthernet0/0 seq
0x21CF opt 0x2 flag 0x7 len 32
00:51:33: OSPF: Send with youngest Key 1
00:51:33: OSPF: Remember old DR 192.168.31.22 (id)
00:51:33: OSPF: End of hello processing
```

Step 4

At this point, SanJose1 should have assumed the role of BDR. Bring SanJose3 back online, and observe the new election process.

1. SanJose3 will assume its former role as DR. Who is elected BDR? Why?

SanJose1 remains the BDR even though SanJose2 has the higher router ID.

Step 5

A router can be manipulated to become the DR by using two methods. The router ID could be changed to a higher number, but that could confuse the loopback addressing system and affect elections on other interfaces. The same router ID is used for every network that a router is a member of. For example, if an OSPF router has an exceptionally high router ID, it could win the election on every multiaccess interface and, as a result, do triple or quadruple duty as a DR.

Instead of reconfiguring router IDs, manipulate the election by configuring OSPF priority values. Because priorities are an interface-specific value, they provide finer control of the OSPF internetwork by allowing a router to be the DR in one network and a DR other in another. Priority values are the first consideration in the DR election, with the highest priority winning. Values can range from 0 to 255. A value of 0 indicates that the interface will not participate in an election. Use the `show ip ospf interface` command as follows to examine the current priority values of the Ethernet interfaces on the three routers:

```
SanJose1#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
Internet Address 192.168.1.1/24, Area 0
Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
Backup Designated router (ID) 192.168.31.11, Interface address 192.168.1.1
Timer intervals configured, Hello 5, Dead 20, Wait 20, Retransmit 5
```

```

    Hello due in 00:00:03
    Index 1/1, flood queue length 0
    Next 0x0(0)/0x0(0)
    Last flood scan length is 1, maximum is 2
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 2, Adjacent neighbor count is 2
      Adjacent with neighbor 192.168.31.33 (Designated Router)
      Adjacent with neighbor 192.168.31.22
    Suppress hello for 0 neighbor(s)
    Message digest authentication enabled
    Youngest key id is 1

```

1. What is the priority value of these interfaces?

The default priority is one (1). Because all have equal priority, router ID is used to determine the DR and BDR.

Modify the priority values so that SanJose1 will become the DR and SanJose2 will become the BDR, regardless of their router ID. Use the following commands:

```

SanJose1(config)#interface fastethernet 0/0
SanJose1(config-if)#ip ospf priority 200

SanJose2(config)#interface fastethernet 0/0
SanJose2(config-if)#ip ospf priority 100

```

In order to reset the election process, write the configuration for each router to NVRAM and reload SanJose1, SanJose2, and SanJose3. Issue the following commands at each router:

```

SanJose1#copy running-config startup-config
SanJose1#reload

```

When the routers finish reloading, try to observe the OSPF election on SanJose1 by using the **debug ip ospf adj** command. Also, verify the configuration by issuing the **show ip ospf interface** command at both SanJose1 and SanJose2.

```

SanJose1#debug ip ospf adj
00:01:20: OSPF: Rcv hello from 192.168.31.22 area 0 from
FastEthernet0/0 192.168.1.2
00:01:20: OSPF: Neighbor change Event on interface FastEthernet0/0
00:01:20: OSPF: DR/BDR election on FastEthernet0/0
00:01:20: OSPF: Elect BDR 192.168.31.22
00:01:20: OSPF: Elect DR 192.168.31.11
00:01:20: DR: 192.168.31.11 (Id) BDR: 192.168.31.22 (Id)
00:01:20: OSPF: End of hello processing

SanJose2#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
 Internet Address 192.168.1.2/24, Area 0
 Process ID 1, Router ID 192.168.31.22, Network Type BROADCAST, Cost: 1
 Transmit Delay is 1 sec, State BDR, Priority 100
 Designated Router (ID) 192.168.31.11, Interface address 192.168.1.1
 Backup Designated router (ID) 192.168.31.22, Interface address 192.168.1.2
 Timer intervals configured, Hello 5, Dead 20, Wait 20,
 Retransmit 5
 Hello due in 00:00:03
 Index 1/1, flood queue length 0
 Next 0x0(0)/0x0(0)
 Last flood scan length is 1, maximum is 1
 Last flood scan time is 0 msec, maximum is 0 msec
 Neighbor Count is 2, Adjacent neighbor count is 2
   Adjacent with neighbor 192.168.31.33
   Adjacent with neighbor 192.168.31.11 (Designated Router)
 Suppress hello for 0 neighbor(s)
 Message digest authentication enabled
 Youngest key id is 1

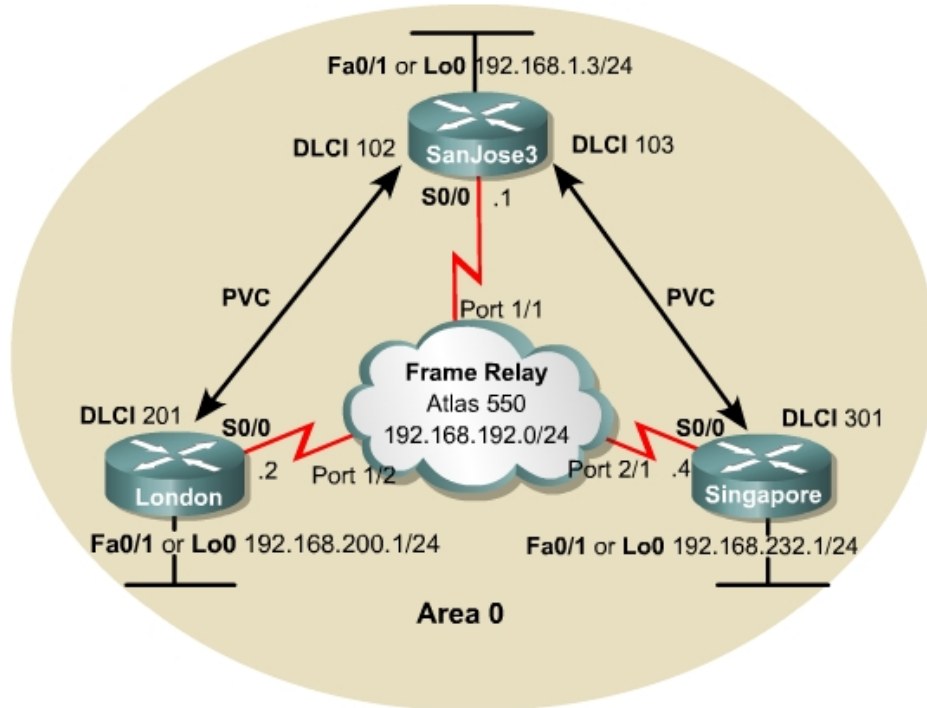
```

After the election is complete, verify that SanJose1 and SanJose2 have assumed the correct roles by using the `show ip ospf neighbor detail` command. Troubleshoot, if necessary.

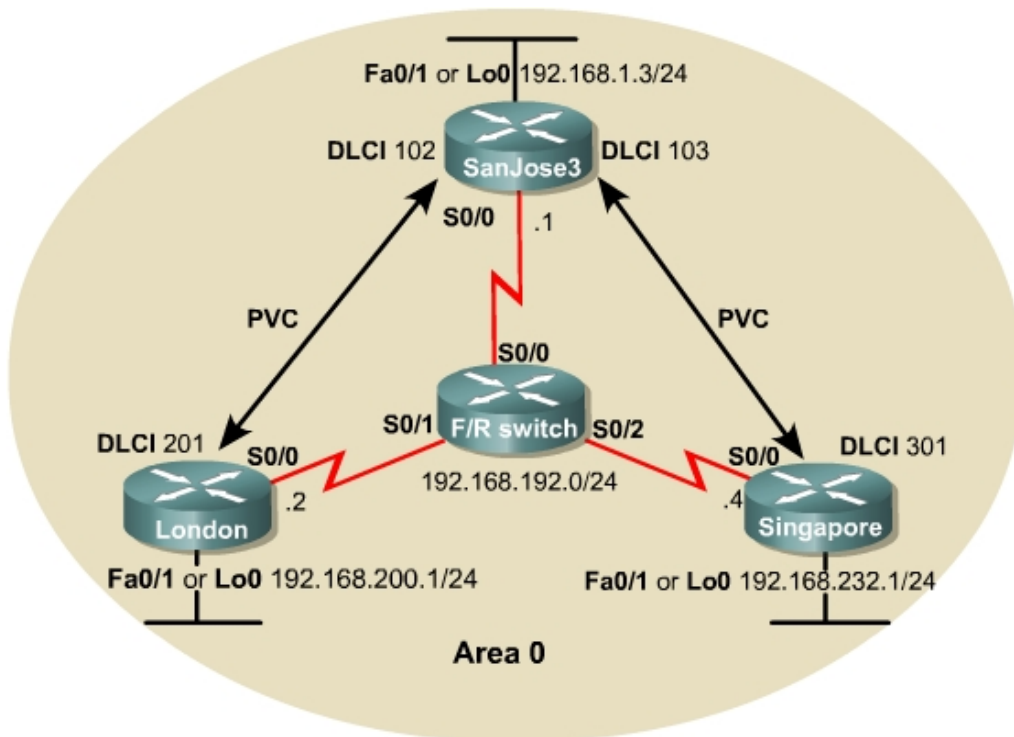
```
SanJose3#show ip ospf neighbor detail
Neighbor 192.168.31.22, interface address 192.168.1.2
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 100, State is FULL, 6 state changes
  DR is 192.168.1.1 BDR is 192.168.1.2
  Options 2
  Dead timer due in 00:00:17
  Index 2/2, retransmission queue length 0, number of retransmission 0
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 0, maximum is 0
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 192.168.31.11, interface address 192.168.1.1
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 200, State is FULL, 6 state changes
  DR is 192.168.1.1 BDR is 192.168.1.2
  Options 2
  Dead timer due in 00:00:19
  Index 1/1, retransmission queue length 0, number of retransmission 2
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

Note that the order in which routers join an area can have the most significant effect on which routers are elected as DR and BDR. An election is necessary only when a DR or BDR does not exist in the network. As a router starts its OSPF process, it checks the network for an active DR and BDR. If they exist, the new router becomes a DROther, regardless of its priority or router ID. Remember, the roles of DR and BDR were created for efficiency. New routers in the network should not force an election when adjacencies are already optimized. However, there is an exception. A known bug in some IOS versions allows a 'new' router with higher election credentials to force an election and assume the role of DR.

Lab 6.9.2b Configuring Point-to-Multipoint OSPF Over Frame Relay



Alternative



Objective

In this lab, configure OSPF as a point-to-multipoint network type so that it operates efficiently over a hub-and-spoke Frame Relay topology.

Scenario

International Travel Agency has just connected two regional headquarters to San Jose using Frame Relay in a hub-and-spoke topology. OSPF routing is to be configured over this type of network, which is known for introducing complications into OSPF adjacency relationships. To avoid these complications, manually override the Non-Broadcast Multi-Access (NBMA) OSPF network type and configure OSPF to run as a point-to-multipoint network. In this environment, no DR or BDR is elected.

Step 1

Cable the network according to the diagram. Configure the FastEthernet or Loopback interface for each router as shown, but leave the serial interfaces and OSPF routing unconfigured for now.

Until Frame Relay is configured, `ping` is not useful for testing connectivity.

Note: This lab requires another router or device to act as a Frame Relay switch. The first diagram assumes that an Adtran Atlas 550 will be used, which is preconfigured. The second diagram assumes that a router will be configured with at least three serial interfaces as a Frame Relay switch. See the configuration at the end of this lab for an example of how to configure a router as a Frame Relay switch. If desired, copy the configuration to a 2600 router for use in this lab.

The Adtran Atlas 550 has a fixed internal configuration that is used for all CCNP 1-4 Version 3.0 labs. The Atlas Frame Relay configuration implements a full mesh topology. To implement a hub-and-spoke topology for this lab, both Frame Relay maps on London reference DLCI 201. Similarly, both Frame Relay maps on Singapore reference DLCI 301. DLCI 201 on London and DLCI 301 on Singapore cause the Atlas to switch frames to the hub router, SanJose3. Using Frame Relay maps on the spoke routers automatically disables Frame Relay inverse ARP on the serial interfaces, thus preventing inadvertent dynamic Frame Relay maps from being formed directly between the spoke routers (which would circumvent the hub router).

Step 2

SanJose3 acts as the hub in this hub-and-spoke network. It reaches London and Singapore through two separate PVCs. Configure Frame Relay on SanJose3's serial interface shown as follows:

```
SanJose3(config)#interface serial 0/0
SanJose3(config-if)#encapsulation frame-relay
SanJose3(config-if)#ip address 192.168.192.1 255.255.255.0
SanJose3(config-if)#no shutdown
SanJose3(config-if)#frame-relay map ip 192.168.192.2 102 broadcast
SanJose3(config-if)#frame-relay map ip 192.168.192.4 103 broadcast
SanJose3(config-if)#ip ospf network point-to-multipoint
```

Notice that this configuration includes `frame-relay map` commands, which are also used on multipoint Frame Relay subinterfaces. These commands are used here with the `broadcast` keyword so that Frame Relay can process broadcast traffic. Without this configuration, OSPF multicast traffic would not be forwarded correctly by the SanJose3 router.

Configure the serial interface for London as follows:

```
London(config)#interface serial 0/0
London(config-if)#encapsulation frame-relay
London(config-if)#ip address 192.168.192.2 255.255.255.0
London(config-if)#no shutdown
London(config-if)#frame-relay map ip 192.168.192.1 201 broadcast
London(config-if)#frame-relay map ip 192.168.192.4 201 broadcast
London(config-if)#ip ospf network point-to-multipoint
```

Finally, configure the serial interface for Singapore as follows:

```
Singapore(config)#interface serial 0/0
Singapore(config-if)#encapsulation frame-relay
Singapore(config-if)#ip address 192.168.192.4 255.255.255.0
Singapore(config-if)#no shutdown
Singapore(config-if)#frame-relay map ip 192.168.192.1 301 broadcast
Singapore(config-if)#frame-relay map ip 192.168.192.2 301 broadcast
Singapore(config-if)#ip ospf network point-to-multipoint
```

Verify Frame Relay operation with a **ping** command from each router to the other two. Use **show frame-relay pvc** and **show frame-relay map** to troubleshoot connectivity problems. Rebooting the Frame Relay switch might also solve connectivity issues.

```
SanJose3#show frame-relay pvc
```

```
PVC Statistics for interface Serial0/0 (Frame Relay DTE)
```

	Active	Inactive	Deleted	Static
Local	2	0	0	0
Switched	0	0	0	0
Unused	0	1	0	0

```
DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0/0
```

```
input pkts 111          output pkts 112          in bytes 10936
out bytes 6259          dropped pkts 0           in pkts dropped 0
out pkts dropped 0     out bytes dropped 0
in FECN pkts 0         in BECN pkts 0          out FECN pkts 0
out BECN pkts 0        in DE pkts 0             out DE pkts 0
out bcast pkts 19      out bcast bytes 1428
pvc create time 00:10:58, last time pvc status changed 00:08:38
```

```
DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0/0
```

```
input pkts 65           output pkts 56           in bytes 5136
out bytes 3752          dropped pkts 0           in pkts dropped 0
out pkts dropped 0     out bytes dropped 0
in FECN pkts 0         in BECN pkts 0          out FECN pkts 0
out BECN pkts 0        in DE pkts 0             out DE pkts 0
out bcast pkts 19      out bcast bytes 1428
pvc create time 00:11:01, last time pvc status changed 00:08:41
```

```
DLCI = 104, DLCI USAGE = UNUSED, PVC STATUS = INACTIVE, INTERFACE =
Serial0/0
```

```
input pkts 0           output pkts 0           in bytes 0
out bytes 0            dropped pkts 0           in pkts dropped 0
out pkts dropped 0     out bytes dropped 0
in FECN pkts 0         in BECN pkts 0          out FECN pkts 0
out BECN pkts 0        in DE pkts 0             out DE pkts 0
out bcast pkts 0       out bcast bytes 0
switched pkts 0
Detailed packet drop counters:
```

```

no out intf 0          out intf down 0          no out PVC 0
in PVC down 0         out PVC down 0          pkt too big 0
shaping Q full 0     pkt above DE 0         policing drop 0
pvc create time 00:10:22, last time pvc status changed 00:09:49

```

```

SanJose3#show frame-relay map
Serial0/0 (up): ip 192.168.192.2 dlci 102(0x66,0x1860), static,
                broadcast,
                CISCO, status defined, active
Serial0/0 (up): ip 192.168.192.4 dlci 103(0x67,0x1870), static,
                broadcast,
                CISCO, status defined, active

```

Step 3

Configure OSPF to run over this point-to-multipoint network. Issue the following commands at the appropriate router:

```

London(config)#router ospf 1
London(config-router)#network 192.168.200.0 0.0.0.255 area 0
London(config-router)#network 192.168.192.0 0.0.0.255 area 0

SanJose3(config)#router ospf 1
SanJose3(config-router)#network 192.168.1.0 0.0.0.255 area 0
SanJose3(config-router)#network 192.168.192.0 0.0.0.255 area 0

Singapore(config)#router ospf 1
Singapore(config-router)#network 192.168.232.0 0.0.0.255 area 0
Singapore(config-router)#network 192.168.192.0 0.0.0.255 area 0

```

Verify the OSPF configuration by issuing the **show ip route** command at each of the routers:

```

London#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

    192.168.192.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.192.0/24 is directly connected, Serial0/0
O       192.168.192.1/32 [110/781] via 192.168.192.1, 00:10:04, Serial0/0
O       192.168.192.4/32 [110/845] via 192.168.192.1, 00:10:04, Serial0/0
C       192.168.200.0/24 is directly connected, Loopback0
    192.168.232.0/32 is subnetted, 1 subnets
O       192.168.232.1 [110/846] via 192.168.192.1, 00:10:04, Serial0/0
    192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.3 [110/782] via 192.168.192.1, 00:10:04, Serial0/0

```

If each router has a complete table, including routes to 192.168.1.0 /24, 192.168.200.0 /24, and 192.168.232.0 /24, OSPF has been successfully configured to operate over Frame Relay.

Test these routes by pinging the FastEthernet interfaces of each router from London's console.

Finally, issue the `show ip ospf neighbor detail` command at any router console:

```
SanJose3#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.200.1	1	FULL/ -	00:01:39	192.168.192.2	Serial0/0
192.168.232.1	1	FULL/ -	00:01:36	192.168.192.4	Serial0/0

```
SanJose3#show ip ospf neighbor detail
```

```
Neighbor 192.168.200.1, interface address 192.168.192.2
  In the area 0 via interface Serial0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 0.0.0.0 BDR is 0.0.0.0
  Options is 0x42
  Dead timer due in 00:01:49
  Neighbor is up for 00:12:25
  Index 2/2, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 192.168.232.1, interface address 192.168.192.4
  In the area 0 via interface Serial0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 0.0.0.0 BDR is 0.0.0.0
  Options is 0x42
  Dead timer due in 00:01:46
  Neighbor is up for 00:12:25
  Index 1/1, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

1. Is there a DR for this network? Why or why not?

There is no DR. The configuration of OSPF point-to-multipoint network type on serial interfaces creates a logical multi-access network over physical point-to-point links. No efficiency would be realized by electing a DR.

Router as Frame Relay Switch Configuration

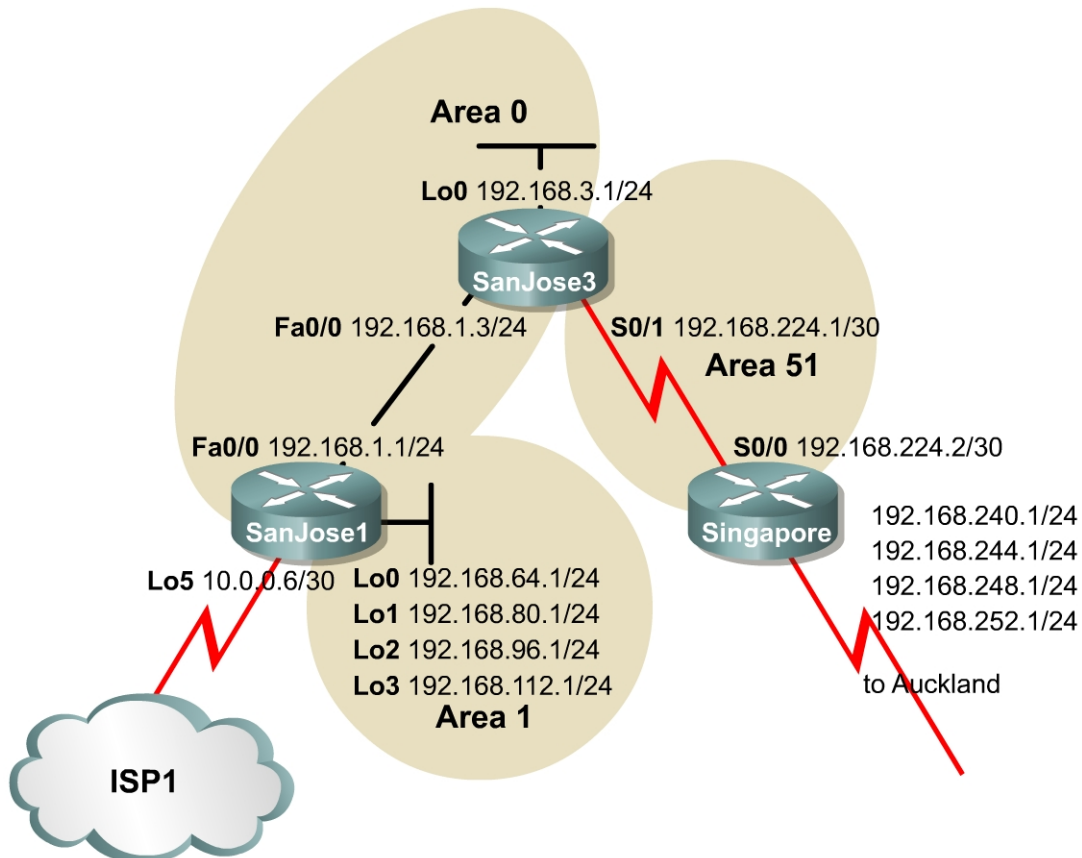
The following example can be used to configure a router as the Frame Relay switch:

```
Frame-Switch#show run
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Frame-Switch
!
ip subnet-zero
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
frame-relay switching
!
process-max-time 200
!
interface Serial0/0
  no ip address
  no ip directed-broadcast
  encapsulation frame-relay
  clockrate 56000
  cdp enable
  frame-relay intf-type dce
  frame-relay route 103 interface Serial0/2 301
  frame-relay route 102 interface Serial0/1 201
!
interface Serial0/1
  no ip address
  no ip directed-broadcast
  encapsulation frame-relay
  clockrate 56000
  cdp enable
  frame-relay intf-type dce
  frame-relay route 201 interface Serial0/0 102
!
interface Serial0/2
  no ip address
  no ip directed-broadcast
  encapsulation frame-relay
  clockrate 56000
  cdp enable

  frame-relay intf-type dce
  frame-relay route 301 interface Serial0/0 103
!
interface Serial0/3
  no ip address
  no ip directed-broadcast
  shutdown
!
ip classless
no ip http server
!
line con 0
  password cisco
  login
  transport input none
line aux 0
line vty 0 4
  password cisco
```

```
login
!  
no scheduler allocate  
end
```

Lab 6.9.3 Configuring Multiarea OSPF



Objective

In this lab configure a multiarea OSPF operation, interarea summarization, external route summarization, and default routing.

Scenario

International Travel Agency (ITA) maintains a complex OSPF environment. The task is to optimize OSPF routing, which creates the need to design and configure multiarea OSPF on the key routers connecting Asian regional headquarters to San Jose corporate headquarters and its local sites.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol yet.

Note: Ignore the ISP1 cloud for now. Also, the Singapore-to-Auckland networks 192.168.240.0/24, 192.168.244.0/24, 192.168.248.0/24, and 192.168.252.0/24 will be configured as static routes to Null0 in Steps 5 and 6, so should be deferred until then.

Configure each router with the loopback address indicated in the diagram. Be sure to configure SanJose1 with additional loopbacks of Lo0, Lo1, Lo2, and Lo3. These loopback interfaces simulate the serial links to local San Jose sites: Westasman, Baypointe, Vista, and Eastasman.

Use **ping** to test connectivity between all interfaces. Each router should be able to ping its link partner.

Step 2

Configure multiarea OSPF. On SanJose1, configure FastEthernet 0/0 as a member of Area 0 and all other interfaces as members of Area 1 by using the following commands:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#network 192.168.1.0 0.0.0.255 area 0
SanJose1(config-router)#network 192.168.64.0 0.0.63.255 area 1
```

The last command conveniently enables all loopback interfaces on SanJose1 to participate in the OSPF process.

On SanJose3, configure E0 and Lo0 as members of Area 0, but configure Serial 0/0 as part of Area 51 as follows:

```
SanJose3(config)#router ospf 1
SanJose3(config-router)#network 192.168.1.0 0.0.0.255 area 0
SanJose3(config-router)#network 192.168.224.0 0.0.0.3 area 51
SanJose3(config-router)#network 192.168.3.0 0.0.0.255 area 0
```

Finally, on Singapore, configure Serial 0/0 to belong to Area 51 as follows:

```
Singapore(config)#router ospf 1
Singapore(config-router)#network 192.168.224.0 0.0.0.3 area 51
```

Issue the **show ip ospf** command as follows on all three routers:

```
SanJose3#show ip ospf
Routing Process "ospf 1" with ID 192.168.3.1
Supports only single TOS(TOS0) routes
It is an area border router
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x0
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 2
    Area has no authentication
    SPF algorithm executed 6 times
    Area ranges are
    Number of LSA 8. Checksum Sum 0x42B0C
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
  Area 51
    Number of interfaces in this area is 1
    Area has no authentication
    SPF algorithm executed 4 times
    Area ranges are
    Number of LSA 8. Checksum Sum 0x59B4F
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

1. According to the output of the `show ip ospf` command, which of these routers is an ABR?

Area border routers connect one or more adjacent OSPF areas to the backbone area.

2. Are there any ASBRs?

Autonomous system border routers connect external, non-OSPF, networks to the OSPF internetwork.

Issue the `show ip ospf neighbor detail` command on SanJose3:

```
SanJose3#show ip ospf neighbor detail
Neighbor 192.168.112.1, interface address 192.168.1.1
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.1.1 BDR is 192.168.1.3
  Options 2
  Dead timer due in 00:00:33
  Index 1/1, retransmission queue length 0, number of retransmission 2
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 192.168.252.1, interface address 192.168.224.2
  In the area 51 via interface Serial0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 0.0.0.0 BDR is 0.0.0.0
  Options 2
  Dead timer due in 00:00:32
  Index 1/2, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

3. Is there a DR election on the 192.168.1.0/24 network? Why or why not?

4. Is there a DR election on the 192.168.224.0/30 network? Why or why not?

These are different types of OSPF networks. The Ethernet core network is designated as “broadcast”, and the WAN link between SanJose3 and Singapore is designated “point-to-point”. On a point-to-point link, there is no need to elect a DR to reduce the number of adjacencies, because only two routers exist in the network. The Ethernet segment has only two routers. However, a DR and BDR are elected because neighbor routers could join the area.

Step 3

Check the routing table on each router. The output should show OSPF inter-area routes, which are denoted by an O and other routes denoted by an IA.


```

Singapore#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
      i - IS-IS, 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
  192.168.224.0/30 is subnetted, 1 subnets
C      192.168.224.0 is directly connected, Serial0/0
  192.168.64.0/32 is subnetted, 1 subnets
O IA   192.168.64.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
  192.168.80.0/32 is subnetted, 1 subnets
O IA   192.168.80.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
  192.168.96.0/32 is subnetted, 1 subnets
O IA   192.168.96.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
  192.168.112.0/32 is subnetted, 1 subnets
O IA   192.168.112.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
O IA   192.168.1.0/24 [110/782] via 192.168.224.1, 00:01:31, Serial0/0
  192.168.3.0/32 is subnetted, 1 subnets
O IA   192.168.3.1 [110/782] via 192.168.224.1, 00:01:31, Serial0/0

```

1. What does IA stand for?

Check the codes listed with the routing table. Interarea routes point to networks in separate areas within the same OSPF autonomous system.

Verify that the routing tables are complete. Notice that SanJose1's loopback interfaces appear in the other routing tables of other routers that have a 32-bit mask. Any route with a 32-bit mask is called a 'host route', because it is a route to a host, not to a network. OSPF does not advertise loopback interfaces as if they were connected to a network.

2. How many host routes are in Singapore's table?

There should be a host route for every remote loopback advertised through OSPF.

Verify connectivity. From Singapore, ping SanJose3's Lo0 interface (192.168.3.1) and SanJose1's Lo2 interface (192.168.96.1).

Step 4

To reduce routing table entries it is necessary to implement interarea route summarization throughout the internetwork. Start by configuring SanJose1 to summarize the networks for Area 1 and advertise this summary route to Area 0.

On SanJose1, enter the following commands to perform interarea summarization:

```

SanJose1(config)#router ospf 1
SanJose1(config-router)#area 1 range 192.168.64.0 255.255.192.0

```

When finished configuring the summary address, check the routing tables of SanJose3 and Singapore. If the expected changes do not occur, save and reload the routers.

```
Singapore#show ip route
```

```
<output omitted>
```

```
    192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
O IA 192.168.1.0/24 [110/782] via 192.168.224.1, 00:01:38, Serial0/0
    192.168.3.0/32 is subnetted, 1 subnets
O IA   192.168.3.1 [110/782] via 192.168.224.1, 00:01:38, Serial0/0
O IA 192.168.64.0/18 [110/783] via 192.168.224.1, 00:00:02, Serial0/0
```

1. What happened to the host routes?

How many host routes does Singapore have?

2. Singapore should still be able to ping 192.168.96.1. Why?

3. What is the destination IP network of the ICMP request?

Singapore should have only one host route of 192.168.3.1/32 from SanJose3 Lo0. A host route points to one host. A network route points to multiple hosts in one broadcast domain. A summarized route points to a numerically contiguous series of networks.

Step 5

Singapore must be configured to redistribute external routes from Auckland into the OSPF autonomous system. For the purposes of this lab, simulate the Auckland connection by configuring a static route in Singapore to the Auckland LAN (192.168.248.0/24). Use the following commands:

```
Singapore(config)#ip route 192.168.248.0 255.255.255.0 null0
Singapore(config)#router ospf 1
Singapore(config-router)#redistribute static
```

Because the route to 192.168.248.0/24 is imaginary, null0 is used as the exit interface. The **redistribute** command imports the static route into OSPF. Routes originated from anything but OSPF are considered external to the OSPF database. By default, when Singapore redistributes into Area 51, it creates and advertises Type 2 (E2) external routes using Type 5 LSAs.

The use of static routes to a null interface is a commonly used routing trick. Typically this technique is used to initialize or advertise a supernet route so that packets destined to an unknown subnet of a classful network are forwarded to 'this' router for handling. This technique is particularly useful when configuring Border Gateway Protocol (BGP).

Issue the **show ip ospf** command on Singapore.

1. According to the output of this command, what type of OSPF router is Singapore?

```
Singapore#show ip ospf
```

```

Routing Process "ospf 1" with ID 192.168.252.1
Supports only single TOS(TOS0) routes
It is an autonomous system boundary router
Redistributing External Routes from,
    static
SPF schedule delay 5 secs, Hold time between two SPF's 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 1. Checksum Sum 0x8650
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
External flood list length 0
  Area 51
    Number of interfaces in this area is 1
    Area has no authentication
    SPF algorithm executed 4 times
    Area ranges are
    Number of LSA 5. Checksum Sum 0x3A27A
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0

```

Recall that ASBRs connect external networks to the OSPF autonomous system.

Now check the routing table of SanJose1. The routing table should have an E2 route to 192.168.248.0/24.

```

SanJose1#show ip route
<output omitted>
  192.168.224.0/30 is subnetted, 1 subnets
O IA   192.168.224.0 [110/782] via 192.168.1.3, 00:04:39, FastEthernet0/0
  192.168.64.0/30 is subnetted, 1 subnets
C     192.168.64.0 is directly connected, Loopback0
  192.168.80.0/30 is subnetted, 1 subnets
C     192.168.80.0 is directly connected, Loopback1
  192.168.96.0/30 is subnetted, 1 subnets
C     192.168.96.0 is directly connected, Loopback2
O E2 192.168.248.0/24 [110/20] via 192.168.1.3, 00:03:57, FastEthernet0/0
  192.168.112.0/30 is subnetted, 1 subnets
C     192.168.112.0 is directly connected, Loopback3
C     192.168.1.0/24 is directly connected, FastEthernet0/0
  192.168.3.0/32 is subnetted, 1 subnets
O     192.168.3.1 [110/2] via 192.168.1.3, 00:08:08, FastEthernet0/0

```

2. What is the metric, or OSPF cost, of this route?

Check the routing table of SanJose3. This router should also have the external route.

3. What is the metric of SanJose3's route to 192.168.248.0/24?

SanJose1 and SanJose3 should have the same cost. This might be surprising, because SanJose1 has an additional network to traverse.

A second link to the external network is about to come online. If the network is designed so that OSPF routers can have multiple external routes to the same destination, consider using Type 1 (E1) external routes. Type 2 (E2) external routes have static metrics throughout the OSPF autonomous system (AS). Type 1 routes consider metrics internal and external to the AS for accurate route selection when multiple external routes exist. The decision is made that Singapore should advertise external routes as Type 1 (E1). To configure Type 1, use the following commands on Singapore:

```
Singapore(config)#router ospf 1
Singapore(config-router)#redistribute static metric-type 1
```

After reconfiguring Singapore, check SanJose3's table again. SanJose3's route to 192.168.248.0/24 should now be Serial 0/1.

4. What is the metric of this route?

Check SanJose1's route to 192.168.248.0/24.

5. What is the metric of Singapore's route?

Typically, the cost of a route increases with every hop. Type2 (E2) routes ignore internal OSPF metrics. Type1 (E1) routes accumulate costs while being produced through the OSPF AS. With one exit point for the AS, Type2 (E2) routes might be adequate.

Step 6

Over time, notice that as the Auckland office grows, many more Type 1, or FastEthernet 0/1, networks are propagated through the internetwork. To optimize the internetwork by reducing the routing table size, implement Classless Interdomain Routing (CIDR) to advertise all Auckland networks with one route. Create routes to these Auckland networks with three more static routes as follows:

```
Singapore(config)#ip route 192.168.240.0 255.255.255.0 null0
Singapore(config)#ip route 192.168.244.0 255.255.255.0 null0
Singapore(config)#ip route 192.168.252.0 255.255.255.0 null0
```

Configure Singapore to advertise all Auckland networks with a summary route:

```
Singapore(config)#router ospf 1
Singapore(config-router)#summary-address 192.168.240.0 255.255.240.0
```

After configuring the summary, check the routing tables on SanJose1 and SanJose3. Both routers should receive and install the supernet route, 192.168.240.0/20.

Note: On routers with very large routing tables the command `show ip route supernet` will show only aggregate routes.

```
SanJose3#show ip route
<output omitted>
 192.168.224.0/30 is subnetted, 1 subnets
 C    192.168.224.0 is directly connected, Serial0/1
 C    192.168.1.0/24 is directly connected, FastEthernet0/0
 C    192.168.3.0/24 is directly connected, Loopback0
 O E1 192.168.240.0/20 [110/801] via 192.168.224.2, 00:00:05, Serial0/1
 O IA 192.168.64.0/18 [110/2] via 192.168.1.1, 00:05:36, FastEthernet0/0

SanJose1#show ip route supernet
<output omitted>
 O E1 192.168.240.0/20 [110/802] via 192.168.1.3, 00:01:08, FastEthernet0/0
```

1. Is 192.168.248.0/24 still in SanJose1 or SanJose3's routing table?

It should not be present because 192.168.248.0/24 is included in the range 192.168.240.0/20.

Internet connectivity is by way of ISP1 through SanJose1. The link is not active yet, but OSPF is configured in advance. Simulate the link with a loopback interface as follows:

```
SanJose1(config)#interface lo5
SanJose1(config-if)#ip address 10.0.0.6 255.255.255.252
```

Use the following commands to create and advertise a default route on SanJose1:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#default-information originate always
```

The **always** keyword instructs OSPF to advertise the default route whether or not the router has one in the routing table. In this case, the router will install a gateway of last resort as displayed in the output. Check the routing tables on SanJose3 and Singapore. Both should now have a default route of 0.0.0.0/0.

```
SanJose3#show ip route
<output omitted>
Gateway of last resort is 192.168.1.1 to network 0.0.0.0
  192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/1
C       192.168.1.0/24 is directly connected, FastEthernet0/0
C       192.168.3.0/24 is directly connected, Loopback0
O*E2 0.0.0.0/0 [110/1] via 192.168.1.1, 00:00:09, FastEthernet0/0
O E1 192.168.240.0/20 [110/801] via 192.168.224.2, 00:00:09, Serial0/1
O IA 192.168.64.0/18 [110/2] via 192.168.1.1, 00:00:09, FastEthernet0/0
```

2. What type of OSPF route is the default?

3. What is the metric of this route on SanJose3?

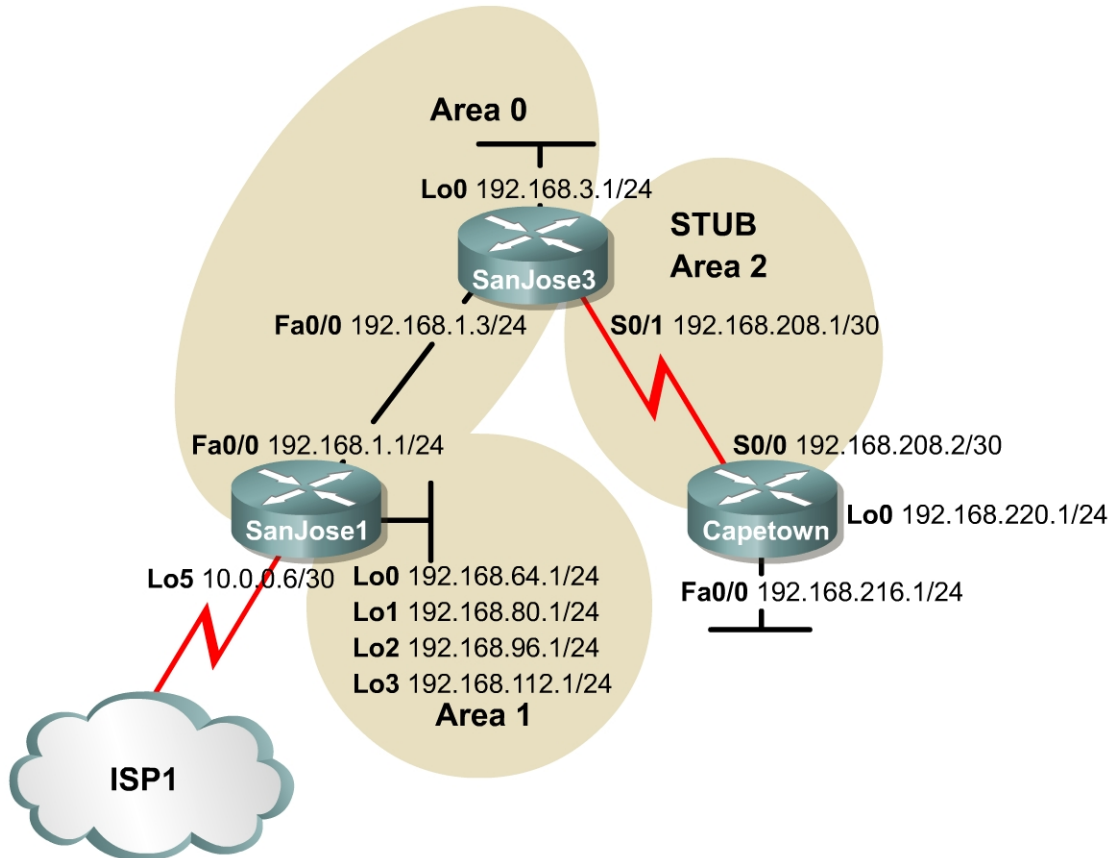
4. What is the metric of this route on Singapore?

The default route is considered External Type2 (E2). The default cost of one (1) will be retained throughout the autonomous system.

Verify that default routing is working by asking Singapore to ping a host that is not represented in its routing table. From Singapore, ping 10.0.0.6. If the default route is working, Singapore should receive replies. Troubleshoot, if necessary.

Save these configuration files for each router.

Lab 6.9.4 Configuring a Stub Area and a Totally Stubby Area



Objective

In this lab, an OSPF stub area and a totally stubby area will be configured.

Scenario

The Capetown router needs to be upgraded as it is suspected that the router is not keeping up with the growth of the OSPF internetwork. Diagnostics are performed and it is discovered that the router could benefit from more memory due to the large routing table. The router could also use a faster processor because of frequent Shortest Path First calculations. It is decided instead to create a smaller and more stable routing table using a stub or totally stubby area configuration.

Step 1

Build and configure the network according to the diagram. Configure multiarea OSPF according to the diagram. Configure Area 2, but do not make it a stub area yet. Use the configuration files from the previous lab if available and make adjustments as necessary.

Note: The loopback, Lo5, on SanJose1 can be ignored for now.

Configure each router with the loopback address as indicated in the diagram. Be sure to configure SanJose1 with additional loopbacks using Lo0, Lo1, Lo2, and Lo3. These loopback interfaces will simulate the serial links to other local San Jose sites.

```
Capetown#show ip route
<output omitted>
Gateway of last resort is not set
  192.168.208.0/30 is subnetted, 1 subnets
C       192.168.208.0 is directly connected, Serial0/0
  192.168.64.0/32 is subnetted, 1 subnets
O IA    192.168.64.1 [110/66] via 192.168.208.1, 00:20:04, Serial0/0
C       192.168.216.0/24 is directly connected, FastEthernet0/0
  192.168.80.0/32 is subnetted, 1 subnets
O IA    192.168.80.1 [110/66] via 192.168.208.1, 00:20:04, Serial0/0
  192.168.96.0/32 is subnetted, 1 subnets
O IA    192.168.96.1 [110/66] via 192.168.208.1, 00:20:04, Serial0/0
  192.168.112.0/32 is subnetted, 1 subnets
O IA    192.168.112.1 [110/66] via 192.168.208.1, 00:20:05, Serial0/0
C       192.168.220.0/24 is directly connected, Loopback0
O IA    192.168.1.0/24 [110/65] via 192.168.208.1, 00:20:05, Serial0/0
  192.168.3.0/32 is subnetted, 1 subnets
O IA    192.168.3.1 [110/65] via 192.168.208.1, 00:20:07, Serial0/0
```

Use ping and show ip route to test connectivity between all interfaces. Each router should be able to ping all network interfaces.

Step 2

Create a loopback interface as follows to simulate the serial interface connecting to ISP1:

```
SanJose1(config)#interface lo5
SanJose1(config-if)#ip address 10.0.0.6 255.255.255.252
```

Configure SanJose1 as follows to redistribute an external route into the OSPF domain:

```
SanJose1(config)#ip route 10.0.0.0 255.0.0.0 null0
SanJose1(config)#router ospf 1
SanJose1(config-router)#redistribute static
```

Check the routing tables of all three routers. They should be complete.

```
Capetown#show ip route
<output omitted>
Gateway of last resort is not set
  192.168.208.0/30 is subnetted, 1 subnets
C       192.168.208.0 is directly connected, Serial0/0
  192.168.64.0/32 is subnetted, 1 subnets
O IA    192.168.64.1 [110/66] via 192.168.208.1, 00:07:32, Serial0/0
C       192.168.216.0/24 is directly connected, FastEthernet0/0
  192.168.80.0/32 is subnetted, 1 subnets
O IA    192.168.80.1 [110/66] via 192.168.208.1, 00:07:32, Serial0/0
O E2    10.0.0.0/8 [110/20] via 192.168.208.1, 00:00:35, Serial0/0
  192.168.96.0/32 is subnetted, 1 subnets
O IA    192.168.96.1 [110/66] via 192.168.208.1, 00:07:32, Serial0/0
  192.168.112.0/32 is subnetted, 1 subnets
O IA    192.168.112.1 [110/66] via 192.168.208.1, 00:07:32, Serial0/0
C       192.168.220.0/24 is directly connected, Loopback0
O IA    192.168.1.0/24 [110/65] via 192.168.208.1, 00:07:34, Serial0/0
  192.168.3.0/32 is subnetted, 1 subnets
O IA    192.168.3.1 [110/65] via 192.168.208.1, 00:07:34, Serial0/0
```

SanJose3 and Capetown should also have a Type 2 external route to 10.0.0.0/8. They will not have a specific route to the loopback network, 10.0.0.4/30. That network has not clearly been advertised by any means.

Step 3

Capetown has several interarea (IA) routes and one external (E2) route. In complex OSPF networks, a large number of external and interarea routes can needlessly weigh down some routers. Capetown is in a stub area, an area with one egress point. Capetown does not need external routing information, or even interarea summaries. Capetown just needs a default route to the ABR, SanJose3.

By configuring Area 2 as a stub area, SanJose3 automatically produces a default route into Area 2. Use the following commands to configure the stub area:

```
SanJose3(config)#router ospf 1
SanJose3(config-router)#area 2 stub
```

Also configure Capetown as follows:

```
Capetown(config)#router ospf 1
Capetown(config-router)#area 2 stub
```

Verify that Area 2 is a stub by issuing the `show ip ospf` command:

```
CapeTown#show ip ospf
Routing Process "ospf 1" with ID 192.168.220.1
Supports only single TOS(TOS0) routes
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x0
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 1. 0 normal 1 stub 0 nssa
External flood list length 0
  Area 2
    Number of interfaces in this area is 2
    It is a stub area
    Area has no authentication
    SPF algorithm executed 6 times
    Area ranges are
    Number of LSA 9. Checksum Sum 0x428E6
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

1. According to the output of this command, what type of OSPF area is Area 2?
-

Now check Capetown's routing table. Notice that a default route, 0.0.0.0/0, has been generated by the ABR, SanJose3, on the stub area and now appears in Capetown's table.

```
Capetown#show ip route
<output omitted>
Gateway of last resort is 192.168.208.1 to network 0.0.0.0

    192.168.208.0/30 is subnetted, 1 subnets
C       192.168.208.0 is directly connected, Serial0/0
    192.168.64.0/32 is subnetted, 1 subnets
O IA   192.168.64.1 [110/66] via 192.168.208.1, 00:01:01, Serial0/0
C       192.168.216.0/24 is directly connected, FastEthernet0/0
```



```

    192.168.80.0/32 is subnetted, 1 subnets
O IA   192.168.80.1 [110/66] via 192.168.208.1, 00:01:01, Serial0/0
    192.168.96.0/32 is subnetted, 1 subnets
O IA   192.168.96.1 [110/66] via 192.168.208.1, 00:01:01, Serial0/0
    192.168.112.0/32 is subnetted, 1 subnets
O IA   192.168.112.1 [110/66] via 192.168.208.1, 00:01:02, Serial0/0
C     192.168.220.0/24 is directly connected, Loopback0
O IA   192.168.1.0/24 [110/65] via 192.168.208.1, 00:01:02, Serial0/0
    192.168.3.0/32 is subnetted, 1 subnets
O IA   192.168.3.1 [110/65] via 192.168.208.1, 00:01:03, Serial0/0
O*IA  0.0.0.0/0 [110/65] via 192.168.208.1, 00:01:03, Serial0/0

```

2. What type of OSPF route is Capetown's default route?

Recall that interarea (IA) routes point to networks in different areas within the same OSPF autonomous system.

Because Area 2 is a stub area, all external routes, Type 5 LSAs, have been prevented from reaching internal routers.

3. Look carefully at Capetown's routing table. Does it still have a route to 10.0.0.0/8?

All external routes are filtered from stub areas and are replaced with a default route.

Step 4

It is decided that the stub area configuration is not making a substantial impact on Area 2. Because Capetown can use the default route to its ABR for all nonlocal area traffic, it is decided to filter Type 3 and Type 4 interarea routes from Area 2. To do this, Area 2 must be configured as a totally stubby area, which is a Cisco proprietary feature.

Use the following commands on SanJose3, the ABR, to configure Area 2 as a totally stubby area:

```

SanJose3(config)#router ospf 1
SanJose3(config-router)#no area 2 stub
SanJose3(config-router)#area 2 stub no-summary

```

The **no-summary** keyword at the ABR keeps interarea routes from entering stub Area 2, creating a totally stubby area. Only the ABR needs the additional configuration. The role of Area 2 internal routers has not changed.

Return to Capetown and check its routing table:

```

Capetown#show ip route
<output omitted>
Gateway of last resort is 192.168.208.1 to network 0.0.0.0

    192.168.208.0/30 is subnetted, 1 subnets
C     192.168.208.0 is directly connected, Serial0/0
C     192.168.216.0/24 is directly connected, FastEthernet0/0
C     192.168.220.0/24 is directly connected, Loopback0
O*IA  0.0.0.0/0 [110/65] via 192.168.208.1, 00:00:25, Serial0/0

```

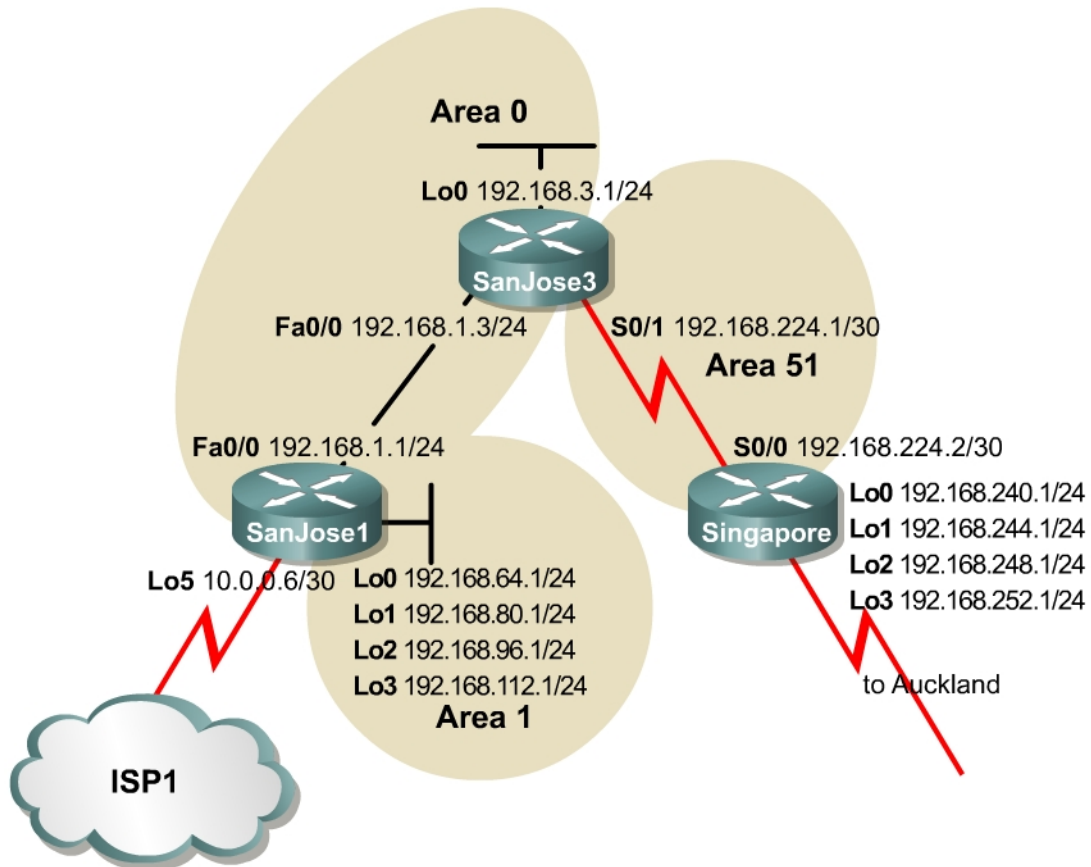
1. What has changed?

2. Does Area 2 still have connectivity to 10.0.0.0/8? Test with **ping 10.0.0.6**.

Interarea routes have also been replaced by a default route.

Capetown should get a positive response by forwarding ICMP requests to SanJose3 using the default route 0.0.0.0/0. SanJose3 has a default route to network 10.0.0.0/8, and SanJose1 has a directly connected route to 10.0.0.4/30 with the loopback interface 10.0.0.6/30.

Lab 6.9.5 Configuring an NSSA



Objective

In this lab, the student will configure an OSPF NSSA in order to import external routing information while retaining the benefits of a stub area.

Scenario

The implementation of a totally stubby area in Area 2 was very successful. Now implement it in Area 51 for more efficient routing and greater route stability. A stub or totally stubby area will not work, because the Singapore router in Area 51 has the added responsibility of redistributing external routes from Auckland using Type 5 LSAs. To meet every need, it is decided to configure Area 51 as an a Not So Stubby Area (NSSA).

Step 1

Build and configure the network according to the diagram. Also configure multiarea OSPF according to the diagram. However, do not configure NSSA yet. Use the configuration files from the previous lab if available and make adjustments as necessary. In this case it is easiest to just remove and reapply the OSPF process. Reboot after reconfiguring OSPF if there are any problems.

Note: This lab requires the use of subnet 0.

Configure each router with the loopback address indicated in the diagram. Be sure to configure SanJose1 and Singapore with additional loopbacks (Lo0, Lo1, Lo2, Lo3). On SanJose1, these loopback interfaces simulate the serial links to local San Jose sites: Westasman, Baypointe, Vista, and Eastasman. On Singapore, the loopbacks simulate Auckland networks.

Use `ping` and `show ip route` to test connectivity between all interfaces. Each router should be able to ping all network interfaces as the following shows:

```
SanJose3#show ip route
<output omitted>
 192.168.224.0/30 is subnetted, 1 subnets
C    192.168.224.0 is directly connected, Serial0/0
 192.168.64.0/32 is subnetted, 1 subnets
O IA  192.168.64.1 [110/2] via 192.168.1.1, 00:03:49, FastEthernet0/0
 192.168.80.0/32 is subnetted, 1 subnets
O IA  192.168.80.1 [110/2] via 192.168.1.1, 00:03:49, FastEthernet0/0
 192.168.96.0/32 is subnetted, 1 subnets
O IA  192.168.96.1 [110/2] via 192.168.1.1, 00:03:49, FastEthernet0/0
 192.168.112.0/32 is subnetted, 1 subnets
O IA  192.168.112.1 [110/2] via 192.168.1.1, 00:03:49, FastEthernet0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.3.0/24 is directly connected, Loopback0
```

Step 2

Configure Singapore as follows to redistribute connected routes into the OSPF domain:

```
Singapore(config)#router ospf 1
Singapore(config-router)#redistribute connected subnets
```

This command advertises Singapore's loopbacks as external networks. Check the routing tables of all three routers. They should be complete. SanJose1 and SanJose3 should also have Type 2 external routes to the Auckland networks as the following shows:

```
SanJose1#show ip route
<output omitted>
 192.168.224.0/30 is subnetted, 1 subnets
O IA  192.168.224.0 [110/782] via 192.168.1.3, 00:11:16, FastEthernet0/0
 192.168.240.0/30 is subnetted, 1 subnets
O E2  192.168.240.0 [110/20] via 192.168.1.3, 00:04:54, FastEthernet0/0
O E2  192.168.244.0/24 [110/20] via 192.168.1.3, 00:09:34, FastEthernet0/0
 192.168.64.0/30 is subnetted, 1 subnets
C    192.168.64.0 is directly connected, Loopback0
 192.168.80.0/30 is subnetted, 1 subnets
C    192.168.80.0 is directly connected, Loopback1
 192.168.96.0/30 is subnetted, 1 subnets
C    192.168.96.0 is directly connected, Loopback2
O E2  192.168.248.0/24 [110/20] via 192.168.1.3, 00:09:35, FastEthernet0/0
 192.168.112.0/30 is subnetted, 1 subnets
C    192.168.112.0 is directly connected, Loopback3
C    192.168.1.0/24 is directly connected, FastEthernet0/0
O E2  192.168.252.0/24 [110/20] via 192.168.1.3, 00:09:38, FastEthernet0/0
 192.168.3.0/32 is subnetted, 1 subnets
 192.168.3.1 [110/2] via 192.168.1.3, 00:11:19, FastEthernet0/0
```

Step 3

The following shows that Singapore has several interarea (IA) routes.

```
Singapore#show ip route
<output omitted>
Gateway of last resort is not set
  192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
  192.168.240.0/30 is subnetted, 1 subnets
C       192.168.240.0 is directly connected, Loopback0
C       192.168.244.0/24 is directly connected, Loopback1
  192.168.64.0/32 is subnetted, 1 subnets
O IA   192.168.64.1 [110/66] via 192.168.224.1, 00:00:48, Serial0/0
  192.168.80.0/32 is subnetted, 1 subnets
O IA   192.168.80.1 [110/66] via 192.168.224.1, 00:00:48, Serial0/0
  192.168.96.0/32 is subnetted, 1 subnets
O IA   192.168.96.1 [110/66] via 192.168.224.1, 00:00:49, Serial0/0
C       192.168.248.0/24 is directly connected, Loopback2
  192.168.112.0/32 is subnetted, 1 subnets
O IA   192.168.112.1 [110/66] via 192.168.224.1, 00:00:49, Serial0/0
O IA   192.168.1.0/24 [110/65] via 192.168.224.1, 00:00:49, Serial0/0
C       192.168.252.0/24 is directly connected, Loopback3
  192.168.3.0/32 is subnetted, 1 subnets
O IA   192.168.3.1 [110/65] via 192.168.224.1, 00:00:49, Serial0/0
```

In Lab 6.9.4, Capetown's table was minimized by configuring Area 2 as a stub. Attempt to repeat this configuration with the following commands on Singapore:

```
Singapore(config)#router ospf 1
Singapore(config-router)#area 51 stub
```

1. What does the router output when this command is entered?

Because Singapore imports routes that are external to OSPF, it is considered an ASBR. ASBRs cannot be members of a stub area. Stub areas do not permit Type 5 LSAs. Issue the **show ip ospf database** command on Singapore. Note that OSPF Router IDs are used as references in managing the link-state database. The OSPF process may have to be removed and reinstalled or possibly the routers will need to be rebooted to get the desired result:

```
Singapore#show ip ospf database

          OSPF Router with ID (192.168.252.1) (Process ID 1)

          Router Link States (Area 51)
Link ID        ADV Router    Age         Seq#         Checksum Link count
192.168.3.1    192.168.3.1   817        0x80000004  0xF239   2
192.168.252.1 192.168.252.1 1307       0x80000002  0xB918   2

          Summary Net Link States (Area 51)
Link ID        ADV Router    Age         Seq#         Checksum
192.168.1.0    192.168.3.1  1262       0x80000003  0xABB6
192.168.3.1    192.168.3.1  1308       0x80000001  0x8FD1
192.168.64.1   192.168.3.1  1258       0x80000001  0xF72B
192.168.80.1   192.168.3.1  1258       0x80000001  0x47CB
192.168.96.1   192.168.3.1  1258       0x80000001  0x966C
192.168.112.1  192.168.3.1  1258       0x80000001  0xE50D
```

Type-5 AS External Link States						
Link ID	ADV Router	Age	Seq#	Checksum	Tag	
192.168.224.0	192.168.252.1	429	0x80000001	0x7D74	0	
192.168.240.0	192.168.252.1	432	0x80000001	0xCC15	0	
192.168.244.0	192.168.252.1	713	0x80000001	0xB228	0	
192.168.248.0	192.168.252.1	713	0x80000001	0x8650	0	
192.168.252.0	192.168.252.1	713	0x80000001	0x5A78	0	

2. According to the output of this command, what link IDs are included under Type 5 AS External Link States?

All Auckland network routes, loopbacks, are Type5 external links.

The workaround for this situation is to configure Area 51 as an NSSA. Enter the following commands:

```
Singapore(config)#router ospf 1
Singapore(config-router)#area 51 nssa
```

```
SanJose3(config)#router ospf 1
SanJose3(config-router)#area 51 nssa
```

Now use the **show ip ospf database** command on Singapore. Because stub areas do not support Type 5 LSAs, external routes are redistributed and are advertised as Type 7 LSAs. The output of this command should verify that Type 5 LSAs have been replaced by Type 7 LSAs.

```
Singapore#show ip ospf database
```

```
OSPF Router with ID (192.168.252.1) (Process ID 1)
```

Router Link States (Area 51)						
Link ID	ADV Router	Age	Seq#	Checksum	Link count	
192.168.3.1	192.168.3.1	10	0x80000006	0x9A87	2	
192.168.252.1	192.168.252.1	10	0x80000004	0x5B6E	2	

Summary Net Link States (Area 51)					
Link ID	ADV Router	Age	Seq#	Checksum	
192.168.1.0	192.168.3.1	137	0x80000004	0x4F0C	
192.168.3.1	192.168.3.1	137	0x80000002	0x3327	
192.168.64.1	192.168.3.1	138	0x80000002	0x9B80	
192.168.80.1	192.168.3.1	138	0x80000002	0xEA21	
192.168.96.1	192.168.3.1	138	0x80000002	0x3AC1	
192.168.112.1	192.168.3.1	138	0x80000002	0x8962	

Type-7 AS External Link States (Area 51)						
Link ID	ADV Router	Age	Seq#	Checksum	Tag	
192.168.224.0	192.168.252.1	19	0x80000001	0xA0FA	0	
192.168.240.0	192.168.252.1	20	0x80000001	0xEF9B	0	
192.168.244.0	192.168.252.1	21	0x80000001	0xD5AE	0	
192.168.248.0	192.168.252.1	21	0x80000001	0xA9D6	0	
192.168.252.0	192.168.252.1	21	0x80000001	0x7DFE	0	

Enter the **show ip route** command on Singapore. Below you will see how the routing table changes with the **no-summary** option in OSPF.

NSSA routers receive updates from the ABR the same way stub area routers do. Singapore's routing table should look similar to how Capetown's table did when it was in a stub area. See Lab 6.8.2. SanJose3 continues to flood Area 51 with summary link, Type 3 and Type 4, LSAs. Because the goal is to reduce the burden on Area 51 routers, reconfigure SanJose3 as follows to filter interarea summary LSAs:

```
SanJose3(config)#router ospf 1
```

```
SanJose3(config-router)#area 51 nssa no-summary
```

Again, check Singapore's routing table:

```
Singapore#show ip route
<output omitted>
Gateway of last resort is 192.168.224.1 to network 0.0.0.0

   192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
   192.168.240.0/30 is subnetted, 1 subnets
C       192.168.240.0 is directly connected, Loopback0
C       192.168.244.0/24 is directly connected, Loopback1
C       192.168.248.0/24 is directly connected, Loopback2
C       192.168.252.0/24 is directly connected, Loopback3
O*IA 0.0.0.0/0 [110/65] via 192.168.224.1, 00:00:04, Serial0/0
```

3. What has changed?

All interarea (IA) routes are replaced with the 0.0.0.0/0 default route. Area 51 is now acting like Area 2 when it was configured as totally stubby. See Lab 6.8.2. The primary difference is that an NSSA can redistribute external routes.

NSSAs allow the OSPF link state databases to be minimized within an area, yet still import external routes as Type 7 LSAs. The NSSA ABR, in this case SanJose3, must convert these Type 7s into Type 5s, which will overflow into Area 0. On SanJose3, issue the `show ip ospf database` command as follows:

```
SanJose3#show ip ospf database
```

```
OSPF Router with ID (192.168.3.1) (Process ID 1)

Router Link States (Area 0)
Link ID          ADV Router      Age           Seq#           Checksum Link count
192.168.3.1     192.168.3.1    170          0x80000007    0x45B2    2
192.168.112.1   192.168.112.1 1711         0x80000008    0x148A    1

Net Link States (Area 0)
Link ID          ADV Router      Age           Seq#           Checksum
192.168.1.1     192.168.112.1 1712         0x80000001    0xA10A

Summary Net Link States (Area 0)
Link ID          ADV Router      Age           Seq#           Checksum
192.168.64.1    192.168.112.1 1238         0x80000005    0xE7CA
192.168.80.1    192.168.112.1 1238         0x80000005    0x376B
192.168.96.1    192.168.112.1 1238         0x80000005    0x860C
192.168.112.1   192.168.112.1 1238         0x80000005    0xD5AC
192.168.224.0   192.168.3.1    1748         0x80000001    0x92E5

Router Link States (Area 51)
Link ID          ADV Router      Age           Seq#           Checksum
Link count
192.168.3.1     192.168.3.1    165          0x8000000B    0x908C    2
192.168.252.1   192.168.252.1 278          0x80000004    0x5B6E    2

Summary Net Link States (Area 51)
Link ID          ADV Router      Age           Seq#           Checksum
0.0.0.0         192.168.3.1    172          0x80000001    0x12B6

Type-7 AS External Link States (Area 51)
Link ID          ADV Router      Age           Seq#           Checksum Tag
192.168.224.0   192.168.252.1 287          0x80000001    0xA0FA    0
192.168.240.0   192.168.252.1 287          0x80000001    0xEF9B    0
192.168.244.0   192.168.252.1 287          0x80000001    0xD5AE    0
192.168.248.0   192.168.252.1 287          0x80000001    0xA9D6    0
192.168.252.0   192.168.252.1 287          0x80000001    0x7DFE    0

Type-5 AS External Link States
```

Link ID	ADV Router	Age	Seq#	Checksum	Tag
192.168.240.0	192.168.3.1	161	0x80000001	0x5A35	0
192.168.244.0	192.168.3.1	163	0x80000001	0x4048	0
192.168.248.0	192.168.3.1	163	0x80000001	0x1470	0
192.168.252.0	192.168.3.1	163	0x80000001	0xE798	0

4. Does SanJose3's database include link IDs that use Type 7 LSAs?

5. Does SanJose3's database include link IDs that use Type 5 LSAs?

SanJose3 converts the Type7 LSAs from Singapore and reproduces them as Type 5 LSAs to SanJose1.

Issue the **show ip route** command on SanJose3:

```
SanJose3#show ip route
<output omitted>
Gateway of last resort is not set
  192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
  192.168.240.0/30 is subnetted, 1 subnets
O N2   192.168.240.0 [110/20] via 192.168.224.2, 00:03:23, Serial0/0
O N2   192.168.244.0/24 [110/20] via 192.168.224.2, 00:03:23, Serial0/0
  192.168.64.0/32 is subnetted, 1 subnets
O IA   192.168.64.1 [110/2] via 192.168.1.1, 00:03:23, FastEthernet0/0
  192.168.80.0/32 is subnetted, 1 subnets
O IA   192.168.80.1 [110/2] via 192.168.1.1, 00:03:23, FastEthernet0/0
  192.168.96.0/32 is subnetted, 1 subnets
O IA   192.168.96.1 [110/2] via 192.168.1.1, 00:03:24, FastEthernet0/0
O N2   192.168.248.0/24 [110/20] via 192.168.224.2, 00:03:24, Serial0/0
  192.168.112.0/32 is subnetted, 1 subnets
IA     192.168.112.1 [110/2] via 192.168.1.1, 00:03:30, FastEthernet0/0
C     192.168.1.0/24 is directly connected, FastEthernet0/0
O N2   192.168.252.0/24 [110/20] via 192.168.224.2, 00:03:30, Serial0/0
C     192.168.3.0/24 is directly connected, Loopback0
```

6. According to the output of this command, what kind of OSPF route is the external route to 192.168.248.0/24?

NSSA Type 2 (N2) routes are learned through Type 7 LSAs.

Finally, check SanJose1's routing table. The external route to 192.168.248.0/24 should still be installed. Issue the **show ip ospf database** command on SanJose1:

```
SanJose1#show ip ospf database

          OSPF Router with ID (192.168.112.1) (Process ID 1)
          Router Link States (Area 0)
Link ID      ADV Router    Age          Seq#          Checksum
Link count
192.168.3.1  192.168.3.1   390         0x80000007   0x45B2    2
192.168.112.1 192.168.112.1 1931       0x80000008   0x148A    1

          Net Link States (Area 0)
Link ID      ADV Router    Age          Seq#          Checksum
192.168.1.1  192.168.112.1 1931       0x80000001   0xA10A

          Summary Net Link States (Area 0)
```



```

Link ID          ADV Router      Age           Seq#           Checksum
192.168.64.1    192.168.112.1  1456         0x80000005    0xE7CA
192.168.80.1    192.168.112.1  1457         0x80000005    0x376B
192.168.96.1    192.168.112.1  1457         0x80000005    0x860C
192.168.112.1   192.168.112.1  1457         0x80000005    0xD5AC
192.168.224.0   192.168.3.1    1967         0x80000001    0x92E5

Router Link States (Area 1)
Link ID          ADV Router      Age           Seq#           Checksum
Link count
192.168.112.1   192.168.112.1  1457         0x80000006    0x39FE    4

Summary Net Link States (Area 1)
Link ID          ADV Router      Age           Seq#           Checksum
192.168.1.0     192.168.112.1  1924         0x80000009    0xA14D
192.168.3.1     192.168.112.1  1919         0x80000001    0x9B57
192.168.224.0   192.168.112.1  1919         0x80000001    0x9E6B

Summary ASB Link States (Area 1)
Link ID          ADV Router      Age           Seq#           Checksum
192.168.3.1     192.168.112.1  387          0x80000003    0x7F71

Type-5 AS External Link States
Link ID          ADV Router      Age           Seq#           Checksum Tag
192.168.240.0   192.168.3.1    383          0x80000001    0x5A35    0
192.168.244.0   192.168.3.1    383          0x80000001    0x4048    0
192.168.248.0   192.168.3.1    383          0x80000001    0x1470    0
192.168.252.0   192.168.3.1    384          0x80000001    0xE798    0

```

7. Does SanJose1's database include link IDs that use Type 7 LSAs?

8. Does SanJose1's database include link IDs that use Type 5 LSAs?

Because SanJose3 converts Type 7 LSAs to Type 5, SanJose1 is unaware of the NSSA configuration of Area 51.

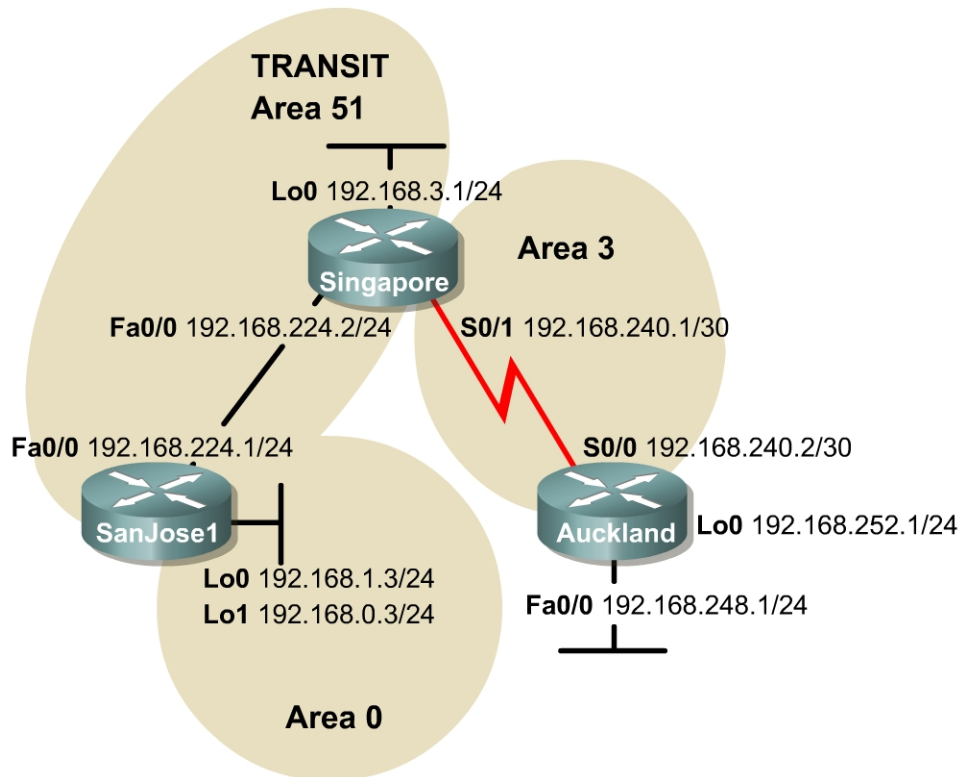
```

SanJose1#show ip route
<output omitted>
Gateway of last resort is not set
  192.168.224.0/30 is subnetted, 1 subnets
O IA  192.168.224.0 [110/782] via 192.168.1.3, 00:06:38, FastEthernet0/0
  192.168.240.0/30 is subnetted, 1 subnets
O E2  192.168.240.0 [110/20] via 192.168.1.3, 00:06:32, FastEthernet0/0
O E2  192.168.244.0/24 [110/20] via 192.168.1.3, 00:06:32, FastEthernet0/0
  192.168.64.0/30 is subnetted, 1 subnets
C     192.168.64.0 is directly connected, Loopback0
C     192.168.80.0/30 is subnetted, 1 subnets
C     192.168.80.0 is directly connected, Loopback1
C     192.168.96.0/30 is subnetted, 1 subnets
C     192.168.96.0 is directly connected, Loopback2
O E2  192.168.248.0/24 [110/20] via 192.168.1.3, 00:06:33, FastEthernet0/0
  192.168.112.0/30 is subnetted, 1 subnets
C     192.168.112.0 is directly connected, Loopback3
C     192.168.1.0/24 is directly connected, FastEthernet0/0
O E2  192.168.252.0/24 [110/20] via 192.168.1.3, 00:06:35, FastEthernet0/0
  192.168.3.0/32 is subnetted, 1 subnets
O     192.168.3.1 [110/2] via 192.168.1.3, 00:06:41, FastEthernet0/0

```

Save the configuration files on each router.

Lab 6.9.6 Configuring Virtual Links



Objective

In this lab, you will configure an OSPF virtual link so that a disconnected area can reach the backbone, as required by OSPF.

Scenario

While asleep at home in San Jose, California, the pager goes off. Information is given that the connectivity to Auckland and Singapore has been intermittent for several hours. Logging on to the corporate network from home, and running some diagnostics, it is determined that Auckland cannot be reached. Also, it is noticed that the shortest path first algorithm is being recalculated often on the core routers. The instability seems to be associated with the Asian region on the network. Singapore local time is approximately 4:30 p.m. The technical support lead in Singapore is called and asked if they are experiencing any network connectivity issues. Technical support is disappointed that this was already noticed, but they indicate that OSPF Area 3 in Auckland has already been added. They say that therefore external routes do not need to be redistributed. It is agreed that it would be best to include Auckland in the OSPF autonomous system. However, there is disagreement over whether another area should be created. A teleconference is set for the next day to discuss the situation, while engaging in restoring connectivity and stability. A proper OSPF design has all areas adjacent to Area 0, but Area 3 is disconnected from the backbone. A virtual link through Area 51 will be configured, connecting Area 3 to the backbone, Area 0.

Step 1

Build and configure the network according to the diagram. Also configure multiarea OSPF according to the diagram. However, do not configure the virtual link yet. Configure each router with the loopback address indicated in the diagram. Use the configuration files from the previous lab if available. Make adjustments as necessary. However, it is easiest to just remove and reapply the OSPF process.

Use **ping** to test connectivity between all directly connected interfaces. Each router should be able to ping its serial link partner.

Step 2

After configuring the network according to the diagram, check Auckland's routing table as follows:

```
Auckland#show ip route
<output omitted>
Gateway of last resort is not set

    192.168.240.0/30 is subnetted, 1 subnets
C       192.168.240.0 is directly connected, Serial0/0
C       192.168.248.0/24 is directly connected, FastEthernet0/0
C       192.168.252.0/24 is directly connected, Loopback0
```

1. The routing table should be devoid of OSPF routes. Why?

Inter-area traffic must transit the backbone area. Even though Area 51 and Area 3 are adjacent, they do not share OSPF routing updates.

Verify that Auckland has established a neighbor relationship with Singapore by using the **show ip ospf neighbor** command:

```
Auckland#show ip ospf neighbor

Neighbor ID      Pri   State   Dead Time   Address        Interface
192.168.240.1    1     FULL/   00:00:33   192.168.240.1 Serial0/0
```

2. What state exists between Singapore and Auckland?

Singapore and Auckland should have successfully established adjacencies, shown as the "FULL" neighbor state.

Step 3

Because Area 3 is not connected to the backbone, OSPF routing is broken in this network. Configure a virtual link, or drastically redesign the network, in order to make routing work. To quickly restore connectivity, configure a virtual link between Singapore and SanJose1. Singapore is the ABR for Area 3, while SanJose1 is the ABR for Area 0. Therefore, the transit area between Area 3 and Area 0 will be Area 51. Enter the following commands on Singapore:

```
Singapore(config)#router ospf 1
Singapore(config-router)#area 51 virtual-link 192.168.1.3
```

Note: SanJose1 must be specified by its router ID.

In order for the virtual link to function, configure both ends of the link. On SanJose1, issue the following commands:

```
SanJose1 (config)#router ospf 1
SanJose1(config-router)#area 51 virtual-link 192.168.3.1
```

Verify the creation of the virtual link by checking Auckland's routing table as follows:

```
Auckland#show ip route
<output omitted>
Gateway of last resort is not set
O IA 192.168.224.0/24 [110/845] via 192.168.240.1, 00:01:25, Serial0/0
    192.168.240.0/30 is subnetted, 1 subnets
C    192.168.240.0 is directly connected, Serial0/0
O IA 192.168.3.0/24 [110/65] via 192.168.240.1, 00:01:25, Serial0/0
C    192.168.248.0/24 is directly connected, FastEthernet0/0
    192.168.0.0/32 is subnetted, 1 subnets
O IA    192.168.0.3 [110/846] via 192.168.240.1, 00:00:35, Serial0/0
    192.168.1.0/32 is subnetted, 1 subnets
O IA    192.168.1.3 [110/846] via 192.168.240.1, 00:00:35, Serial0/0
C    192.168.252.0/24 is directly connected, Loopback0
```

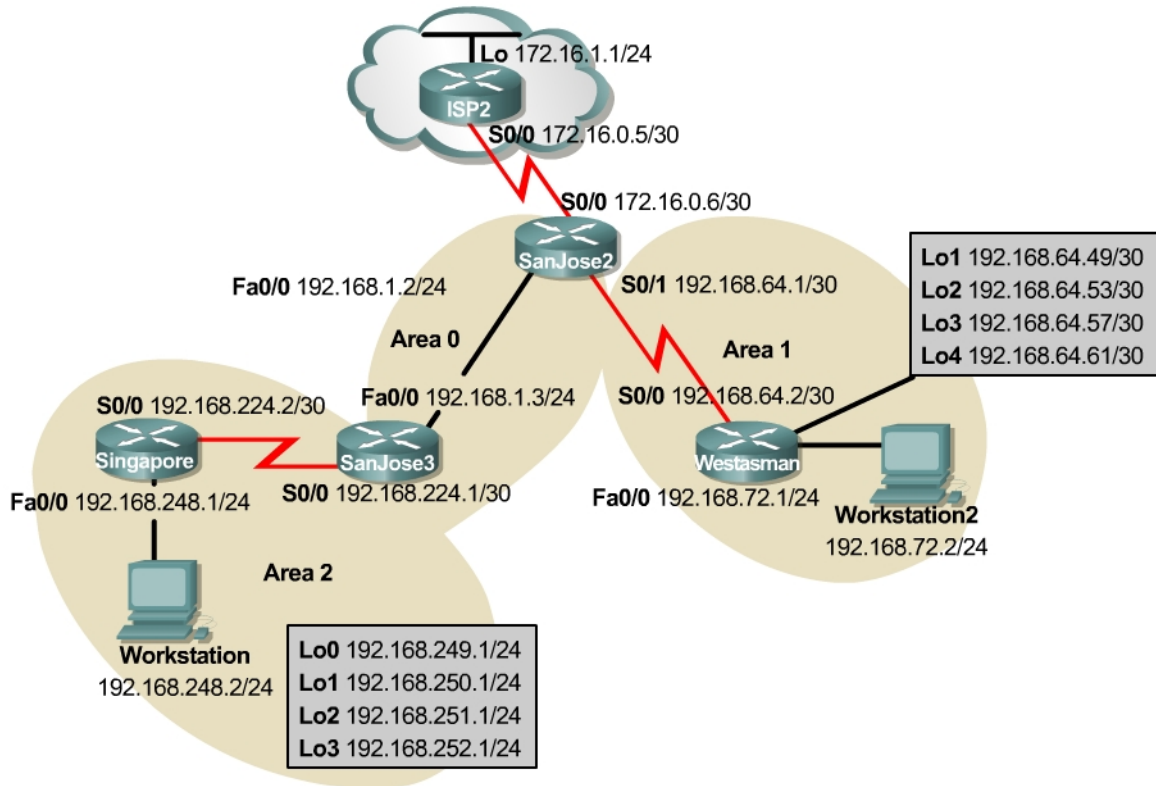
If it receives OSPF routes, the virtual link is operational.

Alternatively, the command `show ip ospf virtual-links` can be issued on Singapore:

```
Singapore#show ip ospf virtual-links
Virtual Link OSPF_VL0 to router 192.168.1.3 is up
  Run as demand circuit
  DoNotAge LSA allowed.
  Transit area 51, via interface Serial0/0, Cost of using 781
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
  Retransmit 5
  Hello due in 00:00:00
  Adjacency State FULL (Hello suppressed)
  Index 1/3, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

1. According to the output of this command, what is the state of the virtual link?
-

Lab 6.10.1 OSPF Challenge Lab



Objective

In this lab, create a multiarea OSPF autonomous system that includes a totally stubby area, injection of external routes, and a persistent default route toward the ISP.

Scenario

As the Enterprise Network Administrator for International Travel Agency, responsibilities include, but are not limited to, designing and implementing internetwork connectivity. To ensure success by reducing complexity, start scaling the network by connecting only the Asia region and one local site, Westasman, to the San Jose corporate headquarters and ISP2. When satisfied with the results, implement all other regions and sites.

Design Considerations

At this point, Westasman is in stub Area 1 with one exit point and no need to redistribute external routes. The router at Westasman has been in service for several years and might not be able to keep up with a large OSPF internetwork. The autonomous system also has only one exit point to the Internet. Therefore, creating a totally stubby area is preferred.

Instead of the administrative burden of many static routes, use a stable default route advertised through OSPF. There is concern about route flapping if the WAN link to ISP2 is unstable. A persistent default route to ISP2 is required.

When provisioning the network, the memory and processor had been upgraded on SanJose2. It is intended for it to be the ASBR and the DR for any area that requires one.

Only summarized or unique networks should be advertised through Area 0.

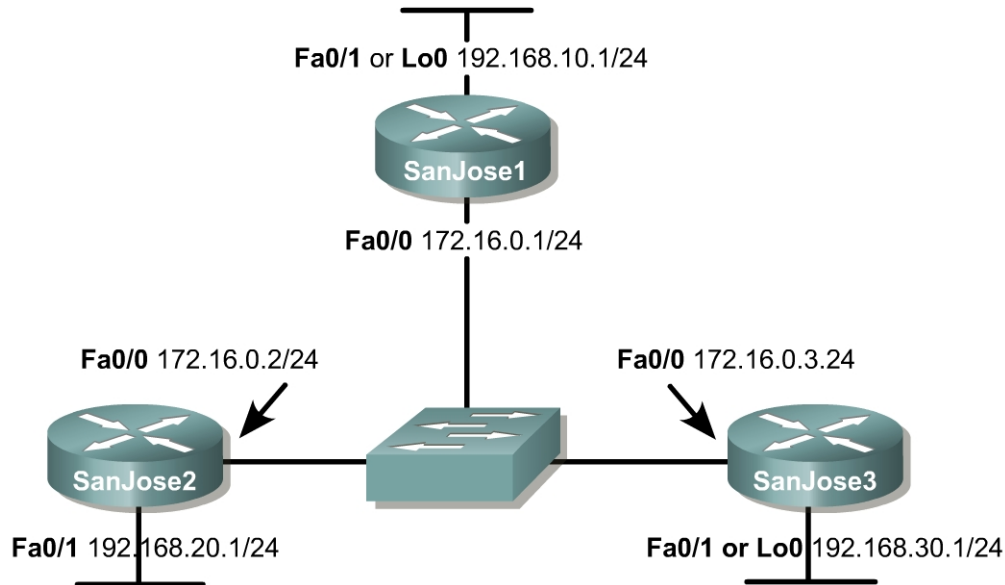
Implementation Requirements

- Configure NAT overload on SanJose2 S0/0 interface. Therefore, no routing is necessary on ISP2.
- Configure Area 1 as a totally stubby area.
- Advertise a persistent default route from SanJose2 through OSPF.
- SanJose2 will always be the DR in Area 0.
- SanJose3 will never be the DR in Area 0.
- Summarize routes at the ABR and ASBR. When summarizing inter-area routes, the summary routes may need to be configured on a router other than the router originating the routes.

Implementation Completion Tests

- Successful pings to ISP2 from workstation1 and workstation2.
- Successful pings between workstation1 and workstation2.
- Only a default route in the Westasman route table, injected from SanJose2.
- The `show` command verifies that SanJose2 is DR.
- The `show ip route` command shows summary addresses for all loopback networks.
- All loopback addresses can be reached from anywhere in the network.
- Two minutes after a WAN link failure, by disconnecting the serial cable from ISP2, an E2 default route is still present in Singapore.

Lab 7.7.1 Configuring Basic Integrated IS-IS



Objective

In this lab, basic Integrated IS-IS will be configured. IS-IS authentication will also be implemented for security purposes.

Scenario

The IS-IS routing protocol has become increasingly popular with widespread usage among Service Providers. The International Travel Agency (ITA) is thinking about implementing IS-IS because it is a link state protocol that enables very fast convergence with large scalability and flexibility. However, before making a final decision, management wants a non-production network set up to test the IS-IS routing protocol.

The backbone of the production ITA WAN consists of three routers connected by way of an Ethernet core. Because the core routers are also connected to the Internet, authentication will be configured to prevent unauthorized routers from participating in the IS-IS process.

Hardware and Software Requirements

Three Cisco 2620, 2621, 2620XM, or 2621XM routers or a combination may be used for this lab. Cisco IOS Release 12.2(12) with the Enterprise Plus or Enterprise Plus IPsec 56 feature set is used. The Enterprise Plus feature set is the minimum requirement for IS-IS support.

Cisco IOS 12.2(12) with the Enterprise Plus feature set requires a minimum of 16 MB of Flash and 48 MB of RAM. The Enterprise Plus IPsec 56 feature set requires a minimum of 16 MB of Flash and 64 MB of RAM.

The image names for the Cisco IOS Release 12.2(12) with the Enterprise Plus and Plus IPsec 56 feature sets are c2600-js-mz.122-12.bin and c2600-jk8s-mz.122-12.bin, respectively. The “j” indicates “Enterprise” and the “s” indicates “Plus”.

Step 1

Build and configure the network according to the diagram, but do not configure IS-IS yet. Loopback addresses can be used to simulate the FastEthernet 0/1 interfaces. When using the FastEthernet 0/1 interfaces, there is the option of configuring **no keepalive** on these interfaces to bring them to the “up/up” state without physically cabling the interfaces. This is opposed to actually connecting the FastEthernet 0/1 interfaces to switch ports. It must be ensured that each switch port resides in a different VLAN from the switch ports connecting to the FastEthernet 0/0 interfaces and the other FastEthernet 0/1 interfaces.

Note: IS-IS routing cannot be enabled on an interface until an IP address has been configured on the interface. Configure interface Loopback 0 in place of interface FastEthernet 0/1 on each router for the remainder of the lab. If FastEthernet 0/1 interfaces are used on these routers, the lab will work the same. However, the interface output will vary accordingly.

Use **ping** to test connectivity between the directly connected FastEthernet interfaces.

Optional: To allow smooth transition between routers through Telnet, apply the following script on each router in global configuration mode:

```
ip host r1 172.16.0.1
ip host r2 172.16.0.2
ip host r3 172.16.0.3
!
line vty 0 4
  privilege level 15
  no login
```

Once this script is applied to each router, type **r1** on any router. This moves the user immediately to the privileged mode of SanJose1 without being prompted for a password. It is much faster to type **r1** than **SanJose1**, so we use **r1** as an abbreviated representation of **SanJose1**. This process will also be used for **SanJose2** and **SanJose3** by typing either **r2** or **r3**, respectively. This is useful in a lab setting for moving quickly between routers.

Step 2

IS-IS (ISO/IEC 10589) is implemented with network service access point (NSAP) addresses consisting of three fields: area address, system ID, and N-selector byte: service identifier (NSEL). The area address field may be from one to thirteen octets, the system ID field is normally six octets (must be six for Cisco IOS); and the NSEL identifies a process on the device. It is a loose equivalent to a port or socket in IP, the NSEL is not used in routing decisions.

When the NSEL is set to 00, the NSAP is referred to as the network entity title (NET). NETs and NSAPs are represented in hexadecimal and must start and end on a byte boundary, such as **49.0001.1111.1111.1111.00**

Level 1, or L1, IS-IS routing is based upon system ID. Therefore, each router must have a unique system ID within the area. L1 IS-IS routing equates to intra-area routing. It is customary to use either a MAC address from the router or, for Integrated IS-IS, to code the IP address, of a Loopback address, for example, into the system ID. However, numbering 1, 2, 3, 4, and so on is also acceptable.

Area addresses starting with a value of 48, 49, 50, or 51 specify private addresses. This group of addresses should not be advertised to other connectionless network service (CLNS) networks. The area address must be the same for all routers in an area.

On a LAN, one of the routers will be elected the designated intermediate system (DIS) based on interface priority. The default is 64. If all interface priorities are the same, the router with the highest subnetwork point of attachment (SNPA) address is selected. The (Ethernet) MAC addresses serves as the SNPA addresses for Ethernet LANs. The DIS serves the same purpose for IS-IS as the designated router (DR) does for OSPF. The ITA network engineer decides that SanJose1 will be the DIS, so its priority must be set higher than the default setting on the SanJose2 and SanJose3 routers.

Now, configure Integrated IS-IS on each router and set a priority of 100 on the FastEthernet 0/0 interface of SanJose1 as shown in the following:

```
SanJose1(config)#router isis
SanJose1(config-router)#net 49.0001.1111.1111.1111.00
SanJose1(config-router)#interface fa0/0
SanJose1(config-if)#ip router isis
SanJose1(config-if)#isis priority 100
SanJose1(config-if)#interface lo0
SanJose1(config-if)#ip router isis

SanJose2(config)#router isis
SanJose2(config-router)#net 49.0001.2222.2222.2222.00
SanJose2(config-router)#interface fa0/0
SanJose2(config-if)#ip router isis
SanJose2(config-if)#interface lo0
SanJose2(config-if)#ip router isis

SanJose3(config)#router isis
SanJose3(config-router)#net 49.0001.3333.3333.3333.00
SanJose3(config-router)#interface fa0/0
SanJose3(config-if)#ip router isis
SanJose3(config-if)#interface lo0
SanJose3(config-if)#ip router isis
```

1. Identify parts of the NSAP/NET addresses.

- a. Area Address: _____
- b. SanJose1 System ID: _____
- c. SanJose2 System ID: _____
- d. SanJose3 System ID: _____
- e. NSEL: _____

Step 3

Verify IS-IS operation using various **show** commands on any of the three routers. The commands and sample output for SanJose1 is shown as follows:

```
SanJose1#show ip protocols
Routing Protocol is "isis"
  Invalid after 0 seconds, hold down 0, flushed after 0
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: isis
  Address Summarization:
    None
  Maximum path: 4
  Routing for Networks:
    FastEthernet0/0
    FastEthernet0/1
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.30.1     115          00:00:36
    192.168.20.1     115          00:00:36
  Distance: (default is 115)
```

Notice the update timers are set to zero (0). Updates are not sent at regular intervals since they are event-driven. The “Last Update” field indicates how long it has been since the last update as hours:minutes:seconds.

Issue the **show clns neighbors** command to view adjacencies.

```
SanJose1#show clns neighbors
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
SanJose2	Fa0/0	0004.9ad2.d0c0	Up	9	L1L2	IS-IS
SanJose3	Fa0/0	0002.16f4.1ba0	Up	29	L1L2	IS-IS

Neighbor ISs and neighbor ESs are shown, if applicable. The optional keyword **detail** can be used to display comprehensive neighbor information as follows:

```
SanJose1#show clns neighbors detail
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
SanJose2	Fa0/0	0004.9ad2.d0c0	Up	24	L1L2	IS-IS
Area Address(es): 49.0001						
IP Address(es): 172.16.0.2*						
Uptime: 00:07:30						
SanJose3	Fa0/0	0002.16f4.1ba0	Up	27	L1L2	IS-IS
Area Address(es): 49.0001						
IP Address(es): 172.16.0.3*						
Uptime: 00:07:00						

Notice that the system ID of the IS neighbors are the hostnames of the respective neighbor routers. Cisco routers support dynamic hostname mapping starting with IOS Release 12.0(5) and the feature is enabled by default. As seen in the sample output, the configured system ID of 2222.2222.2222 has been replaced by the hostname “SanJose2”. Similarly, “SanJose3” replaces 3333.3333.3333.

Also notice that the adjacency Type for both neighbors is “L1L2”. By default, Cisco IOS enables both L1 and L2 adjacency negotiation on IS-IS routers. The router configuration mode command, **is-type**, or the interface configuration command, **isis circuit-type**, can be used to prescribe how the router operates in terms of L1 and L2 routing.

The **show isis database** and the **show clns interface fa0/0** commands can be used to obtain DIS and related information. First, type the **clear isis *** command on all routers to force IS-IS to refresh its link-state databases and recalculate all routes. A minute or two may be needed for all routers to update their respective IS-IS databases.

```
All_Router#clear isis *
```

Issue the **show isis database** command to view the content of the IS-IS database:

```
SanJose1#show isis database
```

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x00000008   0x088F        1191          0/0/0
SanJose1.01-00 * 0x00000002   0x9B60        1192          0/0/0
SanJose2.00-00 0x00000001   0x8736        1190          0/0/0
SanJose3.00-00 0x00000002   0x39A1        1195          0/0/0
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x00000017   0x4E1B        1195          0/0/0
SanJose1.01-00 * 0x00000002   0x4D37        1192          0/0/0
SanJose2.00-00 0x00000010   0xF4B9        1191          0/0/0
SanJose3.00-00 0x00000002   0xD703        1195          0/0/0
```

IS-IS retains a separate database for L1 and L2 routing. Because IS-IS is a link-state protocol, the link-state database should be the same for the three San Jose routers.

As discussed earlier, if the `isis priority 100` command had not been placed on the FastEthernet 0/0 interface of SanJose1, the DIS would have been elected on the basis of the highest SNPA. DIS election is preemptive, unlike the behavior with OSPF. The `isis priority 100` command ensures that SanJose1 is elected the DIS, regardless of router boot order. But how can it be determined from the `show isis database` output that SanJose1 is indeed the DIS?

Look at the entries under the link state protocol data unit ID (LSPID) column. The first six octets form the system ID. As addressed earlier, because of the dynamic host mapping feature, the respective router names are listed instead of the numerical system ID. Following the system ID are two octets.

The first octet is the pseudonode ID, representing a LAN. The pseudonode ID is used to distinguish between LAN IDs on the same DIS. When this value is non-zero, the associated LSP is a pseudonode LSP originating from the DIS. The DIS is the only system that originates pseudonode LSPs. The DIS creates one pseudonode LSP for L1 and one for L2, as shown in the previous output.

The pseudonode ID will vary upon reboot of the router as a function of the creation or deletion of virtual interfaces, such as loopback interfaces. The system ID and pseudonode ID together is referred to as the circuit ID. An example is "SanJose1.01".

A non-pseudonode LSP represents a router and is distinguished by the fact that the two-byte value in the circuit ID is 00.

The last octet forms the LSP fragmentation number. "00" indicates all data fit into a single link state packet (LSP). If there had been more information that did not fit into the first LSP, IS-IS would have created additional LSPs with increasing LSP numbers such as 01, 02, and so on. The asterisk (*) indicates that the LSP was originated by the local system.

Issue the `show clns interface fa0/0` command:

```
SanJose1#show clns interface fa0/0
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 8 seconds
  Routing Protocol: IS-IS
  Circuit Type: level-1-2
  Interface number 0x0, local circuit ID 0x1
  Level-1 Metric: 10, Priority: 100, Circuit ID: SanJose1.01
  Number of active level-1 adjacencies: 2
  Level-2 Metric: 10, Priority: 100, Circuit ID: SanJose1.01
  Number of active level-2 adjacencies: 2
  Next IS-IS LAN Level-1 Hello in 803 milliseconds
  Next IS-IS LAN Level-2 Hello in 2 seconds
```

Notice that the circuit ID, SanJose1.01, which is made up of the system ID and pseudonode ID, identifies the DIS. Circuit Types, Levels, Metric, and Priority information is also displayed.

Additional information about a specific LSP ID may be obtained by appending the LSP ID and `detail` keyword to the `show isis database` command, as shown in the output. The hostname is case sensitive. Also, note that this command can be used to view the IS-IS database of a neighbor router by referencing its hostname in the command.

```
SanJose1#show isis database SanJose1.00-00 detail

IS-IS Level-1 LSP SanJose1.00-00
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x0000000B  0x0292        831            0/0/0
```

```

Area Address: 49.0001
NLPID:      0xCC
Hostname:   SanJose1
IP Address: 192.168.10.1
Metric: 10      IP 172.16.0.0 255.255.255.0
Metric: 10      IP 192.168.10.0 255.255.255.0
Metric: 10      IS SanJose1.02
Metric: 10      IS SanJose1.01

IS-IS Level-2 LSP SanJose1.00-00
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x0000000D  0x4703        709           0/0/0
Area Address: 49.0001
NLPID:      0xCC
Hostname:   SanJose1
IP Address: 192.168.10.1
Metric: 10      IS SanJose1.02
Metric: 10      IS SanJose1.01
Metric: 20      IP 192.168.30.0 255.255.255.0
Metric: 10      IP 192.168.10.0 255.255.255.0
Metric: 10      IP 172.16.0.0 255.255.255.0
Metric: 20      IP 192.168.20.0 255.255.255.0

```

The default IS-IS metric for every link is 10, but notice the metric for the 192.168.20.0 and 192.168.30.0 networks are both 20. This is explained by the fact that the networks are not directly connected but are directly connected to neighbor routers.

Issue the **show isis topology** command as follows to display the paths to the other intermediate systems:

```

SanJose1#show isis topology

IS-IS paths to level-1 routers
System Id      Metric  Next-Hop      Interface  SNPA
SanJose1      --
SanJose2      10      SanJose2      Fa0/0      0004.9ad2.d0c0
SanJose3      10      SanJose3      Fa0/0      0002.16f4.1ba0

IS-IS paths to level-2 routers
System Id      Metric  Next-Hop      Interface  SNPA
SanJose1      --
SanJose2      10      SanJose2      Fa0/0      0004.9ad2.d0c0
SanJose3      10      SanJose3      Fa0/0      0002.16f4.1ba0

```

The highlighted entries in the SNPA column are the MAC addresses of the SanJose2 and SanJose3 FastEthernet 0/0 interfaces.

Issue the **show isis route** as follows to command to view the IS-IS L1 routing table:

```

SanJose1#show isis route

IS-IS not running in OSI mode (*) (only calculating IP routes)

(*) Use "show isis topology" command to display paths to all routers

```

This command has no useful output because the command is specific to OSI routing. Remember, IP IS-IS was enabled on each router. If CLNP were configured in the network, more interesting output would appear.

Issue the **show clns route** command as follows to view the IS-IS L2 routing table:

```
SanJose1#show clns route
Codes: C - connected, S - static, d - DecnetIV
       I - ISO-IGRP, i - IS-IS, e - ES-IS

C 49.0001.1111.1111.1111.00 [1/0], Local IS-IS NET
C 49.0001 [2/0], Local IS-IS Area
```

Again, there is no useful output here because this command applies to OSI routing and not IP routing.

Issue the **show ip route** command to view the IP routing table:

```
SanJose1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

i L1 192.168.30.0/24 [115/20] via 172.16.0.3, FastEthernet0/0
C    192.168.10.0/24 is directly connected, Loopback0
     172.16.0.0/24 is subnetted, 1 subnets
C    172.16.0.0 is directly connected, FastEthernet0/0
i L1 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
```

Notice how the routes to the 192.168.30.0 and 192.168.20.0 networks were learned.

The **show clns neighbors**, **show isis database**, **show clns interface**, **show isis topology**, **show isis route**, and **show clns route** commands illustrate the somewhat confusing nature of IS-IS verification and troubleshooting. There is no clear pattern as to whether incorporation of the keyword **isis** or **clns** in a **show** command applies to IP routing or to OSI routing.

Step 4

L1 routers communicate with other L1 routers in the same area while L2 routers route between L1 areas, forming an interdomain routing backbone. This lab scenario does not illustrate the typical multi-area composition of the set of L2 routers in an IS-IS domain, because the San Jose routers all reside in Area 49.0001. Since the San Jose routers main function is simply to route between areas in the ITA internetwork, they should be configured as L2-only routers. Configure each San Jose router as an L2-only router as follows:

```
SanJose1(config)#router isis
SanJose1(config-router)#is-type level-2-only

SanJose2(config)#router isis
SanJose2(config-router)#is-type level-2-only

SanJose3(config)#router isis
SanJose3(config-router)#is-type level-2-only
```

Note: The **isis circuit-type** interface command can be used to selectively override the router configuration **is-type**, which are now L2-only.

To see the effect of the **is-type** command, reenter the various **show** commands previously issued: **show ip protocols**, **show clns neighbors**, **show isis database**, **show clns interface fa0/0**, **show isis database SanJose1.00-00 detail**, **show isis topology**, and **show ip route**. Sample outputs are shown as follows:

```
SanJose1#show ip protocols
Routing Protocol is "isis"
  Invalid after 0 seconds, hold down 0, flushed after 0
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: isis
  Address Summarization:
    None
  Maximum path: 4
  Routing for Networks:
    FastEthernet0/0
    FastEthernet0/1
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.30.1     115          00:08:48
    192.168.20.1     115          00:00:09
  Distance: (default is 115)
```

```
SanJose1#show clns neighbors
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
SanJose2	Fa0/0	0004.9ad2.d0c0	Up	26	L2	IS-IS
SanJose3	Fa0/0	0002.16f4.1ba0	Up	22	L2	IS-IS

```
SanJose1#show isis database
```

```
IS-IS Level-2 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	* 0x00000001	0x623C	1086	0/0/0
SanJose1.01-00	* 0x0000000F	0x3344	1092	0/0/0
SanJose2.00-00	0x00000001	0x13AA	1091	0/0/0
SanJose3.00-00	0x00000002	0xD703	1096	0/0/0

If the LSP ID is seen with an LSP Holdtime of 0 followed by a parenthetical value, that rogue entry can be purged by invoking the **clear isis *** command.

```
SanJose1#show clns interface fa0/0
```

```
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 16 seconds
  Routing Protocol: IS-IS
  Circuit Type: level-1-2
  Interface number 0x0, local circuit ID 0x1
  Level-2 Metric: 10, Priority: 100, Circuit ID: SanJose1.01
  Number of active level-2 adjacencies: 2
  Next IS-IS LAN Level-2 Hello in 2 seconds
```

Despite the fact that the Circuit Type is "level-1-2", the entries following the Circuit Type show that only L2 operations are taking place.

```
SanJose1#show isis database SanJose1.00-00 detail
```

```
IS-IS Level-2 LSP SanJose1.00-00
```

```

LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00      * 0x00000001  0x623C        892            0/0/0
Area Address: 49.0001
NLPID:              0xCC
Hostname: SanJose1
IP Address: 192.168.10.1
Metric: 10          IS SanJose1.02
Metric: 10          IS SanJose1.01
Metric: 10          IP 192.168.10.0 255.255.255.0
Metric: 10          IP 172.16.0.0 255.255.255.0

```

The output shows that the IDs, SanJose1.02 and SanJose.01, on the circuits are used to number the router interfaces participating in IS-IS. This is also seen in the **show clns interface** output.

```
SanJose1#show isis topology
```

```
IS-IS paths to level-2 routers
```

System Id	Metric	Next-Hop	Interface	SNPA
SanJose1	--			
SanJose2	10	SanJose2	Fa0/0	0004.9ad2.d0c0
SanJose3	10	SanJose3	Fa0/0	0002.16f4.1ba0

```
SanJose1#show ip route
```

```

Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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
```

```

i L2 192.168.30.0/24 [115/20] via 172.16.0.3, FastEthernet0/0
C    192.168.10.0/24 is directly connected, Loopback0
     172.16.0.0/24 is subnetted, 1 subnets
C    172.16.0.0 is directly connected, FastEthernet0/0
i L2 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0

```

2. What types of routes are being placed into the routing table?

Step 5

The default value of the hello interval is ten seconds and the default value of the hello multiplier is three. The hello multiplier specifies the number of IS-IS hello PDUs a neighbor must miss before the router declares the adjacency as down. So, with the default hello interval of ten seconds, it takes 30 seconds for an adjacency to be declared down due to missed hello PDUs. The analogous settings with OSPF are governed by the **ip ospf hello-interval** and **ip ospf dead-interval** interface commands.

A decision is made to adjust the IS-IS timers so that the core routers will detect network failures in less time. This will increase traffic, but this is much less of a concern on the high-speed core Ethernet segment than on a busy WAN link. It is determined that the need for quick convergence on the core outweighs the negative effect of extra control traffic. Change the hello interval to 5 on all Fa0/0 interfaces, as shown below for the SanJose1 router:

```

SanJose1(config)#interface fastethernet 0/0
SanJose1(config-if)#isis hello-interval 5

```

1. How long will it take for an adjacency to be declared down with the new hello interval of five?
-

Step 6

There should not be any unauthorized routers forming adjacencies within the IS-IS core. Adding authentication to each IS-IS enabled interface can help to ensure this.

Configure interface authentication on SanJose1 as shown below.

```
SanJose1(config)#interface FastEthernet 0/0
SanJose1(config-if)#isis password cisco level-2
```

This command gives the ability to prevent unauthorized routers from forming level-2 adjacencies with this router.

Important: Be sure to add the keyword `level-2`, which refers to the level-2 database, not an encryption level. If no keyword is specified, the default is level-1. Keep in mind the passwords are exchanged in clear text and provide only limited security.

Wait 20 seconds then issue the `show clns neighbors` command on SanJose1.

1. Does SanJose1 still show that it has IS-IS neighbors? Why or why not?
-
-

Issue the `debug isis adj-packets` command to verify that SanJose1 does not recognize its neighbors because it requires authentication that has not been configured on SanJose 2 and SanJose3 yet.

```
SanJose1#debug isis adj-packets
IS-IS Adjacency related packets debugging is on
SanJose1#
03:22:28: ISIS-Adj: Sending L2 LAN IIH on FastEthernet0/0, length 1497
03:22:29: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
03:22:30: ISIS-Adj: Sending L2 LAN IIH on FastEthernet0/0, length 1497
03:22:31: ISIS-Adj: Rec L2 IIH from 0004.9ad2.d0c0 (FastEthernet0/0), cir
type L2, cir id 1111.1111.1111.01, length 1497
03:22:31: ISIS-Adj: Authentication failed
```

IS-IS routers will not communicate unless the authentication parameters match. However, many other interface-specific IS-IS parameters can vary on a given segment without disrupting communication, such as those set by the commands `isis hello-interval`, `isis hello-multiplier`, `isis retransmit-interval`, `isis retransmit-throttle-interval`, and `isis csnp-interval`. Of course, it makes sense for these parameters to coincide on a given segment.

Correct the authentication mismatch by configuring interface authentication on SanJose2 and SanJose3. After configurations are complete, verify that the routers can communicate by using the `show clns neighbors` command on SanJose1.

```
SanJose2(config)#interface FastEthernet 0/0
SanJose2(config-if)#isis password cisco level-2

SanJose3(config)#interface FastEthernet 0/0
```



```
SanJose3(config-if)#isis password cisco level-2
```

```
SanJose1#show clns neighbors
```

System Id Protocol	Interface	SNPA	State	Holdtime	Type	
SanJose2	Fa0/0	0004.9ad2.d0c0	Up	23	L2	IS-IS
SanJose3	Fa0/0	0002.16f4.1ba0	Up	26	L2	IS-IS

The system IDs will resolve, in time, to the router names. This is done through the dynamic hostname mapping feature automatically enabled on Cisco routers. In the interim, the output may appear with the actual numerical ID for that system.

Step 7

IS-IS provides two additional layers of authentication to prevent unauthorized adjacencies between routers. These are area passwords for L1 and domain passwords for L2. The interface, area, and domain password options for IS-IS all use plain text authentication and therefore are of limited use. However, beginning with IOS Release 12.2(13)T MD5 authentication is available for IS-IS.

The command for L1 password authentication is **area-password {password}**. Using the **area-password** command on all routers in an area will prevent unauthorized routers from injecting false routing information into the L1 database.

The command for L2 password authentication is **domain-password {password}**. Using the **domain-password** command on all L2 routers in a domain will prevent unauthorized routers from injecting false routing information into the L2 database. Since the core routers are operating at L2, implement domain password authentication as follows:

```
SanJose1(config)#router isis
SanJose1(config-router)#domain-password sanjose
```

Note that the password itself is case sensitive. It is worth configuring mismatched passwords in each case, for instance, interface, area, and domain. This should be done at least once to see what the effect is on IS-IS functionality.

Force IS-IS to refresh its link-state database and recalculate all routes by issuing the **clear isis *** command on all routers. A minute or two may be needed for all routers to update their respective IS-IS databases.

```
All_Router#clear isis *
```

View the SanJose1 link state database to see the following change:

```
SanJose1#show isis database
```

```
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x00000004  0xDCB5        1155           0/0/0
SanJose1.01-00 * 0x00000007  0xB4C1        1156           0/0/0
```

Change the other routers to reflect the new authentication policy.

```
SanJose2(config)#router isis
SanJose2(config-router)#domain-password sanjose
SanJose3(config)#router isis
SanJose3(config-router)#domain-password sanjose
```

View the SanJose1 link state database to verify propagation of LSPs.

```
SanJose1#show isis database
```

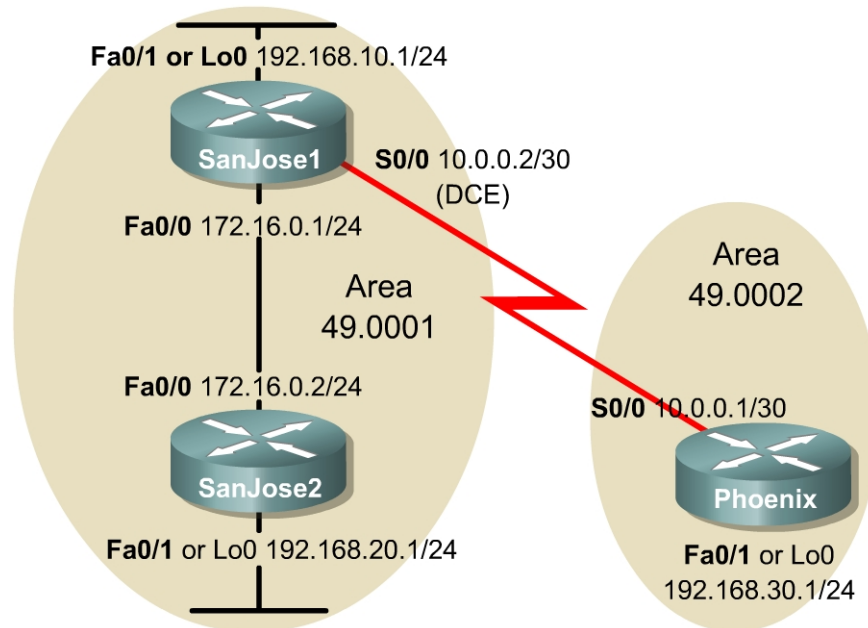
```
IS-IS Level-2 Link State Database:
```

LSPID		LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	*	0x00000001	0xE2B2	1189	0/0/0
SanJose1.01-00	*	0x00000002	0xBEBC	1195	0/0/0
SanJose2.00-00		0x00000002	0x5A59	1190	0/0/0
SanJose3.00-00		0x00000002	0xF3DD	1185	0/0/0

The configuration of basic Integrated IS-IS routing protocol is now complete. In addition to enabling Integrated IS-IS, L2-specific routing was enabled, and the hello-interval was changed to enable IS-IS to detect network failures faster. Two types of password authentication, interface and domain, were enabled to prevent unauthorized routers from forming adjacencies with the SanJose core routers.

Save the SanJose1 and SanJose2 configurations for use with the next lab.

Lab 7.7.2 Configuring Multi-Area Integrated IS-IS



Objective

In this lab, multiarea Integrated IS-IS and level-specific routers will be configured.

Scenario

Previous tests demonstrated that Integrated IS-IS worked well with Level-2 routers in the ITA Ethernet core. Management now wants to establish a point-to-point connection between a new Phoenix office and SanJose1. Phoenix will be in a different area from the core so SanJose2 will now be configured as an L1 router, SanJose1 as an L1L2 router, and Phoenix as an L2 router.

Hardware and Software Requirements

Three Cisco 2620, 2621, 2620XM, or 2621XM routers or a combination may be used for this lab. Cisco IOS Release 12.2(12) with the Enterprise Plus or Enterprise Plus IPsec 56 feature set is used. The Enterprise Plus feature set is the minimum requirement for IS-IS support.

Cisco IOS 12.2(12) with the Enterprise Plus feature set requires a minimum of 16 MB of Flash and 48 MB of RAM. The Enterprise Plus IPsec 56 feature set requires a minimum of 16 MB of Flash and 64 MB of RAM.

The image names for the Cisco IOS Release 12.2(12) with the Enterprise Plus and Plus IPsec 56 feature sets are c2600-js-mz.122-12.bin and c2600-jk8s-mz.122-12.bin, respectively. The “j” indicates “Enterprise” and the “s” indicates “Plus”.

Step 1

Load the SanJose1 and SanJose2 configurations from the previous lab. Clear and reload the router to be used as Phoenix.

Configure the IP address and clock rate on the serial interface of SanJose1. Use loopback interfaces in place of FastEthernet 0/1 interfaces on SanJose2 and Phoenix. Configure the Telnet shortcut to Phoenix on SanJose1 and SanJose2. Configure the hostname, turn off DNS lookup, add the Telnet shortcuts, configure the IP address on the serial interface, and configure the loopback IP address on Phoenix.

```
SanJose1(config)#interface serial 0/0
SanJose1(config-if)#ip address 10.0.0.2 255.255.255.252
SanJose1(config-if)#clockrate 128000
SanJose1(config-if)#no shutdown
SanJose1(config-if)#exit
SanJose1(config)#ip host r3 10.0.0.1

SanJose2(config)#ip host r3 10.0.0.1

Router(config)#hostname Phoenix
Phoenix(config)#no ip domain-lookup
Phoenix(config)#ip host r1 10.0.0.2
Phoenix(config)#ip host r2 172.16.0.2

Phoenix(config)#interface serial 0/0
Phoenix(config-if)#ip address 10.0.0.1 255.255.255.252
Phoenix(config-if)#no shutdown
Phoenix(config-if)#interface loopback 0
Phoenix(config-if)#ip address 192.168.30.1 255.255.255.0
```

Use **ping** to verify connectivity between directly connected interfaces. SanJose1 should also be able to reach the loopback address of SanJose2 and vice versa.

Step 2

Recall from Lab 7.1 that SanJose1 was configured to be the DIS by setting the **isis priority** to 100 on the FastEthernet 0/0 interface. SanJose1 and SanJose2 were also configured to be Level-2 only routers. Verify the configuration by issuing the **show clns neighbors** and **show isis database** commands on either router. Sample outputs are shown as follows:

Note: While not absolutely necessary, it may be a good idea to first issue a **clear isis *** command to force IS-IS to update its database.

```
SanJose1#show clns neighbors
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
SanJose2	Fa0/0	0004.9ad2.d0c0	Up	12	L2	IS-IS

```
SanJose1#show isis database
```

```
IS-IS Level-2 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	* 0x00000014	0xBCC5	409	0/0/0
SanJose1.01-00	* 0x00000015	0x1B0D	819	0/0/0
SanJose2.00-00	0x00000016	0x326D	698	0/0/0

Notice that the neighbor Type is still L2. There is only one L2 link-state database and SanJose1 is still the DIS, LSPID SanJose1.01-00 has a non-zero pseudonode ID. Also, the LSPID may appear as

SanJose1.02-00, depending on whether a loopback was used on SanJose1 in place of interface Fa0/0 and the timing of the configuration of the loopback interface.

Step 3

Configure IS-IS on Phoenix, area 2, and on the Serial 0/0 interface of SanJose1 as shown in the following:

```
Phoenix(config)#router isis
Phoenix(config-router)#net 49.0002.3333.3333.00
Phoenix(config-router)#interface serial 0/0
Phoenix(config-if)#ip router isis
Phoenix(config-router)#interface loopback 0
Phoenix(config-if)#ip router isis

SanJose1(config)#interface serial 0/0
SanJose1(config-if)#ip router isis
```

Step 4

Verify IS-IS operation between SanJose1 and Phoenix. A ping from Phoenix to loopback addresses on SanJose1 and SanJose2 should be successful. Issue various show commands on Phoenix as the following will show. Resulting output should be similar to the samples shown.

```
Phoenix#show clns neighbor
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
SanJose1	Se0/0	*HDLC*	Up	28	L2	IS-IS

Recall that serial interfaces do not have a MAC address so the encapsulation type for the serial link is listed in the SNPA column.

```
Phoenix#show isis database
```

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
Phoenix.00-00	* 0x00000009	0x8FFA	1180	1/0/0

IS-IS Level-2 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	0x0000001C	0x25EC	1174	0/0/0
SanJose1.01-00	0x00000017	0x170F	965	0/0/0
SanJose2.00-00	0x00000018	0x2E6F	794	0/0/0
Phoenix.00-00	* 0x00000008	0x4551	1176	0/0/0

By default, Phoenix is an L1L2 router so it retains a separate link-state database for each level. Note too that SanJose1 is identified as the DIS. SanJose1 and SanJose2 are not listed in the IS-IS Level-1 link-state database because both were previously configured as L2-only routers.

```
Phoenix#show clns interface serial 0/0
Serial0/0 is up, line protocol is up
  Checksums enabled, MTU 1500, Encapsulation HDLC
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 26 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x100
    Neighbor System-ID: SanJose1
    Level-1 Metric: 10, Priority: 64, Circuit ID: Phoenix.00
    Number of active level-1 adjacencies: 0
```

```
Level-2 Metric: 10, Priority: 64, Circuit ID: Phoenix.00
Number of active level-2 adjacencies: 1
Next IS-IS Hello in 7 seconds
```

Note that the circuit ID is "Phoenix.00".

From SanJose1, ping 192.168.30.1 on Phoenix. The ping should not be successful.

Check the IP routing table of SanJose1.

```
SanJose1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    192.168.10.0/24 is directly connected, FastEthernet0/1
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
i L2 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0
```

All prior checks indicated IS-IS was working properly between SanJose1 and Phoenix. However, there is no entry in the routing table for the 192.168.30.0 network.

Step 5

Recall that domain password authentication was configured on both SanJose1 and SanJose2. If domain authentication is to be retained, Phoenix also needs to be configured appropriately as follows:

```
Phoenix(config)#router isis
Phoenix(config-router)#domain-password sanjose
```

Now examine the routing table of either SanJose1 or SanJose2. A sample for SanJose1 is shown as follows:

```
SanJose1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

i L2 192.168.30.0/24 [115/20] via 10.0.0.1, Serial0/0
C    192.168.10.0/24 is directly connected, FastEthernet0/1
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
i L2 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0
```

The route to 192.168.30.0 now appears and a **ping** from SanJose1 or SanJose2 to 192.168.30.1 should be successful.

Step 6

In this topology, SanJose1 is an L1L2 router. However, SanJose1 was previously configured as an L2-only router. Reconfigure SanJose1 to be an L1L2 router.

```
SanJose1(config)#router isis
SanJose1(config-router)#no is-type or is-type level-1-2
```

In this topology, SanJose2 is a Level-1 only router. However, SanJose2 was also configured as a Level-2 only router. Reconfigure SanJose2 to be a Level-1 only router.

```
SanJose2(config)#router isis
SanJose2(config-router)#is-type level-1
```

Note that “-only” is not part of the level-1 command as is required for the **is-type level-2-only** command

Recall that an interface password authentication for L2 was also configured on SanJose1 and SanJose2. Since SanJose2 is now an L1-only router, making the link with SanJose1 an L1 connection, the interface password authentication should be changed to L1 as the following shows:

```
SanJose1(config)#interface fastethernet0/0
SanJose1(config-if)#isis password cisco level-1

SanJose2(config)#interface fastethernet0/0
SanJose2(config-if)#isis password cisco level-1
```

Verify authentication with a **ping** from SanJose1 to 192.168.20.1. The **ping** should be successful, indicating authentication is working properly.

Issue the **clear isis *** command on all routers to force IS-IS to recalculate routes and to refresh its link-state databases. Wait a minute or two after issuing the **clear** command before continuing to issue the respective **show** commands on SanJose1 to verify the changes made.

```
Router#clear isis *
```

```
SanJose1#show clns neighbors
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
SanJose2	Fa0/0	0004.9ad2.d0c0	Up	14	L1	IS-IS
Phoenix	Se0/0	*HDLc*	Up	23	L2	IS-IS

SanJose2 is shown as an L1 Type of router. Although Phoenix is an L1L2 router, Phoenix shows up as Type L2 because of the inter-area connection between Phoenix and SanJose1.

```
SanJose1#show isis database
```

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x00000002   0xDC22        1187           0/0/0
SanJose1.01-00 * 0x00000002   0xBFDF        1188           0/0/0
SanJose2.00-00 0x00000002   0x833B        1187           0/0/0
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 * 0x00000005   0xD732        1198           0/0/0
```

```

SanJose1.01-00      * 0x00000001  0x890C      1183      0/0/0
Phoenix.00-00      0x00000004  0xD7B9      1193      0/0/0

```

The presence of L1 and L2 link-state databases confirm that SanJose1 is now an L1L2 router.

```

SanJose1#show clns interface fa0/0
FastEthernet0/0 is up, line protocol is up
Checksums enabled, MTU 1497, Encapsulation SAP
ERPDUs enabled, min. interval 10 msec.
CLNS fast switching enabled
CLNS SSE switching disabled
DEC compatibility mode OFF for this interface
Next ESH/ISH in 36 seconds
Routing Protocol: IS-IS
Circuit Type: level-1-2
Interface number 0x0, local circuit ID 0x1
Level-1 Metric: 10, Priority: 100, Circuit ID: SanJose1.01
Number of active level-1 adjacencies: 1
Level-2 Metric: 10, Priority: 100, Circuit ID: SanJose1.01
Number of active level-2 adjacencies: 0
Next IS-IS LAN Level-1 Hello in 938 milliseconds
Next IS-IS LAN Level-2 Hello in 74 milliseconds

```

In addition to confirming SanJose1 is an L1L2 router, the priority of 100 and the SanJose1.01 circuit ID indicate that SanJose1 is the DIS. This would be the same for SanJose1.02, as noted in Step 2.

Issue the following to obtain neighbor adjacency information for SanJose2:

```

SanJose2#show clns neighbors

System Id      Interface  SNPA          State  Holdtime  Type Protocol
SanJose1      Fa0/0     0002.16de.3440 Up      4          L1    IS-IS

```

Although SanJose1 is an L1L2 router, the adjacency is an L1 connection.

```

SanJose2#show isis database

IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
SanJose1.00-00 0x0000001C   0xB02C        1024           1/0/0
SanJose1.01-00 0x0000001C   0x8918        1112           0/0/0
SanJose2.00-00 * 0x0000001B  0x5154        554            0/0/0

```

Only an L1 link-state database is maintained, confirming that SanJose2 is now an L1-only router.

```

SanJose2#show clns interface fa0/0
FastEthernet0/0 is up, line protocol is up
Checksums enabled, MTU 1497, Encapsulation SAP
ERPDUs enabled, min. interval 10 msec.
CLNS fast switching enabled
CLNS SSE switching disabled
DEC compatibility mode OFF for this interface
Next ESH/ISH in 41 seconds
Routing Protocol: IS-IS
Circuit Type: level-1-2
Interface number 0x1, local circuit ID 0x2
Level-1 Metric: 10, Priority: 64, Circuit ID: SanJose1.01
Number of active level-1 adjacencies: 1
Next IS-IS LAN Level-1 Hello in 2 seconds

```

In addition to confirming SanJose2 is an L1-only router, the circuit ID shows that SanJose1 is the DIS.

Step 7

Issue the **show clns interface serial10/0** command on the Phoenix router as follows:

```
Phoenix#show clns interface serial 0/0
Serial0/0 is up, line protocol is up
Checksums enabled, MTU 1500, Encapsulation HDLC
ERPDUs enabled, min. interval 10 msec.
CLNS fast switching enabled
CLNS SSE switching disabled
DEC compatibility mode OFF for this interface
Next ESH/ISH in 22 seconds
Routing Protocol: IS-IS
  Circuit Type: level-1-2
  Interface number 0x0, local circuit ID 0x100
  Neighbor System-ID: SanJose1
  Level-1 Metric: 10, Priority: 64, Circuit ID: Phoenix.00
  Number of active level-1 adjacencies: 0
  Level-2 Metric: 10, Priority: 64, Circuit ID: Phoenix.00
  Number of active level-2 adjacencies: 1
  Next IS-IS Hello in 1 seconds
```

Since Phoenix is presently an L1L2 router, it will maintain information for both levels. This is unnecessary, since Phoenix should be an L2-only router. Configure Phoenix for L2-only routing as follows:

```
Phoenix(config)#router isis
Phoenix(config-router)#is-type level-2-only
```

Verify the configuration with the **show clns interface serial10/0** or **show isis database** command:

```
Phoenix#show clns interface serial10/0
Serial0/0 is up, line protocol is up
Checksums enabled, MTU 1500, Encapsulation HDLC
ERPDUs enabled, min. interval 10 msec.
CLNS fast switching enabled
CLNS SSE switching disabled
DEC compatibility mode OFF for this interface
Next ESH/ISH in 28 seconds
Routing Protocol: IS-IS
  Circuit Type: level-1-2
  Interface number 0x0, local circuit ID 0x100
  Level-2 Metric: 10, Priority: 64, Circuit ID: Phoenix.00
  Number of active level-2 adjacencies: 1
  Next IS-IS Hello in 1 seconds
```

```
Phoenix#show isis database
```

```
IS-IS Level-2 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	0x00000021	0x9F4E	1117	0/0/0
SanJose1.01-00	0x0000001B	0x5526	741	0/0/0
Phoenix.00-00	* 0x00000021	0x9DD6	1119	0/0/0

Both outputs show only L2 information, confirming Phoenix is now an L2-only router.

A successful ping throughout the network indicates multi-area Integrated IS-IS with authentication has been properly configured.

Step 8

Issue the `show ip route` command on SanJose2:

```
SanJose2#show ip route
```

```
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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 172.16.0.1 to network 0.0.0.0
```

```
i L1 192.168.10.0/24 [115/20] via 172.16.0.1, FastEthernet0/0
    172.16.0.0/24 is subnetted, 1 subnets
C    172.16.0.0 is directly connected, FastEthernet0/0
C    192.168.20.0/24 is directly connected, Loopback0
    10.0.0.0/30 is subnetted, 1 subnets
i L1 10.0.0.0 [115/20] via 172.16.0.1, FastEthernet0/0
i*L1 0.0.0.0/0 [115/10] via 172.16.0.1, FastEthernet0/0
```

The SanJose2 routing table shown would have included an entry for 192.168.30.0 as an L2 route if SanJose2 had been left as an L2-only router. However, since it was changed to an L1-only router, it no longer has any L2 routes.

Note that the gateway of last resort has been set in the SanJose2 routing table. L1-only routers, such as SanJose2, always learn a default route from a neighboring L1/L2 router. In this case it was SanJose1. This is standard operating procedure for Integrated IS-IS. SanJose2 learns to exit area 49.0001 by way of SanJose1 as a result of the attached bit (ATT) being set in the L1 non-pseudonode LSP sent by SanJose1.

Issue the `show isis database` command on SanJose2:

```
SanJose2#show isis database
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	0x0000001F	0xAA2F	690	1/0/0
SanJose1.01-00	0x0000001E	0x851A	900	0/0/0
SanJose2.00-00	* 0x0000001E	0x4B57	934	0/0/0

The attached bit (ATT) indicates that SanJose1 is also an L2 router and can reach other areas.

The attached bit can also be seen in the SanJose1 L1 link-state database:

```
SanJose1#show isis database
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	* 0x0000001F	0xAA2F	640	1/0/0
SanJose1.01-00	* 0x0000001E	0x851A	849	0/0/0
SanJose2.00-00	0x0000001E	0x4B57	879	0/0/0

```
IS-IS Level-2 Link State Database:
```

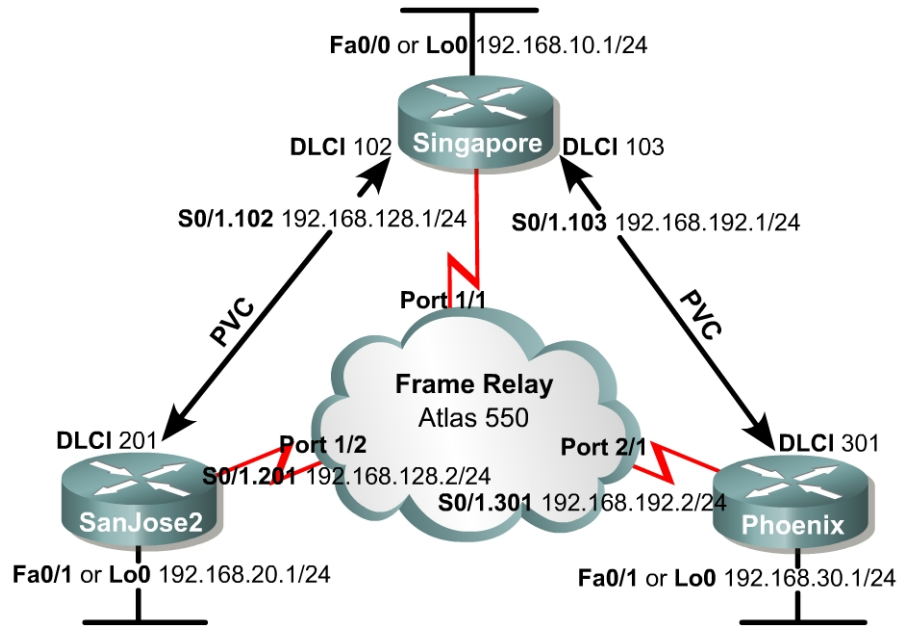
LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
SanJose1.00-00	* 0x00000022	0x9D4F	583	0/0/0
SanJose1.01-00	* 0x0000001D	0x5128	890	0/0/0
Phoenix.00-00	0x00000022	0x9BD7	584	0/0/0

Save all configurations for future reference.

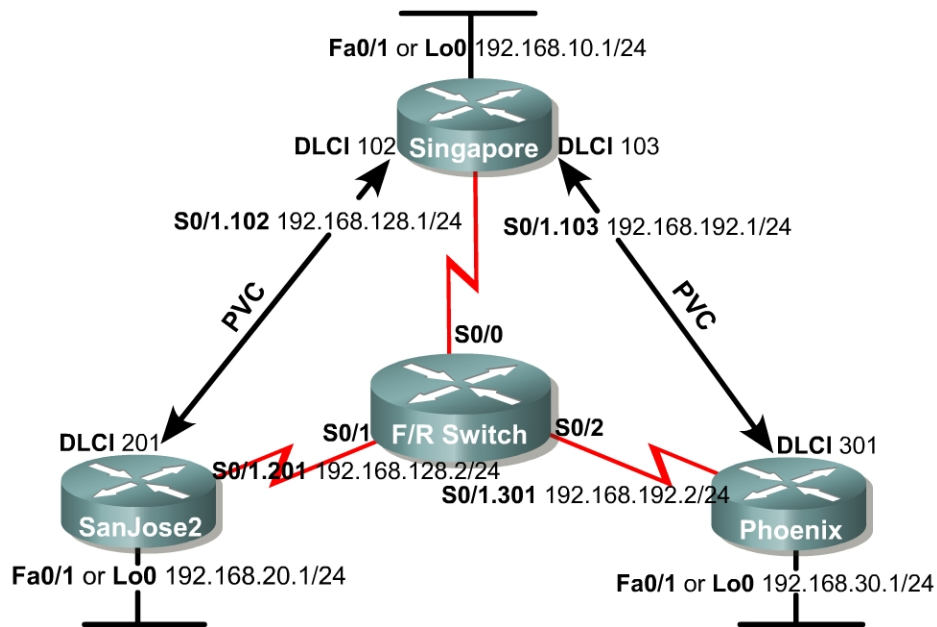
Reflection

Even though SanJose2 and Phoenix were configured as L1-only and L2-only routers, respectively, they could have been left with the default setting of L1L2. The result would have been each forming adjacencies for both levels, but unnecessarily. Why should unnecessary IS-IS adjacencies be eliminated?

Lab 7.7.3 Configuring IS-IS Over Frame Relay



Alternate



Objective

In this lab, you will configure IS-IS over a hub-and-spoke Frame Relay topology using point-to-point (p2p) subinterfaces. Multipoint configurations are not used with IS-IS as they are in OSPF.

Scenario

International Travel Agency has just connected two regional headquarters to Singapore using Frame Relay in a hub-and-spoke topology. You are asked to configure IS-IS routing over this network.

Hardware and Software Requirements

Three Cisco 2620, 2621, 2620XM, or 2621XM routers or a combination may be used for this lab. Cisco IOS Release 12.2(12) with the Enterprise Plus or Enterprise Plus IPsec 56 feature set is used. The Enterprise Plus feature set is the minimum requirement for IS-IS support.

Cisco IOS 12.2(12) with the Enterprise Plus feature set requires a minimum of 16 MB of Flash and 48 MB of RAM and the Enterprise Plus IPsec 56 feature set requires a minimum of 16 MB of Flash and 64 MB of RAM.

The image names for the Cisco IOS Release 12.2(12) with the Enterprise Plus and Plus IPsec 56 feature sets are c2600-js-mz.122-12.bin and c2600-jk8s-mz.122-12.bin, respectively. The “j” indicates “Enterprise” and the “s” indicates “Plus”.

This lab requires another router or device to act as a Frame Relay switch. The first diagram assumes that you will use an Adtran Atlas 550, which is preconfigured with the CCNP Version 3.0 Adtran configuration file. The second diagram assumes that you will configure a router with at least three serial interfaces as a Frame Relay switch (such as a 2600 router with two WIC-2A/S installed). See the configuration at the end of this lab for an example of how to configure a router as a Frame Relay switch. If desired, you can copy the configuration to a 2600 router for use in this lab.

Step 1

Cable the network according to the diagram. Configure the hostnames according to the diagram. Configure the hostname, turn off DNS lookup, add the Telnet shortcuts as was done in Lab 7.7.1, configure the IP address on the FastEthernet or Loopback interfaces, whichever option was selected.

Configure each router's FastEthernet interface or Loopback interface as shown, but leave the serial interfaces and IS-IS routing unconfigured for now. Until you configure Frame Relay, you will not be able to use ping to test connectivity.

Step 2

Singapore acts as the hub in this hub-and-spoke network. It reaches SanJose2 and Phoenix via two separate PVCs.

IS-IS can work only over NBMA clouds (such as Frame Relay) configured with a full mesh. Anything less than a full mesh can cause serious connectivity and routing issues. Even if a full mesh is configured, it is no guarantee that a full mesh will exist at all times. A failure in the underlying switched WAN network, or a misconfiguration on one or more routers, could break the full mesh either temporarily or permanently. Avoid NBMA multipoint configurations for IS-IS networks; use point-to-point subinterfaces.

Configure Frame Relay on Singapore's serial interface as shown here:

```
Singapore(config)#interface serial 0/1
Singapore(config-if)#encapsulation frame-relay
Singapore(config-if)#no shutdown
Singapore(config-if)#interface s0/1.102 point-to-point
Singapore(config-subif)#ip address 192.168.128.1 255.255.255.0
Singapore(config-subif)#frame-relay interface-dlci 102
Singapore(config-subif)#interface s0/1.103 point-to-point
Singapore(config-subif)#ip address 192.168.192.1 255.255.255.0
```

```
Singapore(config-subif)#frame-relay interface-dlci 103
```

Configure SanJose2's serial interface:

```
SanJose2(config)#interface serial 0/1  
SanJose2(config-if)#encapsulation frame-relay  
SanJose2(config-if)#no shutdown  
SanJose2(config-if)#interface s0/1.201 point-to-point  
SanJose2(config-subif)#ip address 192.168.128.2 255.255.255.0  
SanJose2(config-subif)#frame-relay interface-dlci 201
```

Finally, configure Phoenix's serial interface:

```
Phoenix(config)#interface serial 0/1  
Phoenix(config-if)#encapsulation frame-relay  
Phoenix(config-if)#no shutdown  
Phoenix(config-if)#interface s0/1.301 point-to-point  
Phoenix(config-subif)#ip address 192.168.192.2 255.255.255.0  
Phoenix(config-subif)#frame-relay interface-dlci 301
```

Verify Frame Relay operation with a ping from Singapore to SanJose2 and Phoenix.

1. Are you able to ping all the interfaces?

Issue a **show frame-relay pvc** and **show frame-relay map** to troubleshoot connectivity problems.

```
Singapore#show frame-relay pvc
```

```
PVC Statistics for interface Serial0/1 (Frame Relay DTE)
```

	Active	Inactive	Deleted	Static
Local	2	0	0	0
Switched	0	0	0	0
Unused	0	1	0	0

```
DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0/1.102
```

```
input pkts 51          output pkts 55          in bytes 14032  
out bytes 15488        dropped pkts 0          in pkts dropped 0  
out pkts dropped 0    out bytes dropped 0  
in FECN pkts 0        in BECN pkts 0         out FECN pkts 0  
out BECN pkts 0       in DE pkts 0           out DE pkts 0  
out bcast pkts 50     out bcast bytes 14968  
pvc create time 00:50:57, last time pvc status changed 00:31:03
```

```
DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0/1.103
```

```
input pkts 48          output pkts 49          in bytes 13093  
out bytes 13811        dropped pkts 0          in pkts dropped 0  
out pkts dropped 0    out bytes dropped 0  
in FECN pkts 0        in BECN pkts 0         out FECN pkts 0  
out BECN pkts 0       in DE pkts 0           out DE pkts 0  
out bcast pkts 44     out bcast bytes 13291  
pvc create time 00:51:00, last time pvc status changed 00:31:07
```

```
DLCI = 104, DLCI USAGE = UNUSED, PVC STATUS = INACTIVE, INTERFACE = Serial0/1
```

```
input pkts 0           output pkts 0           in bytes 0  
out bytes 0           dropped pkts 0          in pkts dropped 0
```

```

out pkts dropped 0                out bytes dropped 0
in FECN pkts 0                    in BECN pkts 0          out FECN pkts 0
out BECN pkts 0                    in DE pkts 0            out DE pkts 0
out bcast pkts 0                    out bcast bytes 0
switched pkts 0
Detailed packet drop counters:
no out intf 0                      out intf down 0        no out PVC 0
in PVC down 0                      out PVC down 0         pkt too big 0
shaping Q full 0                    pkt above DE 0         policing drop 0
pvc create time 00:28:02, last time pvc status changed 00:28:02

```

```

Singapore#show frame-relay map
Serial0/1.103 (up): point-to-point dlci, dlci 103(0x67,0x1870), broadcast
status defined, active
Serial0/1.102 (up): point-to-point dlci, dlci 102(0x66,0x1860), broadcast
status defined, active

```

You can disregard the DLCI 104 information in the show frame-relay pvc output – it is discovered via LMI exchanges with the switch (the Adtran Atlas 550 is configured to advertise DLCI's 102, 103, and 104 out port 1/1). DLCI 104 is inactive because there is no device connected to port 2/2. The 550 is configured to support a 4-node full mesh.

Step 3

Like OSPF, IS-IS is configured by enabling an IS-IS process and specifying which interfaces are to participate in the IS-IS process. Configure IS-IS to run over this point-to-point network with the following commands:

```

Singapore(config)#router isis
Singapore(config-router)#net 49.0001.1111.1111.1111.00
Singapore(config)#int serial 0/1.102
Singapore(config-if)#ip router isis
Singapore(config)#int serial 0/1.103
Singapore(config-if)#ip router isis
Singapore(config)#int lo0
Singapore(config-if)#ip router isis

SanJose2(config)#router isis
SanJose2(config-router)#net 49.0001.2222.2222.2222.00
SanJose2(config)#int serial 0/1.201
SanJose2(config-if)#ip router isis
SanJose2(config)#int lo0
SanJose2(config-if)#ip router isis

Phoenix(config)#router isis
Phoenix(config-router)#net 49.0001.3333.3333.3333.00
Phoenix(config)# int serial 0/1.301
Phoenix(config-if)#ip router isis
Phoenix(config)#int lo0
Phoenix(config-if)#ip router isis

```

Verify your IS-IS configuration by issuing the **show ip route** command on each of the routers:

```

Phoenix#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C       192.168.192.0/24 is directly connected, Serial0/1.301

```

```

C 192.168.30.0/24 is directly connected, Loopback0
i L1 192.168.128.0/24 [115/20] via 192.168.192.1, Serial0/1.301
i L1 192.168.10.0/24 [115/20] via 192.168.192.1, Serial0/1.301
i L1 192.168.20.0/24 [115/30] via 192.168.192.1, Serial0/1.301

```

If each router has a complete table, including routes to 192.168.10.0/24, 192.168.20.0/24, and 192.168.30.0/24, you have successfully configured IS-IS to operate over Frame Relay.

Test these routes by pinging the FastEthernet/Loopback interfaces of each router from Phoenix's console.

1. Are you able to ping all the FastEthernet/Loopback interfaces?

Finally, issue the **show isis database** and **show isis topology** commands:

```
Singapore#show isis database
```

```

IS-IS Level-1 Link State Database:
LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
Singapore.00-00     * 0x00000007  0x3B7A        737            0/0/0
SanJose2.00-00      0x00000004  0xA0ED        736            0/0/0
Phoenix.00-00       0x00000003  0x7603        666            0/0/0
IS-IS Level-2 Link State Database:
LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
Singapore.00-00     * 0x00000009  0x2F3C        744            0/0/0
SanJose2.00-00      0x00000006  0x90E7        747            0/0/0
Phoenix.00-00       0x00000004  0x5B53        742            0/0/0

```

```
SanJose2#show isis topology
```

```

IS-IS paths to level-1 routers
System Id            Metric  Next-Hop            Interface  SNPA
Singapore            10     Singapore           Se0/1.201  DLCI 201
SanJose2             --
Phoenix              20     Singapore           Se0/1.201  DLCI 201

IS-IS paths to level-2 routers
System Id            Metric  Next-Hop            Interface  SNPA
Singapore            10     Singapore           Se0/1.201  DLCI 201
SanJose2             --
Phoenix              20     Singapore           Se0/1.201  DLCI 201

```

Note that no pseudonode LSP's (with non-zero circuit ID's) appear in the **show isis database** output because we are using p2p links to connect the routers.

2. How is the subnetwork point of attachment (SNPA) expressed in a Frame Relay network?

Step 4

A common error with IS-IS configuration is mismatched interface types in an NBMA environment (normally Frame Relay or ATM). To illustrate this, switch SanJose2's point-to-point interface to a multipoint interface:

```

SanJose2(config)#interface s0/1.201
SanJose2(config-subif)#no ip address
SanJose2(config-subif)#no ip router isis
SanJose2(config-subif)#no frame-relay interface-dlci 201
SanJose2(config)#interface s0/1.2001 multipoint
SanJose2#(config)#ip address 192.168.128.2 255.255.255.0

```



```
SanJose2#(config)#ip router isis
SanJose2#(config)#frame-relay interface-dlci 201
```

Allow the Frame Relay PVC to become active. Then, view the output of **show clns neighbors** command on Singapore and SanJose2:

```
Singapore#show clns neighbors
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
Phoenix	Se0/1.103	DLCI 103	Up	27	L1L2	IS-IS

```
SanJose2#show clns neighbors
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
Singapore	Se0/1.2001	DLCI 201	Up	258	IS	ES-IS

The output indicates mismatched interface types! Recall from the curriculum that, since IOS Release 12.1(1)T, an Integrated IS-IS mismatch is indicated in this case:

- SanJose2 (multipoint) receives a point-to-point hello PDU, realizes it is the wrong hello type, and installs the neighbor as an ES. SanJose shows Singapore in the **show clns neighbors** with protocol "ES-IS".
- Singapore (point-to-point) receives the LAN hello PDU, recognizes the mismatch, and ignores the neighbor. SanJose2 does not appear at all in Singapore's **show clns neighbors** output. A **debug isis adj-packets** output shows the incoming LAN IIH PDU and R2 declaring the mismatch.

```
SanJose2#debug isis adj-packets
```

```
IS-IS Adjacency related packets debugging is on
```

```
00:31:58: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
```

```
00:31:58: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
```

```
00:31:59: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/1.2001
```

```
00:31:59: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/1.2001
```

```
00:32:01: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
```

```
00:32:01: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
```

```
00:32:02: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/1.2001
```

```
00:32:03: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/1.2001
```

```
00:32:04: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
```

```
00:32:04: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
```

```
00:32:04: ISIS-Adj: Rec serial IIH from DLCI 201 (Serial0/1.2001), cir type L1L2, cir id 00, length 1499
```

```
00:32:04: ISIS-Adj: Point-to-point IIH received on multi-point interface: ignored IIH
```

```
00:32:05: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/1.2001
```

```
00:32:06: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/1.2001
```

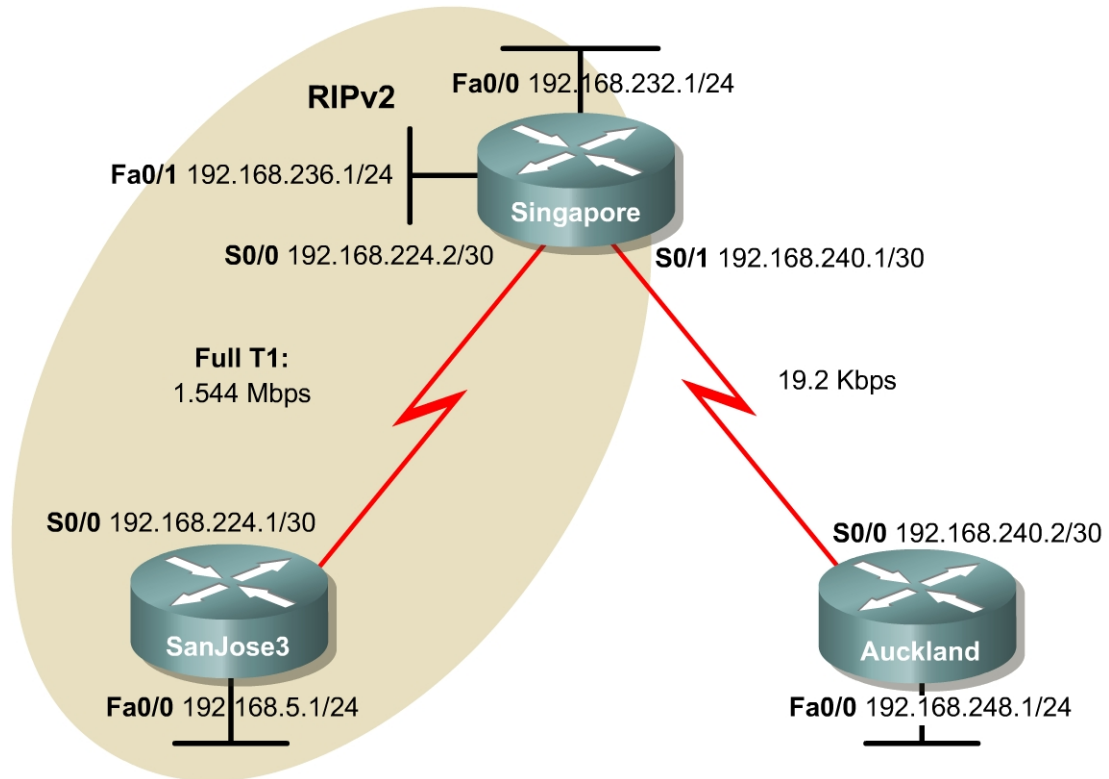
This completes the IS-IS over Frame Relay lab. Integrated IS-IS can be easily configured over a Frame Relay cloud. The only caveat is that IS-IS NBMA configurations, unlike OSPF, are essentially limited to point-to-point implementations. Mismatched interface types in an NBMA environment is a common problem – the symptoms are reflected in the output of the **show clns neighbors** command and the **debug isis adj-packets** command.

Router as Frame Relay Switch Configuration

The following configuration enables a 2600 router with two WIC-2A/S to act as a Frame Relay switch for this lab.

```
Frame-Switch#show run
version 12.2
service timestamps debug uptime
service timestamps log uptime
service password-encryption
!
hostname Frame-Switch
!
ip subnet-zero
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
frame-relay switching
!
process-max-time 200
!
interface Serial0/0
no ip address
no ip directed-broadcast
encapsulation frame-relay
clockrate 128000
frame-relay intf-type dce
frame-relay route 102 interface Serial0/1 201
frame-relay route 103 interface Serial0/2 301
!
interface Serial0/1
no ip address
no ip directed-broadcast
encapsulation frame-relay
clockrate 128000
frame-relay intf-type dce
frame-relay route 201 interface Serial0/0 102
!
interface Serial0/2
no ip address
no ip directed-broadcast
encapsulation frame-relay
clockrate 128000
frame-relay intf-type dce
frame-relay route 301 interface Serial0/0 103
!
interface Serial0/3
no ip address
no ip directed-broadcast
shutdown
!
ip classless
no ip http server
!
line con 0
password cisco
login
transport input none
line aux 0
line vty 0 4
password cisco
login
!
no scheduler allocate
end
```

Lab 8.5.1 Configuring Distribute Lists and Passive Interfaces



Objective

In this lab, a combination of advanced routing features will be used to optimize routing. These features include distribute lists, passive interfaces, default routes, and route redistribution.

Scenario

International Travel Agency (ITA) uses RIP v2 for dynamic routing. Perform an analysis to determine whether RIP v2 is optimized.

A very slow 19.2 Kbps link is used to connect Singapore and Auckland until a faster link can be provisioned. To reduce traffic, try to avoid dynamic routing on this link.

The LAN connected to SanJose3 is a stub network and is near saturation. To reduce traffic, filter RIP v2 updates from entering the Ethernet LAN 192.168.5.0/24 of router SanJose3, since the updates serve no purpose.

ITA has a large research and development division in Singapore. The R&D engineers are on LAN 192.168.232.0/24. The R&D managers on the 192.168.236.0/24 LAN need access to this experimental network. However, this LAN needs to be 'invisible' to the rest of the company, that is, subnets not attached to the Singapore site. Also, the two R&D LANs have many UNIX hosts that need to exchange RIP v2 updates with the Singapore router.

Step 1

Build and configure the network according to the diagram, but do not configure RIP v2 yet.

Use CDP to verify Layer 2 connectivity with directly connected neighbors. Use `ping` to verify the work and test connectivity between the serial interfaces. Ping only the other side of the link that is the directly connected neighbor IP address.

Note: Auckland should not be able to ping SanJose3 until additional configurations have been made.

Step 2

On SanJose3, configure RIP v2 to advertise both connected networks, as shown in the following:

```
SanJose3(config)#router rip
SanJose3(config-router)#version 2
SanJose3(config-router)#network 192.168.224.0
SanJose3(config-router)#network 192.168.5.0
```

On the ethernet LAN of SanJose3, no routers or hosts require RIP v2. However, if the 192.168.5.0 network in the RIP v2 configuration is not included, SanJose3 will not advertise the network to Singapore. FastEthernet 0/0 can be configured as a passive interface, keeping the router from sending RIP v2 updates out the FastEthernet 0/0 interface. Use the following commands:

```
SanJose3(config)#router rip
SanJose3(config-router)#passive-interface fastethernet0/0
```

RIP v2 updates will no longer be sent through FastEthernet 0/0.

Step 3

Now configure RIP v2 on Singapore. At this point, issue the following enable RIP v2 only on the 192.168.224.0/30 network so that Singapore can exchange routing information with SanJose3:

```
Singapore(config)#router rip
Singapore(config-router)#version 2
Singapore(config-router)#network 192.168.224.0
```

After this RIP v2 configuration on Singapore has been entered, check the routing table on SanJose3 with the `show ip route` command as follows:

Note: SanJose3 has not learned any routes through RIP v2.

```
SanJose3#show ip route
<output omitted>
C    192.168.5.0/24 is directly connected, FastEthernet0/0
C    192.168.224.0/24 is directly connected, Serial0/0
```

1. SanJose3 has not learned about 192.168.232.0/24 and 192.168.236.0/24. Why not? Issue the **debug ip rip** command on SanJose3 to validate this assumption. Are RIP updates seen coming in through the Serial 0/0 interface?

RIP has not been configured on Singapore to advertise the Ethernet networks. Also, RIP will not advertise a route for 192.168.224.0/30 out interface serial 0/0, where the network resides.

Step 4

Review the network requirements. Then issue the following to enable RIP v2 on the Ethernet interfaces of Singapore so that UNIX hosts on these LANs can receive routing information:

```
Singapore(config)#router rip
Singapore(config-router)#Version 2
Singapore(config-router)#network 192.168.232.0
Singapore(config-router)#network 192.168.236.0
```

RIP v2 is now sending updates to these networks, as required for the UNIX hosts. Reissue the **show ip route** command recheck the routing table of SanJose3:

Note: Turn off the **debug ip rip** before continuing.

```
SanJose3#show ip route

Gateway of last resort is not set

    192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
C       192.168.5.0/24 is directly connected, FastEthernet0/0
R       192.168.232.0/24 [120/1] via 192.168.224.1, 00:00:13, Serial0/0
R       192.168.236.0/24 [120/1] via 192.168.224.1, 00:00:09, Serial0/0
```

The **network** command enables RIP updates on interfaces within that major network and advertises those networks out all other RIP enabled interfaces. SanJose3 now has routes to 192.168.232.0/24, and 192.168.236.0/24. Having route 192.168.232.0/24 is intended. However, having route 192.168.236.0/24 is a potential problem. Remember that this network is to be kept invisible to the rest of the company.

Step 5

RIP advertisements regarding the 192.168.236.0/24 network can be omitted from updates in one of two ways. If the **no network 192.168.236.0** command was issued on the Singapore router, this would halt advertisements about this network. However, by using this method, network 192.168.236.0 is no longer visible to the UNIX hosts that are on this network. The preferred method of filtering this network advertisement from reaching the SanJose3 router is to filter routing protocol updates with the **distribute-list** command.

Distribution lists define which networks are permitted or denied when receiving or sending routing updates. Distribution lists require an access list to define which networks are permitted and which networks are denied.

Because 192.168.236.0/24 is to be filtered from outgoing updates to the SanJose3 router, use the following commands:

```
Singapore(config)#access-list 1 deny 192.168.236.0
Singapore(config)#access-list 1 permit any
Singapore(config)#router rip
Singapore(config-router)#distribute-list 1 out serial 0/0
```

It is critical to include the interface at the end of the `distribute-list` command so that this filter is only applied to routing updates sent out to SanJose3. Without the reference to the particular interface, the router will filter out all advertisement of the 192.168.236.0/24 network to all interfaces, including the Unix hosts connected to the 192.168.232.0 LAN on Singapore.

Verify that this filter has been applied by issuing the `show ip protocols` command on Singapore.

```
Singapore#show ip protocol
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 4 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
    Serial0/0 filtered by 1 (per-user), default is 1
  Incoming update filter list for all interfaces is
  Redistributing: rip
  Default version control: send version 2, receive version 2
  Interface          Send  Recv  Triggered RIP  Key-chain
  FastEthernet0/0    2     2
  Serial0/0          2     2
  FastEthernet0/1    2     2
Routing for Networks:
  192.168.224.0
  192.168.232.0
  192.168.236.0
Passive Interface(s):
  Serial0/1
Routing Information Sources:
  Gateway            Distance      Last Update
  192.168.224.2      120          00:00:03
Distance: (default is 120)
```

1. According to the output of this command, which interface is the outgoing update filter list applied to?

The list that is applied to all of RIP-enabled interfaces should not be set. Instead notice that the Serial 0/0 interface is being filtered by list 1. List 1 happens to be the access list number that was configured in the previous example.

With the distribute list configured on Singapore, return to SanJose3 and flush the routing table with the `clear ip route *` command. Wait at least five seconds, and then use the `show ip route` command as follows to check the routing table of SanJose3:

```
SanJose3#show ip route

Gateway of last resort is not set

    192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
C       192.168.5.0/24 is directly connected, FastEthernet0/0
R       192.168.232.0/24 [120/1] via 192.168.224.1, 00:00:01,
Serial0/0
```

Is the route to 192.168.236.0/24 in SanJose3's table? Looking at the routing table of San Jose3, is 192.168.236.0/24 present?

The distribute list should have removed 192.168.236.0/24 from further RIP updates. 192.168.232.0/24 should be the only RIP route in SanJose3 routing table at this point.

Step 6

The SanJose3 routing table is almost complete, but it does not include a route to 192.168.240.0/30, which is directly connected to Singapore. There are two methods to advertise the link between Singapore and Auckland by way of RIP. The first is very similar to what was done previously with the other routers and the advertisement of their directly connected networks. The process would be to enter a network command in the RIP v2 configuration of router Singapore so that it will advertise the 192.168.240.0/30 network. Of course, RIP v2 updates should not be sent out the 19.2 Kbps link. Therefore S0/1 of Singapore would need to be placed into passive mode. This is done with the `passive-interface serial 0/1` command while at the Singapore RIP router configuration prompt. This network must be advertised using a different approach. The alternative method, is to configure the Singapore router to redistribute connected networks into RIP v2. Enter the following commands on Singapore:

```
Singapore(config)#router rip
Singapore(config-router)#redistribute connected
Singapore(config-router)#no auto-summary
```

When issuing these commands, Singapore imports all directly connected routes into the RIP process. Therefore, 192.168.240.0/30 will be redistributed into RIP v2 and sent to SanJose3 as part of each RIP v2 update. Verify the configuration by issuing the following command on Singapore:

```
Singapore #show ip route 192.168.240.1
Routing entry for 192.168.240.0/30
```

```
Known via 'connected', distance 0, metric 0 (connected, via interface)
Redistributing via rip
Advertised by rip
Routing Descriptor Blocks:
* directly connected, via Serial0/1
  Route metric is 0, traffic share count is 1
```

The output of this command should confirm that this connected route is being redistributed and advertised by RIP v2.

Check the routing table of SanJose3 with the **show ip route** command as follows:

```
SanJose3#show ip route
Gateway of last resort is not set
  192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
  192.168.240.0/30 is subnetted, 1 subnets
R       192.168.240.0 [120/1] via 192.168.224.1, 00:00:02, Serial0/0
R  192.168.240.0/24 [120/1] via 192.168.224.1 00:01:17 Serial 0/0
C  192.168.5.0/24 is directly connected, FastEthernet0/0
R  192.168.232.0/24 [120/1] via 192.168.224.1, 00:00:02, Serial0/0
```

SanJose3 should now have RIP v2 routes to both 192.168.240.0/30 and 192.168.232.0/24.

Step 7

With routing between Singapore and SanJose3 almost complete, now view Auckland. Avoid dynamic routing on the WAN link of router Auckland, and use a static route.

First, try to ping Auckland serial interface 192.168.240.2. Is this successful? _____

Auckland is a stub network. It has only one exit point to the rest of the world. In this situation, configure a static default route that will work for all non local traffic by using the following command:

```
Auckland(config)#ip route 0.0.0.0 0.0.0.0 192.168.240.1 210
```

The administrative distance of 210 was added so that the static route will not default to one (1). A distance of one (1) would not allow an administrator to override the route if the topology changes in the future. Although this is not required, it is a best practice to avoid routes that end up with administrative distance equal to one (1).

Verify that Auckland is using a default route. From the console of SanJose3, enter the **debug ip packet** command as follows:

```
SanJose3#debug ip packet
```

Leave the SanJose3 router console session open and then return to Auckland. From the Auckland router console, ping the SanJose FastEthernet 0/0 at 192.168.5.1.

The following shows that debug output can be seen on the SanJose3 router:


```
IP packet debugging is on
00:53:31: IP: s=192.168.240.2 (Serial0/0), d=192.168.5.1, len 100,
rcvd 4
00:53:31: IP: s=192.168.5.1 (local), d=192.168.240.2 (Serial0/0),
len 100, sending
```

These pings should be successful.

Note: The debug output of SanJose3 reports that the pings have been received and replied to.

Next, ping SanJose3 using **extended ping** commands. Invoke extended ping by typing **ping** and pressing **Enter** in privileged mode. Use the extended commands and source the ping from the FastEthernet 0/0 address of Auckland, 192.168.248.1 as follows:

```
Auckland#ping
Protocol [ip]: ip
Target IP address: 192.168.5.1
Repeat count [5]: 5
Datagram size [100]: 100
Timeout in seconds [2]: 2
Extended commands [n]: y
Source address or interface: 192.168.248.1
Type of service [0]: 0
Set DF bit in IP header? [no]: no
Validate reply data? [no]: no
Data pattern [0xABCD]: 0xABCD
Loose, Strict, Record, Timestamp, Verbose[none]: none
Sweep range of sizes [n]: n
```

1. Were these pings successful?

Check the **debug ip packet** output on SanJose3.

The following shows the **debug** output as seen on the SanJose3 router:

```
IP packet debugging is on
00:56:53: IP: s=192.168.248.1 (Serial0/0), d=192.168.5.1, len 100,
rcvd 4
00:56:53: IP: s=192.168.5.1 (local), d=192.168.248.1, len 100, unroutable
```

2. The arrival of the ICMP echo requests, or pings, should be able to be seen. SanJose3 did not respond. Why not?

3. Check the routing table of SanJose3. Does SanJose3 have a route to the 192.168.248.0/24 network?

At this point, SanJose3 does not have a route to network 192.168.248.0/24 or a default route for unknown destinations.

Step 8

In order for Singapore and SanJose3 to route to 192.168.248.0/24, it must be configured to a static route. It has been decided to configure the static route on Singapore and then let Singapore propagate this route to other routers, such as SanJose3, dynamically. This will save the task of entering a static route on every router. Enter the following command on Singapore:

```
Singapore(config)#ip route 192.168.248.0 255.255.255.0 192.168.240.2 210
```

This command configures a static route for the 192.168.248.0/24 network using the S0 of Auckland as the next hop with an administrative distance of 210.

In order for Singapore to dynamically update SanJose3 with this information, RIP v2 must be configured to redistribute static routes on Singapore. Issue the following commands:

```
Singapore(config)#router rip
Singapore(config-router)#redistribute static metric 2
```

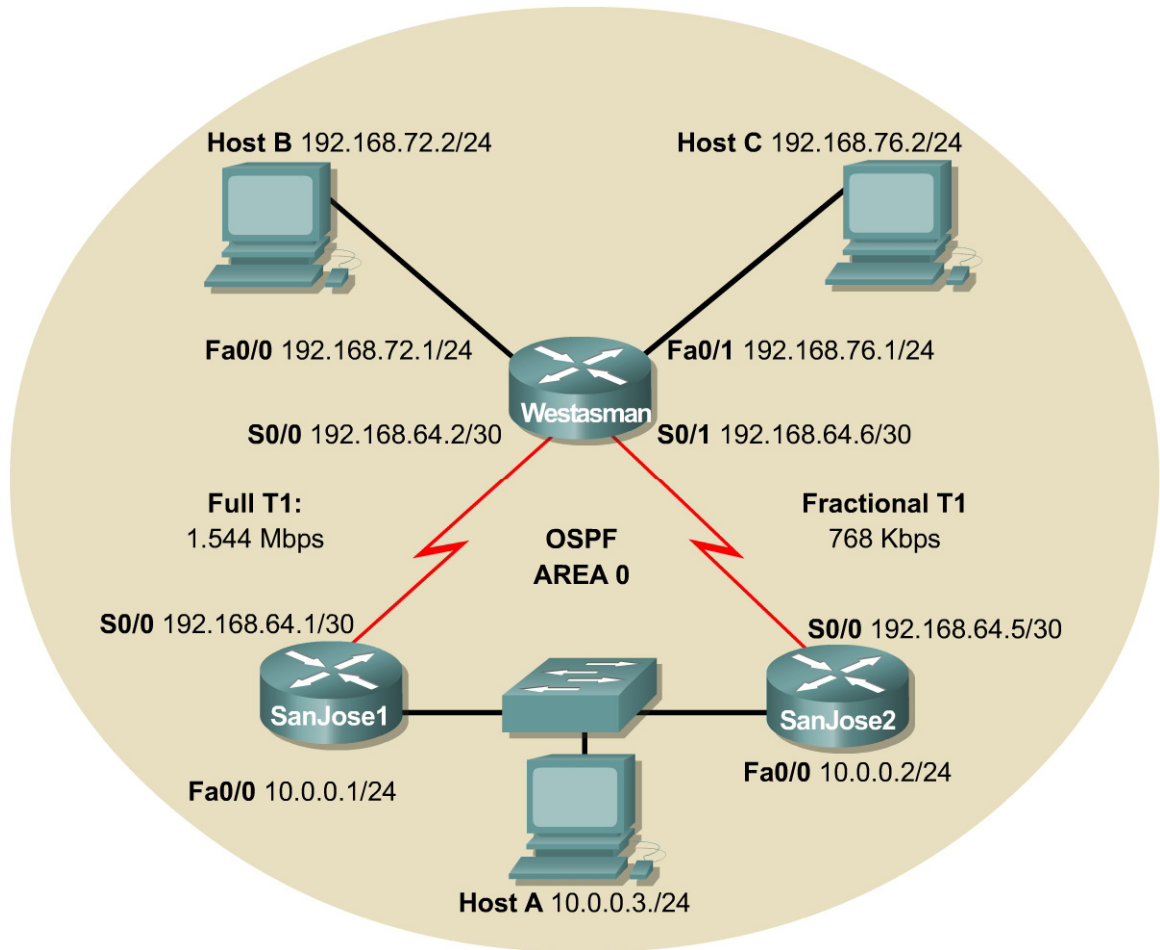
Although not required when redistributing a static route into RIP, it is a good idea to include a metric. The value of two (2) will indicate to the SanJose3 router that the 192.168.248.0/24 network exists one hop beyond the advertising Singapore router.

Finally, check the routing table on SanJose3 as follows:

```
SanJose3#show ip route
Gateway of last resort is not set
  192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
  192.168.240.0/30 is subnetted, 1 subnets
R       192.168.240.0 [120/1] via 192.168.224.1, 00:00:01, Serial0/0
C       192.168.5.0/24 is directly connected, FastEthernet0/0
R       192.168.232.0/24 [120/1] via 192.168.224.1, 00:00:02, Serial0/0
R       192.168.248.0/24 [120/2] via 192.168.224.1, 00:00:02, Serial0/0
```

This should now be complete. Verify connectivity with an extended ping from the FastEthernet 0/0 of SanJose3 to the FastEthernet 0/0 of Auckland.

Lab 8.5.2a Configuring Route Maps



Objective

In this lab, apply a routing policy by configuring a route map.

Scenario

International Travel Agency maintains two WAN links from the West Tasman site to its core network 10.0.0.0/24. West Tasman is also referred to as Westasman. One link is full T1 or 1.544 Mbps. The other link is a fractional T1 with a capacity of 768 Kbps. Under OSPF, West Tasman prefers the Full T1 link by virtue of its higher bandwidth and lower cost. All traffic that originates from the 192.168.72.0/24 network that is destined for the 10.0.0.0/24 network needs to be routed through the fractional T1 link. This T1 link has a Crypto Box allowing encryption and improved security. Apply this policy by configuring a route map on the West Tasman router.

Step 1

Build and configure the network according to the diagram. Insure that the bandwidth for each serial interface listed above is set to 1544kbps. Do not configure the link between Westasman and SanJose2 as a fractional T1 yet. WIC 2T and standard serial interfaces will default to 1544k. Serial interfaces that are Sync/Async will default to 128k. If using a WIC 2A/S in one of the lab routers, be sure to adjust the bandwidth initially to 1544. Configure all interfaces for OSPF Area 0. Configure Host A and Host B with IP addresses and default gateways as indicated in the diagram. Initially configure the serial links for equal cost share. That is, do not configure the serial link bandwidth statements at this time.

Note: Use SanJose1 as the gateway of HostA.

Use **ping** and **show ip route** to verify the work and test connectivity between all interfaces and hosts.

Step 2

Check the routing table on Westasman as follows:

```
Westasman#show ip route

Gateway of last resort is not set

C    192.168.72.0/24 is directly connected, FastEthernet0/0
C    192.168.76.0/24 is directly connected, FastEthernet0/1
     192.168.64.0/30 is subnetted, 2 subnets
C    192.168.64.0 is directly connected, Serial0/0
C    192.168.64.4 is directly connected, Serial0/1
     10.0.0.0/24 is subnetted, 1 subnets
O    10.0.0.0 [110/65] via 192.168.64.1, 00:00:17, Serial0/0
     [110/65] via 192.168.64.5, 00:00:17, Serial0/1
```

1. How many routes does Westasman have to 10.0.0.0/24?

Two equal cost routes are in the routing table.

Configure S0/1 on Westasman and S0/0 on SanJose2 to accurately reflect the bandwidth of the WAN link as follows:

```
Westasman(config)#interface serial0/1
Westasman(config-if)#bandwidth 768
Westasman(config)#interface serial0/0
Westasman(config-if)#bandwidth 1544
```

After setting the bandwidth, check the routing table on Westasman as follows:

```
Westasman#show ip route

Gateway of last resort is not set

C    192.168.72.0/24 is directly connected, FastEthernet0/0
C    192.168.76.0/24 is directly connected, FastEthernet0/1
```

```
192.168.64.0/30 is subnetted, 2 subnets
C    192.168.64.0 is directly connected, Serial0/0
C    192.168.64.4 is directly connected, Serial0/1
10.0.0.0/24 is subnetted, 1 subnets
O    10.0.0.0 [110/65] via 192.168.64.1, 00:00:01, Serial0/0
```

2. How many routes are there to 10.0.0.0/24?

3. Which interface is OSPF using to route to 10.0.0.0/24?

Westasman should have one route to the core FastEthernet network using S0/0. OSPF uses bandwidth to derive cost for each route. With unequal costs, only the preferred lower cost route is placed in the routing table.

Step 3

Configure a route map to force Westasman to use S0/1 to route traffic from 192.168.72.0/24 bound for 10.0.0.0/24. Before configuring the route map, create an access list that will match the traffic that needs to be policy routed. Because traffic sourced from 192.168.72.0/24 is to be affected, create the following access list on Westasman:

```
Westasman (config)#access-list 101 permit ip 192.168.72.0 0.0.0.255
10.0.0.0 0.0.0.255
```

Next, create the route map, which will be called CRYPTO. The route map will reference access list 101, which was just created. Use the following commands:

```
Westasman(config)#route-map CRYPTO permit 10
Westasman(config-route-map)#match ip address 101
Westasman(config-route-map)#set interface serial 0/1
```

This policy will be applied to the FastEthernet 0/0 of Westasman, because this is the interface that will accept the traffic that is to be policy routed. On FastEthernet 0/0, enter the following commands:

```
Westasman(config)#interface fastethernet 0/0
Westasman(config-if)#no ip route-cache
Westasman(config-if)#ip policy route-map CRYPTO
```

Route map CRYPTO is now applied to FastEthernet 0/0. To verify this, issue the **show ip interface fastethernet 0/0** command as follows:

```
Westasman#show ip interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
Internet address is 192.168.72.1/24
Broadcast address is 255.255.255.255
Address determined by setup command
```

```
MTU is 1500 bytes
Helper address is not set
Directed broadcast forwarding is disabled
Multicast reserved groups joined: 224.0.0.5 224.0.0.6
Outgoing access list is not set
Inbound access list is not set
Proxy ARP is enabled
Security level is default
Split horizon is enabled
ICMP redirects are always sent
ICMP unreachable are always sent
ICMP mask replies are never sent
IP fast switching is disabled
IP fast switching on the same interface is disabled
IP Flow switching is disabled
IP Feature Fast switching turbo vector
IP multicast fast switching is enabled
IP multicast distributed fast switching is disabled
IP route-cache flags are Fast
Router Discovery is disabled
IP output packet accounting is disabled
IP access violation accounting is disabled
TCP/IP header compression is disabled
RTP/IP header compression is disabled
Probe proxy name replies are disabled
Policy routing is enabled, using route map CRYPTO
Network address translation is disabled
WCCP Redirect outbound is disabled
WCCP Redirect inbound is disabled
WCCP Redirect exclude is disabled
BGP Policy Mapping is disabled
```

Another simple way to verify that the route-map is properly applied to the interface is to issue the **show ip policy** command. The output is displayed as follows:

```
Westasman#show ip policy
Interface      Route map
Fa0/0          CRYPTO
```

After this configuration is completed, use **show ip route** to verify that S0/0 is still the exit interface for router Westasman to network 10.0.0.0/24.

Step 4

Verify that the policy has taken effect. Issue the `debug ip policy` command at the Westasman console. Leave this window open or issue the `logging buffered` command.

```
Westasman#debug ip policy
Westasman#config t
Westasman(config)#logging buffered
```

From Host B, use a trace route program, such as `tracert`, to trace the route to 10.0.0.1.

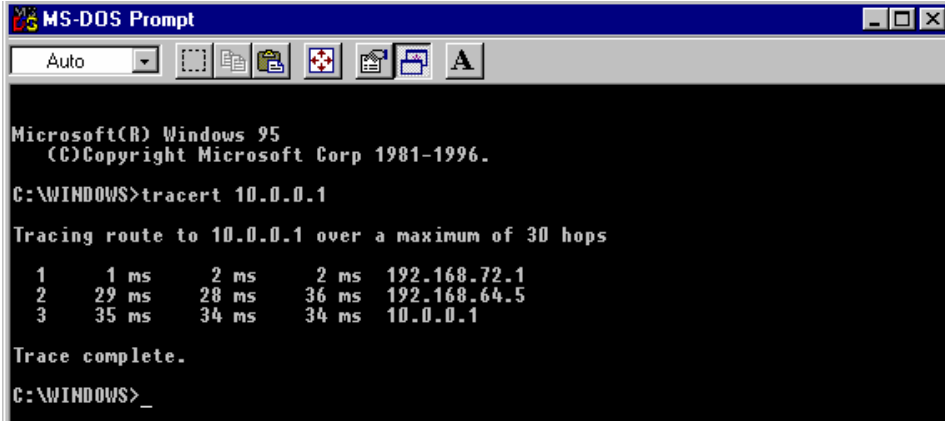
During the trace, the output from the `debug ip policy` command should be seen, indicating that packets are being policy routed. If the output from the Westasman router was not visible, then issue `show logging` to see the output. Using either approach should display output that is similar to the following:

```
01:02:06: IP: s=192.168.72.2 (FastEthernet0/0), d=10.0.0.1, len
78, policy match 01:02:06: IP: route map CRYPTO, item 10, permit

01:02:06: IP: s=192.168.72.2 (FastEthernet0/0), d=10.0.0.1
(Serial0/1), len 78, policy routed
```

Examine the output from the trace route of Host B.

1. Did this trace hop through 192.168.64.5?



```
Microsoft(R) Windows 95
(C)Copyright Microsoft Corp 1981-1996.
C:\WINDOWS>tracert 10.0.0.1

Tracing route to 10.0.0.1 over a maximum of 30 hops

  0  1 ms    2 ms    2 ms   192.168.72.1
  1  29 ms   28 ms   36 ms   192.168.64.5
  2  35 ms   34 ms   34 ms   10.0.0.1

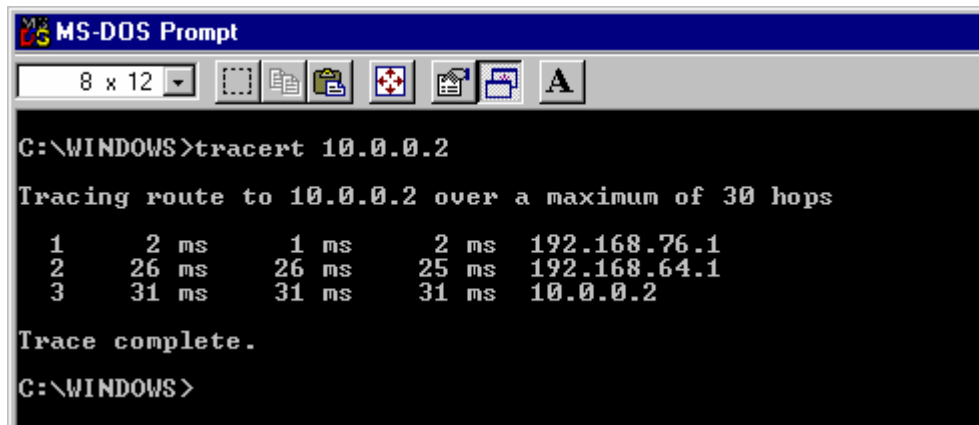
Trace complete.
C:\WINDOWS>
```

The next hop should have been 192.168.64.5.

2. From which of the interfaces of Westasman did this packet exit?

The exit interface should have been S0/1.

From Host C, use a trace route program to trace the route to 10.0.0.2 and examine the output from the trace route.



```
C:\WINDOWS>tracert 10.0.0.2

Tracing route to 10.0.0.2 over a maximum of 30 hops

  0  0 ms  0 ms  0 ms  192.168.76.1
  1  2 ms  1 ms  2 ms  192.168.76.1
  2 26 ms 26 ms 25 ms 192.168.64.1
  3 31 ms 31 ms 31 ms 10.0.0.2

Trace complete.

C:\WINDOWS>
```

3. Did this trace hop through 192.168.64.1?

4. From which of the interfaces of Westasman did this packet exit?

The ICMP packets of Host C took a different route to network 10.0.0.0/24. The Host C IP address was denied by the access list associated with the route map. It was not permitted to be policy routed.

Finally, issue the `show route-map` command on Westasman as follows:

```
Westasman#show route-map CRYPTO
route-map CRYPTO, permit, sequence 10
  Match clauses:
    ip address (access-lists): 101
  Set clauses:
    interface Serial0/1
  Policy routing matches: 33 packets, 4149 bytes
```

5. How many packets have been matched for policy routing?

Step 5

1. Is the network configuration finished?

Security can be easily compromised if return traffic to the 192.168.72.0/24 network is not returned through the link with the Crypto Box. The following commands will complete the scenario.

On router SanJose1 create a route-map named RETURN_TRAFFIC that will route all traffic coming from the 10.0.0.0/24 network to the SanJose2 next hop IP address 10.0.0.2.

```
SanJose1(config)#route-map RETURN_TRAFFIC permit 10
SanJose1(config-route-map)#match ip address 101
SanJose1(config-route-map)#set interface fastethernet 0/0
SanJose1(config-route-map)#set ip next-hop 10.0.0.2
```

Create the access list that is referenced in the above route map.

```
SanJose1(config)#access-list 101 permit ip 10.0.0.0 0.0.0.255 192.168.72.0
0.0.0.255
```

Activate this route map by issuing the following commands:

```
SanJose1(config)#interface fastethernet 0/0
SanJose1(config-if)#no ip route-cache
SanJose1(config-if)#ip policy route-map RETURN_TRAFFIC
```

Verify that the route map is active with the **show ip policy** or **show ip interface fastethernet 0/0** command as follows:

```
SanJose1#show ip policy
Interface      Route map
Fa0/0         RETURN_TRAFFIC

SanJose1#show ip interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet address is 10.0.0.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.5 224.0.0.6
  Outgoing access list is not set
  Inbound access list is not set
  Proxy ARP is enabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachable are always sent
  ICMP mask replies are never sent
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
```

```
IP Feature Fast switching turbo vector
IP multicast fast switching is enabled
IP multicast distributed fast switching is disabled
IP route-cache flags are Fast
Router Discovery is disabled
IP output packet accounting is disabled
IP access violation accounting is disabled
TCP/IP header compression is disabled
RTP/IP header compression is disabled
Probe proxy name replies are disabled
Policy routing is enabled, using route map RETURN_TRAFFIC
Network address translation is disabled
WCCP Redirect outbound is disabled
WCCP Redirect inbound is disabled
WCCP Redirect exclude is disabled
BGP Policy Mapping is disabled
```

Step 6

Insure that the SanJose2 router does not send the route request back to the SanJose1 router. To do so, create a policy that will override the routing table on SanJose2. To complete this requirement, issue the following commands:

```
SanJose2(config)#route-map RETURN_TRAFFIC permit 10
SanJose2(config-route-map)#match ip address 101
SanJose2(config-route-map)#set interface serial 0/0
```

Create the access list that is referenced in the above route map.

```
SanJose2(config)#access-list 101 permit ip 10.0.0.0 0.0.0.255 192.168.72.0
0.0.0.255
```

Activate this route map by issuing the following commands:

```
SanJose2(config)#interface fastethernet 0/0
SanJose2(config-if)#no ip route-cache
SanJose2(config-if)#ip policy route-map RETURN_TRAFFIC
```

Verify that the route map is active with the **show ip policy** or **show ip interface fastethernet 0/0** command as follows:

```
SanJose2#show ip policy
Interface      Route map
Fa0/0          RETURN_TRAFFIC

SanJose2#show ip interface fastethernet 0/0
```

```
FastEthernet0/0 is up, line protocol is up
  Internet address is 10.0.0.2/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.5 224.0.0.6
  Outgoing access list is not set
  Inbound access list is not set
  Proxy ARP is enabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachable are always sent
  ICMP mask replies are never sent
  IP fast switching is enabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP Feature Fast switching turbo vector
  IP multicast fast switching is enabled
  IP multicast distributed fast switching is disabled
  IP route-cache flags are Fast
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
  Probe proxy name replies are disabled
  Policy routing is enabled, using route map RETURN_TRAFFIC
  Network address translation is disabled
  WCCP Redirect outbound is disabled
  WCCP Redirect inbound is disabled
  WCCP Redirect exclude is disabled
  BGP Policy Mapping is disabled
```

Step 7

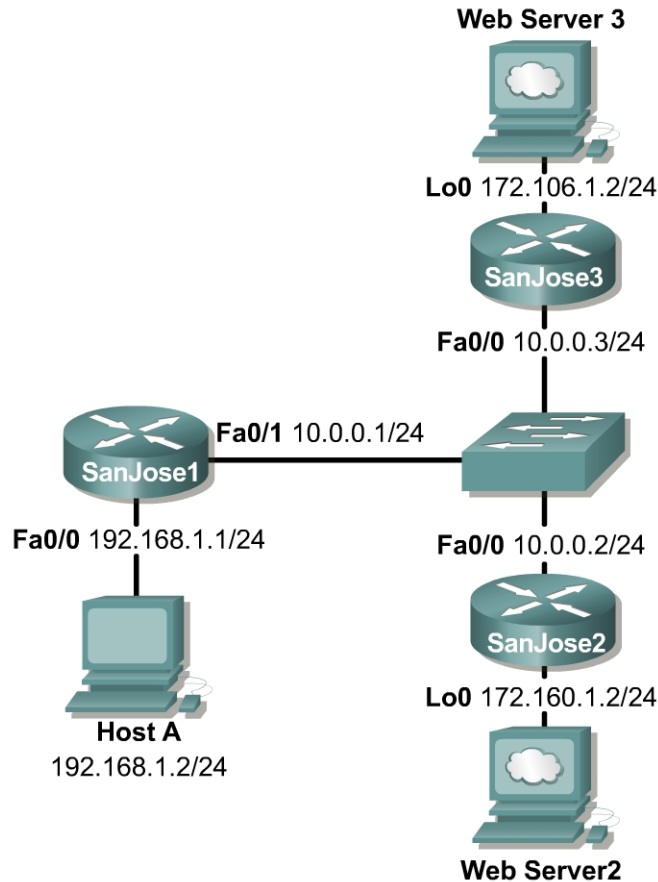
Verify that the router maps are active. Does each router enforce the policy when a ping originates from host 192.168.72.2 that is destined for host 10.0.0.3?

The following output was collected from router SanJose2:

```
02:34:27: IP: s=10.0.0.3 (FastEthernet0/0), d=192.168.72.2, len 100, policy
match
02:34:27: IP: route map RETURN_TRAFFIC, item 10, permit
```

```
02:34:27: IP: s=10.0.0.3 (FastEthernet0/0), d=192.168.72.2 (Serial0/0), len  
100,  
policy routed
```

Lab 8.5.2b NAT: Dynamic Translation with Multiple Pools Using Route Maps



Objective

In this lab, dynamic Network Address Translation (NAT) will be configured with multiple pools using Route Maps.

Scenario

The single Class C address used on the SanJose1 LAN is not sufficient for the users and devices. Therefore, NAT is being used to represent all inside local addresses, 192.168.1.x. However, all users on the SanJose1 LAN require HTTP access to the Web Servers on the SanJose2 and SanJose3 LANs. This is represented by the respective Loopback addresses. Therefore, a multiple pool of addresses must be used and it is required that all the hosts on the 192.168.1.0 network be translated as follows:

172.106.2.0 when accessing Web Server 3 on the 172.106.1.0 network and
 172.160.2.0 when accessing Web Server 2 on the 172.160.1.0 network.

As the Network Administrator, configure the SanJose1 router according to the requirements described using dynamic NAT translation with multiple pools and route maps.

Step 1

Build and configure the network according to the diagram. Also, enable the SanJose2 and SanJose3 routers for HTTP access as shown in the following to simulate the attached Web Servers:

```
SanJose2(config)#ip http server
SanJose3(config)#ip http server
```

Since no routing protocol is being used, static routes must be configured on SanJose1 to the respective Web Servers on the SanJose2 and SanJose3 LANs. Default routes must be configured to the 192.168.1.0 network from SanJose2 and SanJose3.

```
SanJose1(config)#ip route 172.106.1.0 255.255.255.0 10.0.0.3
SanJose1(config)#ip route 172.160.1.0 255.255.255.0 10.0.0.2

SanJose2(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.1
SanJose3(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.1
```

Test connectivity between the routers and between the SanJose1 Host A and its gateway with a **ping**.

Step 2

Create the pool of addresses that will be used to translate hosts on the 192.168.1.0 network. Create the access control lists to allow hosts on the 192.168.1.0 network access to the 172.106.1.0 and 172.160.1.0 networks.

```
SanJose1(config)#ip nat pool pool106 172.106.2.1 172.106.2.254 prefix-
length 24
SanJose1(config)#ip nat pool pool160 172.160.2.1 172.160.2.254 prefix-
length 24

SanJose1(config)#access-list 106 permit ip 192.168.1.0 0.0.0.255
172.106.1.0 0.0.0.255
SanJose1(config)#access-list 160 permit ip 192.168.1.0 0.0.0.255
172.160.1.0 0.0.0.255
```

Step 3

Designate at least one inside NAT interface and one outside NAT interface on the NAT router, SanJose1.

```
SanJose1(config)#interface fastethernet 0/0
SanJose1(config-if)#ip nat inside

SanJose1(config-if)#interface fastethernet 0/1
SanJose1(config-if)#ip nat outside
```

Step 4

So far, every task completed is exactly the same as if using the access control lists with no overload approach.

Recall that NAT uses access lists and route maps only when it needs to create a translation entry. If a translation entry already exists that matches the traffic then that will be used and any access lists or route maps will not be consulted. The difference between using an access list or route map is the type of translation entry that will be created.

When NAT uses a route map to create a translation entry, it will always create a “fully extended” translation entry. This translation entry will contain both the inside and outside, local and global, addresses and any TCP or UDP port information.

When NAT uses an access list, it will create a simple translation entry. This simple entry will only contain local and global IP address entries for just the inside or outside. This also depends on whether the `ip nat inside` or `ip nat outside` command is configured. Also, it will not include any TCP or UDP port information.

Test the access list approach to see exactly why it does not provide the ideal solution for network address translation in this situation.

Configure the inside source access lists and address pools.

```
SanJose1(config)#ip nat inside source list 106 pool pool106
SanJose1(config)#ip nat inside source list 160 pool pool160
```

Enable `debug ip packet` on the SanJose1 and SanJose3 routers.

Open a browser window from the SanJose1 Host A to access Web Server 3 on the SanJose3 LAN, loopback address 172.106.1.2. Observe the `debug` outputs on SanJose1 and SanJose3. Sample output is shown as follows:

```
SanJose1#debug ip packet
IP packet debugging is on
SanJose1#
00:35:10: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2
(FastEthernet0/1),
g=10.0.0.3, len 44, forward
00:35:10: IP: s=172.106.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 44, forward
00:35:10: IP: s=172.106.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 40, forward
00:35:10: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2
(FastEthernet0/1),
g=10.0.0.3, len 40, forward
--output omitted--
SanJose1#

SanJose3#debug ip packet
IP packet debugging is on
SanJose3#
SanJose3#
```

```

00:35:37: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2, len 44, rcvd 4
00:35:37: IP: s=172.106.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
44, se
nding
00:35:37: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2, len 40, rcvd 4
00:35:37: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2, len 364, rcvd
4
00:35:37: IP: s=172.106.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
596, s
ending
00:35:37: IP: s=172.106.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
596, s
ending
--output omitted--
SanJose3#

```

Issue the **show ip nat translations verbose** command on the SanJose1 router. Sample output is shown as follows:

```

SanJose1#show ip nat translations verbose
Pro Inside global      Inside local      Outside local      Outside global
--- 172.106.2.1        192.168.1.2      ---                ---
      create 00:01:37, use 00:00:31, left 23:59:28,
      flags:
      none, use_count: 0

```

1. Why are only the inside global and local address translations shown and no protocol or port information?
-

Enable **debug ip packet** on the SanJose2 router and SanJose1 if necessary.

Now from SanJose1 Host A, use a browser to access Web Server 2 on the SanJose2 LAN, loopback address 172.160.1.2. Observe the **debug** outputs on SanJose1 and SanJose 2. Sample output is shown as follows:

```

SanJose1#debug ip packet
IP packet debugging is on
SanJose1#
00:55:22: IP: s=172.106.2.1 (FastEthernet0/0), d=172.160.1.2
(FastEthernet0/1),
g=10.0.0.2, len 44, forward
00:55:22: IP: s=172.160.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 44, forward
00:55:22: IP: s=172.160.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 40, forward

```



```
00:55:22: IP: s=172.106.2.1 (FastEthernet0/0), d=172.160.1.2
(FastEthernet0/1),
g=10.0.0.2, len 40, forward
SanJose1#
```

```
SanJose2#debug ip packet
```

```
IP packet debugging is on
```

```
SanJose2#
```

```
00:55:56: IP: s=172.106.2.1 (FastEthernet0/0), d=172.160.1.2, len 44, rcvd 4
```

```
00:55:56: IP: s=172.160.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
44, se
```

```
nding
```

```
00:55:56: IP: s=172.106.2.1 (FastEthernet0/0), d=172.160.1.2, len 40, rcvd 4
```

```
00:55:56: IP: s=172.106.2.1 (FastEthernet0/0), d=172.160.1.2, len 364, rcvd
4
```

```
00:55:56: IP: s=172.160.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
596, s
```

```
ending
```

```
00:55:56: IP: s=172.160.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
596, s
```

```
ending
```

```
--output omitted--
```

```
SanJose2#
```

Issue the **show ip nat translations verbose** command on the SanJose1 router. Sample output is shown as follows:

```
SanJose1#show ip nat translations verbose
```

```
Pro Inside global      Inside local      Outside local      Outside global
```

```
--- 172.106.2.1        192.168.1.2        ---                ---
```

```
create 00:21:44, use 00:00:26, left 23:59:33,
```

```
flags:
```

```
none, use_count: 0
```

```
SanJose1#
```

2. After analyzing the data output, document the problem.
-
-

Step 5

Before configuring route maps, disable the `debug ip packet` command by using the `undebug ip packet` command on SanJose1. Then remove the previously configured inside source access lists and address pools.

```
SanJose1#undebug ip packet

SanJose1#clear ip nat translation * (Be sure to include the asterisk in this command)
SanJose1#configure terminal
SanJose1(config)#no ip nat inside source list 106 pool pool106
SanJose1(config)#no ip nat inside source list 160 pool pool160
```

Now configure route maps to resolve the problems encountered when using the access lists. Create the inside source route maps and address pools as follows:

```
SanJose1(config)#ip nat inside source route-map MAP-106 pool pool106
SanJose1(config)#ip nat inside source route-map MAP-160 pool pool160
```

Create the route maps as follows:

```
SanJose1(config)#route-map MAP-106 permit 10
SanJose1(config-route-map)#match ip address 106

SanJose1(config-route-map)#route-map MAP-160 permit 10
SanJose1(config-route-map)#match ip address 160
```

Step 6

Enable `debug ip packet` on the SanJose1 router.

Open a browser window from the SanJose1 Host A to access Web Server 3 on the SanJose3 LAN, loopback address 172.106.1.2. Observe the `debug` outputs on SanJose1 and SanJose 3. Sample from both routers is shown as follows:

```
SanJose1#debug ip packet
IP packet debugging is on
SanJose1#
01:13:52: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2
(FastEthernet0/1),
g=10.0.0.3, len 44, forward
```

```

01:13:52: IP: s=172.106.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 44, forward
01:13:52: IP: s=172.106.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 40, forward
01:13:52: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2
(FastEthernet0/1),
g=10.0.0.3, len 40, forward
SanJose1#

```

```

SanJose3#debug ip packet
IP packet debugging is on
SanJose3#

```

```

01:14:19: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2, len 44, rcvd 4
01:14:19: IP: s=172.106.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
44, se
nding
01:14:19: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2, len 40, rcvd 4
01:14:19: IP: s=172.106.2.1 (FastEthernet0/0), d=172.106.1.2, len 234, rcvd
4
01:14:19: IP: s=172.106.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
596, s
ending
01:14:19: IP: s=172.106.1.2 (local), d=172.106.2.1 (FastEthernet0/0), len
596, s
ending
--output omitted--
SanJose3#

```

Issue the **show ip nat translations verbose** command on the SanJose1 router. Sample output is shown as follows:

```

SanJose1#show ip nat translations verbose
Pro Inside global      Inside local      Outside local      Outside global
tcp 172.106.2.1:1118   192.168.1.2:1118   172.106.1.2:80     172.106.1.2:80
      create 00:00:08, use 00:00:07, left 00:00:52,
      flags:
extended, timing-out, use_count: 0
SanJose1#

```

Notice that while there are no differences in the **debug ip packet** outputs generated previously, the output of the **show ip nat translations verbose** command is different.

1. What additional information is now available and why?

Open a browser window from the SanJose1 Host A to access Web Server 2 on the SanJose2 LAN, loopback address 172.160.1.2. Observe the debug outputs on SanJose1 and SanJose 2. Sample output is shown as follows:

```
SanJose1#debug ip packet
IP packet debugging is on
SanJose1#
01:35:28: IP: s=172.160.2.1 (FastEthernet0/0), d=172.160.1.2
(FastEthernet0/1),
g=10.0.0.2, len 44, forward
01:35:28: IP: s=172.160.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 44, forward
01:35:29: IP: s=172.160.1.2 (FastEthernet0/1), d=192.168.1.2
(FastEthernet0/0),
g=192.168.1.2, len 40, forward
01:35:29: IP: s=172.160.2.1 (FastEthernet0/0), d=172.160.1.2
(FastEthernet0/1),
g=10.0.0.2, len 40, forward
SanJose1#

SanJose2#debug ip packet
IP packet debugging is on
SanJose2#
01:35:54: IP: s=172.160.2.1 (FastEthernet0/0), d=172.160.1.2, len 44, rcvd 4
01:35:54: IP: s=172.160.1.2 (local), d=172.160.2.1 (FastEthernet0/0), len
44, se
nding
01:35:54: IP: s=172.160.2.1 (FastEthernet0/0), d=172.160.1.2, len 40, rcvd 4
01:35:54: IP: s=172.160.2.1 (FastEthernet0/0), d=172.160.1.2, len 234, rcvd
4
01:35:54: IP: s=172.160.1.2 (local), d=172.160.2.1 (FastEthernet0/0), len
596, s
ending
01:35:54: IP: s=172.160.1.2 (local), d=172.160.2.1 (FastEthernet0/0), len
596, s
ending
--output omitted--
SanJose2#
```

Issue the **show ip nat translations verbose** command on the SanJose1 router. Sample output is shown as follows:

```
SanJose1#show ip nat translations verbose
```

```

Pro Inside global      Inside local      Outside local      Outside global
tcp 172.160.2.1:1122   192.168.1.2:1122  172.160.1.2:80    172.160.1.2:80
    create 00:00:34, use 00:00:34, left 00:00:25,
    flags:
extended, timing-out, use_count: 0
SanJose1#

```

Dynamic NAT with multiple pools using route maps is now successfully configured.

2. Why does the translation from the SanJose1 Host A to the Web Server 2 on the SanJose2 LAN now work correctly with route maps?

```

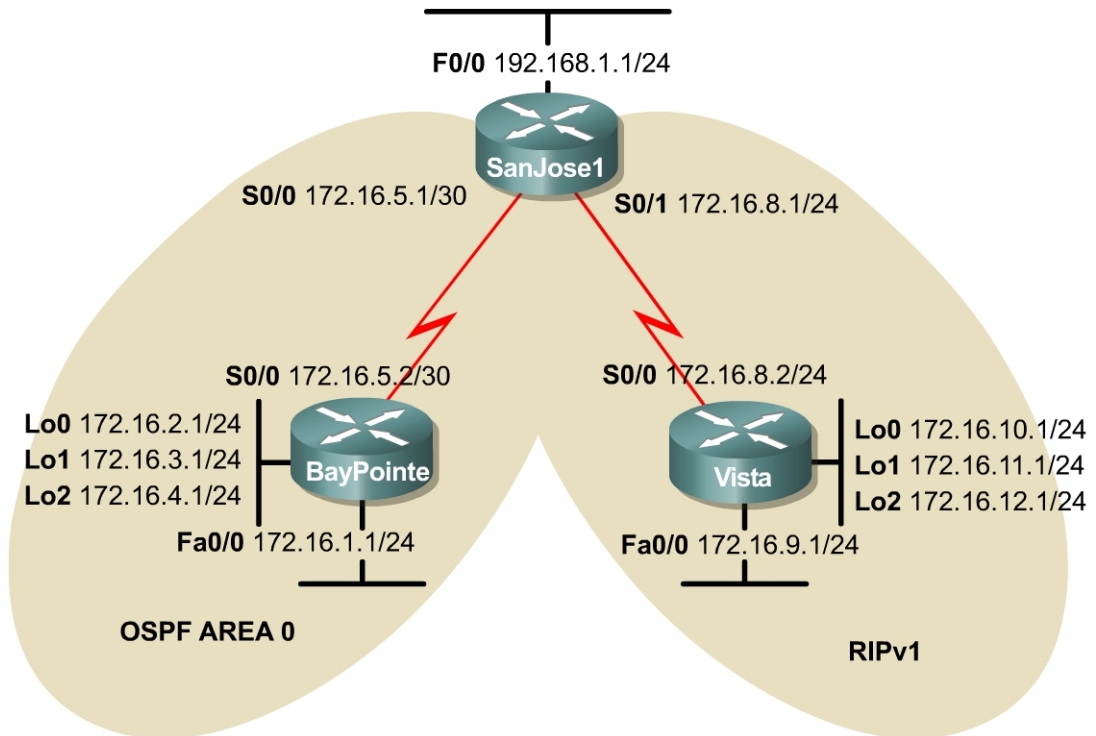
SanJose1#show ip nat translations verbose
Pro Inside global      Inside local      Outside local      Outside global
tcp 172.106.2.1:1126   192.168.1.2:1126  172.106.1.2:80    172.106.1.2:80
    create 00:00:04, use 00:00:04, left 00:00:55,
    flags:
extended, timing-out, use_count: 0
tcp 172.160.2.1:1125   192.168.1.2:1125  172.160.1.2:80    172.160.1.2:80
    create 00:00:24, use 00:00:24, left 00:00:35,
    flags:
extended, timing-out, use_count: 0
SanJose1#

```

Note: NAT ability to use route maps with static translations was introduced with Cisco IOS version 12.2(4)T and 12.2(4)T2 for the Cisco 7500 series routers.

NAT with access list and overload will create a “fully extended” translation and is the same as the route map.

Lab 8.5.3 Redistributing RIP and OSPF with Distribution Lists



Objective

In this lab, configure mutual redistribution between RIP v1 and OSPF.

Scenario

International Travel Agency is adding two new sites to the San Jose campus. BayPointe uses OSPF, and Vista supports only RIP v1 until the hardware is upgraded. The mutual redistribution between the two protocols on the ASBR, SanJose1 is to be configured. Routers in the RIP v1 domain should learn about OSPF networks, and routers in the OSPF domain should learn about RIP v1 networks. Network 172.16.4.0 24 on BayPointe should be advertised within the OSPF Area. However, it should not be passed into the RIP region. Likewise, each of the RIP subnets should be redistributed into the OSPF region with the exception of network 172.16.12.0/24 located on Vista.

Step 1

Build and configure the network according to the diagram. Configure the loopback interfaces with the IP addresses according to the diagram. The loopbacks will simulate networks within each routing domain. Configure OSPF on BayPointe for all connected networks, and RIP v1 on Vista for all connected networks. Do not configure routing on SanJose1 at this time.

Use `show running-config` to verify the work.

Step 2

Configure routing on the serial interfaces for SanJose1. Use the following commands to configure SanJose1 routing processes:

```
SanJose1(config)#router rip
SanJose1(config-router)#network 172.16.0.0
SanJose1(config-router)#passive-interface serial0/0
SanJose1(config-router)#passive-interface fastethernet0/0
SanJose1(config-router)#router ospf 1
SanJose1(config-router)#network 172.16.5.0 0.0.0.3 area 0
```

1. Why are the **passive interface** statements applied to Serial 0/0 and FastEthernet 0/0 in RIP?

There are no other RIP hosts on those networks. Periodic RIP updates should be turned off on all RIP enabled interfaces that do not require them.

2. It is not necessary to configure any passive interfaces in the OSPF configuration. Why not?

Updates are sent and acknowledged between OSPF neighbors. OSPF does not begin to send multicast hello packets out an interface until a network statement is added to the OSPF configuration that includes or overlaps with the interface IP address.

After the routing is configured, check the routing table of SanJose1 as follows:

```
SanJose1#show ip route
Gateway of last resort is not set
  172.16.0.0/16 is variably subnetted, 10 subnets, 3 masks
R       172.16.12.0/24 [120/1] via 172.16.8.2, 00:00:02, Serial0/1
C       172.16.8.0/24 is directly connected, Serial0/1
R       172.16.9.0/24 [120/1] via 172.16.8.2, 00:00:02, Serial0/1
R       172.16.10.0/24 [120/1] via 172.16.8.2, 00:00:02, Serial0/1
R       172.16.11.0/24 [120/1] via 172.16.8.2, 00:00:02, Serial0/1
O       172.16.4.1/32 [110/782] via 172.16.5.2, 00:09:07, Serial0/0
C       172.16.5.0/30 is directly connected, Serial0/0
O       172.16.1.0/24 [110/782] via 172.16.5.2, 00:09:08, Serial0/0
O       172.16.3.1/32 [110/782] via 172.16.5.2, 00:09:08, Serial0/0
O       172.16.2.1/32 [110/782] via 172.16.5.2, 00:09:08, Serial0/0
C       192.168.1.0/24 is directly connected, FastEthernet0/0
```

SanJose1 should learn about the connected networks of BayPointe by way of OSPF and the connected networks of Vista by way of RIP v1. Troubleshoot, if necessary. The loopbacks advertised on the BayPointe router will be seen by SanJose1 and Vista as /32 networks regardless of the subnetmask assigned to the loopback interface. This is the standard method by which OSPF treats

advertised loopback interfaces. Although this occurs regularly in this lab environment, it is not customary to create and advertise loopback networks on a production network.

Issue the **show ip route** command to check the routing table of BayPointe as follows:

```
BayPointe#show ip route
Gateway of last resort is not set
    172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
C       172.16.4.0/24 is directly connected, Loopback2
C       172.16.5.0/30 is directly connected, Serial0/0
C       172.16.1.0/24 is directly connected, FastEthernet0/0
C       172.16.2.0/24 is directly connected, Loopback0
C       172.16.3.0/24 is directly connected, Loopback1
```

No dynamically learned routes should be present. Finally, issue the **show ip route** command to check the routing table of Vista as follows:

```
Vista#show ip route
Gateway of last resort is not set
    172.16.0.0/24 is subnetted, 5 subnets
C       172.16.12.0 is directly connected, Loopback2
C       172.16.8.0 is directly connected, Serial0/0
C       172.16.9.0 is directly connected, FastEthernet0/0
C       172.16.10.0 is directly connected, Loopback0
C       172.16.11.0 is directly connected, Loopback1
```

3. Has Vista learned about any routes by way of RIP v1? Why?

Vista is directly connected to all RIP v1 networks, and redistribution has not been configured.

Step 3

Configure redistribution on SanJose1 so that all of the OSPF routes except 172.16.4.0/24 are injected into the RIP v1 process. Use the following commands to configure redistribution on SanJose1:

```
SanJose1(config)#router rip
SanJose1(config-router)#redistribute ospf 1
SanJose1(config-router)#default-metric 2
```

1. What is the **default-metric** command used for? Does it have to be used?

2. Does this accomplish the network design goal? Does this allow for the redistribution of the unintended subnet as well?
-
-

Consider a route filter policy similar to the previous lab that will allow for the filtering out of the 172.16.4.0 route. Issue the following commands to complete this route filter requirement:

```
SanJose1(config)#access-list 10 deny 172.16.4.0 0.0.0.255
SanJose1(config)#access-list 10 permit any
SanJose1(config)#router rip
SanJose1(config-router)#distribute-list 10 out s0/1
```

This completes the filtering. Now the previous commands in step 3 will only redistribute the desired networks.

Check the routing table of Vista in the RIP v1 domain as follows:

Note: Use the `clear ip route *` command first.

```
Vista#show ip route
Gateway of last resort is not set
      172.16.0.0/16 is variably subnetted, 8 subnets, 2 masks
C       172.16.12.0/24 is directly connected, Loopback2
C       172.16.8.0/24 is directly connected, Serial0/0
C       172.16.9.0/24 is directly connected, FastEthernet0/0
C       172.16.10.0/24 is directly connected, Loopback0
C       172.16.11.0/24 is directly connected, Loopback1
R       172.16.1.0/24 [120/2] via 172.16.8.1, 00:00:05, Serial0/0
R       172.16.3.1/32 [120/2] via 172.16.8.1, 00:00:05, Serial0/0
R       172.16.2.1/32 [120/2] via 172.16.8.1, 00:00:06, Serial0/0
```

3. Has Vista learned about any of the networks from the OSPF side?
-

Creating a seed metric can minimize routing loops or black holes in the network. RIP cannot differentiate between internal and external redistributed routes. When a route on a network is redistributed without a default metric, the network appears to be adjacent to the autonomous system. Elevating the external default metric above any internal routes is a crude but effective way of differentiating between internal and external routes.

In summary, insure that a metric statement is included at the end of the redistribute command or else identify a default metric value on a separate line. Failure to do so will result in a route being redistributed with an unreachable value.

4. What is the metric for each of these routes?

The metric should be two (2).

Step 4

Configure redistribution on SanJose1 so that RIP v1 routes are injected into the OSPF process. Use the following commands to configure mutual redistribution on SanJose1:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#redistribute rip
SanJose1(config-router)#default-metric 10
```

Now include the following necessary commands to filter out the 172.16.12.0/24 network from being advertised:

```
SanJose1(config)#access-list 20 deny 172.16.12.0 0.0.0.255
SanJose1(config)#access-list 20 permit any
SanJose1(config)#router ospf 1
SanJose1(config-router)#distribute-list 20 out
```

Notice when applying the distribution list within OSPF the interface option was omitted. OSPF will not allow a distribute list applied in the outbound direction for one particular interface. It must be configured as a global distribute list. RIP does not have this same restriction so the interface and direction was specified in the command syntax in Step 3.

Check the routing table of BayPointe in the OSPF domain. BayPointe has not learned about any of the networks from the RIP v1 side.

1. Why has not BayPointe learned about any of the networks from the RIP v1 side?

BayPointe should not have any new routes in its routing table. That is because OSPF will not redistribute RIP subnets unless explicitly configured with the subnets keyword. Return to SanJose1 and enter the following configuration:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#redistribute rip subnets
```

After these commands are entered, check the routing table of BayPointe again as follows:

```
BayPointe#show ip route
Gateway of last resort is not set
 172.16.0.0/16 is variably subnetted, 9 subnets, 2 masks
O E2   172.16.8.0/24 [110/10] via 172.16.5.1, 00:00:10, Serial0/0
O E2   172.16.9.0/24 [110/10] via 172.16.5.1, 00:00:10, Serial0/0
O E2   172.16.10.0/24 [110/10] via 172.16.5.1, 00:00:10, Serial0/0
O E2   172.16.11.0/24 [110/10] via 172.16.5.1, 00:00:10, Serial0/0
C       172.16.4.0/24 is directly connected, Loopback2
C       172.16.5.0/30 is directly connected, Serial0/0
```

```
C      172.16.1.0/24 is directly connected, FastEthernet0/0
C      172.16.2.0/24 is directly connected, Loopback0
C      172.16.3.0/24 is directly connected, Loopback1
```

2. Has BayPointe learned about the routes from the RIP v1 domain? What is the metric for these routes?

The metric should be ten (10).

In the routing table, the redistributed routes tagged with the characters "E2" will be seen.

3. What do these characters mean?

Recall that Type 2 (E2) routes originated outside the OSPF AS and were redistributed into OSPF using Type 5 LSA.

Step 5

Look carefully at the routing table of BayPointe.

1. Is there a route to 192.168.1.0/24?

2. Does Vista have a route to 192.168.1.0/24?

3. Why is this route missing from routing tables of BayPointe and Vista?

Interface FastEthernet0/0 on SanJose1 is not enabled for either OSPF or RIP v1.

Complete the routing table of BayPointe as follows by configuring SanJose1 to redistribute connected routes into OSPF as a type 1 external route with a metric of 5000:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#redistribute connected subnets metric-type 1 metric 5000
```

4. What will be the metric for redistributed connected routes? Will it use the 5000 issued or the default metric of ten (10) configured previously?

Issue the following to configure the RIP v1 process of SanJose1 to redistribute the connected route:

```
SanJose1(config)#router rip
SanJose1(config-router)#redistribute connected
```

Check the routing tables one more time. BayPointe and SanJose1 should contain all routes.

```
BayPointe#show ip route
```

Gateway of last resort is not set

```
    172.16.0.0/16 is variably subnetted, 9 subnets, 2 masks
O E1   172.16.8.0/24 [110/5781] via 172.16.5.1, 00:01:52, Serial0/0
O E2   172.16.9.0/24 [110/10] via 172.16.5.1, 00:01:52, Serial0/0
O E2   172.16.10.0/24 [110/10] via 172.16.5.1, 00:01:52, Serial0/0
O E2   172.16.11.0/24 [110/10] via 172.16.5.1, 00:01:52, Serial0/0
C      172.16.4.0/24 is directly connected, Loopback2
C      172.16.5.0/30 is directly connected, Serial0/0
C      172.16.1.0/24 is directly connected, FastEthernet0/0
C      172.16.2.0/24 is directly connected, Loopback0
C      172.16.3.0/24 is directly connected, Loopback1
O E1  192.168.1.0/24 [110/5781] via 172.16.5.1, 00:01:53, Serial0/0
```

SanJose1#show ip route

Gateway of last resort is not set

```
    172.16.0.0/16 is variably subnetted, 10 subnets, 3 masks
R      172.16.12.0/24 [120/1] via 172.16.8.2, 00:00:03, Serial0/1
C      172.16.8.0/24 is directly connected, Serial0/1
R      172.16.9.0/24 [120/1] via 172.16.8.2, 00:00:03, Serial0/1
R      172.16.10.0/24 [120/1] via 172.16.8.2, 00:00:03, Serial0/1
R      172.16.11.0/24 [120/1] via 172.16.8.2, 00:00:03, Serial0/1
O      172.16.4.1/32 [110/65] via 172.16.5.2, 00:03:23, Serial0/0
C      172.16.5.0/30 is directly connected, Serial0/0
O      172.16.1.0/24 [110/65] via 172.16.5.2, 00:03:24, Serial0/0
O      172.16.3.1/32 [110/65] via 172.16.5.2, 00:03:24, Serial0/0
O      172.16.2.1/32 [110/65] via 172.16.5.2, 00:03:24, Serial0/0
C      192.168.1.0/24 is directly connected, FastEthernet0/0
```

Vista#show ip route

Gateway of last resort is not set

```
    172.16.0.0/16 is variably subnetted, 8 subnets, 2 masks
C      172.16.12.0/24 is directly connected, Loopback2
C      172.16.8.0/24 is directly connected, Serial0/0
C      172.16.9.0/24 is directly connected, FastEthernet0/0
C      172.16.10.0/24 is directly connected, Loopback0
C      172.16.11.0/24 is directly connected, Loopback1
R      172.16.1.0/24 [120/2] via 172.16.8.1, 00:00:07, Serial0/0
R      172.16.3.1/32 [120/2] via 172.16.8.1, 00:00:07, Serial0/0
R      172.16.2.1/32 [120/2] via 172.16.8.1, 00:00:08, Serial0/0
R      192.168.1.0/24 [120/1] via 172.16.8.1, 00:00:08, Serial0/0
```

Vista will not have a route to 172.16.5.0/30, because 172.16.0.0 is variably subnetted and RIP v1 does not support VLSM. The 32-bit networks listed are allowed by the `ip classless` command to support default networks in RIP and IGRP.

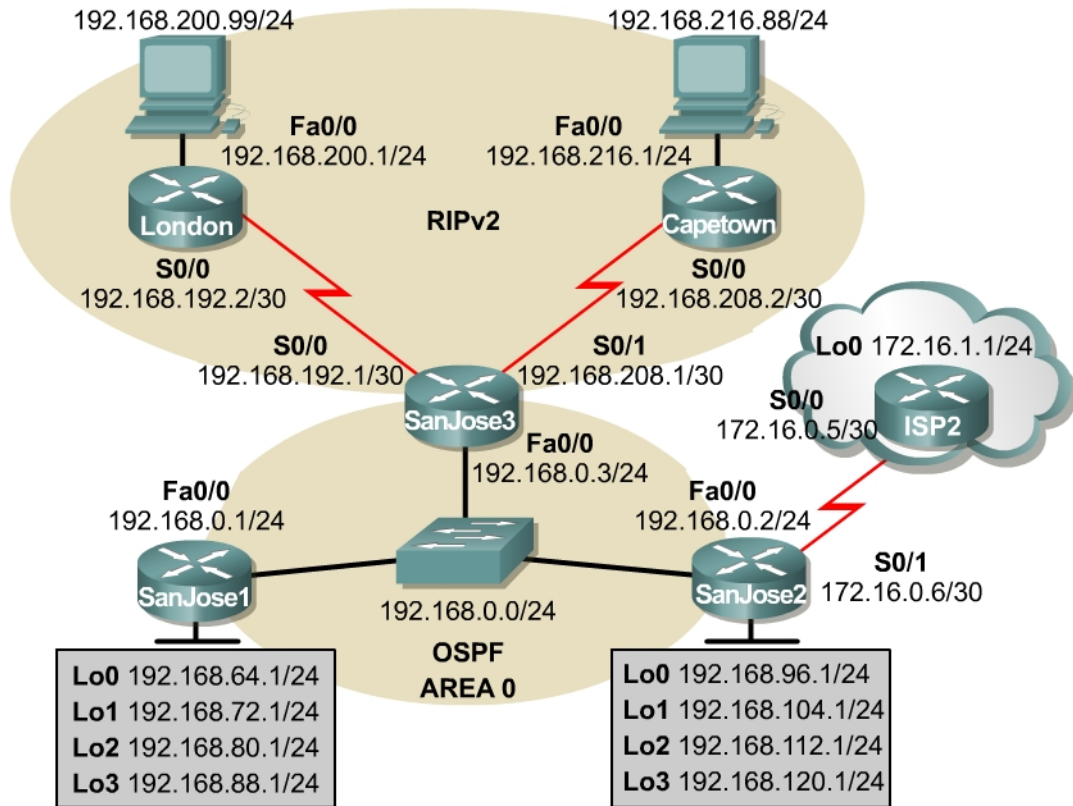
Finally, summarize the RIP routes that are being sent to the BayPointe router. To do this, issue the following command on the SanJose1 router:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#summary-address 172.16.8.0 255.255.252.0
```

Verify that the summary statement was effective by viewing the routing table of the BayPointe router:

```
Gateway of last resort is not set
  172.16.0.0/16 is variably subnetted, 6 subnets, 3 masks
O E2 172.16.8.0/22 [110/10] via 172.16.5.1, 00:01:33, Serial0/0
C    172.16.4.0/24 is directly connected, Loopback2
C    172.16.5.0/30 is directly connected, Serial0/0
C    172.16.1.0/24 is directly connected, FastEthernet0/0
C    172.16.2.0/24 is directly connected, Loopback0
C    172.16.3.0/24 is directly connected, Loopback1
O E1 192.168.1.0/24 [110/5781] via 172.16.5.1, 00:13:14, Serial0/0
```

Lab 8.6.1 Route Optimization Challenge Lab



Objective

Create and optimize a network utilizing RIP v2 and OSPF. The network must connect to the Internet.

Scenario

International Travel Agency is finally connecting its disparate networks. Working as the network engineer, all locations need to communicate by the end of the month per the agencies request. The only monies available for the project are for provisioning WAN links.

Design Considerations

Work with the existing routers in London and Cape Town that support only RIP v2. For simplicity, propagate a default route from SanJose2 to as many routers as possible. Redistribute the connected loopbacks on SanJose1 and SanJose2, simulating sections of the internetwork. Summarize, if appropriate.

Implementation Requirements

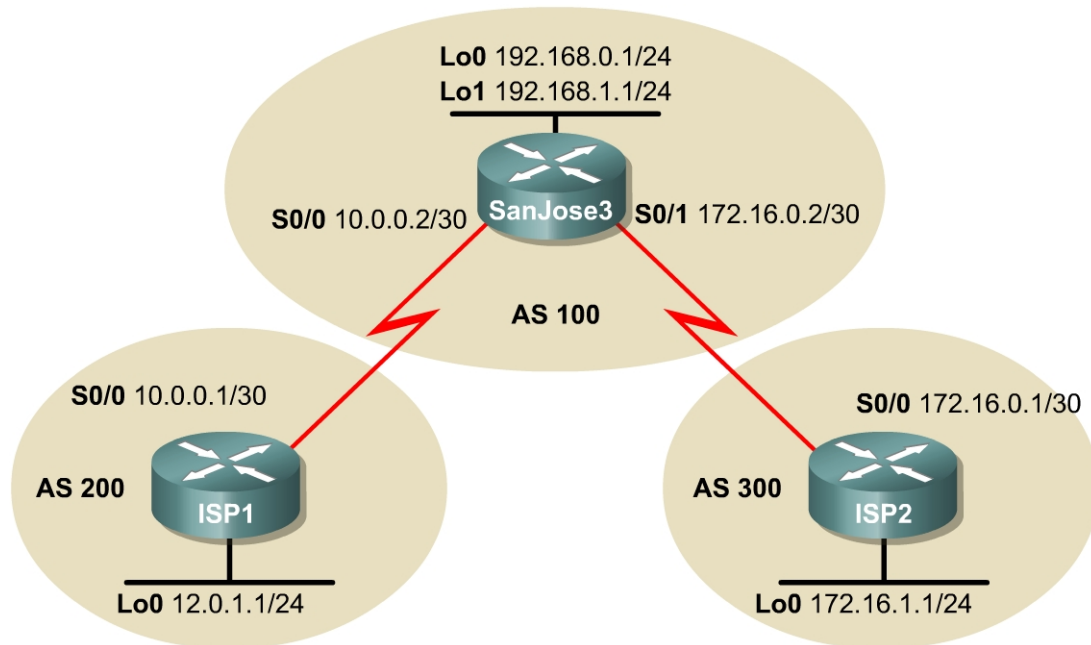
- All RIP v2 networks will be redistributed into OSPF. Summarize, if appropriate.
- Use default routes between SanJose2 and ISP2.

- SanJose3 will advertise a default route through the RIP v2 network.
- Redistribute connected loopbacks on SanJose1 and SanJose2. Filter the ISP2 WAN link from being advertised by SanJose2.
- SanJose1 will always be the DR in the core network.
- Minimize the number of routes exchanged between core routers.

Implementation Completion Tests

- Successful pings from all hosts to the Internet, ISP2 Lo0.
- SanJose1 is the DR.

Lab 9.11.1 Configuring BGP with Default Routing



Objective

In this lab, the student will configure BGP to exchange routing information with two Internet Service Providers (ISPs).

Scenario

The International Travel Agency relies extensively on the Internet for sales. The company has contracted with two ISPs for Internet connectivity with fault tolerance. The BGP that runs between the SanJose3 boundary router and the two ISP routers needs to be configured.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol. Configure a loopback interface with an IP address for each ISP router, as shown in the Figure. These loopbacks simulate real networks that can be reached through the ISP. Configure two loopback interfaces with the IP addresses for the SanJose3 router. These loopbacks simulate the connections between the core routers.

Use `ping` to test connectivity between the directly connected routers.

Note: The ISP1 router will not be able to reach the ISP2 router.

Step 2

Configure the ISP routers. In this lab, configure the providers' equipment as well as the International Travel Agency's boundary router, SanJose3. On the ISP1 router, enter the following configuration:


```
ISP1(config)#router bgp 200
ISP1(config-router)#neighbor 10.0.0.2 remote-as 100
ISP1(config-router)#network 12.0.1.0 mask 255.255.255.0
```

On the router for ISP2, configure BGP as shown in the following:

```
ISP2(config)#router bgp 300
ISP2(config-router)#neighbor 172.16.0.2 remote-as 100
ISP2(config-router)#network 172.16.1.0 mask 255.255.255.0
```

With the ISP routers configured, now set up the International Travel Agency's boundary router, SanJose3.

Step 3

Configure the SanJose3 router to run BGP with both providers. Use the following configuration:

```
SanJose3(config)#router bgp 100
SanJose3(config-router)#neighbor 10.0.0.1 remote-as 200
SanJose3(config-router)#neighbor 172.16.0.1 remote-as 300
SanJose3(config-router)#network 192.168.0.0
SanJose3(config-router)#network 192.168.1.0
```

This completes the BGP configuration. Check the routing table for SanJose3 with the `show ip route` command as follows:

```
SanJose3#show ip route

Gateway of last resort is not set

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.0.0/30 is directly connected, Serial0/1
B       172.16.1.0/24 [20/0] via 172.16.0.1, 00:00:03
      10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0
C      192.168.0.0/24 is directly connected, Loopback0
      12.0.0.0/24 is subnetted, 1 subnets
B       12.0.1.0 [20/0] via 10.0.0.1, 00:00:42
C      192.168.1.0/24 is directly connected, Loopback1
```

SanJose3 has routes to the loopback networks at each ISP router. Verify that SanJose3 has connectivity to these networks by pinging each loopback address from its console. These pings should be successful.

Step 4

Use **show** commands to verify the operation of SanJose3. On SanJose3, issue the **show ip bgp** command as follows:

```
SanJose3#show ip bgp
BGP table version is 5, local router ID is 192.168.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
*> 12.0.1.0/24      10.0.0.1           0           0 200 i
*> 172.16.1.0/24    172.16.0.1         0           0 300 i
*> 192.168.0.0      0.0.0.0            0          32768 i
*> 192.168.1.0      0.0.0.0            0          32768 i
```

1. What do the asterisks (*) next to each route indicate?

2. What do the ">" symbols next to each route indicate?

3. What is the local router ID?

4. Which table version is displayed?

On the ISP1 router, issue the **shutdown** command on Loopback0. Return to SanJose3 and issue the **show ip bgp** command again.

5. Which table version is displayed?

The version number will vary, but the **shutdown** command should have caused a routing table update, so the version should be one higher than the last.

Bring the ISP1 router Loopback0 back up by issuing the **no shutdown** command.

On SanJose3, issue the **show ip bgp neighbors** command. The following is a partial sample output of the command:

```
BGP neighbor is 172.16.0.1, remote AS 300, external link
Index 2, Offset 0, Mask 0x4
BGP version 4, remote router ID 172.16.1.1
BGP state = Established, table version = 5, up for 00:02:24
Last read 00:00:24, hold time is 180
```

6. Based on the output of this command, what is the BGP state between this router and ISP2?

7. How long has this connection been up?

Step 5

Check the routing table from ISP2 with the `show ip route` command. ISP2 should have a route that belongs to ISP1, 12.0.1.0.

SanJose3 may advertise a route belonging to ISP1. ISP2 then installs that route in its table. ISP2 might then attempt to route transit traffic through the International Travel Agency. Configure the SanJose3 router so that it advertises only International Travel Agency networks 192.168.0.0 and 192.168.1.0 to both providers. On the SanJose3 router, configure the following access list:

```
SanJose3(config)#access-list 1 permit 192.168.0.0 0.0.1.255
```

Then apply this access list as a route filter as follows, using the `distribute-list` keyword with the BGP `neighbor` statement:

```
SanJose3(config)#router bgp 100
SanJose3(config-router)#neighbor 10.0.0.1 distribute-list 1 out
SanJose3(config-router)#neighbor 172.16.0.1 distribute-list 1 out
```

After the route filter has been configured, check the routing table for ISP2 again. The route to 12.0.1.0, ISP1, should still be in the table.

Return to SanJose3 and issue the `clear ip bgp *` command. Wait until the routers reach the Established state, which might take several seconds.

After the routers reach the Established state, recheck the ISP2 routing table. The route to ISP1 should no longer be in the routing table.

The route to 172.16.1.0, ISP2, should not be in the routing table for ISP1.

Step 6

Now that bidirectional communication has been established with each ISP by way of BGP, it is now time to declare the primary route and backup route. This can be done with floating static routes or within BGP.

To look at the floating static route method, issue the `show ip route` command as follows on SanJose3 router:

```
Gateway of last resort is not set
```

```
172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C    172.16.0.0/30 is directly connected, Serial0/1
B    172.16.1.0/24 [20/0] via 172.16.0.1, 00:07:37
    10.0.0.0/30 is subnetted, 1 subnets
C    10.0.0.0 is directly connected, Serial0/0
C    192.168.0.0/24 is directly connected, Loopback0
```

```

12.0.0.0/24 is subnetted, 1 subnets
B    12.0.1.0 [20/0] via 10.0.0.1, 00:07:42
C    192.168.1.0/24 is directly connected, Loopback1

```

Notice that there is no Gateway of Last Resort defined. This is a huge problem since SanJose3 is the border router for the corporate network. Assume that ISP1 is the primary provider and ISP2 will act as the backup provider. Configure static routes to reflect this policy.

```

SanJose3(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.1 210
SanJose3(config)#ip route 0.0.0.0 0.0.0.0 172.16.0.1 220

```

Now verify that a default route is defined. Issue the `show ip route` command as follows:

```

Gateway of last resort is 10.0.0.1 to network 0.0.0.0

172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C    172.16.0.0/30 is directly connected, Serial0/1
B    172.16.1.0/24 [20/0] via 172.16.0.1, 00:16:34
10.0.0.0/30 is subnetted, 1 subnets
C    10.0.0.0 is directly connected, Serial0/0
C    192.168.0.0/24 is directly connected, Loopback0
12.0.0.0/24 is subnetted, 1 subnets
B    12.0.1.0 [20/0] via 10.0.0.1, 00:16:39
C    192.168.1.0/24 is directly connected, Loopback1
S*  0.0.0.0/0 [210/0] via 10.0.0.1

```

Test this default route by first creating an unadvertised loopback on the router for ISP1 as follows:

```

ISP1#config t
ISP1(config)#int loopback 100
ISP1(config-if)#ip address 210.210.210.1 255.255.255.0

```

Issue the `clear ip bgp 10.0.0.1` command to re-establish a conversation with the 10.0.0.1 BGP speaker as follows:

```

SanJose3#clear ip bgp 10.0.0.1

```

Wait until the BGP conversation is re-established with the 10.0.0.1 host.

Issue the `show ip route` command to insure that the newly added 210.210.210.0 /24 network does not appear in the routing table.

```

SanJose3#show ip route

Gateway of last resort is 10.0.0.1 to network 0.0.0.0

```

```

172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C    172.16.0.0/30 is directly connected, Serial0/1
B    172.16.1.0/24 [20/0] via 172.16.0.1, 00:27:40
    10.0.0.0/30 is subnetted, 1 subnets
C    10.0.0.0 is directly connected, Serial0/0
C    192.168.0.0/24 is directly connected, Loopback0
    12.0.0.0/24 is subnetted, 1 subnets
B    12.0.1.0 [20/0] via 10.0.0.1, 00:27:45
C    192.168.1.0/24 is directly connected, Loopback1
S*  0.0.0.0/0 [210/0] via 10.0.0.1

```

Issue an extended **ping** to the 210.210.210.1 loopback interface originating from the 192.168.1.1, SanJose3, interface as follows:

```

SanJose3#ping
Protocol [ip]:
Target IP address: 210.210.210.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.1.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 210.210.210.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/32/36 ms

```

Step 7

Another solution uses the **default-network** command instead of a 0.0.0.0/0 route.

Remove the floating static routes issued from the previous step as follows:

```

SanJose3(config)#no ip route 0.0.0.0 0.0.0.0 10.0.0.1 210
SanJose3(config)#no ip route 0.0.0.0 0.0.0.0 172.16.0.1 220

```

The network that was added in the last step, 210.210.210.0/24, should now be advertised on the ISP1 router for this portion of the lab exercise.

```
ISP1(config)#router bgp 200
ISP1(config-router)#network 210.210.210.0

ISP1#clear ip bgp 10.0.0.2
```

The SanJose3 router now needs to be configured with a **default-network** statement to re-establish a Gateway of Last Resort. Make sure that the classful network 210.210.210.0 /24 appears in the routing table and is followed with the **ip default-network** statement:

```
Gateway of last resort is not set
```

```
B 210.210.210.0/24 [20/0] via 10.0.0.1, 00:04:51
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C 172.16.0.0/30 is directly connected, Serial0/1
B 172.16.1.0/24 [20/0] via 172.16.0.1, 00:21:19
    10.0.0.0/30 is subnetted, 1 subnets
C 10.0.0.0 is directly connected, Serial0/0
C 192.168.0.0/24 is directly connected, Loopback0
    12.0.0.0/24 is subnetted, 1 subnets
B 12.0.1.0 [20/0] via 10.0.0.1, 00:04:51
C 192.168.1.0/24 is directly connected, Loopback1
```

```
SanJose3(config)#ip default-network 210.210.210.0
```

Wait a few seconds, and then re-examine the routing table on SanJose3 as follows:

```
Gateway of last resort is 10.0.0.1 to network 210.210.210.0
```

```
B* 210.210.210.0/24 [20/0] via 10.0.0.1, 00:04:28
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C 172.16.0.0/30 is directly connected, Serial0/1
B 172.16.1.0/24 [20/0] via 172.16.0.1, 00:20:56
    10.0.0.0/30 is subnetted, 1 subnets
C 10.0.0.0 is directly connected, Serial0/0
C 192.168.0.0/24 is directly connected, Loopback0
    12.0.0.0/24 is subnetted, 1 subnets
B 12.0.1.0 [20/0] via 10.0.0.1, 00:04:28
C 192.168.1.0/24 is directly connected, Loopback1
```

This will establish ISP1 as the only default route. This route can be manipulated with policy routing. Correct this by adding a backup route to the 172.16.0.1 host on ISP2 as follows:

```
SanJose3(config)#ip route 0.0.0.0 0.0.0.0 172.16.0.1 220
```

EBGP learned routes have an administrative distance of 20 and will be preferred to any routes with administrative distance greater than 20, such as the default route defined above with administrative distance 220. This will act as a backup if the 210.210.210.0 /24 network is unavailable. This network could be unavailable due to a fault, misconfiguration, or the short period after a `clear ip bgp 10.0.0.1` command is issued.

Verify that this newly added route establishes a consistent default route while the BGP conversation between SanJose3 and ISP1 re-establishes. Notice that the routing table includes two candidate default routes (*) only one of which is used because of different administrative distances.

```
SanJose3#show ip route
```

```
Codes: C - connected, S - static, I - IGRP, 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,
E - EGP i - IS-IS, 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 10.0.0.1 to network 210.210.210.0
```

```
B* 210.210.210.0/24 [20/0] via 10.0.0.1, 00:19:17
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C    172.16.0.0/30 is directly connected, Serial0/1
B    172.16.1.0/24 [20/0] via 172.16.0.1, 00:35:45
    10.0.0.0/30 is subnetted, 1 subnets
C    10.0.0.0 is directly connected, Serial0/0
C    192.168.0.0/24 is directly connected, Loopback0
    12.0.0.0/24 is subnetted, 1 subnets
B    12.0.1.0 [20/0] via 10.0.0.1, 00:19:17
C    192.168.1.0/24 is directly connected, Loopback1
S* 0.0.0.0/0 [220/0] via 172.16.0.1
```

```
SanJose3#clear ip bgp 10.0.0.1
```

```
SanJose3#show ip route
```

```
Gateway of last resort is 172.16.0.1 to network 0.0.0.0
```

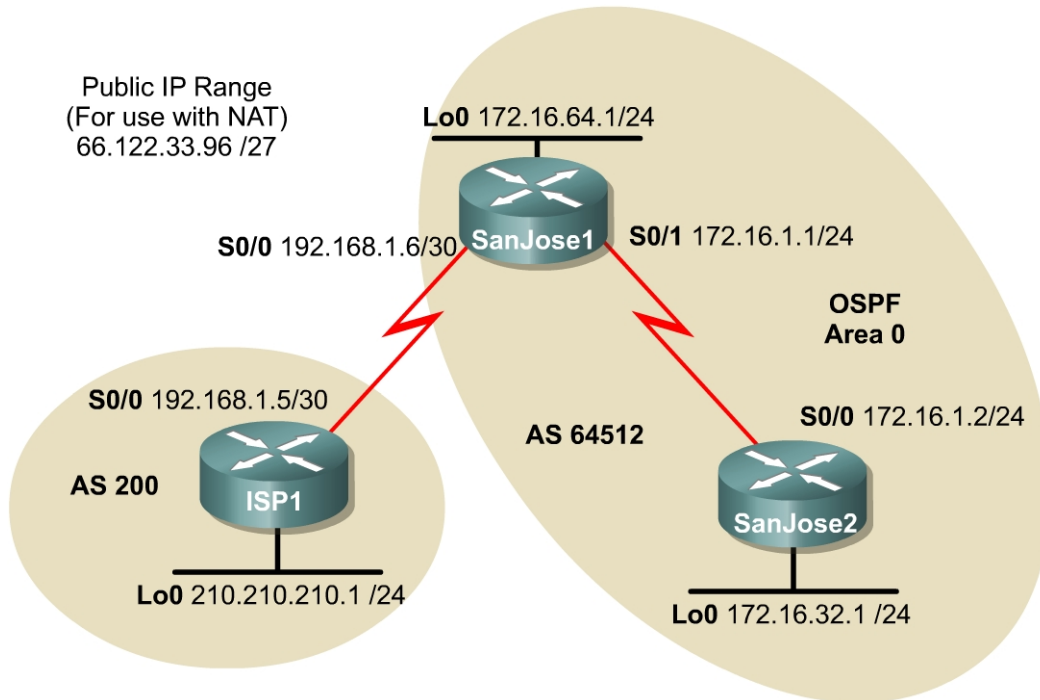
```
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C    172.16.0.0/30 is directly connected, Serial0/1
B    172.16.1.0/24 [20/0] via 172.16.0.1, 00:45:31
    10.0.0.0/30 is subnetted, 1 subnets
C    10.0.0.0 is directly connected, Serial0/0
C    192.168.0.0/24 is directly connected, Loopback0
C    192.168.1.0/24 is directly connected, Loopback1
S* 0.0.0.0/0 [220/0] via 172.16.0.1
```

```
SanJose3#show ip route
```

```
Gateway of last resort is 10.0.0.1 to network 210.210.210.0
B* 210.210.210.0/24 [20/0] via 10.0.0.1, 00:01:03
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C    172.16.0.0/30 is directly connected, Serial0/1
B    172.16.1.0/24 [20/0] via 172.16.0.1, 00:46:42
    10.0.0.0/30 is subnetted, 1 subnets
C    10.0.0.0 is directly connected, Serial0/0
C   192.168.0.0/24 is directly connected, Loopback0
    12.0.0.0/24 is subnetted, 1 subnets
B    12.0.1.0 [20/0] via 10.0.0.1, 00:01:03
C   192.168.1.0/24 is directly connected, Loopback1
S*  0.0.0.0/0 [220/0] via 172.16.0.1
```

As expected, while the BGP conversation was down between SanJose3 and ISP1, the route to ISP2 was added as the Gateway of Last Resort. However, once BGP reestablished the conversation between SanJose3 and ISP1 the default route of 210.210.210.0 was again, set as the Gateway of Last Resort on SanJose3.

Lab 9.11.2 Configuring BGP with NAT



Objective

In this lab, the student will configure EBGP with ISP1. Configure NAT with the S0/0 link to the ISP using the public IP address range of 66.122.33.96/27. This network range will need to be advertised by way of BGP.

Scenario

The International Travel Agency runs BGP on its SanJose1 router externally with ISP1, AS 200. OSPF will be used as the internal routing protocol between the SanJose1 and SanJose2 routers. EBGP needs to be configured between ISP1 and SanJose1, and finally NAT needs to be configured on the border router in AS 64512.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol. Configure a loopback interface on the three routers as shown in the figure. These loopbacks will be used to give a stable router ID for OSPF and BGP as well as simulate an existing network segment.

Use `ping` to test connectivity between the directly connected routers.

Note: The SanJose1 router should be able to ping the neighbor address of 192.168.1.5 and 172.16.1.2. SanJose2 will not be able to ping the ISP1 router and visa versa.

Step 2

Configure OSPF between the SanJose1 and SanJose2 routers with the following commands:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#network 172.16.64.1 0.0.0.0 area 0
SanJose1(config-router)#network 172.16.1.1 0.0.0.0 area 0

SanJose2(config)#router ospf 1
SanJose2(config-router)#network 172.16.32.1 0.0.0.0 area 0
SanJose2(config-router)#network 172.16.1.2 0.0.0.0 area 0
```

Verify that the SanJose1 and SanJose2 routers have formed an OSPF adjacency. Troubleshoot as necessary, first with the `show ip ospf neighbor` command, secondly with the `show ip ospf interface` command. The following output should be seen:

```
SanJose1#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time   Address        Interface
172.16.32.1      1    FULL/ -         00:00:37   172.16.1.2    Serial0/1

SanJose1#show ip ospf interface

Loopback0 is up, line protocol is up
  Internet Address 172.16.64.1/24, Area 0
  Process ID 1, Router ID 172.16.64.1, Network Type LOOPBACK, Cost: 1
  Loopback interface is treated as a stub Host
Serial0/1 is up, line protocol is up
  Internet Address 172.16.1.1/24, Area 0
  Process ID 1, Router ID 172.16.64.1, Network Type POINT_TO_POINT, Cost:64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 172.16.32.1
  Suppress hello for 0 neighbor(s)
```

The OSPF cost on Serial 0/1 may be different from the 64 listed in the output.

Note: Remember that OSPF calculates its costs by dividing 100,000,000 by the bandwidth.

1. What must be the bandwidth configured on the Serial 0/1 interface?

Router SanJose1 should have a route to the 172.16.32.0 /24 network that is learned through OSPF. Also, SanJose2 should have a route to the 172.16.64.0 /24 network also learned through OSPF.

Step 3

Configure EBGP between the ISP1 and SanJose1 routers. On the ISP1 router, enter the following configuration:

```
ISP1(config)#router bgp 200
ISP1(config-router)#network 210.210.210.0
ISP1(config-router)#neighbor 192.168.1.6 remote-as 64512

SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 remote-as 200
SanJose1#clear ip bgp *
```

The 172.16.0.0 /16 network has purposely not been advertised through BGP. This is because it is a private address that will not be able to route through the network. After a few minutes pass, issue the `show ip bgp summary` command on the SanJose1 router.

1. Has a BGP conversation with ISP1 router been formed?

Because BGP will eventually advertise outside networks that are not part of the OSPF area, the following command on the SanJose1 router must be entered:

```
SanJose1(config)#router bgp 64512
SanJose1(config-router)#no synchronization
```

The `no synchronization` command permits BGP to advertise networks without caring whether the IGP, in this case, OSPF, has the route. Usually, a BGP speaker does not advertise a route to an external neighbor unless that route is local or exists in the IGP.

The routing table of SanJose1 should look similar to the output that follows:

```
Gateway of last resort is not set

B    210.210.210.0/24 [20/0] via 192.168.1.5, 00:03:24
     172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
O    172.16.32.1/32 [110/65] via 172.16.1.2, 00:41:55, Serial0/1
C    172.16.1.0/24 is directly connected, Serial1
C    172.16.64.0/24 is directly connected, Loopback0
     192.168.1.0/30 is subnetted, 1 subnets
C    192.168.1.4 is directly connected, Serial0/0
```

There is no 150.150.150.0 network, much less host.

An extended **ping** to the 210.210.210.1 host sourced from the Loopback 0, 172.16.64.1, should not be successful.

2. Why not?

Step 4

It is now time to configure Network Address Translation, NAT, to change the source IP addresses on packets from our internal private numbered network, 172.16.0.0, into public addresses that are routable on the Internet.

```
SanJose1(config)#int s0/0
SanJose1(config-if)#ip nat outside
SanJose1(config-if)#int lo 0
SanJose1(config-if)#ip nat inside
SanJose1(config-if)#int s0/1
SanJose1(config-if)#ip nat inside
```

Next, configure the NAT pool name and NAT translation policy as follows:

```
SanJose1(config)#ip nat pool NAT_PUBLIC_SUBNET 66.122.33.98 66.122.33.126
netmask 255.255.255.224
SanJose1(config)#ip nat inside source list 10 pool NAT_PUBLIC_SUBNET
overload
SanJose1(config)#access-list 10 permit 172.16.0.0 0.0.255.255
```

Access-list 10 is used to declare eligibility for NAT. Only those addresses that are permitted in this access-list will be eligible for NAT translation. Any IP address that is not included in the permit range will not be translated but will still be routed. This ACL is not intended as the only means of securing the network. Imagine SanJose2 added a 172.20.1.0 /24 network and access-list 10 had not been updated to reflect this additional network, perhaps for security reasons. Each packet that originates from the new 172.20.1.0 /24 network, that is destined for either network 210.210.210.0 or the Internet, will not be translated. Therefore, they are dropped by the ISP as unrouteable. While this will keep these nodes from being able to connect to the Internet, it does so at a considerable cost. Each of the packets that are dropped will cross the WAN link to the ISP, but they will never return.

Verify that NAT is working properly. An attempt to ping from the inside interface on SanJose1 to the ISP will result in dropped packets since the ISP still does not know about the 66.122.33.96 /27 network. Issue the **debug ip nat** command and then issue an extended **ping** from an inside address to an outside address as follows:

```
SanJose1#debug ip nat
IP NAT debugging is on

SanJose1#ping
Protocol [ip]:
Target IP address: 192.168.1.6
Repeat count [5]:
Datagram size [100]:
```

```

Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 172.16.64.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.6, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/48/52 ms

00:22:13: NAT: s=172.16.64.1->66.122.33.98, d=192.168.1.6 [0]
00:22:13: NAT: s=192.168.1.6, d=66.122.33.98->172.16.64.1 [0]
00:22:13: NAT: s=172.16.64.1->66.122.33.98, d=192.168.1.6 [1]
00:22:13: NAT: s=192.168.1.6, d=66.122.33.98->172.16.64.1 [1]
00:22:13: NAT: s=172.16.64.1->66.122.33.98, d=192.168.1.6 [2]
00:22:13: NAT: s=192.168.1.6, d=66.122.33.98->172.16.64.1 [2]
00:22:13: NAT: s=172.16.64.1->66.122.33.98, d=192.168.1.6 [3]
00:22:13: NAT: s=192.168.1.6, d=66.122.33.98->172.16.64.1 [3]
00:22:13: NAT: s=172.16.64.1->66.122.33.98, d=192.168.1.6 [4]
00:22:13: NAT: s=192.168.1.6, d=66.122.33.98->172.16.64.1 [4]

```

This debug output shows that source 172.16.64.1 is re-encapsulated as public (external) host 66.122.33.98 destined for host 192.168.1.6. The next line shows that the return packet sources from 192.168.1.6 and is sent to destination, external, host 66.122.33.98. This is actually re-encapsulated to internal host IP 172.16.64.1.

Connectivity to the ISP is sometimes lost not because of a routing issue, but rather because NAT is not translating properly. When in doubt, issue `debug ip nat` and look for output that is similar to the previous output. Notice that this never left the SanJose1 router and therefore was not influenced by routing or BGP issues that may exist. Attempt to localize your troubleshooting.

Step 5

Configure SanJose1 router to advertise the NAT pool via BGP. Reset the BGP conversation and test connectivity with an extended `ping` from SanJose1 to the ISP1 router as follows:

```

SanJose1(config)#router bgp 64512
SanJose1(config-router)#network 66.122.33.96 mask 255.255.255.224

SanJose1#clear ip bgp *

```

1. Was the extended `ping` successful from either Lo0 or S0/1 on SanJose1 to either interface IP address of the ISP1 router?

2. Issue the `show ip bgp` command to investigate. What was found? Is there anything missing from this output that was expected to be seen here?

```
BGP table version is 4, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 172.16.0.0	0.0.0.0	0		32768	i
*> 210.210.210.0	192.168.1.5	0			0 200i

If the local routes listed in the `show ip bgp` output cannot be seen by the user, then the ISP1 router, BGP Peer, will not see these routes either.

Note: Remember that BGP will advertise routes that are directly connected, identified by a static route. Routes that exist in the routing table by way of a dynamic routing protocol that has been redistributed into BGP may also be advertised. There are two options here. Either a loopback interface can be created using one of the IP addresses from the NAT pool or a static route referencing the NAT pool can be created. Review the following solutions from these options:

Using a loopback interface results in the following:

```
SanJose1(config)#interface loopback 100
SanJose1(config-if)#ip addr 66.122.33.97 255.255.255.224
SanJose1(config-if)#ip nat outside

SanJose1#show ip bgp
BGP table version is 4, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 66.122.33.96/27	0.0.0.0	0		32768	i
*> 172.16.0.0	0.0.0.0	0		32768	i
*> 210.210.210.0	192.168.1.5	0			0 200 i

Using a static route results in the following:

```
SanJose1(config)#ip route 66.122.33.96 255.255.255.224 null0 230
SanJose1#show ip bgp
BGP table version is 6, local router ID is 172.16.64.1
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 66.122.33.96/27	0.0.0.0	0		32768	i
*> 172.16.0.0	0.0.0.0	0		32768	i
*> 210.210.210.0	192.168.1.5	0		0 200	i

Note: Using the loopback address assigned to IP NAT outside can be very useful for testing. Imagine that the link to the ISP had not been provisioned. Using an outside loopback address allows for configuration and testing prior to this link being put into production. The negative is that it uses one of the IP addresses from the public range, in this case it was a subnet of 32 hosts. The NAT pool started at X.X.X.98 instead of X.X.X.97 in anticipation of this loopback address.

Testing connectivity to the 210.210.210.1 host off ISP1 shows that any interface, or subnet, on SanJose1 can ping successfully.

Step 6

SanJose2 cannot reach the 210.210.210.1 when attempting communication from any one of its three interfaces.

1. Why is this the case?

Issue the `debug ip packet` and reattempt the `ping` from the SanJose2 router to 210.210.210.1. Notice that each attempted packet was dropped because of unroutable error messages?

```
SanJose2#ping 210.210.210.1

Sending 5, 100-byte ICMP Echos to 210.210.210.1, timeout is 2 seconds:

00:35:29: IP: s=172.16.32.1 (local), d=210.210.210.1, len 100, unroutable.
00:35:31: IP: s=172.16.32.1 (local), d=210.210.210.1, len 100, unroutable
00:35:33: IP: s=172.16.32.1 (local), d=210.210.210.1, len 100, unroutable.
00:35:35: IP: s=172.16.32.1 (local), d=210.210.210.1, len 100, unroutable.
00:35:37: IP: s=172.16.32.1 (local), d=210.210.210.1, len 100, unroutable
Success rate is 0 percent (0/5)
```

Look at the routing table on SanJose2 and check to see whether a Gateway of Last Resort has been defined. Now check the SanJose1 router for the same information.

2. Does either router have a default route or Gateway of Last Resort?

Step 7

Establish a default route on SanJose1 and allow it to be advertised within OSPF to SanJose2.

```
SanJose1(config)#ip default-network 210.210.210.0
SanJose1(config)#router ospf 1
SanJose1(config-router)#default-information originate always metric 2500
metric-type 1
```

Use the `show ip route` command on SanJose2 to verify that SanJose1 is advertising the candidate default route by way of OSPF.

```
Gateway of last resort is 172.16.1.1 to network 0.0.0.0

    172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
C       172.16.1.0/24 is directly connected, Serial0/1
O       172.16.64.1/32 [110/65] via 172.16.1.1, 00:03:15, Serial0/1
O*E1 0.0.0.0/0 [110/2564] via 172.16.1.1, 00:02:24, Serial0/1
```

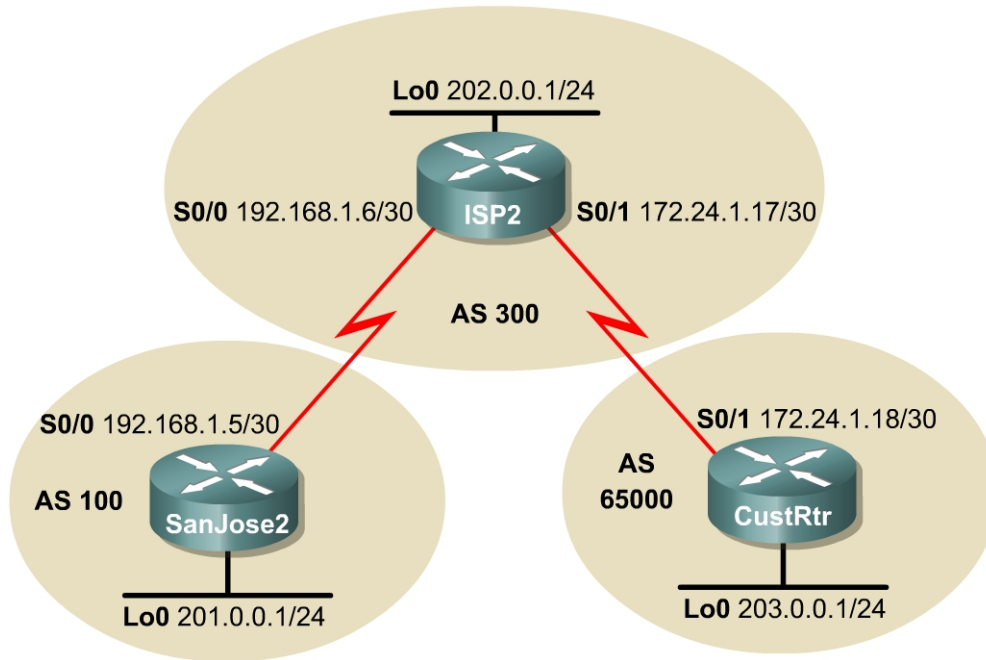
From any of the interface IP addresses on SanJose2, ping the 210.210.210.1, ISP1, address. This should now be successful.

```
SanJose2#ping 210.210.210.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 210.210.210.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 80/82/84 ms
```

Also note, that each packet being sent from SanJose2 to ISP1 is also being translated once on the way out and again on the way back as shown below. This is an appropriate area to investigate had we seen unsuccessful ping attempts after having had established the Gateway of Last Resort on SanJose2.

```
SanJose1# (Output from Debug IP NAT while pinging from SanJose2)
01:03:57: NAT: s=172.16.1.2->66.122.33.98, d=210.210.210.1 [20]
01:03:57: NAT: s=210.210.210.1, d=66.122.33.98->172.16.1.2 [20]
01:03:58: NAT: s=172.16.1.2->66.122.33.98, d=210.210.210.1 [21]
01:03:58: NAT: s=210.210.210.1, d=66.122.33.98->172.16.1.2 [21]
01:03:58: NAT: s=172.16.1.2->66.122.33.98, d=210.210.210.1 [22]
01:03:58: NAT: s=210.210.210.1, d=66.122.33.98->172.16.1.2 [22]
01:03:58: NAT: s=172.16.1.2->66.122.33.98, d=210.210.210.1 [23]
01:03:58: NAT: s=210.210.210.1, d=66.122.33.98->172.16.1.2 [23]
01:03:58: NAT: s=172.16.1.2->66.122.33.98, d=210.210.210.1 [24]
01:03:58: NAT: s=210.210.210.1, d=66.122.33.98->172.16.1.2 [24]
01:04:02: NAT: expiring 66.122.33.98 (172.16.1.2) icmp 4548 (4548)
01:04:03: NAT: expiring 66.122.33.98 (172.16.1.2) icmp 4549 (4549)
01:04:03: NAT: expiring 66.122.33.98 (172.16.1.2) icmp 4550 (4550)
01:04:03: NAT: expiring 66.122.33.98 (172.16.1.2) icmp 4551 (4551)
01:04:03: NAT: expiring 66.122.33.98 (172.16.1.2) icmp 4552 (4552)
```


Lab 9.11.3 Using the AS_PATH Attribute



Objective

In this lab, the student will use BGP commands to prevent private AS numbers from being advertised to the outside world. The student will also use the AS_PATH attribute to filter BGP routes based on their source AS numbers.

Scenario

The International Travel Agency’s Internet service provider ISP2 has been assigned an AS number of 300. This provider uses BGP to exchange routing information with several customer networks. Each customer network is assigned an AS number from the private range, such as AS 65000. Configure ISP2 to remove the private AS numbers within the AS_Path information from the CusRtr. In addition, Provider ISP2 would like to prevent its customer networks from receiving route information from International Travel Agency’s AS 100. Use the AS_PATH attribute to implement this policy.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol.

Use `ping` to test connectivity between the directly connected routers.

Note: SanJose2 will not be able to reach the customer network for ISP2, CustRtr. It will not be able to reach it by the IP address in the link leading to the CustRtr, nor the loopback interface, 202.0.0.1/24.

Step 2

Configure BGP for normal operation. Enter the appropriate BGP commands on each router so that they will identify their BGP neighbors and advertise their Ethernet networks:

```
SanJose2(config)#router bgp 100
SanJose2(config-router)#no synchronization
SanJose2(config-router)#neighbor 192.168.1.6 remote-as 300
SanJose2(config-router)#network 201.0.0.0

ISP2(config)#router bgp 300
ISP2(config-router)#no synchronization
ISP2(config-router)#neighbor 192.168.1.5 remote-as 100
ISP2(config-router)#neighbor 172.24.1.18 remote-as 65000
ISP2(config-router)#network 202.0.0.0

CustRtr(config)#router bgp 65000
CustRtr(config-router)#no synchronization
CustRtr(config-router)#neighbor 172.24.1.17 remote-as 300
CustRtr(config-router)#network 203.0.0.0
```

Verify that these routers have established the appropriate neighbor relationships by issuing the `show ip bgp neighbors` command at each router.

Step 3

Check the routing table from SanJose2 by using the `show ip route` command. SanJose2 should have a route to both 202.0.0.0 and 203.0.0.0. Troubleshoot, if necessary.

1. Can the SanJose2 router be pinged to the 203.0.0.0 /24 network off of CustRtr?

2. A ping should not be successful when issuing just a standard `ping`. Why is this the case?

Try the `ping` again, this time as an extended `ping`, sourcing from the Loopback 0 interface as follows:

```
SanJose2#ping
Protocol [ip]:
Target IP address: 203.0.0.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
```

```

Extended commands [n]: y
Source address or interface: 201.0.0.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 203.0.0.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 64/64/68 ms

```

Check the BGP table from SanJose2 by using the **show ip bgp** command. Note the AS path for the 203.0.0.0 network. The AS 65000 should be listed in the path to 203.0.0.0. Why is this a problem?

```

BGP table version is 4, local router ID is 201.0.0.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal   Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
* > 201.0.0.0       0.0.0.0           0         32768 i
* > 202.0.0.0       192.168.1.6      0           0 300 i
* > 203.0.0.0       192.168.1.6      0           0 300 65000 i

```

Configure ISP2 to strip the private AS numbers from BGP routes exchanged with SanJose2. Use the following commands:

```

ISP2(config)#router bgp 300
ISP2(config-router)#neighbor 192.168.1.5 remove-private-as

```

After issuing these commands, use the **clear ip bgp *** command on SanJose2 to re-establish the BGP relationships between the three routers.

Wait several seconds, and then return to SanJose2 to check its routing table.

3. Does SanJose2 still have a route to 203.0.0.0?

SanJose2 should be able to ping 203.0.0.0.

Now check the BGP table on SanJose2. The AS_PATH to the 203.0.0.0 network should be AS 300.

```

BGP table version is 8, local router ID is 201.0.0.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal   Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 201.0.0.0	0.0.0.0	0		32768	i
*> 202.0.0.0	192.168.1.6	0		0	300 i
*> 203.0.0.0	192.168.1.6			0	300 i

Step 4

As a final configuration, use the AS_PATH attribute to filter routes based on their origin. In a complex environment, this attribute can be used to enforce routing policy. In this case, the provider router, ISP2, must be configured so that it does not propagate routes that originate from AS 100 to the customer router, CustRtr.

First, configure a special kind of access list to match BGP routes with an AS_PATH attribute that both begins and ends with the number 100. Enter the following commands on ISP2:

```
ISP2(config)#ip as-path access-list 1 deny ^100$
ISP2(config)#ip as-path access-list 1 permit .*
```

The first command uses the ^ character to indicate that the AS_PATH must begin with the given number, 100. The \$ character indicates that the AS_PATH attribute must also end with 100. Essentially, this statement matches only paths that are sourced from AS 100. Other paths, which might include AS 100 along the way, will not match this list.

In the second statement, the . character is a wildcard, and the * symbol stands for a repetition of the wildcard. Together, .* matches any value of the AS_PATH attribute, which in effect permits any update that has not been denied by the previous access-list statement.

Now that the access list has been configured, apply it as follows:

```
ISP2(config)#router bgp 300
ISP2(config-router)#neighbor 172.24.1.18 filter-list 1 out
```

The **out** keyword specifies that the list should be applied to routing information sent to this neighbor.

Use the **clear ip bgp *** command to reset the routing information. Wait several seconds, and then check the routing table for ISP2. The route to 201.0.0.0 should be in the routing table.

Check the routing table for CustRtr. It should not have a route to 201.0.0.0 in its routing table.

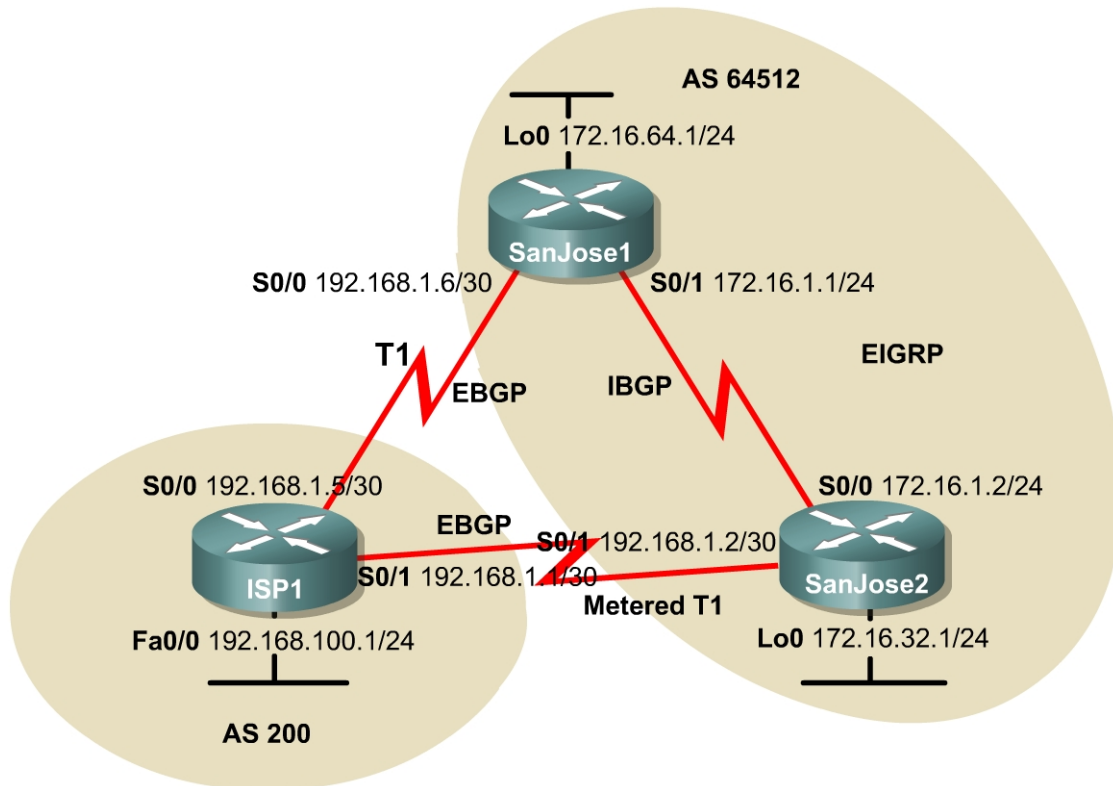
Return to ISP2 and verify that the filter is working as intended. Issue the command **show ip bgp regexp ^100\$**.

The output of this command shows all matches for the regular expressions that were used in the access list. The path to 201.0.0.0 matches the access list and is filtered out of updates to CustRtr.

```
ISP2#show ip bgp regexp ^100$
BGP table version is 4, local router ID is 202.0.0.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal   Origin codes: i - IGP, e - EGP, ? - incomplete

Network          Next Hop          Metric LocPrf Weight Path
*> 201.0.0.0     192.168.1.5      0             0 100 i
```

Lab 9.11.4a Configuring IBGP and EBGP Sessions, Local Preference and MED



Objective

In this lab, the student will configure both IBGP and EBGP. In order for IBGP peers to correctly exchange routing information, the `next-hop-self` command must be used. Use of `Local-Preference` and `MED` attributes must also be used. This is to insure that the flat rate unlimited use T1 link is used for sending and receiving data to and from the AS 200 on ISP. The metered T1 should only be used in the event that the primary T1 link has failed. Traffic sent across the metered T1 link offers the same bandwidth of the primary link but at a huge expense. Insure that this link is not used unnecessarily.

Scenario

The International Travel Agency runs BGP on its SanJose1 and SanJose2 routers externally with ISP1, AS 200. IBGP is run internally between SanJose1 and SanJose2. The job is to configure both EBGP and IBGP for this internetwork to allow for redundancy.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol. Configure a loopback interface on the SanJose1 and SanJose2 routers as shown. These loopbacks will be used with BGP **neighbor** statements for increased stability.

Use **ping** to test connectivity between the directly connected routers.

Note: The ISP1 router will not be able to reach the segment between SanJose1 and SanJose2. Both SanJose routers should be able to ping each other as well as their local ISP serial link IP address.

Step 2

Configure EIGRP between the SanJose1 and SanJose2 routers with the same commands as follows:

```
(config)#router eigrp 64512
(config-router)#network 172.16.0.0
```

Step 3

Configure IBGP between the SanJose1 and SanJose2 routers. On the SanJose1 router, enter the following configuration:

```
SanJose1(config)#router bgp 64512
SanJose1(config-router)#no auto-summary
SanJose1(config-router)#neighbor 172.16.32.1 remote-as 64512
SanJose1(config-router)#neighbor 172.16.32.1 update-source lo0
```

This topology uses VLSM. Therefore, automatic summarization along classful boundaries, should be disabled with the **no auto-summary** command.

If multiple pathways to the neighbor exist, then the router can use any IP interface to communicate by way of BGP. The **update-source lo0** command instructs the router to use interface loopback 0 for TCP connections. This command will offer greater fault tolerance in the event that one of the potentially numerous links within the corporate EIGRP WAN cloud fails. For simplicity in the lab environment, only one link is illustrated and will need to be configured.

Because BGP will eventually advertise outside networks that are not part of the EIGRP cloud, the following command must be entered on SanJose1 and SanJose2:

```
SanJose1(config)#router bgp 64512
SanJose1(config-router)#no synchronization

SanJose2(config)#router bgp 64512
SanJose2(config-router)#no synchronization
```

The **no synchronization** command permits BGP to advertise networks regardless of whether EIGRP knows of the network. Usually, a BGP speaker does not advertise a route to an external neighbor unless that route is local or exists in the IGP.

Step 4

Complete the IBGP configuration on SanJose2 by entering the following commands:

```
SanJose2(config)#router bgp 64512
SanJose2(config-router)#no auto-summary
SanJose2(config-router)#neighbor 172.16.64.1 remote-as 64512
SanJose2(config-router)#neighbor 172.16.64.1 update-source lo0
```

Verify that SanJose1 and SanJose2 become BGP neighbors by issuing the `show ip bgp neighbors` command on SanJose1. View the following partial output. If the BGP state is not established, troubleshoot the connection.

The link between SanJose1 and SanJose2 should indicate an internal link as shown in the following:

```
SanJose2#show ip bgp neighbors
BGP neighbor is 172.16.64.1, remote AS 64512, internal link
      BGP version 4, remote router ID 172.16.64.1
      BGP state = Established, up for 00:00:01
```

Step 5

Configure ISP1 to run EBGP with SanJose1 and SanJose2. Enter the following commands on ISP1 as shown in the following:

```
ISP1(config)#router bgp 200
ISP1(config-router)#no auto-summary
ISP1(config-router)#neighbor 192.168.1.6 remote-as 64512
ISP1(config-router)#neighbor 192.168.1.2 remote-as 64512
ISP1(config-router)#network 192.168.100.0
```

Because EBGP sessions are almost always established over point-to-point links, there is no reason to use the `update-source` keyword in this configuration. Only one path exists between the peers. If this path goes down, alternative paths are not available.

Step 6

Configure SanJose1 as an EBGP peer to ISP1 as shown in the following:

```
SanJose1(config)#ip route 172.16.0.0 255.255.0.0 null0
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 remote-as 200
SanJose1(config-router)#network 172.16.0.0
```

Use the `show ip bgp neighbors` command to verify that SanJose1 and ISP1 have reached the Established state. Troubleshoot, if necessary.

Step 7

Configure SanJose2 as an EBGP peer to ISP1:

```
SanJose2(config)#ip route 172.16.0.0 255.255.0.0 null0
SanJose2(config)#router bgp 64512
SanJose2(config-router)#neighbor 192.168.1.1 remote-as 200
SanJose2(config-router)#network 172.16.0.0
```

In Step 6 the `show ip bgp neighbors` command was used to verify that SanJose1 and ISP1 had reached the Established state. A useful alternative command is the `show ip bgp summary` command. Output should be similar to the sample output displayed below:

```
SanJose2#show ip bgp summary

BGP router identifier 172.16.32.1, local AS number 64512
BGP table version is 2, main routing table version 2
1 network entries and 1 paths using 137 bytes of memory
1 BGP path attribute entries using 60 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 2/1 prefixes, 2/1 paths, scan interval 15 secs

Neighbor      V    AS MsgRcvd MsgSent   TblVer  InQ  OutQ  Up/Down
State/PfxRcd
172.16.64.1   4  64512    21     24       2    0    0 00:03:02
0
192.168.1.1   4    200    14     15       2    0    0 00:03:36
0
```

Step 8

Test whether ISP1 can ping the Loopback 0 address of 172.16.64.1 from SanJose1, as well as the serial link between SanJose1 and SanJose2, 172.16.1.1.

Now ping from ISP1 to the Loopback 0 address of 172.16.32.1 from SanJose2, as well as the serial link between SanJose1 and SanJose2. This time try 172.16.1.2.

Successful pings should be seen to each IP address on SanJose2 router. Ping attempts to the 172.16.64.1 and 172.16.1.1 should fail.

1. Why is this the case?
-

Issue the `show ip bgp` command on ISP1 as follows to verify BGP routes and metrics:

```
ISP1#show ip bgp

BGP table version is 3, local router ID is 192.168.100.1
```


Status codes: s suppressed, d damped, h history, * valid, > best, i - internal

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
* 172.16.0.0	192.168.1.6			0	64512 i
*>	192.168.1.2	0		0	64512 i
*> 192.168.100.0	0.0.0.0	0		32768	i

Notice that ISP1 has two valid routes to the 172.16.0.0 network, indicated by the *. However, the link to SanJose2, the metered T1, has been selected as the best path. While that may be better for the ISP, a premium will be paid for each megabyte transferred across this link.

2. Was this a malicious attempt by the ISP to get more money? Why did the ISP prefer the link to SanJose2 over SanJose1?

-
3. Would changing the bandwidth metric on each link help to correct this issue?
-

BGP operates differently than all other protocols. Unlike other routing protocols which may use complex algorithms involving factors such as bandwidth, delay, reliability, and load to formulate a metric, BGP is policy-based. BGP will determine the best path based upon variables such as, AS_Path, Weight, Local Preference, MED, and so on. All things being equal, as in this case, BGP will prefer the route leading to the BGP speaker with the lowest IP address. This was not a malicious attempt by the ISP to get additional funds. In fact, this ISP1 router was configured from the beginning. The SanJose2 router with address 192.168.1.2 was preferred to the higher IP address of the SanJose1 router, 192.168.1.6.

At this point, the ISP1 router should be able to get to each network connected to SanJose1 and SanJose2 from the FastEthernet address 192.168.100.1.

```
ISP1#ping
Protocol [ip]:
Target IP address: 172.16.64.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.100.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 172.16.64.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/48/52 ms
ISP1#ping
Protocol [ip]:
Target IP address: 172.16.1.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.100.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/48/48 ms
ISP1#ping
Protocol [ip]:
Target IP address: 172.16.32.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.100.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.32.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/33/36 ms
ISP1#ping
Protocol [ip]:
Target IP address: 172.16.1.2
```

```

Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.100.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/36/56 ms

```

Complete reachability was proven between the ISP1 router and both SanJose1 and SanJose2.

4. Why do the following ping requests fail?

```

ISP1#ping 172.16.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
ISP1#ping 172.16.64.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.64.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)

```

Step 9

Before the ISP can successfully ping the internal serial interfaces of AS 64512, two issues need to be resolved. First, SanJose1 does not know about the link between the ISP and SanJose2. Second, SanJose2 is unaware of the link between the ISP and SanJose1. This can be resolved by an advertisement of these serial links by way of BGP on the ISP router. This can also be resolved by way of EIGRP on each of the SanJose routers. The preferred method is for the ISP to advertise these links. If they are advertised and then, at a future date, a BGP link is activated to another ISP in addition to ISP1 at AS 200, then there is a risk of becoming a Transit AS.

Issue the following commands on the ISP1 router:

```

ISP1(config)#router bgp 200
ISP1(config-router)#network 192.168.1.0 mask 255.255.255.252

```

```
ISP1(config-router)#network 192.168.1.4 mask 255.255.255.252
```

Clear the IP BGP conversation with the `clear ip bgp *` command on ISP1. Wait for the conversations to reestablish with each SanJose router. Issue the `show ip bgp` command as follows to verify that the ISP1 router can see its own WAN links through BGP:

```
ISP1#show ip bgp
BGP table version is 5, local router ID is 192.168.100.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal Origin codes: i - IGP, e - EGP, ? - incomplete

Network          Next Hop          Metric LocPrf Weight Path
* 172.16.0.0      192.168.1.6              0 64512 i
*>                192.168.1.2              0          0 64512 i
*> 192.168.1.0/30 0.0.0.0              0          32768 i
*> 192.168.1.4/30 0.0.0.0              0          32768 i
*> 192.168.100.0 0.0.0.0              0          32768 i
```

Verify on SanJose1 and SanJose2 that the opposite WAN link is included in the routing table. The output from SanJose2 is shown as follows:

```
Gateway of last resort is not set

172.16.0.0/24 is subnetted, 3 subnets
C    172.16.32.0 is directly connected, Loopback0
C    172.16.1.0 is directly connected, Serial0/0
D    172.16.64.0 [90/20640000] via 172.16.1.1, 00:57:10, Serial0/0
192.168.1.0/30 is subnetted, 2 subnets
C    192.168.1.0 is directly connected, Serial0/1
B    192.168.1.4 [20/0] via 192.168.1.1, 00:04:23
B    192.168.100.0/24 [20/0] via 192.168.1.1, 00:04:23
```

The next issue to consider is BGP policy routing between AS systems. BGP routers do not increment the next hop address to their IBGP peers. The SanJose2 router is passing a policy to SanJose1 and vice versa. The policy for routing from AS 64512 to AS 200 is to forward packets to the 192.168.1.1 interface. SanJose1 has a similar yet opposite policy, forwarding requests to the 192.168.1.5 interface. In the event that either WAN link fails, it is critical that the opposite router become a valid gateway. This is only achieved if the `next-hop-self` command is configured on SanJose1 and SanJose2.

Before the `next-hop-self` command was issued:

```
SanJose2#show ip bgp
BGP table version is 11, local router ID is 172.16.32.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 172.16.0.0	0.0.0.0	0		32768	i
* i192.168.1.0/30	192.168.1.5	0	100	0	200 i
*>	192.168.1.1	0		0	200 i
* i192.168.1.4/30	192.168.1.5	0	100	0	200 i
*>	192.168.1.1	0		0	200 i
* i192.168.100.0	192.168.1.5	0	100	0	200 i
*>	192.168.1.1	0		0	200 i

```
SanJose1(config)#router bgp 64512
```

```
SanJose1(config-router)#neighbor 172.16.32.1 next-hop-self
```

```
SanJose2(config)#router bgp 64512
```

```
SanJose2(config-router)#neighbor 172.16.64.1 next-hop-self
```

After issuing these commands, reset BGP operation on either router by entering the command **clear ip bgp ***.

After the routers have returned to established BGP speakers, issue the **show ip bgp** command to validate that the next hop has also been corrected.

```
SanJose2#show ip bgp
```

```
BGP table version is 11, local router ID is 172.16.32.1
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 172.16.0.0	0.0.0.0	0		32768	i
* i192.168.1.0/30	172.16.64.1	0	100	0	200 i
*>	192.168.1.1	0		0	200 i
* i192.168.1.4/30	172.16.64.1	0	100	0	200 i
*>	192.168.1.1	0		0	200 i
* i192.168.100.0	172.16.64.1	0	100	0	200 i
*>	192.168.1.1	0		0	200 i

Step 10

At this point, everything looks good with the exception of default routes, the outbound flow of data, and inbound packet flow.

Since the local preference value is shared between IBGP neighbors, configure a simple route-map that references local preference value on SanJose1 and SanJose2. This policy will adjust outbound traffic to prefer the link off the SanJose1 router instead of the metered T1 off SanJose2.

Issue the following commands on SanJose1 and SanJose2 respectively:

```

SanJose1(config)#route-map PRIMARY_T1_IN permit 10
SanJose1(config-route-map)#set local-preference 150
SanJose1(config-route-map)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 route-map PRIMARY_T1_IN in

SanJose2(config)#route-map SECONDARY_T1_IN permit 10
SanJose2(config-route-map)#set local-preference 125
SanJose2(config-route-map)#router bgp 64512
SanJose2(config-router)#neighbor 192.168.1.1 route-map SECONDARY_T1_IN in

```

Do not forget to use the command `clear ip bgp *` after configuring this new policy. Once the conversations have been re-established, issue the `show ip bgp` command on SanJose1 and SanJose2 as follows:

```
SanJose1#show ip bgp
```

```

BGP table version is 8, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i172.16.0.0	172.16.32.1	0	100	0	i
*> 192.168.1.0/30	192.168.1.5	0	150	0	200 i
*> 192.168.1.4/30	192.168.1.5	0	150	0	200 i
*> 192.168.100.0	192.168.1.5	0	150	0	200 i

```
SanJose2#show ip bgp
```

```

BGP table version is 11, local router ID is 172.16.32.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 172.16.0.0	0.0.0.0	0		32768	i
*>i192.168.1.0/30	172.16.64.1	0	150	0	200 i
*	192.168.1.1	0	125	0	200 i
*>i192.168.1.4/30	172.16.64.1	0	150	0	200 i
*	192.168.1.1	0	125	0	200 i
*>i192.168.100.0	172.16.64.1	0	150	0	200 i
*	192.168.1.1	0	125	0	200 i

This now indicates that routing to the FastEthernet segment for ISP1, 192.168.100.0 /24, will be reached only through the link common to SanJose1 and ISP1.

Step 11

How will traffic return from network 192.168.100.0 /24? Will it be routed through SanJose1 or SanJose2?

The simplest solution would be to issue `show ip bgp` on ISP1 router. What if access was not given to the ISP router? Would there be a simple way to verify before receiving the monthly bill? Traffic returning from the Internet should not be passed across the metered T1. How can it be checked instantly?

Use an extended `ping` in this situation. Issue the following command and compare the output to that provided in the following:

```
SanJose2#ping
Protocol [ip]:
Target IP address: 192.168.100.1
Repeat count [5]: 2
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 172.16.32.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]: record
Number of hops [ 9 ]:
Loose, Strict, Record, Timestamp, Verbose[RV]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
Packet has IP options: Total option bytes= 39, padded length=40
Record route: <*>
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
```

```

Reply to request 0 (48 ms).  Received packet has options
Total option bytes= 40, padded length=40
Record route:
  (172.16.1.2)
  (192.168.1.6)
  (192.168.100.1)
  (192.168.1.1)
  (172.16.32.1) <*>
  (0.0.0.0)
  (0.0.0.0)
  (0.0.0.0)
  (0.0.0.0)
End of list

```

```

Reply to request 1 (48 ms).  Received packet has options
Total option bytes= 40, padded length=40
Record route:
  (172.16.1.2)
  (192.168.1.6)
  (192.168.100.1)
  (192.168.1.1)
  (172.16.32.1) <*>
  (0.0.0.0)
  (0.0.0.0)
  (0.0.0.0)
  (0.0.0.0)
End of list

```

If the record option has not been used prior to this, the important thing to note is that each of the IP addresses in brackets is an outgoing interface. The output can be interpreted as follows:

1. A **ping** that is sourced from 172.16.32.1 will exit SanJose2 through s0/0, 172.16.1.2. It will then arrive at the S0/1 interface for SanJose1.
2. SanJose1 S0/0, 192.168.1.6, routes the packet out to arrive at the S0/0 interface of ISP1.
3. The target of 192.168.100.1 is reached, 192.168.100.1.
4. The packet is next forwarded out the S0/1, 192.168.1.1, interface for ISP1 and arrives at the S0/1 interface for SanJose2.
5. SanJose2 then forwards the packet out the last interface, Loopback 0, 172.16.32.1.

Although the unlimited use of the T1 from SanJose1 is preferred here, the ISP prefers the link from SanJose2 for all return traffic.

The next step is to create a new policy to force the ISP to return all traffic via SanJose1. Create a second route-map utilizing the MED (metric) which is shared between EBGp neighbors.

```
SanJose1(config)#route-map PRIMARY_T1_MED_OUT permit 10
```



```
SanJose1(config-route-map)#set Metric 50
SanJose1(config-route-map)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 route-map PRIMARY_T1_MED_OUT
out
```

```
SanJose2(config)#route-map SECONDARY_T1_MED_OUT permit 10
SanJose2(config-route-map)#set Metric 75
SanJose2(config-route-map)#exit
SanJose2(config)#router bgp 64512
SanJose2(config-router)#neighbor 192.168.1.1 route-map SECONDARY_T1_MED_OUT
out
```

As before, do not forget to `clear ip bgp *` after issuing this new policy. Issuing the `show ip bgp` command as follows on SanJose1 or SanJose2 will not indicate anything about this newly defined policy:

```
SanJose1#show ip bgp
BGP table version is 10, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i172.16.0.0	172.16.32.1	0	100	0	i
*> 192.168.1.0/30	192.168.1.5	0	150	0	200 i
*> 192.168.1.4/30	192.168.1.5	0	150	0	200 i
*> 192.168.100.0	192.168.1.5	0	150	0	200 i

Now reissue an extended ping with a `record` command as follows:

```
SanJose2#ping
Protocol [ip]:
Target IP address: 192.168.100.1
Repeat count [5]: 2
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 172.16.32.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]: record
Number of hops [ 9 ]:
Loose, Strict, Record, Timestamp, Verbose[RV]:
```

```
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
Packet has IP options: Total option bytes= 39, padded length=40
Record route: <*>
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
Reply to request 0 (64 ms). Received packet has options
Total option bytes= 40, padded length=40
Record route:
(172.16.1.2)
(192.168.1.6)
(192.168.100.1)
(192.168.1.5)
(172.16.1.1)
(172.16.32.1) <*>
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
End of list
Reply to request 1 (64 ms). Received packet has options
Total option bytes= 40, padded length=40
Record route:
(172.16.1.2)
(192.168.1.6)
(192.168.100.1)
(192.168.1.5)
(172.16.1.1)
(172.16.32.1) <*>
(0.0.0.0)
(0.0.0.0)
(0.0.0.0)
End of list
```

Does the output look correct? Does the 192.168.1.5 above mean that the ISP1 will now prefer SanJose1 for return traffic?

There may not be a chance to telnet to the ISP router and to issue the `show ip bgp` command. However, the command on the opposite side of the newly configured policy MED is clear, showing that the lower value is considered best. The ISP now prefers the route with the lower MED value to AS 64512. This is just opposite from the local-preference knob configured earlier.

```
BGP table version is 12, local router ID is 192.168.100.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal   Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
*  172.16.0.0       192.168.1.2      75             0 64512 i
*> 192.168.1.6     192.168.1.6      50             0 64512 i
*> 192.168.1.0/30  0.0.0.0          0              32768 i
*> 192.168.1.4/30  0.0.0.0          0              32768 i
*> 192.168.100.0  0.0.0.0          0              32768 i
```

Step 12

The final step is to establish a default route that uses a policy statement that will adjust to changes in the network. Configure both SanJose1 and SanJose2 to use the 192.168.100.0 /24 network as the default network. The output that follows includes the routing table before the command was issued, the actual command syntax, and then the routing table after the command was issued. Complete the same task on the SanJose2 router.

```
SanJose1#show ip route      ****Note: Prior to Default-Network Statement
Gateway of last resort is not set

  172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
D       172.16.32.0/24 [90/20640000] via 172.16.1.2, 02:43:46, Serial0/1
B       172.16.0.0/16 [200/0] via 172.16.32.1, 00:12:32
C       172.16.1.0/24 is directly connected, Serial0/1
C       172.16.64.0/24 is directly connected, Loopback0
  192.168.1.0/30 is subnetted, 2 subnets
B       192.168.1.0 [20/0] via 192.168.1.5, 00:14:05
C       192.168.1.4 is directly connected, Serial0/0
B       192.168.100.0/24 [20/0] via 192.168.1.5, 00:14:05

SanJose1(config)#ip default-network 192.168.100.0
SanJose1#show ip route
Gateway of last resort is 192.168.1.5 to network 192.168.100.0

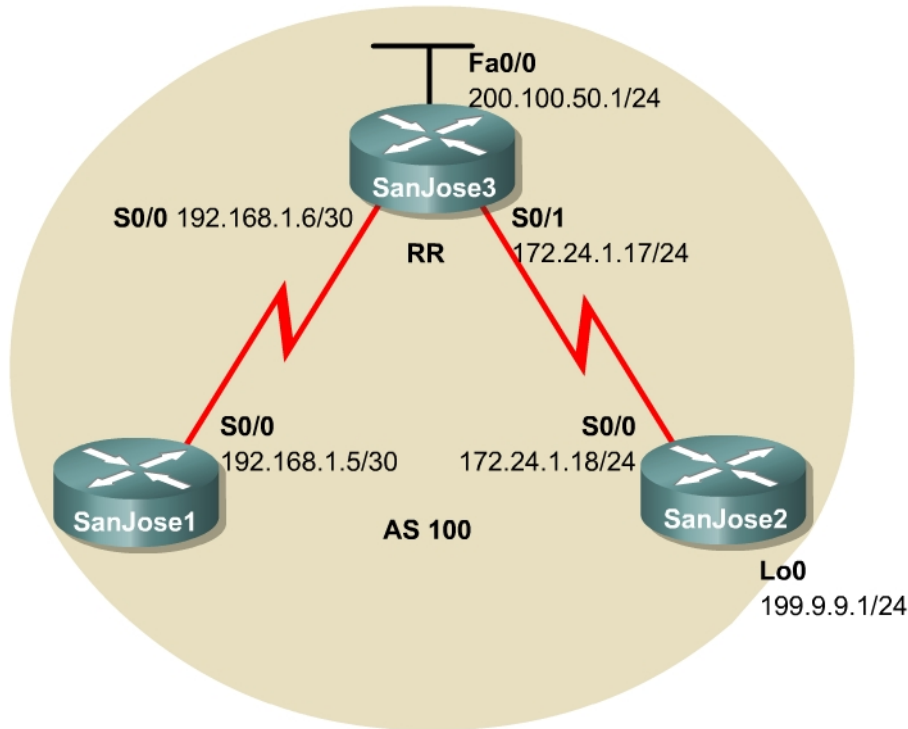
  172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
D       172.16.32.0/24 [90/20640000] via 172.16.1.2, 02:44:09, Serial0/1
B       172.16.0.0/16 [200/0] via 172.16.32.1, 00:12:55
C       172.16.1.0/24 is directly connected, Serial0/1
C       172.16.64.0/24 is directly connected, Loopback0
```

```
192.168.1.0/30 is subnetted, 2 subnets
B      192.168.1.0 [20/0] via 192.168.1.5, 00:14:28
C      192.168.1.4 is directly connected, Serial0/0
B*    192.168.100.0/24 [20/0] via 192.168.1.5, 00:14:29
```

What would be required to add a future T3 link on SanJose2 and for this future link to have preference for incoming and outgoing traffic?

A newly added route would be as easy as adding another route-map for local-preference with a value of 175 and a route-map referencing a MED (metric) value of 35. Issue the `clear ip bgp *` command and this lab is then completed.

Lab 9.11.4b BGP Route Reflectors and Route Filters



Objective

In this lab, the student will configure IBGP routers to use a route reflector and a simple route filter.

Scenario

The International Travel Agency maintains a full-mesh IBGP network that has quickly scaled beyond 100 routers. The company wants to implement route reflectors to work around the full-mesh IBGP requirement. Configure a small cluster and observe how BGP operates in this configuration. Use IP prefix filters to control the updates between IBGP peers.

Step 1

Build and configure the network according to the diagram, and use RIP as the IGP. Do not configure the 199.9.9.0 network. Use `ping` to test connectivity among all interfaces. Each router should have a complete routing table.

Step 2

Configure the IBGP peers for BGP. SanJose3 will later be configured as the route reflector. However, first configure it to peer with both of the other routers, as shown in the following:

```
SanJose3(config)#router bgp 100
SanJose3(config-router)#neighbor 192.168.1.5 remote-as 100
SanJose3(config-router)#neighbor 172.24.1.18 remote-as 100
```

```
SanJose3(config-router)#no auto-summary
SanJose3(config-router)#no synchronization
SanJose3(config-router)#network 200.100.50.0
SanJose3(config-router)#network 172.24.1.0 mask 255.255.255.0
SanJose3(config-router)#network 192.168.1.4 mask 255.255.255.252
```

After SanJose3 is configured, configure the other two routers as route reflector clients. Remember that to set up clients, simply configure peering between the client and the server. IBGP does not need to be configured to a full mesh.

Issue the following commands on SanJose1:

```
SanJose1(config)#router bgp 100
SanJose1(config-router)#neighbor 192.168.1.6 remote-as 100
SanJose1(config-router)#no auto-summary
SanJose1(config-router)#no synchronization
```

Issue the following commands on SanJose2:

```
SanJose2(config)#router bgp 100
SanJose2(config-router)#neighbor 172.24.1.17 remote-as 100
SanJose2(config-router)#no auto-summary
SanJose2(config-router)#no synchronization
```

Verify that SanJose3 has established a peering relationship with both SanJose1 and SanJose2. Troubleshoot, as necessary.

1. SanJose1 and SanJose2 should not have established a connection. Why?

SanJose2 was not configured with the appropriate BGP **neighbor** command. As a route reflector client, SanJose1 will not need to reach an Established state with SanJose2.

Step 3

To observe the full effect of using a route reflector, configure SanJose2 to inject external routing information into BGP as follows:

```
SanJose2(config)#int lo0
SanJose2(config-if)#ip address 199.9.9.1 255.255.255.0
SanJose2(config)#router bgp 100
SanJose2(config-router)#network 199.9.9.0
```

This configuration forces SanJose2 to inject the external route 199.9.9.0 into BGP. Use the **show ip route** command to check if SanJose3 has picked up this route through BGP. SanJose3 should have a route to 199.9.9.0.

1. Is the next hop for this route 172.24.1.18?
-

199.9.9.1 should **ping** from SanJose3. If not, troubleshoot.

Now check the routing table of SanJose1.

2. There should not be a route to 199.9.9.0. Why?
-
-

Remember that SanJose1 is not configured to peer with SanJose2. To eliminate the need for a full IBGP mesh, SanJose3 must be configured as a route reflector server. Issue the following commands on SanJose3:

```
SanJose3(config)#router bgp 100
SanJose3(config-router)#neighbor 192.168.1.5 route-reflector-client
SanJose3(config-router)#neighbor 172.24.1.18 route-reflector-client
```

Verify that an IBGP cluster was successfully created by issuing the **show ip protocols** command on SanJose3. The output of this command should indicate that SanJose3 is a route reflector.

3. How many clients does SanJose3 have?
-

Issue the **show ip protocols** command on SanJose1. The output of this command does not include information about route reflectors. Remember that SanJose1 is a client and not a route reflector server, so it is unaware of route reflection.

Finally, verify that route reflection is working by checking the routing table on SanJose1. SanJose1 should, at least, have a route to 199.9.9.0.

4. Is 172.24.1.18 the IP address of the next hop of this route on the SanJose1 table?
-

5. Notice that SanJose1 is not directly connected to the IP network for the next hop. Why? **Hint:** From which router did SanJose1 learn the route?
-
-

ping 199.9.9.1 from SanJose1. This ping should be successful.

Notice that SanJose1 pings 199.9.9.1 even though the next hop address is not on a directly connected network. For example, the next hop address could be 172.24.1.18.

Step 4

For the purposes of this lab, configure SanJose2 to inject a summary address into BGP, as shown in the following:

```
SanJose2(config)#router bgp 100
SanJose2(config-router)#aggregate-address 199.0.0.0 255.0.0.0
```

BGP should now send the supernet route, 199.0.0.0/8, to SanJose3 with the ATOMIC_AGGREGATE attribute set.

On SanJose3, issue the following command:

```
SanJose3#show ip bgp 199.0.0.0
BGP routing table entry for 199.0.0.0/8, version 6
Paths: (1 available, best #1)
Bestpath transition flag: 0x208
      Advertised to non peer-group peers:
        192.168.1.5
Local, (aggregated by 100 172.24.1.18), (Received from a RR-client)
  172.24.1.18 from 172.24.1.18 (172.24.1.18)
    Origin IGP, localpref 100, valid, internal, atomic-aggregate, best,
    ref 2
```

1. According to the output of this command, what address aggregated this route?

2. What indicates that route reflection is involved in this process?

3. Is there an indication that the ATOMIC_AGGREGATE attribute has been set?

SanJose3 should, in turn, reflect this route to SanJose1. Check both the routing table and BGP table on SanJose1 to be sure. Both the route to 199.9.9.0 and the supernet route, 199.0.0.0, should be installed in both the SanJose1 routing table and the BGP table.

The International Travel Agency has decided to filter specific routes to the 199.0.0.0/8 address space. Configure a route filter to prevent SanJose3 from sending the 199.9.9.0/24 route to its other clients, in this case to SanJose1.

Issue the following commands on SanJose3:

```
SanJose3(config)#ip prefix-list supernetonly permit 199.0.0.0/8
SanJose3(config)#ip prefix-list supernetonly permit 172.24.1.0/24
SanJose3(config)#ip prefix-list supernetonly permit 200.100.50.0/24
```



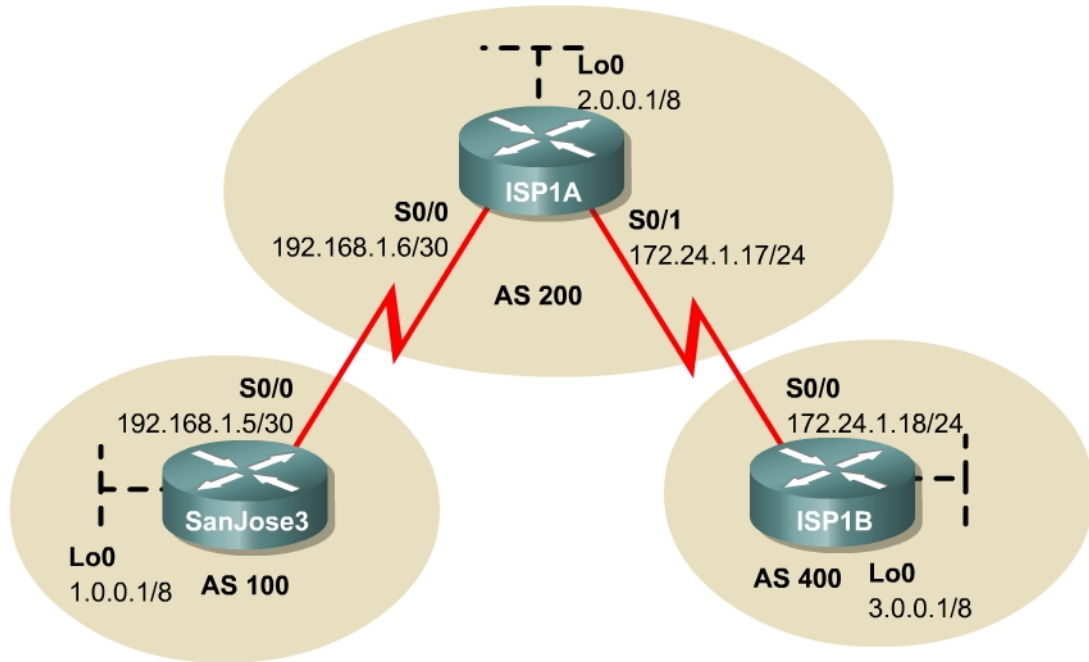
```
SanJose3(config)#router bgp 100
```

```
SanJose3(config-router)#neighbor 192.168.1.5 prefix-list supernetonly out
```

Return to SanJose1, issue the **clear ip bgp *** command, and verify that the prefix list has done its job by issuing a **show ip bgp** command. Troubleshoot, as necessary.

Unlike before, where routes to 199.9.9.0 and 199.0.0.0 were present, now only one route to 199.0.0.0 in the routing and BGP tables should be seen. Troubleshoot as necessary.

Lab 9.11.4c The BGP COMMUNITIES Attribute



Objective

In this lab, the student will use the COMMUNITIES attribute to enforce routing policy.

Scenario

The International Travel Agency peers with Internet Service Provider ISP1A and exchanges complete routing information with its AS 200. However, as a matter of policy, the International Travel Agency does not want AS 400 to learn about specific routes within the International Travel Agency's AS 100. Configure BGP on SanJose3 so that ISP1A will not forward certain routes to ISP1B in AS 400.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol yet. Configure a loopback interface with an IP address for each router, as shown. These loopbacks will simulate networks that reside within each AS.

Use **ping** to test connectivity between all directly connected interfaces.

Step 2

Configure the three routers as EBGP peers. The following is an example of the SanJose3 configuration:

```
SanJose3(config)#router bgp 100
SanJose3(config-router)#neighbor 192.168.1.6 remote-as 200
```

```
SanJose3(config-router)#network 1.0.0.0
```

When BGP has been configured on all three routers, use the `show ip route` and `show ip bgp` commands. This will verify that ISP1B has learned about the network, 1.0.0.0/8, that belongs to AS 100.

Step 3

To influence the routing decisions of ISP1A, manipulate the BGP COMMUNITIES attribute of the route being advertised.

Configure SanJose3, as shown in the following:

```
SanJose3(config)#access-list 1 permit 1.0.0.0 0.255.255.255
SanJose3(config)#route-map NO-ONE-NET 10
SanJose3(config-route-map)#match ip address 1
SanJose3(config-route-map)#set community no-export
SanJose3(config-route-map)#route-map NO-ONE-NET 20
SanJose3(config-route-map)#exit
SanJose3(config)#router bgp 100
SanJose3(config-router)#neighbor 192.168.1.6 route-map NO-ONE-NET out
SanJose3(config-router)#neighbor 192.168.1.6 send-community
```

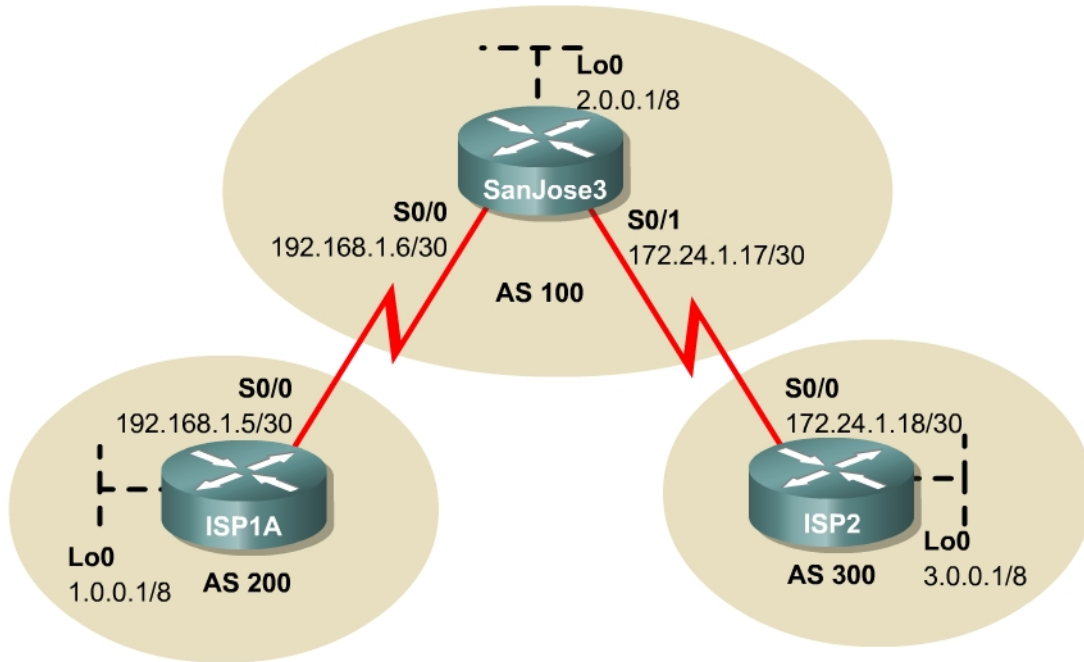
After these commands are entered, issue the `clear ip bgp *` command on ISP1A. Wait a few seconds, and then verify the configuration on ISP1A by entering the following command:

```
ISP1A#show ip bgp 1.0.0.0
```

1. According to the output of this command, what is the community value of this route set to?
-

Now check the routing table on ISP1B to see if this has prevented ISP1A from updating ISP1B. The route to 1.0.0.0/8 should be missing from the routing table of ISP1B. Troubleshoot as necessary.

Lab 9.11.4d BGP Peer Groups



Objective

In this lab, the student will use BGP peer groups to simplify the configuration tasks.

Scenario

The International Travel Agency peers with ISP1A in AS 200 and ISP2 in AS 300. The company applies similar policies to both neighbors. Rather than configuring policies separately for each neighbor, configure a BGP peer group.

Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol yet. Configure a loopback interface with an IP address for each ISP router, as shown. These loopbacks will simulate networks that reside within each AS.

Use **ping** to test connectivity between all directly connected interfaces.

Step 2

Configure ISP1A and ISP2 for EBGP. The following is an example of the ISP1A configuration:

```
ISP1A(config)#router bgp 200
ISP1A(config-router)#neighbor 192.168.1.6 remote-as 100
ISP1A(config-router)#network 1.0.0.0
```

Step 3

Use a peer group to configure SanJose3 so that it will apply policies jointly to both ISP1A and ISP2 as follows:

```
SanJose3(config)#router bgp 100
SanJose3(config-router)#network 2.0.0.0
SanJose3(config-router)#neighbor EBGP-PEERS peer-group
SanJose3(config-router)#neighbor EBGP-PEERS send-community
SanJose3(config-router)#neighbor EBGP-PEERS route-map EXTERNAL out
SanJose3(config-router)#neighbor 192.168.1.5 remote-as 200
SanJose3(config-router)#neighbor 172.24.1.18 remote-as 300
SanJose3(config-router)#neighbor 192.168.1.5 peer-group EBGP-PEERS
SanJose3(config-router)#neighbor 172.24.1.18 peer-group EBGP-PEERS
SanJose3(config-router)#exit
SanJose3(config)#route-map EXTERNAL 10
SanJose3(config-route-map)#set community 40
SanJose3(config-route-map)#exit
```

The neighbors of SanJose3 have been assigned a peer group, in this case, a group called EBGP-PEERS. Because of this, configurations need to be applied only once, to the group itself. The more routers that are added to the peer group, the more time will be saved entering configurations.

Issue the `clear ip bgp *` command on SanJose3. After waiting a few seconds, check the routing tables of the three routers. Eventually, SanJose3 should peer with the other two routers. Both ISP1A and ISP2 will receive a BGP route to the 2.0.0.0/8 network from SanJose3.

When ISP1A and ISP2 have the route to 2.0.0.0, verify that SanJose3 is actually applying the same policies to both neighbors. Issue the following command on ISP1A and ISP2:

```
ISP1A#show ip bgp 2.0.0.0
```

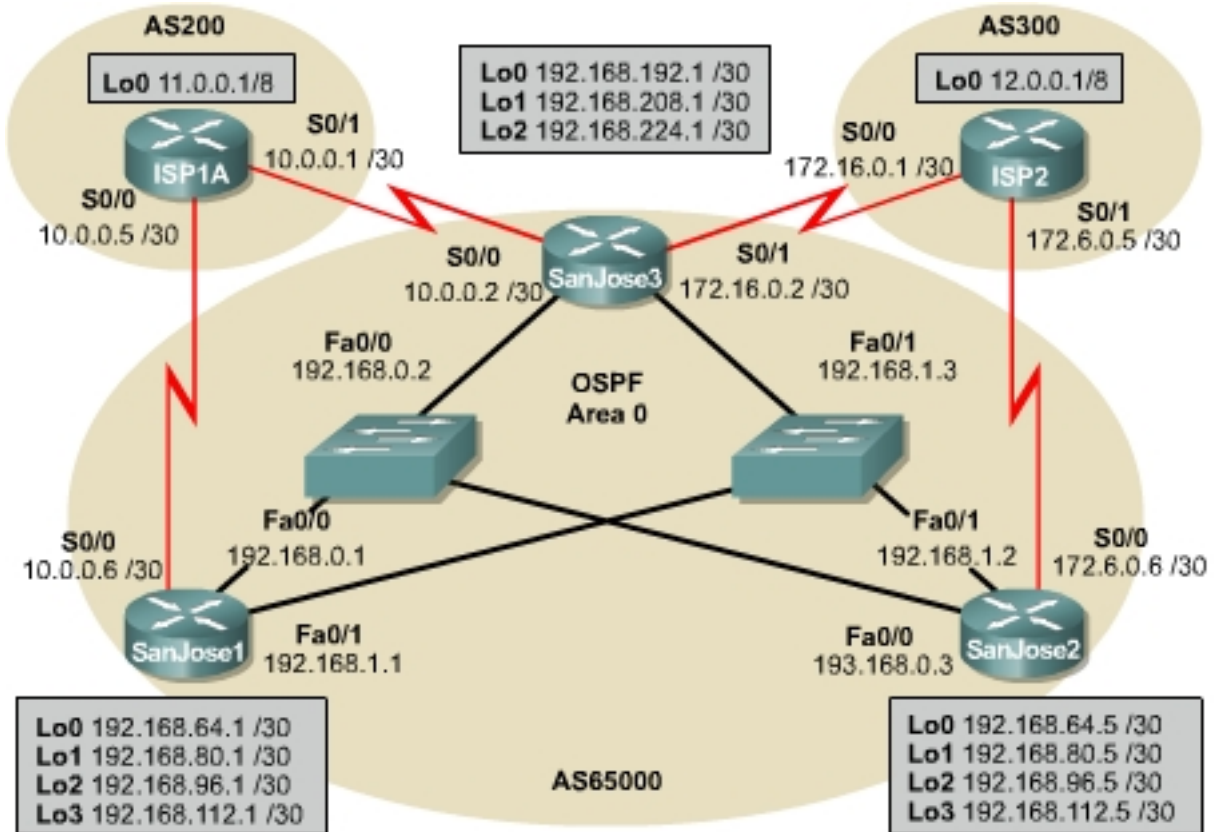
1. According to the output of this command, what is the community value for this route on ISP1A?

2. What is the community value on ISP2?

On SanJose3, issue the command `show ip bgp neighbors`.

Check that both neighbors have member of peer group EBGP-PEERS listed as a session parameter. If not, troubleshoot.

Lab 9.12.1 BGP Challenge Lab



Objective

Configure EBGP between the company's core routers and the two ISP routers. Configure IBGP with peers to create a network that will provide the International Travel Agency with a fully meshed, reliable, and efficient core network.

Scenario

The International Travel Agency relies heavily on the Internet for advertisement, sales, and communication within the company and with their customers throughout the world. They have, therefore, decided to contract with two ISPs. They are connected as shown in the figure. The company requires its network to be readily available and reliable at all times. The loopback addresses on the ISP1A and ISP2 routers represent other customers. The loopback addresses on the San Jose routers represent networks to regional headquarters and local branch offices.

Implementation Requirements

- Configure EBGP between the International Travel Agency core routers and ISP1A and ISP2.
- Configure IBGP between the International Travel Agency core routers.

- Only the internal 192.168.0.0 network should be advertised to ISP1A and ISP2 distributed access lists.
- SanJose1 should be able to communicate with ISP2 through SanJose3. SanJose2 should be able to communicate with ISP1A through SanJose3 using next-hop-self.
- SanJose1 will use ISP1A as its primary ISP through its direct link, and SanJose2 will use ISP2 as its primary ISP.
- If either direct link of SanJose1 or SanJose2 fails for any reason, all traffic should automatically be routed through SanJose3 to either ISP1A or ISP2.
- The International Travel Agency's AS number 65000 should be prevented from being advertised beyond the ISP1A and ISP2 routers to the outside world. It also should not be advertised to their other customer networks, for example, loopback addresses.

Implementation Completion Tests

- A successful `ping` to every network interface from every router.
- The `show` command verifies that routing tables contain the routes specified by the requirements.