



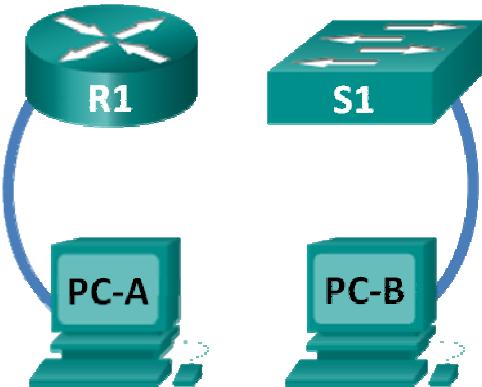
CCNA Routing and Switching: Routing and Switching Essentials Instructor Lab Manual

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Lab - Initializing and Reloading a Router and Switch (**Instructor Version**)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Objectives

Part 1: Set Up Devices in the Network as Shown in the Topology

Part 2: Initialize the Router and Reload

Part 3: Initialize the Switch and Reload

Background / Scenario

Before starting a CCNA hands-on lab that makes use of either a Cisco router or switch, ensure that the devices in use have been erased and have no startup configurations present. Otherwise, the results of your lab may be unpredictable. This lab provides a detail procedure for initializing and reloading a Cisco router and a Cisco switch.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS software, Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports

Part 1: Set Up Devices in the Network as Shown in the Topology

Step 1: Cable the network as shown in the topology.

Attach console cables to the devices shown in the topology diagram.

Step 2: Power on all the devices in the topology.

Wait for all devices to finish the software load process before moving to Part 2.

Part 2: Initialize the Router and Reload

Step 1: Connect to the router.

Console into the router and enter privileged EXEC mode using the **enable** command.

```
Router> enable  
Router#
```

Step 2: Erase the startup configuration file from NVRAM.

Type the **erase startup-config** command to remove the startup configuration from nonvolatile random-access memory (NVRAM).

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

Step 3: Reload the router.

Issue the **reload** command to remove an old configuration from memory. When prompted to Proceed with reload, press Enter to confirm the reload. Pressing any other key will abort the reload.

```
Router# reload  
Proceed with reload? [confirm]  
  
*Nov 29 18:28:09.923: %SYS-5-RELOAD: Reload requested by console. Reload Reason:  
Reload Command.
```

Note: You may receive a prompt to save the running configuration prior to reloading the router. Respond by typing **no** and press Enter.

```
System configuration has been modified. Save? [yes/no]: no
```

Step 4: Bypass the initial configuration dialog.

After the router reloads, you are prompted to enter the initial configuration dialog. Enter **no** and press Enter.

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

Step 5: Terminate the autoinstall program.

You will be prompted to terminate the autoinstall program. Respond **yes** and then press Enter.

```
Would you like to terminate autoinstall? [yes]: yes  
Router>
```

Part 3: Initialize the Switch and Reload

Step 1: Connect to the switch.

Console into the switch and enter privileged EXEC mode.

```
Switch> enable  
Switch#
```

Step 2: Determine if there have been any virtual local-area networks (VLANs) created.

Use the **show flash** command to determine if any VLANs have been created on the switch.

```
Switch# show flash
```

```
Directory of flash:/
```

2	-rwx	1919	Mar 1 1993 00:06:33 +00:00	private-config.text
3	-rwx	1632	Mar 1 1993 00:06:33 +00:00	config.text
4	-rwx	13336	Mar 1 1993 00:06:33 +00:00	multiple-fs
5	-rwx	11607161	Mar 1 1993 02:37:06 +00:00	c2960-lanbasek9-mz.150-2.SE.bin
6	-rwx	616	Mar 1 1993 00:07:13 +00:00	vlan.dat

```
32514048 bytes total (20886528 bytes free)
```

```
Switch#
```

Step 3: Delete the VLAN file.

- If the **vlan.dat** file was found in flash, then delete this file.

```
Switch# delete vlan.dat  
Delete filename [vlan.dat]?
```

You will be prompted to verify the file name. At this point, you can change the file name or just press Enter if you have entered the name correctly.

- When you are prompted to delete this file, press Enter to confirm the deletion. (Pressing any other key will abort the deletion.)

```
Delete flash:/vlan.dat? [confirm]  
Switch#
```

Step 4: Erase the startup configuration file.

Use the **erase startup-config** command to erase the startup configuration file from NVRAM. When you are prompted to remove the configuration file, press Enter to confirm the erase. (Pressing any other key will abort the operation.)

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

Step 5: Reload the switch.

Reload the switch to remove any old configuration information from memory. When you are prompted to reload the switch, press Enter to proceed with the reload. (Pressing any other key will abort the reload.)

```
Switch# reload  
Proceed with reload? [confirm]
```

Note: You may receive a prompt to save the running configuration prior to reloading the switch. Type **no** and press Enter.

```
System configuration has been modified. Save? [yes/no]: no
```

Step 6: Bypass the initial configuration dialog.

After the switch reloads, you should see a prompt to enter the initial configuration dialog. Type **no** at the prompt and press Enter.

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

Reflection

1. Why is it necessary to erase the startup configuration before reloading the router?

The startup configuration file is loaded into memory and becomes the running-config after the router reloads. Erasing this file allows the router to return to its basic configuration after a reload.

2. You find a couple configurations issues after saving the running configuration to the startup configuration, so you make the necessary changes to fix those issues. If you were to reload the device now, what configuration would be restored to the device after the reload?

The configuration at the time of the last save is restored to the device after a reload. Any changes made to the running configuration after the last save would be lost.



Lab - Installing the IPv6 Protocol and Assigning Host Addresses with Windows XP (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Part 1: Install the IPv6 Protocol on a Windows XP PC

- Install the IPv6 protocol.
- Examine IPv6 address information.

Part 2: Use the Network Shell (netsh) Utility

- Work inside the **netsh** utility.
- Configure a static IPv6 address on the local-area network (LAN) interface.
- Exit the **netsh** utility.
- Display IPv6 address information using **netsh**.
- Issue **netsh** instructions from the command prompt.

Background / Scenario

The Internet Protocol Version 6 (IPv6) is not enabled by default in Windows XP. Windows XP includes IPv6 implementation, but the IPv6 protocol must be installed. XP does not provide a way to configure IPv6 static addresses from the Graphical User Interface (GUI), so all IPv6 static address assignments must be done using the Network Shell (**netsh**) utility.

In this lab, you will install the IPv6 protocol on a Windows XP PC. You will then assign a static IPv6 address to the LAN interface.

Required Resources

- 1 Windows XP PC

Part 1: Install the IPv6 Protocol on a Windows XP PC

In Part 1, you will install the IPv6 protocol on a PC running Windows XP. You will also use two commands to view the IPv6 addresses assigned to the PC.

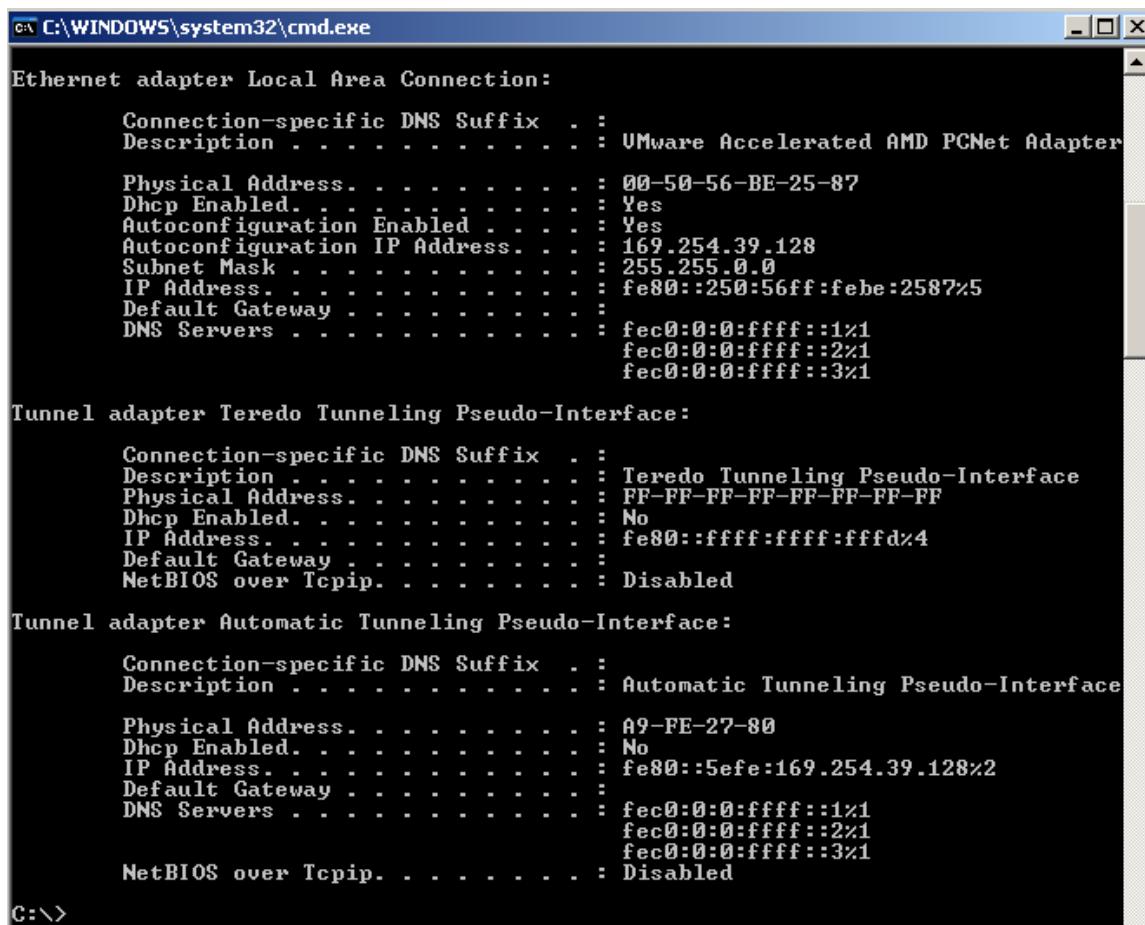
Step 1: Install the IPv6 protocol.

From the command prompt window, type **ipv6 install** to install the IPv6 protocol.

C:\> C:\WINDOWS\system32\cmd.exe
C:\>ipv6 install
Installing...
Succeeded.
C:\>_

Step 2: Examine IPv6 Address Information.

Use the **ipconfig /all** command to view IPv6 address information.



```

C:\WINDOWS\system32\cmd.exe

Ethernet adapter Local Area Connection:
  Connection-specific DNS Suffix . . . . . : 
  Description . . . . . : VMware Accelerated AMD PCNet Adapter
  Physical Address . . . . . : 00-50-56-BE-25-87
  Dhcp Enabled. . . . . : Yes
  Autoconfiguration Enabled . . . . . : Yes
  Autoconfiguration IP Address . . . . . : 169.254.39.128
  Subnet Mask . . . . . : 255.255.0.0
  IP Address. . . . . : fe80::250:56ff:febe:2587%5
  Default Gateway . . . . . : 
  DNS Servers . . . . . : fec0:0:0:ffff::1%1
                           fec0:0:0:ffff::2%1
                           fec0:0:0:ffff::3%1

Tunnel adapter Teredo Tunneling Pseudo-Interface:
  Connection-specific DNS Suffix . . . . . : 
  Description . . . . . : Teredo Tunneling Pseudo-Interface
  Physical Address . . . . . : FF-FF-FF-FF-FF-FF-FF-FF
  Dhcp Enabled. . . . . : No
  IP Address. . . . . : fe80::ffff:ffff:ffffd%4
  Default Gateway . . . . . : 
  NetBIOS over Tcpip. . . . . : Disabled

Tunnel adapter Automatic Tunneling Pseudo-Interface:
  Connection-specific DNS Suffix . . . . . : 
  Description . . . . . : Automatic Tunneling Pseudo-Interface
  Physical Address . . . . . : A9-FE-27-80
  Dhcp Enabled. . . . . : No
  IP Address. . . . . : fe80::5efe:169.254.39.128%2
  Default Gateway . . . . . : 
  DNS Servers . . . . . : fec0:0:0:ffff::1%1
                           fec0:0:0:ffff::2%1
                           fec0:0:0:ffff::3%1
  NetBIOS over Tcpip. . . . . : Disabled

C:>

```

Part 2: Use the Network Shell (netsh) Utility

Network Shell (**netsh**) is a command-line utility included with Windows XP and newer Windows operating systems, such as Vista and Windows 7. It allows you to configure the IPv6 address information on your LAN. In Part 2, you will use the **netsh** utility to configure static IPv6 address information on a Windows XP PC LAN interface. You will also use the **netsh** utility to display the PC LAN interface IPv6 address information.

Step 1: Work inside the Network Shell utility.

- From the command prompt window, type **netsh** and press Enter to start the **netsh** utility. The command prompt changes from **C:>** to **netsh>**.



```

C:\WINDOWS\system32\cmd.exe - netsh
C:>netsh
netsh>

```

- At the prompt, enter a question mark (?) and press Enter to provide the list of available parameters.

```
netsh>?
The following commands are available:
Commands in this context:
.          - Goes up one context level.
?          - Displays a list of commands.
abort      - Discards changes made while in offline mode.
add        - Adds a configuration entry to a list of entries.
alias      - Adds an alias.
bridge     - Changes to the 'netsh bridge' context.
bye        - Exits the program.
commit     - Commits changes made while in offline mode.
delete    ↗ - Deletes a configuration entry from a list of entries.
diag       - Changes to the 'netsh diag' context.
dump      - Displays a configuration script.
exec      - Runs a script file.
exit      - Exits the program.
firewall   - Changes to the 'netsh firewall' context.
help       - Displays a list of commands.
interface  - Changes to the 'netsh interface' context.
lan        - Changes to the 'netsh lan' context.
nap        - Changes to the 'netsh nap' context.
offline    - Sets the current mode to offline.
online     - Sets the current mode to online.
popd      - Pops a context from the stack.
pushd     - Pushes current context on stack.
quit      - Exits the program.
ras        - Changes to the 'netsh ras' context.
routing    - Changes to the 'netsh routing' context.
set        - Updates configuration settings.
show      - Displays information.
unalias   - Deletes an alias.
winsock    - Changes to the 'netsh winsock' context.

The following sub-contexts are available:
  bridge diag firewall interface lan nap ras routing winsock

To view help for a command, type the command, followed by a space, and then
  type ?.

netsh>
```

- c. Type **interface ?** and press Enter to provide the list of interface commands.

```
netsh>interface ?
The following commands are available:
Commands in this context:
?          - Displays a list of commands.
add      - Adds a configuration entry to a table.
delete   - Deletes a configuration entry from a table.
dump     - Displays a configuration script.
help      - Displays a list of commands.
ip        - Changes to the 'netsh interface ip' context.
ipv6     - Changes to the 'netsh interface ipv6' context.
portproxy - Changes to the 'netsh interface portproxy' context.
reset    - Resets information.
set      - Sets configuration information.
show     - Displays information.

The following sub-contexts are available:
  ip ipv6 portproxy

To view help for a command, type the command, followed by a space, and then
  type ?.

netsh>_
```

Note: You can use the question mark (?) at any level in the **netsh** utility to list the available options. The up arrow can be used to scroll through previous **netsh** commands. The **netsh** utility also allows you to abbreviate commands, as long as the abbreviation is unique.

Step 2: Configure a static IPv6 address on the LAN interface.

To add a static IPv6 address to the LAN interface, issue the **interface ipv6 add address** command from inside the **netsh** utility.

```
netsh>interface ipv6 add address "Local Area Connection" 2001:db8:acad:a::3
Ok.

netsh>
```

Step 3: Display IPv6 address information using the netsh utility.

You can display IPv6 address information using the **interface ipv6 show address** command.

```
netsh>interface ipv6 show address
Querying active state...

Interface 5: Local Area Connection
+---+-----+-----+-----+-----+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+-----+-----+-----+-----+
| Manual | Preferred | infinite | infinite | 2001:db8:acad:a::3 |
| Link | Preferred | infinite | infinite | fe80::250:56ff:febe:2587 |

Interface 4: Teredo Tunneling Pseudo-Interface
+---+-----+-----+-----+-----+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+-----+-----+-----+-----+
| Link | Preferred | infinite | infinite | fe80::ffff:ffff:ffffd |

Interface 2: Automatic Tunneling Pseudo-Interface
+---+-----+-----+-----+-----+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+-----+-----+-----+-----+
| Link | Preferred | infinite | infinite | fe80::5efe:169.254.39.128 |

Interface 1: Loopback Pseudo-Interface
+---+-----+-----+-----+-----+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+-----+-----+-----+-----+
| Loopback | Preferred | infinite | infinite | ::1 |
| Link | Preferred | infinite | infinite | fe80::1 |

netsh>_
```

Step 4: Exit the netsh utility.

Use the **exit** command to exit from the **netsh** utility.

```
netsh>exit

C:\>_
```

Step 5: Issue netsh instructions from the command prompt.

All **netsh** instructions can be entered from the command prompt, outside the **netsh** utility, by preceding the instruction with the **netsh** command.

```
C:\>netsh interface ipv6 show address
Querying active state...

Interface 5: Local Area Connection
+---+---+---+---+---+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+---+---+---+---+
| Manual | Preferred | infinite | infinite | 2001:db8:acad:a::3 |
| Link | Preferred | infinite | infinite | fe80::250:56ff:febe:2587 |
+---+---+---+---+---+
Interface 4: Teredo Tunneling Pseudo-Interface
+---+---+---+---+---+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+---+---+---+---+
| Link | Preferred | infinite | infinite | fe80::ffff:ffff:ffffd |
+---+---+---+---+---+
Interface 2: Automatic Tunneling Pseudo-Interface
+---+---+---+---+---+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+---+---+---+---+
| Link | Preferred | infinite | infinite | fe80::5efe:169.254.39.128 |
+---+---+---+---+---+
Interface 1: Loopback Pseudo-Interface
+---+---+---+---+---+
| Addr Type | DAD State | Valid Life | Pref. Life | Address |
+---+---+---+---+---+
| Loopback | Preferred | infinite | infinite | ::1 |
| Link | Preferred | infinite | infinite | fe80::1 |
+---+---+---+---+---+
C:\>
```

Reflection

1. How would you renew your LAN interface address information from the **netsh** utility?

Hint: Use the question mark (?) for help in obtaining the parameter sequence.

Answers may vary, but from the command prompt you would issue the **netsh interface ipv6 renew** command.



Sent or Received (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Describe convergence of data, voice, and video in the context of switched networks.

Students will be able to explain how switches can help LAN end devices send and receive data, voice and video data.

Scenario

Individually, or in groups (per the instructor's decision), discuss various ways hosts send and receive data, voice, and streaming video.

- Develop a matrix (table) listing network data types that can be sent and received. Provide five examples.

Your matrix table might look something like this:

Sent	Received
Client requests a web page from a web server.	Web server send web page to requesting client.

Save your work in either hard- or soft-copy format. Be prepared to discuss your matrix and statements in a class discussion.

Resources

Internet connectivity

Reflection

1. If you are receiving data, how do you think a switch assists in that process?

Students should mention that switches process data to and from end devices - many users can be sending and receiving data at the same time.

2. If you are sending network data, how do you think a switch assists in that process?

Switches allow multiple recipients to send and receive data simultaneously. Compared to hubs, a switch allows for better used of the bandwidth.

Sent or Received

Matrix Answers (will vary)

Instructor Note: This is a representative model that might be "built" as a result of this activity:

Sent	Received
Client requests a web page from a web server.	Automatic updates to your cell telephone applications Web server send web page to requesting client.
Client requests a file from a FTP server.	FTP server sends the requested file to the client.
Client requests a streaming video from a server.	Server transmits video to requesting clients.
Bob sends instant message to Mary.	Mary receives instant from Bob.
Ethernet switch receives an Ethernet frame on ingress port 1.	Ethernet switch forwards frame out egress port 4.
Bob sends VoIP packets from his IP phone.	Mary receives VoIP packets on her IP phone.



It's Network Access Time (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Describe features available for switches to support requirements of a small- to medium-sized business network.

Students will design two networks using Packet Tracer to suffice requirements shown in a LAN and WAN scenarios.

Scenario

Use Packet Tracer for this activity. Work with a classmate to create two network designs to accommodate the following scenarios:

Scenario 1 – Classroom Design (LAN)

- 15 student end devices represented by 1 or 2 PCs.
- 1 instructor end device; a server is preferred.
- Device capability to stream video presentations over LAN connection. Internet connectivity is not required in this design.

Scenario 2 – Administrative Design (WAN)

- All requirements as listed in Scenario 1.
- Add access to and from a remote administrative server for video presentations and pushed updates for network application software.

Both the LAN and WAN designs should fit on to one Packet Tracer file screen. All intermediary devices should be labeled with the switch model (or name) and the router model (or name).

Save your work and be ready to justify your device decisions and layout to your instructor and the class.

Reflection

1. What are some problems that may be encountered if you receive streaming video from your instructor's server through a low-end switch?

Answers will vary – bandwidth might be too low for the video stream to many recipients causing lag time – distortion may result in picture, audio, etc. Some stations could be “kicked out” as a result of traffic overload depending on the application program being used to stream the video, etc. There is also the possibility of “sniffing or snooping” depending on how the switch is configured.

2. How would the traffic flow be determined: multicast or broadcast – in transmission?

When users have to “log in” to the application to receive the video transmission, this would be considered a multicast. If students are set up collectively into a group by the server to push the stream, it would be considered a broadcast on the LAN side.

3. What would influence your decision on the type of switch to use for voice, streaming video and regular data these types of transmissions?

It's Network Access Time

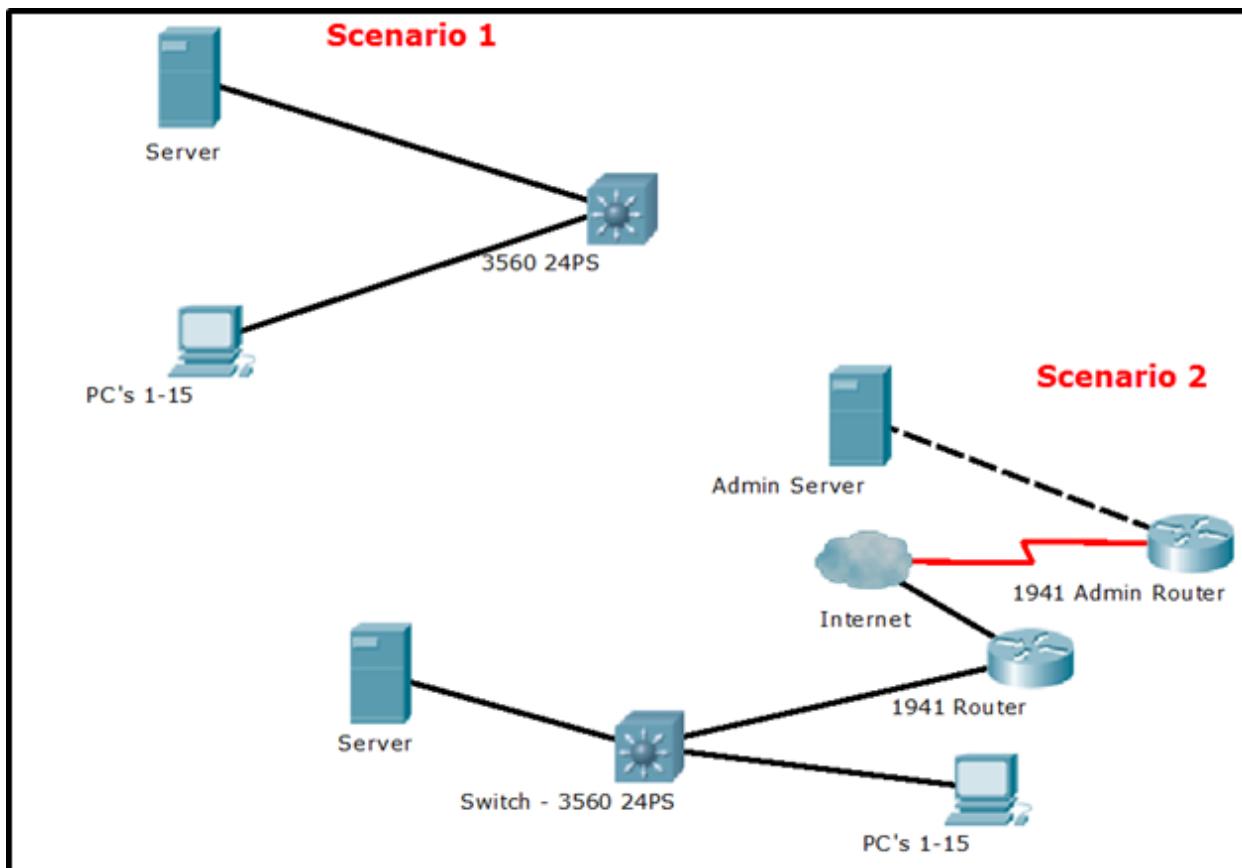
Answers will vary – if the switch will be also used for WAN streams and other intensive download traffic, a higher level switch would be used.

4. As you learned in the first course of the Academy, video and voice use a special TCP/IP model, transport layer protocol. What protocol is used in this layer and why is it important to voice and video streaming?

(UDP is the protocol used for voice and video – it allows for a continuous stream of data to flow without interruption to report delays back to the sender. There is no guaranteed delivery of data from source to destination hosts)

Packet Tracer Example (answers will vary)

Instructor Note: This is a representative model that might be “built” as a result of this activity:



Identify elements of the model that map to IT-related content:

- Voice, video and regular data can traverse networks using different devices, such as routers and switches.
- The type of switch that is used as an intermediary device provides different functional capacities.
- The type of network traffic will impact the switch's performance in sending and delivering data.
- Sufficient bandwidth is necessary to handle different types of traffic; therefore, network switch types/models and their capabilities are important to the switch model and type.
- Security impacts the switch selection. If the switch will be accessible physically, remotely or over the network locally, it will need to have security configured to include ACLs and/or port security.

Stand By Me (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Describe the role of unicast, broadcast, and multicast in a switched network.

Students are given three scenarios where activity-based numbers will need to be recorded. At the end of the activity, students will answer questions about how this introductory process relates to sending and receiving messages on a switch.

501A	501B	501C	501D	501E
502A	502B	502C	502D	502E
503A	503B	503C	503D	503E
504A	504B	504C	504D	504E
505A	505B	505C	505D	505D

Scenario

When you arrived to class today, you were given a number by your instructor to use for this introductory class activity.

Once class begins, your instructor will ask certain students with specific numbers to stand. Your job is to record the standing students' numbers for each scenario.

Scenario 1

Students with numbers **starting** with the number **5** should stand. Record the numbers of the standing students. **All students will stand and all the numbers will be recorded by each student.**

Scenario 2

Students with numbers **ending** in **B** should stand. Record the numbers of the standing students. **More than one student should stand, but not all students will stand. All numbers of standing students will be recorded by all students.**

Scenario 3

Students with the number **504C** should stand. Record the number of the standing student. **Only one student will stand and all students will record that number.**

At the end of this activity, divide into small groups and record answers to the Reflection questions on the PDF for this activity.

Reflection

1. Why do you think you were asked to record the students' numbers when and as requested?

Recording was necessary to see how groups are formed in networking. Recording helps you to identify to which group the students belong. Recording helps to keep a list of who has been seen in certain groups.

2. What is the significance of the number 5 in this activity? How many people were identified with this number?

All students received a number beginning with 5, as this indicates a full group of students. This is similar to a network broadcast situation.

Stand By Me

3. What is the significance of the letter C in this activity? How many people were identified with this number?

The letter C allows a smaller grouping of students to be identified – very similar to a multicast situation.

4. Why did only one person stand for 504C?

This number is unique to the class – therefore, it indicates a unicast form of network transmission.

5. How do you think this activity represents data travelling on local area networks?

When a switch first sees hosts on its network, it will record responses from those hosts in respect to unicasts, multicasts, and broadcasts (flooding). That is how it builds its MAC address table. Once the MAC addresses have been recorded by the switch, specific types of traffic can be switched (unicasts, broadcasts, and multicasts). The significance of the numbers illustrates unicast, multicast, and broadcast selection methods.

Save your work and be prepared to share it with another student or the entire class. (Instructor choice)

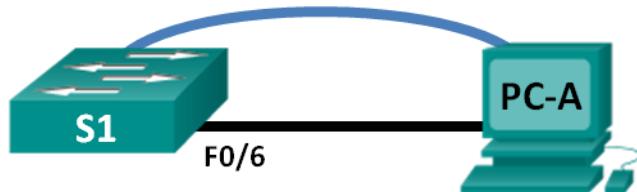
Instructor Note: Identify elements of the model that map to IT-related content:

- Switches record MAC addresses, just as the numbers were recorded during this introductory activity.
- LAN switch unicasts can be sent to and/or received by hosts.
- LAN switch multicasts can be sent to and/or received by hosts.
- LAN broadcasts can be sent to and/or received by hosts.

Lab – Configuring Basic Switch Settings (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 99	192.168.1.2	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.1.10	255.255.255.0	192.168.1.1

Objectives

Part 1: Cable the Network and Verify the Default Switch Configuration

Part 2: Configure Basic Network Device Settings

- Configure basic switch settings.
- Configure the PC IP address.

Part 3: Verify and Test Network Connectivity

- Display device configuration.
- Test end-to-end connectivity with ping.
- Test remote management capabilities with Telnet.
- Save the switch running configuration file.

Part 4: Manage the MAC Address Table

- Record the MAC address of the host.
- Determine the MAC addresses that the switch has learned.
- List the **show mac address-table** command options.
- Set up a static MAC address.

Background / Scenario

Cisco switches can be configured with a special IP address known as Switched Virtual Interface (SVI). The SVI or management address can be used for remote access to the switch to display or configure settings. If the VLAN 1 SVI is assigned an IP address, by default, all ports in VLAN 1 have access to the SVI management IP address.

In this lab, you will build a simple topology using Ethernet LAN cabling and access a Cisco switch using the console and remote access methods. You will examine default switch configurations before configuring basic switch settings. These basic switch settings include device name, interface description, local passwords,

Lab – Configuring Basic Switch Settings

message of the day (MOTD) banner, IP addressing, setting up a static MAC address, and demonstrating the use of a management IP address for remote switch management. The topology consists of one switch and one host using only Ethernet and console ports.

Note: The switch used is a Cisco Catalyst 2960 with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switch has been erased and has no startup configuration. Refer to Appendix A for the procedures to initialize and reload devices.

Required Resources

- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term, and Telnet capability)
- Console cable to configure the Cisco IOS device via the console port
- Ethernet cable as shown in the topology

Part 1: Cable the Network and Verify the Default Switch Configuration

In Part 1, you will set up the network topology and verify default switch settings.

Step 1: Cable the network as shown in the topology.

- a. Cable the console connection as shown in the topology. Do not connect the PC-A Ethernet cable at this time.

Note: If you are using Netlab, you can shut down F0/6 on S1 which has the same effect as not connecting PC-A to S1.

- b. Create a console connection to the switch from PC-A using Tera Term or other terminal emulation program.

Why must you use a console connection to initially configure the switch? Why is it not possible to connect to the switch via Telnet or SSH?

No IP addressing parameters are configured yet. A Cisco 2960 switch first placed into service has no networking configured.

Step 2: Verify the default switch configuration.

In this step, you will examine the default switch settings, such as current switch configuration, IOS information, interface properties, VLAN information, and flash memory.

You can access all the switch IOS commands in privileged EXEC mode. Access to privileged EXEC mode should be restricted by password protection to prevent unauthorized use because it provides direct access to global configuration mode and commands used to configure operating parameters. You will set passwords later in this lab.

The privileged EXEC mode command set includes those commands contained in user EXEC mode, as well as the **configure** command through which access to the remaining command modes is gained. Use the **enable** command to enter privileged EXEC mode.

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- a. Assuming the switch had no configuration file stored in nonvolatile random-access memory (NVRAM), you will be at the user EXEC mode prompt on the switch with a prompt of Switch>. Use the **enable** command to enter privileged EXEC mode.

```
Switch> enable
```

```
Switch#
```

Notice that the prompt changed in the configuration to reflect privileged EXEC mode.

Verify a clean configuration file with the **show running-config** privileged EXEC mode command. If a configuration file was previously saved, it must be removed. Depending on switch model and IOS version, your configuration may look slightly different. However, there should be no configured passwords or IP address. If your switch does not have a default configuration, erase and reload the switch.

Note: Appendix A details the steps to initialize and reload the devices.

- b. Examine the current running configuration file.

```
Switch# show running-config
```

How many FastEthernet interfaces does a 2960 switch have? _____ 24

How many Gigabit Ethernet interfaces does a 2960 switch have? _____ 2

What is the range of values shown for the vty lines? _____ 5-15

- c. Examine the startup configuration file in NVRAM.

```
Switch# show startup-config
```

startup-config is not present

Why does this message appear? _____

Nothing yet has been saved to NVRAM.

- d. Examine the characteristics of the SVI for VLAN 1.

```
Switch# show interface vlan1
```

Is there an IP address assigned to VLAN 1? _____ No

What is the MAC address of this SVI? Answers will vary. _____

0CD9:96E2:3D40 in this case.

Is this interface up?

Cisco switches have the **no shutdown** command configured by default on VLAN 1, but VLAN 1 won't reach the up/up state until a port is assigned to it and this port is also up. If there is no port in the up state in VLAN 1, then the VLAN 1 interface will be up, line protocol down. By default, all ports are assigned initially to VLAN 1.

- e. Examine the IP properties of the SVI VLAN 1.

```
Switch# show ip interface vlan1
```

What output do you see?

Vlan1 is up, line protocol is down
Internet protocol processing disabled

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- f. Connect PC-A Ethernet cable to port 6 on the switch and examine the IP properties of the SVI VLAN 1. Allow time for the switch and PC to negotiate duplex and speed parameters.

Note: If you are using Netlab, enable interface F0/6 on S1.

Switch# **show ip interface vlan1**

What output do you see?

Vlan1 is up, line protocol is up
Internet protocol processing disabled

- g. Examine the Cisco IOS version information of the switch.

Switch# **show version**

What is the Cisco IOS version that the switch is running? _____

Answers may vary. c2960-lanbasek9-mz.150-2-SE.bin

What is the system image filename? _____

Answers may vary. c2960-LANBASEK9-MZ

What is the base MAC address of this switch? Answers will vary.

Answers will vary. 0C:D9:96:E2:3D:00.

- h. Examine the default properties of the FastEthernet interface used by PC-A.

Switch# **show interface f0/6**

Is the interface up or down? _____ It should be up unless there is a cabling problem.

What event would make an interface go up? _____

Connecting a host or other device

What is the MAC address of the interface? _____ 0CD9:96E2:3D06 (Varies)

What is the speed and duplex setting of the interface? _____ Full-duplex, 100Mb/s

- i. Examine the default VLAN settings of the switch.

Switch# **show vlan**

What is the default name of VLAN 1? _____ default

Which ports are in this VLAN? _____

all ports; Fa0/1 – Fa0/24; Gi0/1, Gi0/2

Is VLAN 1 active? _____ Yes

What type of VLAN is the default VLAN? _____ enet (Ethernet)

- j. Examine flash memory.

Issue one of the following commands to examine the contents of the flash directory.

Switch# **show flash**

Switch# **dir flash:**

Files have a file extension, such as .bin, at the end of the filename. Directories do not have a file extension.

Lab – Configuring Basic Switch Settings

What is the filename of the Cisco IOS image? _____
c2960-lanbasek9-mz.150-2.SE.bin (may vary)

Part 2: Configure Basic Network Device Settings

In Part 2, you configure basic settings for the switch and PC.

Step 1: Configure basic switch settings including hostname, local passwords, MOTD banner, management address, and Telnet access.

In this step, you will configure the PC and basic switch settings, such as hostname and an IP address for the switch management SVI. Assigning an IP address on the switch is only the first step. As the network administrator, you must specify how the switch is managed. Telnet and SSH are the two most common management methods. However, Telnet is not a secure protocol. All information flowing between the two devices is sent in plain text. Passwords and other sensitive information can be easily looked at if captured by a packet sniffer.

- a. Assuming the switch had no configuration file stored in NVRAM, verify you are at privileged EXEC mode. Enter **enable** if the prompt has changed back to Switch>.

```
Switch> enable  
Switch#
```

- b. Enter global configuration mode.

```
Switch# configure terminal  
Enter configuration commands, one per line. End with CNTL/Z.  
Switch(config) #
```

The prompt changed again to reflect global configuration mode.

- c. Assign the switch hostname.

```
Switch(config) # hostname S1  
S1(config) #
```

- d. Configure password encryption.

```
S1(config) # service password-encryption  
S1(config) #
```

- e. Assign **class** as the secret password for privileged EXEC mode access.

```
S1(config) # enable secret class  
S1(config) #
```

- f. Prevent unwanted DNS lookups.

```
S1(config) # no ip domain-lookup  
S1(config) #
```

- g. Configure a MOTD banner.

```
S1(config) # banner motd #  
Enter Text message. End with the character '#'.  
Unauthorized access is strictly prohibited. #
```

- h. Verify your access settings by moving between modes.

```
S1(config) # exit  
S1#
```

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```
*Mar 1 00:19:19.490: %SYS-5-CONFIG_I: Configured from console by console
S1# exit
S1 con0 is now available
```

Press RETURN to get started.

Unauthorized access is strictly prohibited.

S1>

Which shortcut keys are used to go directly from global configuration mode to privileged EXEC mode?

_____ **Ctrl-Z**

- i. Go back to privileged EXEC mode from user EXEC mode. Enter **class** as the password when prompted.

```
S1> enable
```

Password:

S1#

Note: The password does not display when entering.

- j. Enter global configuration mode to set the SVI IP address of the switch. This allows remote management of the switch.

Before you can manage S1 remotely from PC-A, you must assign the switch an IP address. The default configuration on the switch is to have the management of the switch controlled through VLAN 1. However, a best practice for basic switch configuration is to change the management VLAN to a VLAN other than VLAN 1.

For management purposes, use VLAN 99. The selection of VLAN 99 is arbitrary and in no way implies that you should always use VLAN 99.

First, create the new VLAN 99 on the switch. Then set the IP address of the switch to 192.168.1.2 with a subnet mask of 255.255.255.0 on the internal virtual interface VLAN 99.

```
S1# configure terminal
S1(config)# vlan 99
S1(config-vlan)# exit
S1(config)# interface vlan99
%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed state to down
S1(config-if)# ip address 192.168.1.2 255.255.255.0
S1(config-if)# no shutdown
S1(config-if)# exit
S1(config)#
```

Notice that the VLAN 99 interface is in the down state even though you entered the **no shutdown** command. The interface is currently down because no switch ports are assigned to VLAN 99.

- k. Assign all user ports to VLAN 99.

```
S1(config)# interface range f0/1 - 24,g0/1 - 2
S1(config-if-range)# switchport access vlan 99
S1(config-if-range)# exit
```

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```
S1(config)#  
%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down  
%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed state to up
```

To establish connectivity between the host and the switch, the ports used by the host must be in the same VLAN as the switch. Notice in the above output that the VLAN 1 interface goes down because none of the ports are assigned to VLAN 1. After a few seconds, VLAN 99 comes up because at least one active port (F0/6 with PC-A attached) is now assigned to VLAN 99.

- I. Issue **show vlan brief** command to verify that all the user ports are in VLAN 99.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	
99	VLAN0099	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gi0/1, Gi0/2
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdinnet-default	act/unsup	
1005	trnet-default	act/unsup	

- m. Configure the IP default gateway for S1. If no default gateway is set, the switch cannot be managed from a remote network that is more than one router away. It does respond to pings from a remote network. Although this activity does not include an external IP gateway, assume that you will eventually connect the LAN to a router for external access. Assuming that the LAN interface on the router is 192.168.1.1, set the default gateway for the switch.

```
S1(config)# ip default-gateway 192.168.1.1  
S1(config)#
```

- n. Console port access should also be restricted. The default configuration is to allow all console connections with no password needed. To prevent console messages from interrupting commands, use the **logging synchronous** option.

```
S1(config)# line con 0  
S1(config-line)# password cisco  
S1(config-line)# login  
S1(config-line)# logging synchronous  
S1(config-line)# exit  
S1(config)#
```

- o. Configure the virtual terminal (vty) lines for the switch to allow Telnet access. If you do not configure a vty password, you are unable to telnet to the switch.

```
S1(config)# line vty 0 15  
S1(config-line)# password cisco  
S1(config-line)# login  
S1(config-line)# end
```

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```
S1#
*Mar 1 00:06:11.590: %SYS-5-CONFIG_I: Configured from console by console
```

Why is the **login** command required? _____

Without the **login** command, the switch will not prompt for a password to be entered.

Step 2: Configure an IP address on PC-A.

Assign the IP address and subnet mask to the PC as shown in the Addressing Table. An abbreviated version of the procedure is described here. A default gateway is not required for this topology; however, you can enter **192.168.1.1** to simulate a router attached to S1.

- 1) Click the Windows **Start** icon > **Control Panel**.
- 2) Click **View By:** and choose **Small icons**.
- 3) Choose **Network and Sharing Center > Change adapter settings**.
- 4) Select **Local Area Network Connection**, right click and choose **Properties**.
- 5) Choose **Internet Protocol Version 4 (TCP/IPv4) > Properties**.
- 6) Click the **Use the following IP address** radio button and enter the IP address and subnet mask.

Part 3: Verify and Test Network Connectivity

In Part 3, you will verify and document the switch configuration, test end-to-end connectivity between PC-A and S1, and test the switch's remote management capability.

Step 1: Display the switch configuration.

From your console connection on PC-A, display and verify your switch configuration. The **show run** command displays the entire running configuration, one page at a time. Use the spacebar to advance paging.

- a. A sample configuration displays here. The settings you configured are highlighted in yellow. The other configuration settings are IOS defaults.

```
S1# show run
Building configuration...

Current configuration : 2206 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
```

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```
!
!
no ip domain-lookup
!
<output omitted>
!
interface FastEthernet0/24
    switchport access vlan 99
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
    no ip address
    no ip route-cache
!
interface Vlan99
    ip address 192.168.1.2 255.255.255.0
    no ip route-cache
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
banner motd ^C
Unauthorized access is strictly prohibited. ^C
!
line con 0
    password 7 104D000A0618
    logging synchronous
    login
line vty 0 4
    password 7 14141B180F0B
    login
line vty 5 15
    password 7 14141B180F0B
    login
!
end
```

S1#

- b. Verify the management VLAN 99 settings.

```
S1# show interface vlan 99
Vlan99 is up, line protocol is up
    Hardware is EtherSVI, address is 0cd9.96e2.3d41 (bia 0cd9.96e2.3d41)
    Internet address is 192.168.1.2/24
    MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
```

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```
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation ARPA, loopback not set
ARP type: ARPA, ARP Timeout 04:00:00
Last input 00:00:06, output 00:08:45, 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 queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
    175 packets input, 22989 bytes, 0 no buffer
    Received 0 broadcasts (0 IP multicast)
    0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    1 packets output, 64 bytes, 0 underruns
    0 output errors, 0 interface resets
    0 output buffer failures, 0 output buffers swapped out
```

What is the bandwidth on this interface? _____ **1000000 Kb/s (1 Gb/sec)**

What is the VLAN 99 state? _____ **up**

What is the line protocol state? _____ **up**

Step 2: Test end-to-end connectivity with ping.

- a. From the command prompt on PC-A, ping your own PC-A address first.

```
C:\Users\User1> ping 192.168.1.10
```

- b. From the command prompt on PC-A, ping the SVI management address of S1.

```
C:\Users\User1> ping 192.168.1.2
```

Because PC-A needs to resolve the MAC address of S1 through ARP, the first packet may time out. If ping results continue to be unsuccessful, troubleshoot the basic device configurations. You should check both the physical cabling and logical addressing if necessary.

Step 3: Test and verify remote management of S1.

You will now use Telnet to remotely access the switch. In this lab, PC-A and S1 reside side by side. In a production network, the switch could be in a wiring closet on the top floor while your management PC is located on the ground floor. In this step, you will use Telnet to remotely access switch S1 using its SVI management address. Telnet is not a secure protocol; however, you will use it to test remote access. With Telnet, all information, including passwords and commands, are sent across the session in plain text. In subsequent labs, you will use SSH to remotely access network devices.

Instructor Note: Tera Term or other terminal emulation programs with Telnet capability may be used if Telnet from the Windows command prompt is not allowed at your institution.

Note: If you are using Windows 7, the administrator may need to enable the Telnet protocol. To install the Telnet client, open a cmd window and type **pkgrmgr /iu:"TelnetClient"**. An example is shown below.

```
C:\Users\User1> pkgrmgr /iu:"TelnetClient"
```

- a. With the cmd window still open on PC-A, issue a Telnet command to connect to S1 via the SVI management address. The password is **cisco**.

```
C:\Users\User1> telnet 192.168.1.2
```

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- b. After entering the password **cisco**, you will be at the user EXEC mode prompt. Access privileged EXEC mode.
- c. Type **exit** to end the Telnet session.

Step 4: Save the switch running configuration file.

Save the configuration.

```
S1# copy running-config startup-config
Destination filename [startup-config]? [Enter]
Building configuration...
[OK]
S1#
```

Part 4: Manage the MAC Address Table

In Part 4, you will determine the MAC address that the switch has learned, set up a static MAC address on one interface of the switch, and then remove the static MAC address from that interface.

Step 1: Record the MAC address of the host.

From a command prompt on PC-A, issue **ipconfig /all** command to determine and record the Layer 2 (physical) addresses of the PC NIC.

PC-A: 00-50-56-BE-6C-89 (answers will vary)

Step 2: Determine the MAC addresses that the switch has learned.

Display the MAC addresses using the **show mac address-table** command.

```
S1# show mac address-table
```

How many dynamic addresses are there? _____ 1 (can vary)

How many MAC addresses are there in total? _____ 24 (can vary)

Does the dynamic MAC address match the PC-A MAC address? _____ Yes

Step 3: List the show mac address-table options.

- a. Display the MAC address table options.

```
S1# show mac address-table ?
```

How many options are available for the **show mac address-table** command? _____ 12 (can vary)

- b. Issue the **show mac address-table dynamic** command to display only the MAC addresses that were learned dynamically.

```
S1# show mac address-table dynamic
```

How many dynamic addresses are there? _____ 1 (can vary)

- c. View the MAC address entry for PC-A. The MAC address formatting for the command is xxxx.xxxx.xxxx.

```
S1# show mac address-table address <PC-A MAC here>
```

Step 4: Set up a static MAC address.

- Clear the MAC address table.

To remove the existing MAC addresses, use the **clear mac address-table** command from privileged EXEC mode.

```
S1# clear mac address-table dynamic
```

- Verify that the MAC address table was cleared.

```
S1# show mac address-table
```

How many static MAC addresses are there? _____

at least 20 (other static entries could have been manually created)

Instructor Note: The first 20 static addresses in the MAC address table are built-in.

How many dynamic addresses are there? _____

0 (may be 1, depending on how quickly addresses are re-acquired by the switch)

- Examine the MAC table again.

More than likely, an application running on your PC has already sent a frame out the NIC to S1. Look at the MAC address table again in privileged EXEC mode to see if S1 has relearned the MAC address for PC-A.

```
S1# show mac address-table
```

How many dynamic addresses are there? _____ 1

Why did this change from the last display? _____

The switch dynamically reacquired the PC MAC address.

If S1 has not yet relearned the MAC address for PC-A, ping the VLAN 99 IP address of the switch from PC-A, and then repeat the **show mac address-table** command.

- Set up a static MAC address.

To specify which ports a host can connect to, one option is to create a static mapping of the host MAC address to a port.

Set up a static MAC address on F0/6 using the address that was recorded for PC-A in Part 4, Step 1. The MAC address 0050.56BE.6C89 is used as an example only. You must use the MAC address of your PC-A, which is different than the one given here as an example.

```
S1(config)# mac address-table static 0050.56BE.6C89 vlan 99 interface fastethernet 0/6
```

- Verify the MAC address table entries.

```
S1# show mac address-table
```

How many total MAC addresses are there? _____ 21 (varies)

How many static addresses are there? _____

There are 22 static addresses. Total MAC addresses and static addresses should be the same because there are no other devices currently connected to S1.

- Remove the static MAC entry. Enter global configuration mode and remove the command by putting a **no** in front of the command string.

Note: The MAC address 0050.56BE.6C89 is used in the example only. Use the MAC address for your PC-A.

Lab – Configuring Basic Switch Settings

```
S1(config)# no mac address-table static 0050.56BE.6C89 vlan 99 interface  
fastethernet 0/6
```

- g. Verify that the static MAC address has been cleared.

```
S1# show mac address-table
```

How many total static MAC addresses are there? _____ 20 (varies)

Reflection

1. Why should you configure the vty lines for the switch?

If you do not configure a vty password you will not be able to telnet to the switch.

2. Why change the default VLAN 1 to a different VLAN number?

For improved security.

3. How can you prevent passwords from being sent in plain text?

Issue the **service password-encryption** command.

4. Why configure a static MAC address on a port interface?

To specify which ports a host can connect to.

Appendix A: Initializing and Reloading a Router and Switch

Step 1: Initialize and reload the router.

- a. Console into the router and enable privileged EXEC mode.

```
Router> enable
```

```
Router#
```

- b. Enter the **erase startup-config** command to remove the startup configuration from NVRAM.

```
Router# erase startup-config
```

```
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]  
[OK]
```

```
Erase of nvram: complete
```

```
Router#
```

- c. Issue the **reload** command to remove an old configuration from memory. When prompted to Proceed with reload?, press Enter. (Pressing any other key aborts the reload.)

```
Router# reload
```

```
Proceed with reload? [confirm]
```

```
*Nov 29 18:28:09.923: %SYS-5-RELOAD: Reload requested by console. Reload Reason:  
Reload Command.
```

Note: You may receive a prompt asking to save the running configuration prior to reloading the router. Respond by typing **no** and press Enter.

```
System configuration has been modified. Save? [yes/no]: no
```

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- d. After the router reloads, you are prompted to enter the initial configuration dialog. Enter **no** and press Enter.

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

- e. Another prompt asks to terminate autoinstall. Respond by typing **yes** press Enter.

```
Would you like to terminate autoinstall? [yes]: yes
```

Step 2: Initialize and reload the switch.

- a. Console into the switch and enter privileged EXEC mode.

```
Switch> enable
```

```
Switch#
```

- b. Use the **show flash** command to determine if any VLANs have been created on the switch.

```
Switch# show flash
```

```
Directory of flash:/
```

2	-rwx	1919	Mar 1 1993 00:06:33 +00:00	private-config.text
3	-rwx	1632	Mar 1 1993 00:06:33 +00:00	config.text
4	-rwx	13336	Mar 1 1993 00:06:33 +00:00	multiple-fs
5	-rwx	11607161	Mar 1 1993 02:37:06 +00:00	c2960-lanbasek9-mz.150-2.SE.bin
6	-rwx	616	Mar 1 1993 00:07:13 +00:00	vlan.dat

```
32514048 bytes total (20886528 bytes free)
```

```
Switch#
```

- c. If the **vlan.dat** file was found in flash, then delete this file.

```
Switch# delete vlan.dat
```

```
Delete filename [vlan.dat]?
```

- d. You are prompted to verify the filename. If you have entered the name correctly, press Enter; otherwise, you can change the filename.

- e. You are prompted to confirm to delete this file. Press Enter to confirm.

```
Delete flash:/vlan.dat? [confirm]
```

```
Switch#
```

- f. Use the **erase startup-config** command to erase the startup configuration file from NVRAM. You are prompted to remove the configuration file. Press Enter to confirm.

```
Switch# erase startup-config
```

```
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
```

```
[OK]
```

```
Erase of nvram: complete
```

```
Switch#
```

- g. Reload the switch to remove any old configuration information from memory. You will then receive a prompt to confirm to reload the switch. Press Enter to proceed.

```
Switch# reload
```

```
Proceed with reload? [confirm]
```

Note: You may receive a prompt to save the running configuration prior to reloading the switch. Respond by typing **no** and press Enter.

```
System configuration has been modified. Save? [yes/no]: no
```

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- h. After the switch reloads, you should see a prompt to enter the initial configuration dialog. Respond by entering **no** at the prompt and press Enter.

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

Device Configs

Switch S1

```
S1#sh run  
Building configuration...  
Current configuration : 2359 bytes  
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
service password-encryption  
!  
hostname S1  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
!interface FastEthernet0/1  
switchport access vlan 99  
!  
interface FastEthernet0/2  
switchport access vlan 99  
!  
interface FastEthernet0/3  
switchport access vlan 99  
!  
interface FastEthernet0/4  
switchport access vlan 99  
!  
interface FastEthernet0/5
```

Lab – Configuring Basic Switch Settings

```
switchport access vlan 99
!
interface FastEthernet0/6
switchport access vlan 99
!
interface FastEthernet0/7
switchport access vlan 99
!
interface FastEthernet0/8
switchport access vlan 99
!
interface FastEthernet0/9
switchport access vlan 99
!
interface FastEthernet0/10
switchport access vlan 99
!
interface FastEthernet0/11
switchport access vlan 99
!
interface FastEthernet0/12
switchport access vlan 99
!
interface FastEthernet0/13
switchport access vlan 99
!
interface FastEthernet0/14
switchport access vlan 99
!
interface FastEthernet0/15
switchport access vlan 99
!
interface FastEthernet0/16
switchport access vlan 99
!
interface FastEthernet0/17
switchport access vlan 99
!
interface FastEthernet0/18
switchport access vlan 99
!
interface FastEthernet0/19
switchport access vlan 99
!
interface FastEthernet0/20
switchport access vlan 99
!
interface FastEthernet0/21
switchport access vlan 99
```

Lab – Configuring Basic Switch Settings

```
!
interface FastEthernet0/22
 switchport access vlan 99
!
interface FastEthernet0/23
 switchport access vlan 99
!
interface FastEthernet0/24
 switchport access vlan 99
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 no ip address
!
interface Vlan99
 ip address 192.168.1.2 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
banner motd ^C
Unauthorized access is strictly prohibited. ^C
!
line con 0
 password 7 0822455D0A16
logging synchronous
login
line vty 0 4
 password 7 01100F175804
login
line vty 5 15
 password 7 01100F175804
login
!
end
```

Lab – Configuring Switch Security Features (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	172.16.99.1	255.255.255.0	N/A
S1	VLAN 99	172.16.99.11	255.255.255.0	172.16.99.1
PC-A	NIC	172.16.99.3	255.255.255.0	172.16.99.1

Objectives

Part 1: Set Up the Topology and Initialize Devices

Part 2: Configure Basic Device Settings and Verify Connectivity

Part 3: Configure and Verify SSH Access on S1

- Configure SSH access.
- Modify SSH parameters.
- Verify the SSH configuration.

Part 4: Configure and Verify Security Features on S1

- Configure and verify general security features.
- Configure and verify port security.

Background / Scenario

It is quite common to lock down access and install good security features on PCs and servers. It is important that your network infrastructure devices, such as switches and routers, are also configured with security features.

In this lab, you will follow some best practices for configuring security features on LAN switches. You will only allow SSH and secure HTTPS sessions. You will also configure and verify port security to lock out any device with a MAC address not recognized by the switch.

Note: The router used with CCNA hands-on labs is a Cisco 1941 Integrated Services Router (ISR) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switch used is a Cisco Catalyst 2960 with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor or refer to the previous lab for the procedures to initialize and reload devices.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Set Up the Topology and Initialize Devices

In Part 1, you will set up the network topology and clear any configurations if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switch.

If configuration files were previously saved on the router or switch, initialize and reload these devices back to their basic configurations.

Part 2: Configure Basic Device Settings and Verify Connectivity

In Part 2, you configure basic settings on the router, switch, and PC. Refer to the Topology and Addressing Table at the beginning of this lab for device names and address information.

Step 1: Configure an IP address on PC-A.

Step 2: Configure basic settings on R1.

- Configure the device name.
- Disable DNS lookup.
- Configure interface IP address as shown in the Addressing Table.
- Assign **class** as the privileged EXEC mode password.
- Assign **cisco** as the console and vty password and enable login.
- Encrypt plain text passwords.
- Save the running configuration to startup configuration.

Step 3: Configure basic settings on S1.

A good security practice is to assign the management IP address of the switch to a VLAN other than VLAN 1 (or any other data VLAN with end users). In this step, you will create VLAN 99 on the switch and assign it an IP address.

- Configure the device name.
- Disable DNS lookup.
- Assign **class** as the privileged EXEC mode password.

Lab – Configuring Switch Security Features

- d. Assign **cisco** as the console and vty password and then enable login.
- e. Configure a default gateway for S1 using the IP address of R1.
- f. Encrypt plain text passwords.
- g. Save the running configuration to startup configuration.
- h. Create VLAN 99 on the switch and name it **Management**.

```
S1(config)# vlan 99
S1(config-vlan)# name Management
S1(config-vlan)# exit
S1(config)#{
```

- i. Configure the VLAN 99 management interface IP address, as shown in the Addressing Table, and enable the interface.

```
S1(config)# interface vlan 99
S1(config-if)# ip address 172.16.99.11 255.255.255.0
S1(config-if)# no shutdown
S1(config-if)# end
S1#
```

- j. Issue the **show vlan** command on S1. What is the status of VLAN 99? _____ Active
- k. Issue the **show ip interface brief** command on S1. What is the status and protocol for management interface VLAN 99?

Status is up, and protocol is down.

Why is the protocol down, even though you issued the **no shutdown** command for interface VLAN 99?

No physical ports on the switch have been assigned to VLAN 99.

- l. Assign ports F0/5 and F0/6 to VLAN 99 on the switch.

```
S1# config t
S1(config)# interface f0/5
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 99
S1(config-if)# interface f0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 99
S1(config-if)# end
```

- m. Issue the **show ip interface brief** command on S1. What is the status and protocol showing for interface VLAN 99? _____ Up and up

Note: There may be a delay while the port states converge.

Step 4: Verify connectivity between devices.

- a. From PC-A, ping the default gateway address on R1. Were your pings successful? _____ Yes
- b. From PC-A, ping the management address of S1. Were your pings successful? _____ Yes
- c. From S1, ping the default gateway address on R1. Were your pings successful? _____ Yes

Lab – Configuring Switch Security Features

- d. From PC-A, open a web browser and go to `http://172.16.99.11`. If it prompts you for a username and password, leave the username blank and use **class** for the password. If it prompts for secured connection, answer **No**. Were you able to access the web interface on S1? _____ **Yes**
- e. Close the browser session on PC-A.

Note: The non-secure web interface (HTTP server) on a Cisco 2960 switch is enabled by default. A common security measure is to disable this service, as described in Part 4.

Part 3: Configure and Verify SSH Access on S1

Step 1: Configure SSH access on S1.

- a. Enable SSH on S1. From global configuration mode, create a domain name of **CCNA-Lab.com**.

```
S1(config)# ip domain-name CCNA-Lab.com
```

- b. Create a local user database entry for use when connecting to the switch via SSH. The user should have administrative level access.

Note: The password used here is NOT a strong password. It is merely being used for lab purposes.

```
S1(config)# username admin privilege 15 secret sshadmin
```

- c. Configure the transport input for the vty lines to allow SSH connections only, and use the local database for authentication.

```
S1(config)# line vty 0 15
S1(config-line)# transport input ssh
S1(config-line)# login local
S1(config-line)# exit
```

- d. Generate an RSA crypto key using a modulus of 1024 bits.

```
S1(config)# crypto key generate rsa modulus 1024
```

The name for the keys will be: S1.CCNA-Lab.com

```
% The key modulus size is 1024 bits
% Generating 1024 bit RSA keys, keys will be non-exportable...
[OK] (elapsed time was 3 seconds)
```

```
S1(config)#
S1(config)# end
```

- e. Verify the SSH configuration and answer the questions below.

```
S1# show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
Minimum expected Diffie Hellman key size : 1024 bits
IOS Keys in SECSH format(ssh-rsa, base64 encoded):
ssh-rsa AAAAB3NzaC1yc2EAAAQABAAgQCKWqCN0g4XLVdJJUOr+9qoJkFqC/g0OuAV1semr5/
xy0bbUBPywvqhwSPJtucIKxKw/YfrRCeFwY+dct/+jGSeckAHahuv0jJfOdFcqgiKGeeluAu+iQ2drE+k
butn1LTGmtNhdEJMxri/ZeO3BsFcnHpO1hbB6Vsm4XRXGk7OfQ==
```

What version of SSH is the switch using? _____ **1.99**

How many authentication attempts does SSH allow? _____ **3**

Lab – Configuring Switch Security Features

What is the default timeout setting for SSH? _____ **120 seconds**

Step 2: Modify the SSH configuration on S1.

Modify the default SSH configuration.

```
S1# config t  
S1(config)# ip ssh time-out 75  
S1(config)# ip ssh authentication-retries 2  
S1# show ip ssh  
SSH Enabled - version 1.99  
Authentication timeout: 75 secs; Authentication retries: 2  
Minimum expected Diffie Hellman key size : 1024 bits  
IOS Keys in SECSH format(ssh-rsa, base64 encoded):  
ssh-rsa AAAAB3NzaC1yc2EAAAQABAAgQCKWqCN0g4XLVdJJUOr+9qoJkFqC/g0OuAV1semrR5/  
xy0bbUBPywvqhwSPJtucIKxKw/YfrRCeFwY+dc+/jGSeckAHahuv0jJfOdFcgqiKGeeluAu+iQ2drE+k  
butnLTGmtNhdEJMxri/ZeO3BsFcnp01hbB6Vsm4XRXGk70fQ==
```

How many authentication attempts does SSH allow? _____ **2**

What is the timeout setting for SSH? _____ **75 seconds**

Step 3: Verify the SSH configuration on S1.

- Using SSH client software on PC-A (such as Tera Term), open an SSH connection to S1. If you receive a message on your SSH client regarding the host key, accept it. Log in with **admin** for username and **cisco** for the password.

Was the connection successful? _____ **Yes**

What prompt was displayed on S1? Why?

S1 is showing the prompt at privileged EXEC mode because the privilege 15 option was used when configuring username and password

- Type **exit** to end the SSH session on S1.

Part 4: Configure and Verify Security Features on S1

In Part 4, you will shut down unused ports, turn off certain services running on the switch, and configure port security based on MAC addresses. Switches can be subject to MAC address table overflow attacks, MAC spoofing attacks, and unauthorized connections to switch ports. You will configure port security to limit the number of MAC addresses that can be learned on a switch port and disable the port if that number is exceeded.

Step 1: Configure general security features on S1.

- Configure a message of the day (MOTD) banner on S1 with an appropriate security warning message.
- Issue a **show ip interface brief** command on S1. What physical ports are up?

Ports F0/5 and F0/6

- Shut down all unused physical ports on the switch. Use the **interface range** command.

```
S1(config)# interface range f0/1 - 4  
S1(config-if-range)# shutdown  
S1(config-if-range)# interface range f0/7 - 24
```

Lab – Configuring Switch Security Features

```
S1(config-if-range)# shutdown
S1(config-if-range)# interface range g0/1 - 2
S1(config-if-range)# shutdown
S1(config-if-range)# end
S1#
```

- d. Issue the **show ip interface brief** command on S1. What is the status of ports F0/1 to F0/4?

Administratively down.

- e. Issue the **show ip http server status** command.

```
S1# show ip http server status
HTTP server status: Enabled
HTTP server port: 80
HTTP server authentication method: enable
HTTP server access class: 0
HTTP server base path: flash:html
HTTP server help root:
Maximum number of concurrent server connections allowed: 16
Server idle time-out: 180 seconds
Server life time-out: 180 seconds
Maximum number of requests allowed on a connection: 25
HTTP server active session modules: ALL
HTTP secure server capability: Present
HTTP secure server status: Enabled
HTTP secure server port: 443
HTTP secure server ciphersuite: 3des-eede-cbc-sha des-cbc-sha rc4-128-md5 rc4-128-sha
HTTP secure server client authentication: Disabled
HTTP secure server trustpoint:
HTTP secure server active session modules: ALL
```

What is the HTTP server status? _____ **Enabled**

What server port is it using? _____ **80**

What is the HTTP secure server status? _____ **Enabled**

What secure server port is it using? _____ **443**

- f. HTTP sessions send everything in plain text. You will disable the HTTP service running on S1.

```
S1(config)# no ip http server
```

- g. From PC-A, open a web browser session to <http://172.16.99.11>. What was your result?

The web page could not open. HTTP connections are now refused by S1.

- h. From PC-A, open a secure web browser session at <https://172.16.99.11>. Accept the certificate. Log in with no username and a password of **class**. What was your result?

Secure web session was successful.

- i. Close the web session on PC-A.

Step 2: Configure and verify port security on S1.

- a. Record the R1 G0/1 MAC address. From the R1 CLI, use the **show interface g0/1** command and record the MAC address of the interface.

```
R1# show interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is 30f7.0da3.1821 (bia
  3047.0da3.1821)
```

What is the MAC address of the R1 G0/1 interface?

In the example above, it is 30f7.0da3.1821

- b. From the S1 CLI, issue a **show mac address-table** command from privileged EXEC mode. Find the dynamic entries for ports F0/5 and F0/6. Record them below.

F0/5 MAC address: _____ 30f7.0da3.1821
F0/6 MAC address: _____ 00e0.b857.1ccd

- c. Configure basic port security.

Note: This procedure would normally be performed on all access ports on the switch. F0/5 is shown here as an example.

- 1) From the S1 CLI, enter interface configuration mode for the port that connects to R1.

```
S1(config)# interface f0/5
```

- 2) Shut down the port.

```
S1(config-if)# shutdown
```

- 3) Enable port security on F0/5.

```
S1(config-if)# switchport port-security
```

Note: Entering the **switchport port-security** command sets the maximum MAC addresses to 1 and the violation action to shutdown. The **switchport port-security maximum** and **switchport port-security violation** commands can be used to change the default behavior.

- 4) Configure a static entry for the MAC address of R1 G0/1 interface recorded in Step 2a.

```
S1(config-if)# switchport port-security mac-address xxxx.xxxx.xxxx
```

(xxxx.xxxx.xxxx is the actual MAC address of the router G0/1 interface)

Note: Optionally, you can use the **switchport port-security mac-address sticky** command to add all the secure MAC addresses that are dynamically learned on a port (up to the maximum set) to the switch running configuration.

- 5) Enable the switch port.

```
S1(config-if)# no shutdown
```

```
S1(config-if)# end
```

- d. Verify port security on S1 F0/5 by issuing a **show port-security interface** command.

```
S1# show port-security interface f0/5
Port Security          : Enabled
Port Status            : Secure-up
Violation Mode         : Shutdown
Aging Time             : 0 mins
```

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```
Aging Type : Absolute
SecureStatic Address Aging : Disabled
Maximum MAC Addresses : 1
Total MAC Addresses : 1
Configured MAC Addresses : 1
Sticky MAC Addresses : 0
Last Source Address:Vlan : 0000.0000.0000:0
Security Violation Count : 0
```

What is the port status of F0/5?

The status is Secure-up, which indicates that the port is secure, but the status and protocol are up.

- e. From R1 command prompt, ping PC-A to verify connectivity.

```
R1# ping 172.16.99.3
```

- f. You will now violate security by changing the MAC address on the router interface. Enter interface configuration mode for G0/1 and shut it down.

```
R1# config t
R1(config)# interface g0/1
R1(config-if)# shutdown
```

- g. Configure a new MAC address for the interface, using **aaaa.bbbb.cccc** as the address.

```
R1(config-if)# mac-address aaaa.bbbb.cccc
```

- h. If possible, have a console connection open on S1 at the same time that you do this step. You will see various messages displayed on the console connection to S1 indicating a security violation. Enable the G0/1 interface on R1.

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

- i. From R1 privilege EXEC mode, ping PC-A. Was the ping successful? Why or why not?

No, the F0/5 port on S1 is shut down because of the security violation.

- j. On the switch, verify port security with the following commands shown below.

```
S1# show port-security
Secure Port MaxSecureAddr CurrentAddr SecurityViolation Security Action
          (Count)      (Count)      (Count)
-----
Fa0/5           1           1           1       Shutdown
-----
Total Addresses in System (excluding one mac per port) :0
Max Addresses limit in System (excluding one mac per port) :8192
```

```
S1# show port-security interface f0/5
```

```
Port Security : Enabled
Port Status   : Secure-shutdown
Violation Mode : Shutdown
Aging Time    : 0 mins
Aging Type    : Absolute
SecureStatic Address Aging : Disabled
```

Lab – Configuring Switch Security Features

```
Maximum MAC Addresses      : 1
Total MAC Addresses        : 1
Configured MAC Addresses   : 1
Sticky MAC Addresses       : 0
Last Source Address:Vlan  : aaaa.bbbb.cccc:99
Security Violation Count  : 1
```

```
S1# show interface f0/5
FastEthernet0/5 is down, line protocol is down (err-disabled)
    Hardware is Fast Ethernet, address is 0cd9.96e2.3d05 (bia 0cd9.96e2.3d05)
    MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
        reliability 255/255, txload 1/255, rxload 1/255
<output omitted>
```

```
S1# show port-security address
          Secure Mac Address Table
-----
Vlan     Mac Address      Type        Ports      Remaining Age
                                         (mins)
----     -----            ----        -----      -----
99       30f7.0da3.1821   SecureConfigured  Fa0/5      -
-----
Total Addresses in System (excluding one mac per port) :0
Max Addresses limit in System (excluding one mac per port) :8192
```

- k. On the router, shut down the G0/1 interface, remove the hard-coded MAC address from the router, and re-enable the G0/1 interface.

```
R1(config-if)# shutdown
R1(config-if)# no mac-address aaaa.bbbb.cccc
R1(config-if)# no shutdown
R1(config-if)# end
```

- l. From R1, ping PC-A again at 172.16.99.3. Was the ping successful? _____ No
- m. Issue the **show interface f0/5** command to determine the cause of ping failure. Record your findings.
-

F0/5 port on S1 is still in an error disabled state.

```
S1# show interface f0/5
FastEthernet0/5 is down, line protocol is down (err-disabled)
    Hardware is Fast Ethernet, address is 0023.5d59.9185 (bia 0023.5d59.9185)
    MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
        reliability 255/255, txload 1/255, rxload 1/255
```

- n. Clear the S1 F0/5 error disabled status.

```
S1# config t
S1(config)# interface f0/5
S1(config-if)# shutdown
S1(config-if)# no shutdown
```

Note: There may be a delay while the port states converge.

Lab – Configuring Switch Security Features

- o. Issue the **show interface f0/5** command on S1 to verify F0/5 is no longer in error disabled mode.

```
S1# show interface f0/5
FastEthernet0/5 is up, line protocol is up (connected)
  Hardware is Fast Ethernet, address is 0023.5d59.9185 (bia 0023.5d59.9185)
  MTU 1500 bytes, BW 100000 Kbit/sec, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
```

- o. Issue the **show interface f0/5** command on S1 to verify F0/5 is no longer in error disabled mode.
- p. From the R1 command prompt, ping PC-A again. You should be successful.

Reflection

1. Why would you enable port security on a switch?

It would help prevent unauthorized devices from accessing your network if they plugged into a switch on your network.

2. Why should unused ports on a switch be disabled?

One excellent reason is that a user could not connect a device to the switch on an unused port and access the LAN.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1

```
R1#sh run
```

Lab – Configuring Switch Security Features

```
Building configuration...
Current configuration : 1232 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no ip domain-lookup
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 172.16.99.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
 clock rate 2000000
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
control-plane
!
!
!
!line con 0
password 7 030752180500
login
```

Lab – Configuring Switch Security Features

```
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line 67
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
line vty 0 4
password 7 13061E01080344
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1#sh run
Building configuration...
Current configuration : 3762 bytes
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
username admin privilege 15 secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrbp4RFmfqY
!
no ip domain-lookup
ip domain-name CCNA-Lab.com
!
crypto pki trustpoint TP-self-signed-2530358400
enrollment selfsigned
subject-name cn=IOS-Self-Signed-Certificate-2530358400
revocation-check none
rsakeypair TP-self-signed-2530358400
!
crypto pki certificate chain TP-self-signed-2530358400
```

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```
certificate self-signed 01
3082022B 30820194 A0030201 02020101 300D0609 2A864886 F70D0101 05050030
31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
69666963 6174652D 32353330 33353834 3030301E 170D3933 30333031 30303030
35395A17 0D323030 31303130 30303030 305A3031 312F302D 06035504 03132649
4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 35333033
35383430 3030819F 300D0609 2A864886 F70D0101 01050003 818D0030 81890281
8100C0E3 1B8AF1E4 ADA4C4AD F82914AF BF8BCEC9 30CFBF54 D76B3940 38353E50
A9AE0FCE 9CA05B91 24312B31 22D5F89D D249023E AEEC442D F55315F6 D456DA95
16B758FB 8083B681 C1B3A3BF 99420EC7 A7E0AD11 CF031CD1 36A997C0 E72BE4DD
1D745542 1DC958C1 443B6727 F7047747 D94B8CAD 0A99CBDC ADC914C8 D820DC30
E6B70203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF 301F0603
551D2304 18301680 1464D1A8 83DEE145 E35D68C1 D078ED7D 4F6F0B82 9D301D06
03551D0E 04160414 64D1A883 DEE145E3 5D68C1D0 78ED7D4F 6F0B829D 300D0609
2A864886 F70D0101 05050003 81810098 D65CFA1C 3942148D 8961D845 51D53202
EA59B526 7DB308C9 F79859A0 D93D56D6 C584AB83 941A2B7F C44C0E2F DFAF6B8D
A3272A5C 2363116E 1AA246DD 7E54B680 2ABB1F2D 26921529 E1EF4ACC A4FBD14A
BAD41C98 E8D83DEC B85A330E D453510D 89F64023 7B9782E7 200F615A 6961827F
8419A84F 56D71664 5123B591 A62C55
quit
!
ip ssh time-out 75
ip ssh authentication-retries 2
!
interface FastEthernet0/1
shutdown
!
interface FastEthernet0/2
shutdown
!
interface FastEthernet0/3
shutdown
!
interface FastEthernet0/4
shutdown
!
interface FastEthernet0/5
switchport access vlan 99
switchport mode access
switchport port-security
switchport port-security mac-address 30f7.0da3.1821
!
interface FastEthernet0/6
switchport access vlan 99
switchport mode access
!
interface FastEthernet0/7
shutdown
```

Lab – Configuring Switch Security Features

```
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
```

Lab – Configuring Switch Security Features

```
shutdown
!
interface GigabitEthernet0/1
    shutdown
!
interface GigabitEthernet0/2
    shutdown
!
interface Vlan1
    no ip address
    shutdown
!
interface Vlan99
    ip address 172.16.99.11 255.255.255.0
!
ip default-gateway 172.16.99.1
no ip http server
ip http secure-server
!
banner motd ^CWarning! Unauthorized Access is Prohibited.^C
!
line con 0
    password cisco
    logging synchronous
    login
line vty 0 4
    login local
    transport input ssh
line vty 5 15
    login local
    transport input ssh
!
end
```



Switch Trio (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Verify the Layer 2 configuration of a switch port connected to an end station.

Students will use Packet Tracer to configure the first three ports of a switch a permanent MAC address (one MAC address per port) and security shutdown feature. They will validate security implementation and explain the process to another student or the class (Instructor choice).

Scenario

You are the network administrator for a small- to medium-sized business. Corporate headquarters for your business has mandated that on all switches in all offices, security must be implemented. The memorandum delivered to you this morning states:

"By Monday, April 18, 20xx, the first three ports of all configurable switches located in all offices must be secured with MAC addresses — one address will be reserved for the PC, one address will be reserved for the laptop in the office, and one address will be reserved for the office server.

If a port's security is breached, we ask you to shut it down until the reason for the breach can be certified.

Please implement this policy no later than the date stated in this memorandum. For questions, call 1.800.555.1212. Thank you. The Network Management Team"

Work with a partner in the class and create a Packet Tracer example to test this new security policy. Once you have created your file, test it with, at least, one device to ensure it is operational or validated.

Save your work and be prepared to share it with the entire class. (Instructor choice)

Reflection

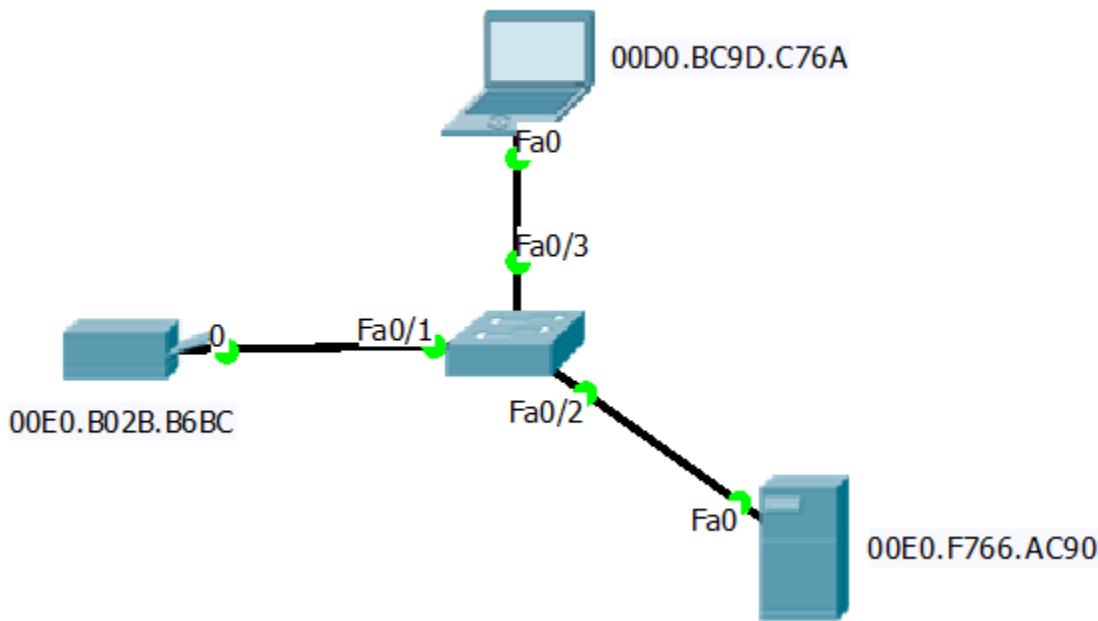
1. Why would one port on a switch be secured on a switch using these scenario parameters (and not all the ports on the same switch)?

Answers will vary – students may mention that securing every port on a switch would make it difficult for many users to connect to the switch, therefore limiting port use to certain pieces of equipment – laptop mobility might be compromised, as users would not be able to connect to the switch unless they knew which port they were allowed to use.

2. Why would a network administrator use a network simulator to create, configure, and validate a security plan, instead of using the small- to medium-sized business' actual, physical equipment?

Using a network simulator can save time and quality of network data delivery by pre-testing and validating new configurations.

Original Physical Topology (for concept representation only)



After configuring port security for the Printer, Server and Laptop – all devices are reporting to the switch on their correct ports.

```
Switch# show port-security address
          Secure Mac Address Table
-----
Vlan   Mac Address     Type      Ports      Remaining Age
           (mins)
-----
1      00E0.B02B.B6BC  SecureSticky  FastEthernet0/1  -
1      00E0.F766.AC90  SecureSticky  FastEthernet0/2  -
1      00D0.BC9D.C76A  SecureSticky  FastEthernet0/3  -
-----
Total Addresses in System (excluding one mac per port) : 0
Max Addresses limit in System (excluding one mac per port) : 1024
```

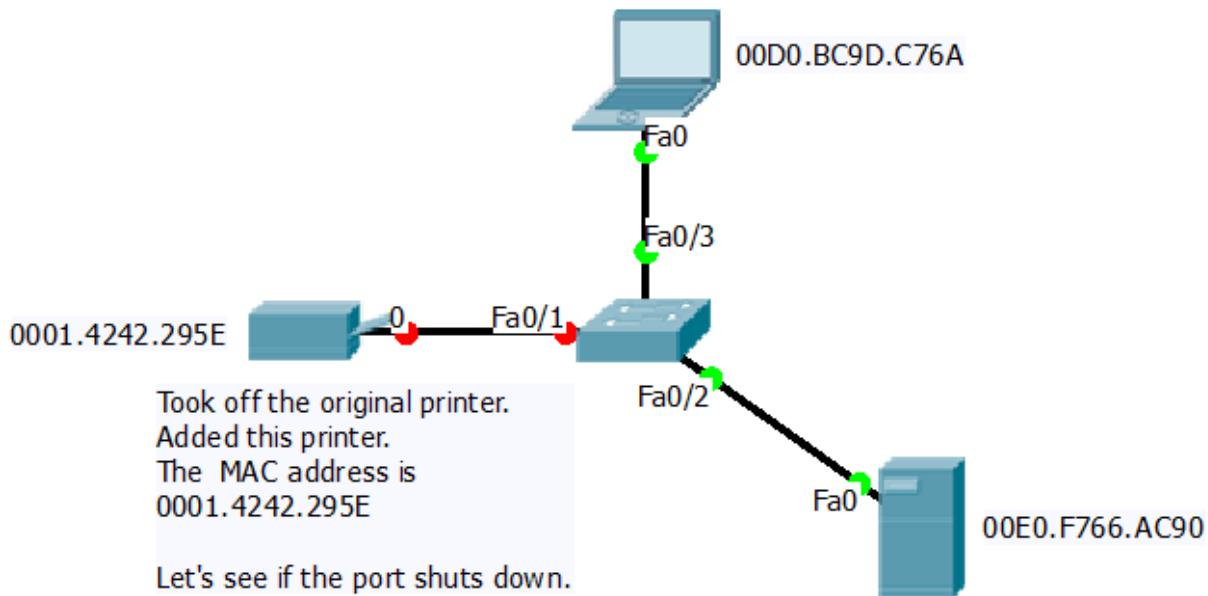
Switch Trio

Output showing port security status for Fa0/1:

```
Switch# show port-security int fa0/1
Port Security          : Enabled
Port Status            : Secure-up
Violation Mode        : Shutdown
Aging Time             : 0 mins
Aging Type             : Absolute
SecureStatic Address Aging : Disabled
Maximum MAC Addresses   : 1
Total MAC Addresses     : 1
Configured MAC Addresses : 0
Sticky MAC Addresses    : 1
Last Source Address:Vlan : 00E0.B02B.B6BC:1
Security Violation Count : 0
```

Topology Change with Security Violation (for concept representation only)

After exchanging the original Printer with a new one, Fa0/1 shuts down on the switch.



Instructor Note: Identify elements of the model that map to IT-related content:

- Switches can be secured by assigning MAC addresses to any and all ports – manually or configuration-based
- LAN switch ports can be shut down if security on the port is breached.
- Network administrators can implement best practice policies devised by management to ensure that networks are not compromised through security attacks.

Vacation Station (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain the purpose of VLANs in a switched network.

To prepare for learning VLAN concepts in a switched network for this chapter, students will envision how and why network VLAN-switching groups are created.

Scenario

You have purchased a vacation home at the beach for rental purposes. There are three, identical floors on each level of the home. Each floor offers one digital television for renters to use.

According to the local Internet service provider, only three stations may be offered within a television package. It is your job to decide which television packages you offer your guests.

- Divide the class into groups of three students per group.
- Choose three different stations to make one subscription package for each floor of your rental home.
- Complete the PDF for this activity.

Share your completed group-reflection answers with the class.

Television Station Subscription Package – Floor 1		
Local News <input type="checkbox"/>	Sports <input type="checkbox"/>	Weather <input type="checkbox"/>
Home Improvement <input type="checkbox"/>	Movies <input type="checkbox"/>	History <input type="checkbox"/>
Television Station Subscription Package – Floor 2		
Local News <input type="checkbox"/>	Sports <input type="checkbox"/>	Weather <input type="checkbox"/>
Home Improvement <input type="checkbox"/>	Movies <input type="checkbox"/>	History <input type="checkbox"/>
Television Station Subscription Package – Floor 3		
Local News <input type="checkbox"/>	Sports <input type="checkbox"/>	Weather <input type="checkbox"/>
Home Improvement <input type="checkbox"/>	Movies <input type="checkbox"/>	History <input type="checkbox"/>

Reflection

1. What were some of the criteria you used to select the final three stations?

Vacation Station

Answers will vary, but some answers might include: local news is usually important to everyone, weather is important to beach vacationers, home improvement might be important to rental property use, watching sports and movies are popular vacation pastimes, and history provides vacationers with information about places they are currently visiting or plan to visit.

2. Why do you think this Internet service provider offers different television station options to subscribers? Why not offer all stations to all subscribers?
-

Limiting options to certain groups allows for ISPs to conserve televised bandwidth to groups with the options selected. It also allows them to charge additional prices for additional options.

3. Compare this scenario to data communications and networks for small- to medium-sized businesses. Why would it be a good idea to divide your small- to medium-sized business networks into logical and physical groups?
-

Answers will vary. Some answers might include: dividing networks into groups allows businesses to: improve network performance; regulate network management and security; use data, voice, network-controlled traffic options more effectively; and group data traffic based upon network-desired functions.

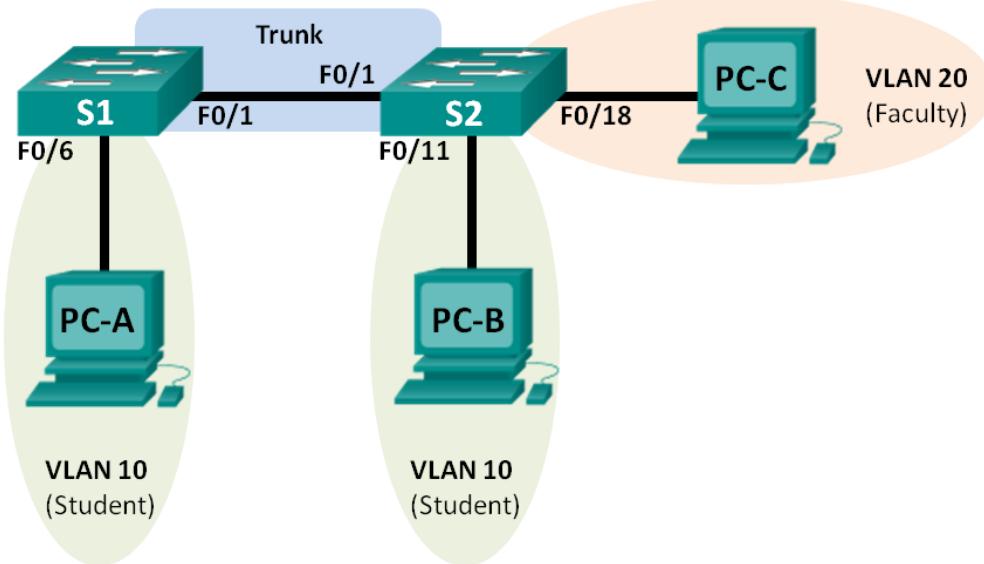
Identify elements of the model that map to IT-related content:

- In this scenario, the ISPs cable modem could function as a network switch.
- Floors 1-3 could be compared to network VLAN groups.
- The digital televisions could be compared to hosts within the VLAN groups.

Lab - Configuring VLANs and Trunking (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 1	192.168.1.11	255.255.255.0	N/A
S2	VLAN 1	192.168.1.12	255.255.255.0	N/A
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.10.4	255.255.255.0	192.168.10.1
PC-C	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Create VLANs and Assign Switch Ports

Part 3: Maintain VLAN Port Assignments and the VLAN Database

Part 4: Configure an 802.1Q Trunk between the Switches

Part 5: Delete the VLAN Database

Background / Scenario

Modern switches use virtual local-area networks (VLANs) to improve network performance by separating large Layer 2 broadcast domains into smaller ones. VLANs can also be used as a security measure by controlling which hosts can communicate. In general, VLANs make it easier to design a network to support the goals of an organization.

Lab - Configuring VLANs and Trunking

VLAN trunks are used to span VLANs across multiple devices. Trunks allow the traffic from multiple VLANs to travel over a single link, while keeping the VLAN identification and segmentation intact.

In this lab, you will create VLANs on both switches in the topology, assign VLANs to switch access ports, verify that VLANs are working as expected, and then create a VLAN trunk between the two switches to allow hosts in the same VLAN to communicate through the trunk, regardless of which switch the host is actually attached to.

Note: The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Ensure that the switches have been erased and have no startup configurations. If you are unsure contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the PC hosts and switches.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

Step 2: Initialize and reload the switches as necessary.

Step 3: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords and enable login for console and vty lines.
- e. Configure **logging synchronous** for the console line.
- f. Configure a MOTD banner to warn users that unauthorized access is prohibited.
- g. Configure the IP address listed in the Addressing Table for VLAN 1 on both switches.
- h. Administratively deactivate all unused ports on the switch.
- i. Copy the running configuration to the startup configuration.

Step 4: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 5: Test connectivity.

Verify that the PC hosts can ping one another.

Note: It may be necessary to disable the PCs firewall to ping between PCs.

Can PC-A ping PC-B? _____ Yes

Can PC-A ping PC-C? _____ No

Can PC-A ping S1? _____ No

Can PC-B ping PC-C? _____ No

Can PC-B ping S2? _____ No

Can PC-C ping S2? _____ No

Can S1 ping S2? _____ Yes

If you answered no to any of the above questions, why were the pings unsuccessful?

Pings were unsuccessful when trying to ping a device on a different subnet. For those pings to be successful, a default gateway must exist to route traffic from one subnet to another.

Part 2: Create VLANs and Assign Switch Ports

In Part 2, you will create student, faculty, and management VLANs on both switches. You will then assign the VLANs to the appropriate interface. The **show vlan** command is used to verify your configuration settings.

Step 1: Create VLANs on the switches.

- Create the VLANs on S1.

```
S1(config)# vlan 10
S1(config-vlan)# name Student
S1(config-vlan)# vlan 20
S1(config-vlan)# name Faculty
S1(config-vlan)# vlan 99
S1(config-vlan)# name Management
S1(config-vlan)# end
```

- Create the same VLANs on S2.

- Issue the **show vlan** command to view the list of VLANs on S1.

```
S1# show vlan
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gi0/1, Gi0/2

Lab - Configuring VLANs and Trunking

```
10 Student active
20 Faculty active
99 Management active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup
```

VLAN	Type	SAID	MTU	Parent	RingNo	BridgeNo	Stp	BrdgMode	Trans1	Trans2
1	enet	100001	1500	-	-	-	-	-	0	0
10	enet	100010	1500	-	-	-	-	-	0	0
20	enet	100020	1500	-	-	-	-	-	0	0
99	enet	100099	1500	-	-	-	-	-	0	0

VLAN	Type	SAID	MTU	Parent	RingNo	BridgeNo	Stp	BrdgMode	Trans1	Trans2
1002	fddi	101002	1500	-	-	-	-	-	0	0
1003	tr	101003	1500	-	-	-	-	-	0	0
1004	fdnet	101004	1500	-	-	-	ieee	-	0	0
1005	trnet	101005	1500	-	-	-	ibm	-	0	0

Remote SPAN VLANs

Primary	Secondary	Type	Ports
---------	-----------	------	-------

What is the default VLAN? _____ **VLAN 1**

What ports are assigned to the default VLAN?

All switch ports are assigned to VLAN 1 by default.

Step 2: Assign VLANs to the correct switch interfaces.

a. Assign VLANs to the interfaces on S1.

1) Assign PC-A to the Student VLAN.

```
S1(config)# interface f0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

2) Move the switch IP address VLAN 99.

```
S1(config)# interface vlan 1
S1(config-if)# no ip address
S1(config-if)# interface vlan 99
S1(config-if)# ip address 192.168.1.11 255.255.255.0
S1(config-if)# end
```

Lab - Configuring VLANs and Trunking

- b. Issue the **show vlan brief** command and verify that the VLANs are assigned to the correct interfaces.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10	Student	active	Fa0/6
20	Faculty	active	
99	Management	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdtnet-default	act/unsup	
1005	trnet-default	act/unsup	

- c. Issue the **show ip interface brief** command.

```
S1# show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Vlan1	unassigned	YES	unset	up	up
Vlan99	192.168.1.11	YES	manual	up	down
FastEthernet0/1	unassigned	YES	unset	up	up
FastEthernet0/2	unassigned	YES	unset	administratively down	down
FastEthernet0/3	unassigned	YES	unset	administratively down	down
FastEthernet0/4	unassigned	YES	unset	administratively down	down
FastEthernet0/5	unassigned	YES	unset	administratively down	down
FastEthernet0/6	unassigned	YES	unset	up	up
FastEthernet0/7	unassigned	YES	unset	administratively down	down

```
<output omitted>
```

What is the status of VLAN 99? Why?

The status of VLAN 99 is up/down, because it has not been assigned to an active port yet.

- d. Use the Topology to assign VLANs to the appropriate ports on S2.
e. Remove the IP address for VLAN 1 on S2.
f. Configure an IP address for VLAN 99 on S2 according to the Addressing Table.
g. Use the **show vlan brief** command to verify that the VLANs are assigned to the correct interfaces.

```
S2# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4

```
Fa0/5, Fa0/6, Fa0/7, Fa0/8  
Fa0/9, Fa0/10, Fa0/12, Fa0/13  
Fa0/14, Fa0/15, Fa0/16, Fa0/17  
Fa0/19, Fa0/20, Fa0/21, Fa0/22  
Fa0/23, Fa0/24, Gi0/1, Gi0/2  


|      |                    |           |        |
|------|--------------------|-----------|--------|
| 10   | Student            | active    | Fa0/11 |
| 20   | Faculty            | active    | Fa0/18 |
| 99   | Management         | active    |        |
| 1002 | fdci-default       | act/unsup |        |
| 1003 | token-ring-default | act/unsup |        |
| 1004 | fdininet-default   | act/unsup |        |
| 1005 | trnet-default      | act/unsup |        |


```

Is PC-A able to ping PC-B? Why?

No. Interface F0/1 is not assigned to VLAN 10, so VLAN 10 traffic will not be sent over it.

Is S1 able to ping S2? Why?

No. The IP addresses for the switches now reside in VLAN 99. VLAN 99 traffic will not be sent over interface F0/1.

Part 3: Maintain VLAN Port Assignments and the VLAN Database

In Part 3, you will change VLAN assignments to ports and remove VLANs from the VLAN database.

Step 1: Assign a VLAN to multiple interfaces.

- On S1, assign interfaces F0/11 – 24 to VLAN 10.

```
S1(config)# interface range f0/11-24  
S1(config-if-range)# switchport mode access  
S1(config-if-range)# switchport access vlan 10  
S1(config-if-range)# end
```

- Issue the **show vlan brief** command to verify VLAN assignments.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Gi0/1, Gi0/2
10	Student	active	Fa0/6, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24
20	Faculty	active	
99	Management	active	
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	

Lab - Configuring VLANs and Trunking

```
1004 fddinet-default          act/unsup
1005 trnet-default           act/unsup
```

- c. Reassign F0/11 and F0/21 to VLAN 20.

```
S1(config)# interface range f0/11, f0/21
S1(config-if-range)# switchport access vlan 20
S1(config-if-range)# end
```

- d. Verify that VLAN assignments are correct.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Gi0/1, Gi0/2
10	Student	active	Fa0/6, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/22, Fa0/23 Fa0/24
20	Faculty	active	Fa0/11, Fa0/21
99	Management	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

Step 2: Remove a VLAN assignment from an interface.

- a. Use the **no switchport access vlan** command to remove the VLAN 10 assignment to F0/24.

```
S1(config)# interface f0/24
S1(config-if)# no switchport access vlan
S1(config-if)# end
```

- b. Verify that the VLAN change was made.

Which VLAN is F0/24 is now associated with?

VLAN 1, the default VLAN.

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/24, Gi0/1, Gi0/2
10	Student	active	Fa0/6, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/22, Fa0/23
20	Faculty	active	Fa0/11, Fa0/21
99	Management	active	

Lab - Configuring VLANs and Trunking

```
1002 fddi-default          act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default       act/unsup
1005 trnet-default         act/unsup
```

Step 3: Remove a VLAN ID from the VLAN database.

- Add VLAN 30 to interface F0/24 without issuing the VLAN command.

```
S1(config)# interface f0/24
S1(config-if)# switchport access vlan 30
% Access VLAN does not exist. Creating vlan 30
```

Note: Current switch technology no longer requires that the **vlan** command be issued to add a VLAN to the database. By assigning an unknown VLAN to a port, the VLAN adds to the VLAN database.

- Verify that the new VLAN is displayed in the VLAN table.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Gi0/1, Gi0/2
10	Student	active	Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/22, Fa0/23
20	Faculty	active	Fa0/11, Fa0/21
30	VLAN0030	active	Fa0/24
99	Management	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

What is the default name of VLAN 30?

VLAN0030

- Use the **no vlan 30** command to remove VLAN 30 from the VLAN database.

```
S1(config)# no vlan 30
S1(config)# end
```

- Issue the **show vlan brief** command. F0/24 was assigned to VLAN 30.

After deleting VLAN 30, what VLAN is port F0/24 assigned to? What happens to the traffic destined to the host attached to F0/24?

Port F0/24 is not assigned to any VLAN. This port will not transfer any traffic.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Gi0/1, Gi0/2

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1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Gi0/1, Gi0/2
10	Student	active	Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/22, Fa0/23
20	Faculty	active	Fa0/11, Fa0/21
99	Management	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdtnet-default	act/unsup	
1005	trnet-default	act/unsup	

- e. Issue the **no switchport access vlan** command on interface F0/24.

```
S1(config)# interface f0/24
S1(config-if)# no switchport access vlan
S1(config-if)# end
```

- f. Issue the **show vlan brief** command to determine the VLAN assignment for F0/24. To which VLAN is F0/24 assigned?

VLAN 1

S1# show vlan brief			
VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/24, Gi0/1, Gi0/2
10	Student	active	Fa0/6, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/22, Fa0/23
20	Faculty	active	Fa0/11, Fa0/21
99	Management	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdtnet-default	act/unsup	
1005	trnet-default	act/unsup	

Note: Before removing a VLAN from the database, it is recommended that you reassign all the ports assigned to that VLAN.

Why should you reassign a port to another VLAN before removing the VLAN from the VLAN database?

The interfaces assigned to a VLAN that is removed from the VLAN database are unavailable for use until they are reassigned to another VLAN. This can be a tricky thing to troubleshoot as trunked interfaces do not show up in the port list as well (Part 4 contains more information about trunked interfaces).

Part 4: Configure an 802.1Q Trunk Between the Switches

In Part 4, you will configure interface F0/1 to use the Dynamic Trunking Protocol (DTP) to allow it to negotiate the trunk mode. After this has been accomplished and verified, you will disable DTP on interface F0/1 and manually configure it as a trunk.

Step 1: Use DTP to initiate trunking on F0/1.

The default DTP mode of a 2960 switch port is dynamic auto. This allows the interface to convert the link to a trunk if the neighboring interface is set to trunk or dynamic desirable mode.

- a. Set F0/1 on S1 to negotiate trunk mode.

```
S1(config)# interface f0/1
S1(config-if)# switchport mode dynamic desirable
*Mar  1 05:07:28.746: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to down
*Mar  1 05:07:29.744: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to down
S1(config-if)#
*Mar  1 05:07:32.772: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
S1(config-if)#
*Mar  1 05:08:01.789: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed
state to up
*Mar  1 05:08:01.797: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to up
```

You should also receive link status messages on S2.

```
S2#
*Mar  1 05:07:29.794: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to down
S2#
*Mar  1 05:07:32.823: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
S2#
*Mar  1 05:08:01.839: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed
state to up
*Mar  1 05:08:01.850: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to up
```

- b. Issue the **show vlan brief** command on S1 and S2. Interface F0/1 is no longer assigned to VLAN 1. Trunked interfaces are not listed in the VLAN table.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/24, Gi0/1, Gi0/2
10	Student	active	Fa0/6, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/22, Fa0/23
20	Faculty	active	Fa0/11, Fa0/21

Lab - Configuring VLANs and Trunking

```
99 Management           active
1002 fddi-default      act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default   act/unsup
1005 trnet-default     act/unsup
```

- c. Issue the **show interfaces trunk** command to view trunked interfaces. Notice that the mode on S1 is set to desirable, and the mode on S2 is set to auto.

S1# **show interfaces trunk**

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	desirable	802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/1	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1,10,20,99

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/1	1,10,20,99

S2# **show interfaces trunk**

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	auto	802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/1	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1,10,20,99

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/1	1,10,20,99

Note: By default, all VLANs are allowed on a trunk. The **switchport trunk** command allows you to control what VLANs have access to the trunk. For this lab, keep the default settings which allows all VLANs to traverse F0/1.

- d. Verify that VLAN traffic is traveling over trunk interface F0/1.

Can S1 ping S2? _____ Yes
Can PC-A ping PC-B? _____ Yes
Can PC-A ping PC-C? _____ No
Can PC-B ping PC-C? _____ No
Can PC-A ping S1? _____ No
Can PC-B ping S2? _____ No
Can PC-C ping S2? _____ No

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If you answered no to any of the above questions, explain below.

PC-C cannot ping PC-A or PC-B because PC-C is in a different VLAN. The switches are in different VLANs than the PCs; therefore, the pings were unsuccessful.

Step 2: Manually configure trunk interface F0/1.

The **switchport mode trunk** command is used to manually configure a port as a trunk. This command should be issued on both ends of the link.

- Change the switchport mode on interface F0/1 to force trunking. Make sure to do this on both switches.

```
S1(config)# interface f0/1  
S1(config-if)# switchport mode trunk  
  
S2(config)# interface f0/1  
S2(config-if)# switchport mode trunk
```

- Issue the **show interfaces trunk** command to view the trunk mode. Notice that the mode changed from **desirable** to **on**.

```
S2# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	99

Port	Vlans allowed on trunk
Fa0/1	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1,10,20,99

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/1	1,10,20,99

Why might you want to manually configure an interface to trunk mode instead of using DTP?

Not all equipment uses DTP. Using the **switchport mode trunk** command ensures that the port will become a trunk no matter what type of equipment is connected to the other end of the link.

Part 5: Delete the VLAN Database

In Part 5, you will delete the VLAN Database from the switch. It is necessary to do this when initializing a switch back to its default settings.

Step 1: Determine if the VLAN database exists.

Issue the **show flash** command to determine if a **vlan.dat** file exists in flash.

```
S1# show flash
```

Lab - Configuring VLANs and Trunking

Directory of flash:/

```
2 -rwx        1285  Mar 1 1993 00:01:24 +00:00  config.text
3 -rwx        43032  Mar 1 1993 00:01:24 +00:00  multiple-fs
4 -rwx          5  Mar 1 1993 00:01:24 +00:00  private-config.text
5 -rwx    11607161  Mar 1 1993 02:37:06 +00:00  c2960-lanbasek9-mz.150-2.SE.bin
6 -rwx        736  Mar 1 1993 00:19:41 +00:00  vlan.dat
```

32514048 bytes total (20858880 bytes free)

Note: If there is a **vlan.dat** file located in flash, then the VLAN database does not contain its default settings.

Step 2: Delete the VLAN database.

- Issue the **delete vlan.dat** command to delete the **vlan.dat** file from flash and reset the VLAN database back to its default settings. You will be prompted twice to confirm that you want to delete the **vlan.dat** file. Press Enter both times.

```
S1# delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:/vlan.dat? [confirm]
S1#
```

- Issue the **show flash** command to verify that the **vlan.dat** file has been deleted.

```
S1# show flash
```

Directory of flash:/

```
2 -rwx        1285  Mar 1 1993 00:01:24 +00:00  config.text
3 -rwx        43032  Mar 1 1993 00:01:24 +00:00  multiple-fs
4 -rwx          5  Mar 1 1993 00:01:24 +00:00  private-config.text
5 -rwx    11607161  Mar 1 1993 02:37:06 +00:00  c2960-lanbasek9-mz.150-2.SE.bin
```

32514048 bytes total (20859904 bytes free)

To initialize a switch back to its default settings, what other commands are needed?

To get a switch back to its default settings, the **erase startup-config** and **reload** commands need to be issued after the **delete vlan.dat** command.

Reflection

- What is needed to allow hosts on VLAN 10 to communicate to hosts on VLAN 20?
-
-

Answers will vary, but Layer 3 routing is needed to route traffic between VLANs.

- What are some primary benefits that an organization can receive through effective use of VLANs?
-

Answers will vary, but VLAN benefits include: better security, cost savings (efficient use of bandwidth and uplinks), higher performance (smaller broadcast domains), broadcast storm mitigation, improved IT staff efficiency, simpler project and application management.

Device Configs - Final

Switch S1

Building configuration...

```
Current configuration : 2571 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
switchport mode trunk
!
interface FastEthernet0/2
shutdown
!
interface FastEthernet0/3
shutdown
!
interface FastEthernet0/4
shutdown
```

Lab - Configuring VLANs and Trunking

```
!
interface FastEthernet0/5
shutdown
!
interface FastEthernet0/6
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/12
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/13
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/14
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/15
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/16
switchport access vlan 10
switchport mode access
shutdown
```

Lab - Configuring VLANs and Trunking

```
!
interface FastEthernet0/17
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/18
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/19
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/20
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/21
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/22
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/23
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/24
switchport mode access
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
!
```

Lab - Configuring VLANs and Trunking

```
interface Vlan99
  ip address 192.168.1.11 255.255.255.0
!
ip http server
ip http secure-server
!
!
banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

Switch S2

```
Building configuration...
```

```
Current configuration : 1875 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
```

Lab - Configuring VLANs and Trunking

```
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
    switchport mode trunk
!
interface FastEthernet0/2
    shutdown
!
interface FastEthernet0/3
    shutdown
!
interface FastEthernet0/4
    shutdown
!
interface FastEthernet0/5
    shutdown
!
interface FastEthernet0/6
    shutdown
!
interface FastEthernet0/7
    shutdown
!
interface FastEthernet0/8
    shutdown
!
interface FastEthernet0/9
    shutdown
!
interface FastEthernet0/10
    shutdown
!
interface FastEthernet0/11
    switchport access vlan 10
    switchport mode access
!
interface FastEthernet0/12
    shutdown
!
interface FastEthernet0/13
    shutdown
!
interface FastEthernet0/14
    shutdown
!
interface FastEthernet0/15
    shutdown
!
```

Lab - Configuring VLANs and Trunking

```
interface FastEthernet0/16
    shutdown
!
interface FastEthernet0/17
    shutdown
!
interface FastEthernet0/18
    switchport access vlan 20
    switchport mode access
!
interface FastEthernet0/19
    shutdown
!
interface FastEthernet0/20
    shutdown
!
interface FastEthernet0/21
    shutdown
!
interface FastEthernet0/22
    shutdown
!
interface FastEthernet0/23
    shutdown
!
interface FastEthernet0/24
    shutdown
!
interface GigabitEthernet0/1
    shutdown
!
Interface GigabitEthernet0/2
    shutdown
!
interface Vlan1
    no ip address
!
interface Vlan99
    ip address 192.168.1.12 255.255.255.0
!
ip http server
ip http secure-server
!
!
banner motd ^C
    Unauthorized Access is Prohibited!
^C
!
line con 0
```

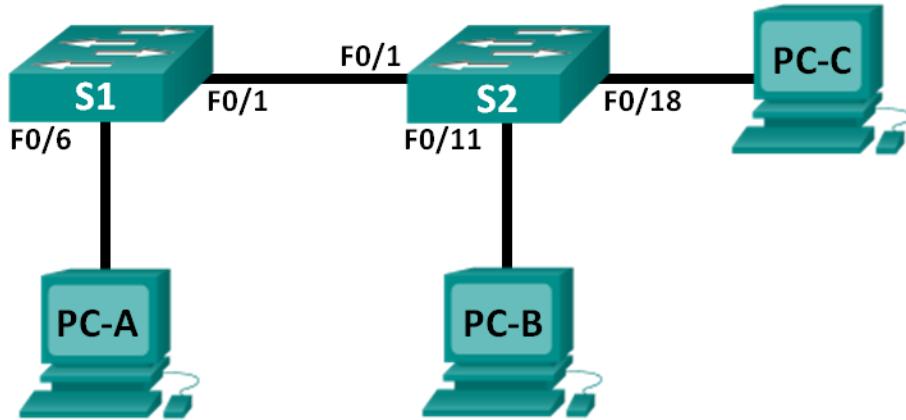
Lab - Configuring VLANs and Trunking

```
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Lab - Troubleshooting VLAN Configurations (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 1	192.168.1.2	255.255.255.0	N/A
S2	VLAN 1	192.168.1.3	255.255.255.0	N/A
PC-A	NIC	192.168.10.2	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-C	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Switch Port Assignment Specifications

Ports	Assignment	Network
F0/1	802.1Q Trunk	N/A
F0/6-12	VLAN 10 – Students	192.168.10.0/24
F0/13-18	VLAN 20 – Faculty	192.168.20.0/24
F0/19-24	VLAN 30 – Guest	192.168.30.0/24

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot VLAN 10

Part 3: Troubleshoot VLAN 20

Background / Scenario

VLANs provide logical segmentation within an internetwork and improve network performance by separating large broadcast domains into smaller ones. By separating hosts into different networks, VLANs can be used to control which hosts can communicate. In this lab, a school has decided to implement VLANs in order to separate traffic from different end users. The school is using 802.1Q trunking to facilitate VLAN communication between switches.

The S1 and S2 switches have been configured with VLAN and trunking information. Several errors in the configuration have resulted in connectivity issues. You have been asked to troubleshoot and correct the configuration errors and document your work.

Note: The switches used with this lab are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the switches with some basic settings, such as passwords and IP addresses. Preset VLAN-related configurations, which contain errors, are provided for you for the initial switch configurations. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the switches as necessary.

Step 4: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure IP address in Addressing Table.
- c. Assign **cisco** as the console and vty passwords and enable login for console and vty lines.
- d. Assign **class** as the privileged EXEC password.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 5: Load switch configurations.

The configurations for the switches S1 and S2 are provided for you. There are errors within these configurations, and it is your job to determine the incorrect configurations and correct them.

Switch S1 Configuration:

Lab - Troubleshooting VLAN Configurations

```
hostname S1
vlan 10
name Students
vlan 2
!vlan 20
name Faculty
vlan 30
name Guest
interface range f0/1-24
switchport mode access
shutdown
!interface f0/1
!switchport mode trunk
!no shutdown
interface range f0/7-12
!interface range f0/6-12
switchport access vlan 10
interface range f0/13-18
switchport access vlan 2
!switchport access vlan 20
interface range f0/19-24
switchport access vlan 30
end
```

Switch S2 Configuration:

```
hostname S2
vlan 10
Name Students
vlan 20
Name Faculty
vlan 30
Name Guest
interface f0/1
switchport mode trunk
switchport trunk allowed vlan 1,10,2,30
!switchport trunk allowed vlan 1,10,20,30
interface range f0/2-24
switchport mode access
shutdown
!interface range f0/6-12
!switchport access vlan 10
interface range f0/13-18
switchport access vlan 20
interface range f0/19-24
switchport access vlan 30
shutdown
end
```

Step 6: Copy the running configuration to the startup configuration.

Part 2: Troubleshoot VLAN 10

In Part 2, you must examine VLAN 10 on S1 and S2 to determine if it is configured correctly. You will troubleshoot the scenario until connectivity is established.

Step 1: Troubleshoot VLAN 10 on S1.

- a. Can PC-A ping PC-B? _____ No
- b. After verifying that PC-A was configured correctly, examine the S1 switch to find possible configuration errors by viewing a summary of the VLAN information. Enter the **show vlan brief** command.

S1# **show vlan brief**

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Gi0/1, Gi0/2
2	Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
10	Students	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12
30	Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdinnet-default	act/unsup	
1005	trnet-default	act/unsup	

- c. Are there any problems with the VLAN configuration?

Yes. The port for PC-A is not assigned to the correct VLAN. The port for F0/1 is assigned to VLAN 1; therefore, it is not acting as a trunk port.

- d. Examine the switch for trunk configurations using the **show interfaces trunk** and the **show interface f0/1 switchport** commands.

S1# **show interfaces trunk**

S1# **show interfaces f0/1 switchport**
Name: Fa0/1
Switchport: Enabled
Administrative Mode: static access
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: Off
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none

Lab - Troubleshooting VLAN Configurations

```
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Capture Mode Disabled
Capture VLANs Allowed: ALL

Protected: false
Unknown unicast blocked: disabled
Unknown multicast blocked: disabled
Appliance trust: none
```

- e. Are there any problems with the trunking configuration?
-

Yes. No trunk ports exist and F0/1 is configured as an access port instead of a trunk port.

- f. Examine the running configuration of the switch to find possible configuration errors.

Are there any problems with the current configuration?

Yes. F0/1-5 are all configured as access ports and all ports on the switch are shutdown.

- g. Correct the errors found regarding F0/1 and VLAN 10 on S1. Record the commands used in the space below.
-
-
-
-
-
-

```
S1(config)# interface f0/1
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/6
S1(config-if)# no shutdown
S1(config-if)# switchport access vlan 10
```

- h. Verify the commands had the desired effects by issuing the appropriate **show** commands.

```
S1# show interface trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/1	1-4094

Lab - Troubleshooting VLAN Configurations

```
Port      Vlans allowed and active in management domain  
Fa0/1    1-2,10,30
```

```
Port      Vlans in spanning tree forwarding state and not pruned  
Fa0/1    1-2,10,30
```

S1# **show vlan brief**

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
2	Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
10	Students	active	Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12
30	Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdinnet-default	act/unsup	
1005	trnet-default	act/unsup	

- i. Can PC-A ping PC-B? _____ **No**

Step 2: Troubleshoot VLAN 10 on S2.

- a. Using the previous commands, examine the S2 switch to find possible configuration errors.
Are there any problems with the current configuration?

Yes. No ports were assigned access to VLAN 10 and ports f0/1 and f0/11 are shutdown.

S2# **show vlan brief**

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Gi0/1 Gi0/2
10	Students	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
20	Faculty	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
30	Guest	active	
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdinnet-default	act/unsup	
1005	trnet-default	act/unsup	

Lab - Troubleshooting VLAN Configurations

- b. Correct the errors found regarding interfaces and VLAN 10 on S2. Record the commands below.

```
S2(config)# interface range f0/6 -12
S2(config-if-range)# switchport access vlan 10
S2(config-if-range)# interface f0/11
S2(config-if)# no shutdown
```

- c. Can PC-A ping PC-B? _____ Yes

Part 3: Troubleshoot VLAN 20

In Part 3, you must examine VLAN 20 on S1 and S2 to determine if it is configured correctly. To verify functionality, you will reassign PC-A into VLAN 20, and then troubleshoot the scenario until connectivity is established.

Step 1: Assign PC-A to VLAN 20.

- On PC-A, change the IP address to 192.168.20.2/24 with a default gateway of 192.168.20.1.
- On S1, assign the port for PC-A to VLAN 20. Write the commands needed to complete the configuration.

```
S1(config)# interface f0/6
S1(config-if)# switchport access vlan 20
```

- c. Verify that the port for PC-A has been assigned to VLAN 20.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
2	Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
10	Students	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12
20	VLAN0020	active	Fa0/6
30	Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

Lab - Troubleshooting VLAN Configurations

d. Can PC-A ping PC-C? _____ No

Step 2: Troubleshoot VLAN 20 on S1.

- Using the previous commands, examine the S1 switch to find possible configuration errors.
Are there any problems with the current configuration?

Yes. VLAN 2 was created instead of VLAN 20 and ports have been assigned to VLAN 2 instead of VLAN 20.

- Correct the errors found regarding VLAN 20.

```
S1(config)# interface range f0/13-18
S1(config-if-range)# switchport access vlan 20
S1(config-if-range)# exit
S1(config)# no vlan 2
S1(config)# vlan 20
S1(config-vlan)# name Faculty
```

- Can PC-A ping PC-C? _____ No

Step 3: Troubleshoot VLAN 20 on S2.

- Using the previous commands, examine the S2 switch to find possible configuration errors.
Are there any problems with the current configuration?

Yes. The trunked interface has been misconfigured to allow communication for VLAN 2 instead of VLAN 20 and port f0/18 is shutdown.

```
S2# show interface trunk

Port      Mode          Encapsulation  Status      Native vlan
Fa0/1     on           802.1q        trunking    1

Port      Vlans allowed on trunk
Fa0/1     1-2,10,30

Port      Vlans allowed and active in management domain
Fa0/1     1,10,30

Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     1,10,30

S2# show run interface fa0/18
Building configuration...

Current configuration : 95 bytes
!
interface FastEthernet0/18
```

Lab - Troubleshooting VLAN Configurations

```
switchport access vlan 20
switchport mode access
shutdown
end
```

- b. Correct the errors found regarding VLAN 20. Record the commands used below.
-
-
-
-

```
S2(config)# interface f0/18
S2(config-if)# no shutdown
S2(config)# interface f0/1
S2(config-if)# switchport trunk allowed vlan remove 2
S2(config-if)# switchport trunk allowed vlan add 20
```

- c. Can PC-A ping PC-C? _____ Yes

Note: It may be necessary to disable the PC firewall to ping between PCs.

Reflection

1. Why is a correctly configured trunk port critical in a multi-VLAN environment?
-
-

An 802.1Q trunk port allows for transmission of multiple VLANs across one link. An incorrectly configured trunk port can prevent VLANs from communicating across switches.

2. Why would a network administrator limit traffic for specific VLANs on a trunk port?
-
-

To prevent unwanted VLAN traffic from traveling through that trunk port.

Device Configs

Instructor Note: The VLANs configured do not display in the running configuration but are stored in the `vlan.dat` file.

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
10	Students	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12
20	Faculty	active	Fa0/6, Fa0/13, Fa0/14, Fa0/15

Lab - Troubleshooting VLAN Configurations

		Fa0/16, Fa0/17, Fa0/18
30 Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22
		Fa0/23, Fa0/24
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S1#show run
Building configuration...

Current configuration : 3966 bytes
!
version 15.0
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$Hf8a$8iwF0hp1dYGtxwlUsJuE5/
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 switchport mode access
```

Lab - Troubleshooting VLAN Configurations

```
shutdown
!
interface FastEthernet0/3
switchport mode access
shutdown
!
interface FastEthernet0/4
switchport mode access
shutdown
!
interface FastEthernet0/5
switchport mode access
shutdown
!
interface FastEthernet0/6
switchport access vlan 20
switchport mode access
!
interface FastEthernet0/7
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/8
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/9
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/10
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/11
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/12
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/13
```

Lab - Troubleshooting VLAN Configurations

```
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/14
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/15
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/16
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/17
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/18
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/19
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/20
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/21
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/22
switchport access vlan 30
switchport mode access
shutdown
!
```

Lab - Troubleshooting VLAN Configurations

```
interface FastEthernet0/23
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/24
switchport access vlan 30
switchport mode access
shutdown
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
ip address 192.168.1.2 255.255.255.0
no ip route-cache
!
ip http server
ip http secure-server
logging esm config
!
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
10	Students	active	Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12
20	Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
30	Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002	fdci-default	act/unsup	

Lab - Troubleshooting VLAN Configurations

```
1003 token-ring-default          act/unsup
1004 fddinet-default            act/unsup
1005 trnet-default              act/unsup
S2# show run
Building configuration...
Current configuration : 3966 bytes
!
! Last configuration change at 00:07:17 UTC Mon Mar 1 1993
!
version 15.0
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$T7f6$AYijjsmnLmWzgIAET.DDj/
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface FastEthernet0/1
  switchport trunk allowed vlan 1,10,20,30
  switchport mode trunk
!
interface FastEthernet0/2
  switchport mode access
  shutdown
!
interface FastEthernet0/3
```

Lab - Troubleshooting VLAN Configurations

```
switchport mode access
shutdown
!
interface FastEthernet0/4
switchport mode access
shutdown
!
interface FastEthernet0/5
switchport mode access
shutdown
!
interface FastEthernet0/6
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/7
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/8
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/9
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/10
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/11
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/12
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/13
switchport access vlan 20
switchport mode access
shutdown
```

Lab - Troubleshooting VLAN Configurations

```
!
interface FastEthernet0/14
 switchport access vlan 20
 switchport mode access
 shutdown

!
interface FastEthernet0/15
 switchport access vlan 20
 switchport mode access
 shutdown

!
interface FastEthernet0/16
 switchport access vlan 20
 switchport mode access
 shutdown

!
interface FastEthernet0/17
 switchport access vlan 20
 switchport mode access
 shutdown

!
interface FastEthernet0/18
 switchport access vlan 20
 switchport mode access
 shutdown

!
interface FastEthernet0/19
 switchport access vlan 30
 switchport mode access
 shutdown

!
interface FastEthernet0/20
 switchport access vlan 30
 switchport mode access
 shutdown

!
interface FastEthernet0/21
 switchport access vlan 30
 switchport mode access
 shutdown

!
interface FastEthernet0/22
 switchport access vlan 30
 switchport mode access
 shutdown

!
interface FastEthernet0/23
 switchport access vlan 30
 switchport mode access
```

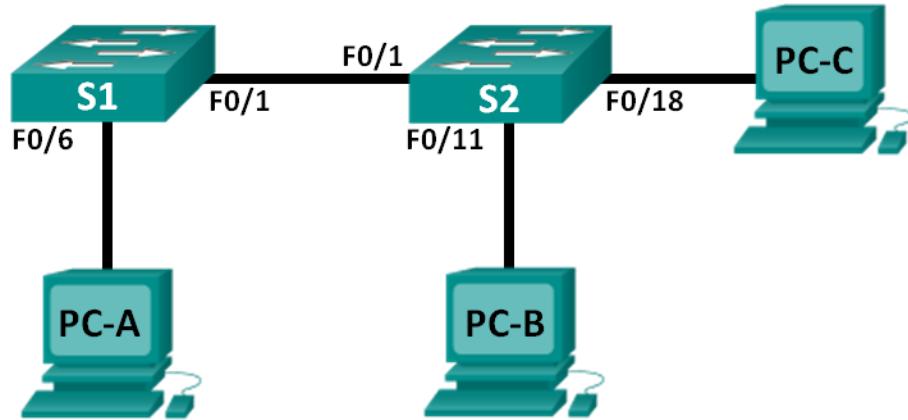
Lab - Troubleshooting VLAN Configurations

```
shutdown
!
interface FastEthernet0/24
switchport access vlan 30
switchport mode access
shutdown
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
ip address 192.168.1.3 255.255.255.0
no ip route-cache
!
ip http server
ip http secure-server
logging esm config
!
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Lab – Implementing VLAN Security (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 99	172.17.99.11	255.255.255.0	172.17.99.1
S2	VLAN 99	172.17.99.12	255.255.255.0	172.17.99.1
PC-A	NIC	172.17.99.3	255.255.255.0	172.17.99.1
PC-B	NIC	172.17.10.3	255.255.255.0	172.17.10.1
PC-C	NIC	172.17.99.4	255.255.255.0	172.17.99.1

VLAN Assignments

VLAN	Name
10	Data
99	Management&Native
999	BlackHole

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Implement VLAN Security on the Switches

Background / Scenario

Best practice dictates configuring some basic security settings for both access and trunk ports on switches. This will help guard against VLAN attacks and possible sniffing of network traffic within the network.

Lab – Implementing VLAN Security

In this lab, you will configure the network devices in the topology with some basic settings, verify connectivity and then apply more stringent security measures on the switches. You will examine how Cisco switches behave by using various **show** commands. You will then apply security measures.

Note: The switches used with this lab are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will configure basic settings on the switches and PCs. Refer to the Addressing Table for device names and address information.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the switches.

Step 3: Configure IP addresses on PC-A, PC-B, and PC-C.

Refer to the Addressing Table for PC address information.

Step 4: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure the device names as shown in the topology.
- c. Assign **class** as the privileged EXEC mode password.
- d. Assign **cisco** as the console and VTY password and enable login for console and vty lines.
- e. Configure synchronous logging for console and vty lines.

Step 5: Configure VLANs on each switch.

- a. Create and name VLANs according to the VLAN Assignments table.
- b. Configure the IP address listed in the Addressing Table for VLAN 99 on both switches.
- c. Configure F0/6 on S1 as an access port and assign it to VLAN 99.
- d. Configure F0/11 on S2 as an access port and assign it to VLAN 10.
- e. Configure F0/18 on S2 as an access port and assign it to VLAN 99.
- f. Issue **show vlan brief** command to verify VLAN and port assignments.

S1# show vlan brief

Lab – Implementing VLAN Security

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10	Data	active	
99	Management&Native	active	Fa0/6
999	BlackHole	active	
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdmnet-default	act/unsup	
1005	trnet-default	act/unsup	

S2# **show vlan brief**

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Data	active	Fa0/11
99	Management&Native	active	Fa0/18
999	BlackHole	active	
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdmnet-default	act/unsup	
1005	trnet-default	act/unsup	

To which VLAN would an unassigned port, such as F0/8 on S2, belong?

All ports by default are assigned to VLAN 1.

Step 6: Configure basic switch security.

- Configure a MOTD banner to warn users that unauthorized access is prohibited.
- Encrypt all passwords.
- Shut down all unused physical ports.
- Disable the basic web service running.

```
S1(config)# no ip http server  
S2(config)# no ip http server
```

Lab – Implementing VLAN Security

- e. Copy the running configuration to startup configuration.

Step 7: Verify connectivity between devices and VLAN information.

- a. From a command prompt on PC-A, ping the management address of S1. Were the pings successful? Why?

Yes, the pings were successful. PC-A is in the same VLAN as the management address on the switch.

- b. From S1, ping the management address of S2. Were the pings successful? Why?

No, the pings were not successful. The management addresses on S1 and S2 are in the same VLAN but interface F0/1 on both switches is not configured as a trunk port. Port F0/1 still belongs to VLAN 1 and not VLAN 99.

- c. From a command prompt on PC-B, ping the management addresses on S1 and S2 and the IP address of PC-A and PC-C. Were your pings successful? Why?

The pings to S1, S2, PC-A, and PC-C from PC-B were all unsuccessful. PC-B is on VLAN 10, and S1, S2, PC-A, and PC-C are on VLAN 99. There is no Layer 3 device to route between networks.

- d. From a command prompt on PC-C, ping the management addresses on S1 and S2. Were you successful? Why?

Partial success. PC-C is in the same VLAN as S1 and S2. PC-C is able to ping the management address of S2 but still cannot ping S1 because a trunk link has not been established yet between S1 and S2.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Part 2: Implement VLAN Security on the Switches

Step 1: Configure trunk ports on S1 and S2.

- a. Configure port F0/1 on S1 as a trunk port.

```
S1(config)# interface f0/1  
S1(config-if)# switchport mode trunk
```

- b. Configure port F0/1 on S2 as a trunk port.

```
S2(config)# interface f0/1  
S2(config-if)# switchport mode trunk
```

- c. Verify trunking on S1 and S2. Issue the **show interface trunk** command on both switches.

```
S1# show interface trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1

Lab – Implementing VLAN Security

```
Port      Vlans allowed on trunk
Fa0/1    1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1    1,10,99,999
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1    1,10,99,999
```

Step 2: Change the native VLAN for the trunk ports on S1 and S2.

Changing the native VLAN for trunk ports from VLAN 1 to another VLAN is a good practice for security.

- What is the current native VLAN for the S1 and S2 F0/1 interfaces?

VLAN 1 is the native VLAN for both switches.

- Configure the native VLAN on the S1 F0/1 trunk interface to Management&Native VLAN 99.

```
S1# config t
S1(config)# interface f0/1
S1(config-if)# switchport trunk native vlan 99
```

- Wait a few seconds. You should start receiving error messages on the console session of S1. What does the %CDP-4-NATIVE_VLAN_MISMATCH: message mean?

This is a Cisco Discovery Protocol (CDP) message indicating that the S1 and S2 native VLANs do not match. S2 still has the native VLAN set to VLAN 1. S1 has set the native VLAN to 99.

- Configure the native VLAN on the S2 F0/1 trunk interface to VLAN 99.

```
S2(config)# interface f0/1
S2(config-if)# switchport trunk native vlan 99
```

- Verify that the native VLAN is now 99 on both switches. S1 output is shown below.

```
S1# show interface trunk
```

```
Port      Mode          Encapsulation  Status       Native vlan
Fa0/1    on           802.1q        trunking    99
```

```
Port      Vlans allowed on trunk
Fa0/1    1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1    1,10,99,999
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1    10,999
```

Step 3: Verify that traffic can successfully cross the trunk link.

- a. From a command prompt on PC-A, ping the management address of S1. Were the pings successful? Why?

Yes, the pings were successful. PC-A is in the same VLAN as the management address on the switch.

- b. From the console session on S1, ping the management address of S2. Were the pings successful? Why?

Yes, the pings were successful. Trunking has been successfully established, and both switches are in VLAN 99.

- c. From a command prompt on PC-B, ping the management addresses on S1 and S2 and the IP address of PC-A and PC-C. Were your pings successful? Why?

The pings to S1, S2, PC-A, and PC-C from PC-B were all unsuccessful. PC-B is on VLAN 10 and S1, S2, PC-A, and PC-C are on VLAN 99. There is no Layer 3 device to route between networks.

- d. From a command prompt on PC-C, ping the management addresses on S1 and S2 and the IP address of PC-A. Were you successful? Why?

The pings were all successful. PC-C is in the same VLAN as S1 and S2 and PC-A.

Step 4: Prevent the use of DTP on S1 and S2.

Cisco uses a proprietary protocol known as the Dynamic Trunking Protocol (DTP) on its switches. Some ports automatically negotiate to trunking. A good practice is to turn off negotiation. You can see this default behavior by issuing the following command:

```
S1# show interface f0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
<Output Omitted>
```

- a. Turn off negotiation on S1.

```
S1(config)# interface f0/1
S1(config-if)# switchport nonegotiate
```

- b. Turn off negotiation on S2.

```
S2(config)# interface f0/1
S2(config-if)# switchport nonegotiate
```

- c. Verify that negotiation is off by issuing the **show interface f0/1 switchport** command on S1 and S2.

```
S1# show interface f0/1 switchport
Name: Fa0/1
```

Lab – Implementing VLAN Security

```
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: Off
<Output Omitted>
```

Step 5: Secure access ports on S1 and S2.

Even though you shut down unused ports on the switches, if a device is connected to one of those ports and the interface is enabled, trunking could occur. In addition, all ports by default are in VLAN 1. A good practice is to put all unused ports in a “black hole” VLAN. In this step, you will disable trunking on all unused ports. You will also assign unused ports to VLAN 999. For the purposes of this lab, only ports 2 through 5 will be configured on both switches.

- Issue the **show interface f0/2 switchport** command on S1. Notice the administrative mode and state for trunking negotiation.

```
S1# show interface f0/2 switchport
Name: Fa0/2
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: On
<Output Omitted>
```

- Disable trunking on S1 access ports.

```
S1(config)# interface range f0/2 - 5
S1(config-if-range)# switchport mode access
S1(config-if-range)# switchport access vlan 999
```

- Disable trunking on S2 access ports.

```
S2(config)# interface range f0/2 - 5
S2(config-if-range)# switchport mode access
S2(config-if-range)# switchport access vlan 999
```

- Verify that port F0/2 is set to access on S1.

```
S1# show interface f0/2 switchport
Name: Fa0/2
Switchport: Enabled
Administrative Mode: static access
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: Off
Access Mode VLAN: 999 (BlackHole)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
<Output Omitted>
```

- Verify that VLAN port assignments on both switches are correct. S1 is shown below as an example.

Lab – Implementing VLAN Security

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Data	active	
99	Management&Native	active	Fa0/6
999	BlackHole	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdinnet-default	act/unsup	
1005	trnet-default	act/unsup	
Restrict VLANs allowed on trunk ports.			

By default, all VLANs are allowed to be carried on trunk ports. For security reasons, it is a good practice to only allow specific desired VLANs to cross trunk links on your network.

- f. Restrict the trunk port F0/1 on S1 to only allow VLANs 10 and 99.

```
S1(config)# interface f0/1
S1(config-if)# switchport trunk allowed vlan 10,99
```

- g. Restrict the trunk port F0/1 on S2 to only allow VLANs 10 and 99.

```
S2(config)# interface f0/1
S2(config-if)# switchport trunk allowed vlan 10,99
```

- h. Verify the allowed VLANs. Issue a **show interface trunk** command in privileged EXEC mode on both S1 and S2.

```
S1# show interface trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	99
Port		Vlans allowed on trunk		
Fa0/1		10,99		
Port		Vlans allowed and active in management domain		
Fa0/1		10,99		
Port		Vlans in spanning tree forwarding state and not pruned		
Fa0/1		10,99		

What is the result?

Only VLANs 10 and 99 are allowed on the trunk link between S1 and S2.

Reflection

What, if any, are the security problems with the default configuration of a Cisco switch?

The fact that all ports are assigned to VLAN 1 by default is one possible security issue. Another is that on many Cisco switches, trunking is set to auto-negotiate, so trunk links may be turned on without your knowledge, if a rogue switch is connected. Another possible answer is that both console and VTY passwords are displayed in plain text by default. In addition, the HTTP server is enabled by default.

Device Configs

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Data	active	
99	Management&Native	active	Fa0/6
999	BlackHole	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdinnet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S1#sh run
Building configuration...
```

```
Current configuration : 3821 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
```

Lab – Implementing VLAN Security

```
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
switchport trunk native vlan 99
switchport trunk allowed vlan 10,99
switchport mode trunk
switchport nonegotiate
!
interface FastEthernet0/2
switchport access vlan 999
switchport mode access
shutdown
!
interface FastEthernet0/3
switchport access vlan 999
switchport mode access
shutdown
!
interface FastEthernet0/4
switchport access vlan 999
switchport mode access
shutdown
!
interface FastEthernet0/5
switchport access vlan 999
switchport mode access
shutdown
!
interface FastEthernet0/6
switchport access vlan 99
switchport mode access
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
```

Lab – Implementing VLAN Security

```
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
```

Lab – Implementing VLAN Security

```
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
shutdown
!
interface Vlan99
ip address 172.17.99.11 255.255.255.0
!
no ip http server
ip http secure-server
!
banner motd ^CWarning. Unauthorized access is prohibited.^C
!
line con 0
password 7 070C285F4D06
logging synchronous
login
line vty 0 4
password 7 070C285F4D06
logging synchronous
login
line vty 5 15
password 7 070C285F4D06
logging synchronous
login
!
end
```

Switch S2

```
S2#show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10	Data	active	Fa0/11
99	Management&Native	active	Fa0/18
999	BlackHole	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fd dinet-default	act/unsup	
1005	tr net-default	act/unsup	

Lab – Implementing VLAN Security

```
S2#sh run
Building configuration...

Current configuration : 3852 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
    switchport trunk native vlan 99
    switchport trunk allowed vlan 10,99
    switchport mode trunk
    switchport nonegotiate
!
interface FastEthernet0/2
    switchport access vlan 999
    switchport mode access
    shutdown
!
interface FastEthernet0/3
    switchport access vlan 999
    switchport mode access
    shutdown
!
interface FastEthernet0/4
    switchport access vlan 999
    switchport mode access
    shutdown
!
```

Lab – Implementing VLAN Security

```
interface FastEthernet0/5
switchport access vlan 999
switchport mode access
shutdown
!
interface FastEthernet0/6
shutdown
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
switchport access vlan 99
switchport mode access
!
```

Lab – Implementing VLAN Security

```
interface FastEthernet0/19
    shutdown
!
interface FastEthernet0/20
    shutdown
!
interface FastEthernet0/21
    shutdown
!
interface FastEthernet0/22
    shutdown
!
interface FastEthernet0/23
    shutdown
!
interface FastEthernet0/24
    shutdown
!
interface GigabitEthernet0/1
    shutdown
!
interface GigabitEthernet0/2
    shutdown
!
interface Vlan1
    no ip address
!
interface Vlan99
    ip address 172.17.99.12 255.255.255.0
!
no ip http server
ip http secure-server
!
banner motd ^CWarning. Unauthorized access is prohibited.^C
!
line con 0
    password 7 00071A150754
    logging synchronous
    login
line vty 0 4
    password 7 00071A150754
    logging synchronous
    login
line vty 5 15
    password 7 070C285F4D06
    logging synchronous
    login
!
end
```



VLAN Plan (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Implement VLANs to segment a small- to medium-sized network.

This class activity focuses students' thoughts on how VLANs are designed. Groups of two or three students should be created to complete this class activity.

Scenario

You are designing a VLAN switched network for your small- to medium- sized business.

Your business owns space on two floors of a high-rise building. The following elements need VLAN consideration and access for planning purposes:

- Management
- Finance
- Sales
- Human Resources
- Network administrator
- General visitors to your business location

You have two Cisco 3560-24PS switches.

Use a word processing software program to design your VLAN-switched network scheme.

Section 1 of your design should include the regular names of your departments, suggested VLAN names and numbers, and which switch ports would be assigned to each VLAN.

Section 2 of your design should list how security would be planned for this switched network.

Once your VLAN plan is finished, complete the reflection questions from this activity.

Save your work. Be able to explain and discuss your VLAN design with another group or with the class.

Required Resources

Word processing program

Reflection

1. What criteria did you use for assigning ports to the VLANs?

Number of users, types of end-devices and how many MAC addresses would need to be assigned to each port of the VLAN, if any.

2. How could these users access your network if the switches were not physically available to general users via direct connection?

An additional network device could be incorporated into the network or perhaps a wireless access point or ISR router with access to the general VLAN switchports. If this is a new building, wired connections could be established allowing separate, direct access to network ports built into office walls or conference tables.

3. Could you reduce the number of switch ports assigned for general users if you used another device to connect them to the VLAN network switch? What would be affected?

Bandwidth would be shared if users shared a port.

Modeling Activity Graphic Representation (designs will vary)

Instructor Notes: This is a representative example that could be “built” as a result of this activity:

Tables are used in this design - students may elect to show their switched network design in graphic format with notes indicating port assignments, department/inter-VLAN associations and security considerations.

In this example, both switches would use the same switchport assignments and VLAN information to facilitate network administration tasks. Switches would be connected via a configured trunk line using one of the Gigabit ports. The remaining Gigabit ports would be reserved for connectivity to intermediary devices, additional trunk lines or servers.

Section 1: VLAN Names and Numbers – VLAN Switchport Assignments

Department	Assigned VLAN Name and Number	Switchport Numbers
Network Administration	Native90	Gi0/1 and Gi0/2
Management	Management10	Fa0/1-0/2
Finance	Finance20	Fa0/3-Fa0/6
Sales	Sales30	Fa0/7-Fa0/10
Human Resources	HR40	Fa0/13-Fa0/16
General	General50	Fa0/17-Fa0/22
(not assigned)	Leave in VLAN1	(Fa0/23 and Fa0/24 will be shut down and reserved for future VLAN consideration)

Section 2: Security Design:

- Ports Fa0/1 and Fa0/02 would be configured with two specific MAC addresses – if a non-specified MAC address from an end-device accesses these two ports, the ports will shut down.
- Fa0/3-Fa0/16 would be assigned specific MAC addresses. The assigned addresses will be based on the addresses recorded from the end-devices located in each department. The ports will shut down if security is breached.
- Ports Fa0/17-Fa0/22 would be open ports for general use within the small- to medium-size business.
- Ports Fa23 and Fa24 would be shut down by the network administrator and saved for future VLAN assignment.

Identify elements of the model that map to IT-related content:

- VLANs
- VLAN trunking
- VLAN domains
- VLAN assignment
- VLAN security

Do We Really Need a Map? (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Describe the primary functions and features of a router.

Routers send and receive information from networks they recognize. The routing table is a very important tool to supply the network administrator with information about how a network delivers data from source to destination between networks. This modeling activity focuses students' thoughts on how routing is mapped and documented.

Scenario

Using the Internet and Google Maps, located at <http://maps.google.com>, find a route between the capital city of your country and some other distant town, or between two places within your own city. Pay close attention to the driving or walking directions Google Maps suggests.

Notice that in many cases, Google Maps suggests more than one route between the two locations you chose. It also allows you to put additional constraints on the route, such as avoiding highways or tolls.

- Copy at least two route instructions supplied by Google Maps for this activity. Place your copies into a word processing document and save it for to use with the next step.
- Open the .pdf accompanying this modeling activity and complete it with a fellow student. Discuss the reflection questions listed on the .pdf and record your answers.

Be prepared to present your answers to the class.

Resources

- Internet connection
- Web browser
- Google Maps, [http://maps.google.com/](http://maps.google.com)

Reflection

1. What do the individual driving, or walking based on your criteria you input, and non-highway directions look like? What exact information do they contain? How do they relate to IP routing?

Each suggested route has its overall length and duration indicated. The two sets of directions consist of detailed step-by-step instructions to reach the other destination. At each significant crossing, you are advised of the very next direction to take and of the distance to the next crossroad.

These instructions closely resemble information in routing tables of IP-based routers. Each crossing can be likened to a router on which the next path selection takes place. The overall length and duration of the route correspond to the route metric, or a measure of its usefulness, from the source to the destination. The advice on which next direction to take from a particular crossing resembles an entry in the particular router's routing table that contains information about the nearest next hop router on the path towards the destination. The distance to the next crossroad is similar to the so-called cost of an interface that is used by routing protocols to compute the resulting metric of a route.

2. If Google Maps offered a set of different routes, what makes this route different from the first? Why would you choose one route over another?

Multiple routes traverse different paths to them same destination. These paths may differ in various characteristics, as some take longer to complete from source to destination and others are physically longer

Do We Really Need a Map?

due to distance; therefore, when comparing this activity to network travel, distance and time can make a difference to the routes displayed.

3. What criteria can be used to evaluate the usefulness of a route?

Criteria could include:

- the number of different paths are available from source to destination, such as direct connections, through other routers;
 - the time it takes to send data from source to destination, which can be based on bandwidth and delay;
 - the reliability of the route from source to destination, such as static vs. dynamic routes;
 - whether the route is the preferred route or a secondary route, such as static routes, default routes and other reported routes;
 - which speeds can be used to move packets from source to destination, such as the type of media/medium used to connect networks.
4. Is it sensible to expect that a single route can be “the best one”, i.e. meeting all various requirements? Justify your answer.

If the route given meets all the criteria requested, the single route can be the best route. Compare this to a default route or the only route available from source to destination.

5. As a network administrator or developer, how could you use a network map, or routing table, in your daily network activities?

Network maps or routing tables can be used to envision and document the best paths for data delivery on networks. They can also be used to structure a direct path, or direct paths, from one network to another.

Modeling Activity Graphic Representation (designs will vary)

Instructor Note: Listed below is representative output from the Google Maps site for Instructor use only.

Do We Really Need a Map?

The image displays two side-by-side screenshots of Google Maps. Both screenshots show the same route information: driving directions from Ashland, Virginia to Richmond, Virginia. The left screenshot shows a simplified interface with basic search fields and a 'GET DIRECTIONS' button. The right screenshot shows an expanded view with route filtering options ('Avoid highways', 'Avoid tolls'), a 'GET DIRECTIONS' button, and a detailed list of suggested routes. Below the routes, a 'Driving directions to Richmond, VA' section provides step-by-step instructions with icons and distances.

Driving directions to Richmond, VA

A. Ashland, VA

1. Head east on England St toward Maple St
1.0 mi
2. Merge onto I-95 S via the ramp to Richmond
17.0 mi
3. Take exit 74C to merge onto US-250 W/E Broad St toward US-33
0.7 mi
4. Turn left onto N 8th St
420 ft
5. Take the 1st right onto E Grace St
190 ft

B. Richmond, VA

Driving directions to Richmond, VA

A. Ashland, VA

1. Head east on England St toward Maple St
0.5 mi
2. Turn right onto U.S. 1 S
10.9 mi
3. Turn left onto Azalea Ave (signs for US-1 S/Richmond)
0.2 mi
4. Turn right onto Chamberlayne Ave
3.4 mi
5. Continue onto N Belvidere St
0.4 mi
6. Turn left onto W Broad St
0.9 mi
7. Turn right onto N 8th St
377 ft
8. Take the 1st right onto E Grace St
190 ft

B. Richmond, VA

Identify elements of the model that map to IT-related content:

- Routes
- Routing Table
- Bandwidth
- Delay
- Cost
- Administrative Distance
- Default Route
- Static Route



Lab - Mapping the Internet (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Part 1: Determine Network Connectivity to a Destination Host

Part 2: Trace a Route to a Remote Server Using Tracert

Background / Scenario

Route tracing computer software lists the networks that data traverses from the user's originating end device to a distant destination device.

This network tool is typically executed at the command line as:

```
tracert <destination network name or end device address>  
(Microsoft Windows systems)
```

or

```
traceroute <destination network name or end device address>  
(UNIX, Linux systems, and Cisco devices, such as switches and routers)
```

Both **tracert** and **traceroute** determine the route taken by packets across an IP network.

The **tracert** (or **traceroute**) tool is often used for network troubleshooting. By showing a list of routers traversed, the user can identify the path taken to reach a particular destination on the network or across internetworks. Each router represents a point where one network connects to another network and through which the data packet was forwarded. The number of routers is known as the number of hops the data traveled from source to destination.

The displayed list can help identify data flow problems when trying to access a service such as a website. It can also be useful when performing tasks, such as downloading data. If there are multiple websites (mirrors) available for the same data file, one can trace each mirror to get a good idea of which mirror would be the fastest to use.

Command-line based route tracing tools are usually embedded with the operating system of the end device. This activity should be performed on a computer that has Internet access and access to a command line.

Instructor Note: Some institutions disable ICMP echo replies throughout the network. Before students begin this activity, make sure there are no local restrictions related to ICMP datagrams. This activity assumes that ICMP datagrams are not restricted by any local security policy.

Required Resources

PC with Internet access

Part 1: Determine Network Connectivity to a Destination Host

To trace the route to a distant network, the PC used must have a working connection to the Internet. Use the **ping** command to test whether a host is reachable. Packets of information are sent to the remote host with instructions to reply. Your local PC measures whether a response is received to each packet, and how long it takes for those packets to cross the network.

- a. At the command-line prompt, type **ping www.cisco.com** to determine if it is reachable.

```
C:\>ping www.cisco.com

Pinging e144.dsrb.akamaiedge.net [23.1.48.170] with 32 bytes of data:
Reply from 23.1.48.170: bytes=32 time=56ms TTL=57
Reply from 23.1.48.170: bytes=32 time=55ms TTL=57
Reply from 23.1.48.170: bytes=32 time=54ms TTL=57
Reply from 23.1.48.170: bytes=32 time=54ms TTL=57

Ping statistics for 23.1.48.170:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 54ms, Maximum = 56ms, Average = 54ms
```

- b. Now ping one of the Regional Internet Registry (RIR) websites located in different parts of the world to determine if it is reachable:

Africa: www.afrinic.net

Australia: www.apnic.net

South America: www.lacnic.net

North America: www.arin.net

Note: At the time of writing, the European RIR www.ripe.net does not reply to ICMP echo requests.

The website you selected will be used in Part 2 for use with the **tracert** command.

Part 2: Trace a Route to a Remote Server Using Tracert

After you determine if your chosen websites are reachable by using **ping**, you will use **tracert** to determine the path to reach the remote server. It is helpful to look more closely at each network segment that is crossed.

Each hop in the **tracert** results displays the routes that the packets take when traveling to the final destination. The PC sends three ICMP echo request packets to the remote host. Each router in the path decrements the time to live (TTL) value by 1 before passing it onto the next system. When the decremented TTL value reaches 0, the router sends an ICMP Time Exceeded message back to the source with its IP address and the current time. When the final destination is reached, an ICMP echo reply is sent to the source host.

For example, the source host sends three ICMP echo request packets to the first hop (192.168.1.1) with the TTL value of 1. When the router 192.168.1.1 receives the echo request packets, it decrements the TTL value to 0. The router sends an ICMP Time Exceeded message back to the source. This process continues until the source host sends the last three ICMP echo request packets with TTL values of 8 (hop number 8 in the output below), which is the final destination. After the ICMP echo request packets arrive at the final destination, the router responds to the source with ICMP echo replies.

For hops 2 and 3, these IP addresses are private addresses. These routers are the typical setup for point-of-presence (POP) of ISP. The POP devices connect users to an ISP network.

A web-based whois tool is found at <http://whois.domaintools.com/>. It is used to determine the domains traveled from the source to destination.

- a. At the command-line prompt, trace the route to www.cisco.com. Save the **tracert** output in a text file. Alternatively, you can redirect the output to a text file by using **>** or **>>**.

```
C:\Users\User1> tracert www.cisco.com
```

or

Lab - Mapping the Internet

```
C:\Users\User1> tracert www.cisco.com > tracert-cisco.txt
```

```
Tracing route to e144.dsrb.akamaiedge.net [23.67.208.170]  
over a maximum of 30 hops:
```

```
 1      1 ms    <1 ms    <1 ms  192.168.1.1  
 2     14 ms     7 ms     7 ms  10.39.0.1  
 3     10 ms     8 ms     7 ms  172.21.0.118  
 4     11 ms    11 ms    11 ms  70.169.73.196  
 5     10 ms     9 ms    11 ms  70.169.75.157  
 6     60 ms    49 ms     *   68.1.2.109  
 7    43 ms    39 ms    38 ms  Equinix-DFW2.netarch.akamai.com [206.223.118.102]  
 8    33 ms    35 ms    33 ms  a23-67-208-170.deploy.akamaitechnologies.com  
[23.67.208.170]
```

Trace complete.

- b. The web-based tool at <http://whois.domaintools.com/> can be used to determine the owners of both the resulting IP address and domain names shown in the tracert tools output. Now perform a **tracert** to one of RIR web sites from Part 1 and save the results.

Africa: www.afrinic.net

Australia: www.apnic.net

Europe: www.ripe.net

South America: www.lacnic.net

North America: www.arin.net

List the domains below from your tracert results using the web-based whois tool.

Answers will vary. cox.net, level3.com, registro.br

- c. Compare the lists of domains crossed to reach the final destinations.

Reflection

What can affect **tracert** results?

Answer will vary but could include network outages, high traffic loads, firewall blocking ICMP packets, ACL on intermediary devices prevents ICMP packets and asymmetric forwarding paths.

Lab – Configuring Basic Router Settings with IOS CLI (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.0	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.0.3	255.255.255.0	192.168.0.1

Objectives

Part 1: Set Up the Topology and Initialize Devices

- Cable equipment to match the network topology.
- Initialize and restart the router and switch.

Part 2: Configure Devices and Verify Connectivity

- Assign static IPv4 information to the PC interfaces.
- Configure basic router settings.
- Verify network connectivity.
- Configure the router for SSH.

Part 3: Display Router Information

- Retrieve hardware and software information from the router.
- Interpret the output from the startup configuration.
- Interpret the output from the routing table.
- Verify the status of the interfaces.

Part 4: Configure IPv6 and Verify Connectivity

Background / Scenario

This is a comprehensive lab to review previously covered IOS router commands. In Parts 1 and 2, you will cable the equipment and complete basic configurations and IPv4 interface settings on the router.

Lab – Configuring Basic Router Settings with IOS CLI

In Part 3, you will use SSH to connect to the router remotely and utilize IOS commands to retrieve information from the device to answer questions about the router. In Part 4, you will configure IPv6 on the router so that PC-B can acquire an IP address and then verify connectivity.

For review purposes, this lab provides the commands necessary for specific router configurations.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960 with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. Refer to Appendix A for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Note: The Gigabit Ethernet interfaces on Cisco 1941 ISRs are autosensing and an Ethernet straight-through cable can be used between the router and PC-B. If using another model Cisco router, it may be necessary to use an Ethernet crossover cable.

Part 1: Set Up the Topology and Initialize Devices

Step 1: Cable the network as shown in the topology.

- a. Attach the devices as shown in the topology diagram, and cable as necessary.
- b. Power on all the devices in the topology.

Step 2: Initialize and reload the router and switch.

Note: Appendix A details the steps to initialize and reload the devices.

Part 2: Configure Devices and Verify Connectivity

Step 1: Configure the PC interfaces.

- a. Configure the IP address, subnet mask, and default gateway settings on PC-A.
- b. Configure the IP address, subnet mask, and default gateway settings on PC-B.

Step 2: Configure the router.

- a. Console into the router and enable privileged EXEC mode.

```
Router> enable  
Router#
```
- b. Enter into global configuration mode.

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

- c. Assign a device name to the router.

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

- d. Disable DNS lookup to prevent the router from attempting to translate incorrectly entered commands as though they were hostnames.

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

- e. Require that a minimum of 10 characters be used for all passwords.

```
R1(config)# security passwords min-length 10
```

Besides setting a minimum length, list other ways to strengthen passwords.

Use capital letters, numbers, and special characters in passwords.

- f. Assign **cisco12345** as the privileged EXEC encrypted password.

```
R1(config)# enable secret cisco12345
```

- g. Assign **ciscoconpass** as the console password, establish a timeout, enable login, and add the **logging synchronous** command. The **logging synchronous** command synchronizes debug and Cisco IOS software output and prevents these messages from interrupting your keyboard input.

```
R1(config)# line con 0  
R1(config-line)# password ciscoconpass  
R1(config-line)# exec-timeout 5 0  
R1(config-line)# login  
R1(config-line)# logging synchronous  
R1(config-line)# exit  
R1(config) #
```

For the **exec-timeout** command, what do the **5** and **0** represent?

The session will timeout in 5 minutes and 0 seconds.

- h. Assign **ciscovtypass** as the vty password, establish a timeout, enable login, and add the **logging synchronous** command.

```
R1(config)# line vty 0 4  
R1(config-line)# password ciscovtypass  
R1(config-line)# exec-timeout 5 0  
R1(config-line)# login  
R1(config-line)# logging synchronous  
R1(config-line)# exit  
R1(config) #
```

- i. Encrypt the clear text passwords.

```
R1(config)# service password-encryption
```

- j. Create a banner that warns anyone accessing the device that unauthorized access is prohibited.

```
R1(config)# banner motd #Unauthorized access prohibited!#
```

- k. Configure an IP address and interface description. Activate both interfaces on the router.

```
R1(config)# int g0/0
R1(config-if)# description Connection to PC-B
R1(config-if)# ip address 192.168.0.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)# int g0/1
R1(config-if)# description Connection to S1
R1(config-if)# ip address 192.168.1.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)# exit
R1(config)# exit
R1#
```

- I. Set the clock on the router; for example:

```
R1# clock set 17:00:00 18 Feb 2013
```

- m. Save the running configuration to the startup configuration file.

```
R1# copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
R1#
```

What would be the result of reloading the router prior to completing the **copy running-config startup-config** command?

The contents of the running configuration would be erased. In this lab, the router would have no startup configuration. Upon a reboot, a user would be asked if they would like to enter initial configuration dialog.

Step 3: Verify network connectivity.

- a. Ping PC-B from a command prompt on PC-A.

Note: It may be necessary to disable the PCs firewall.

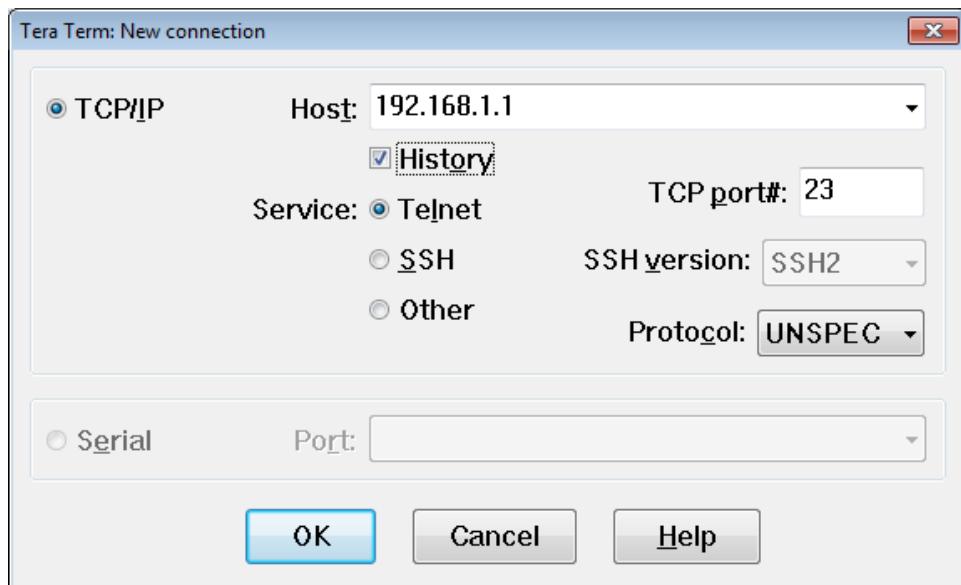
Were the pings successful? _____ Yes

After completing this series of commands, what type of remote access could be used to access R1?

Telnet

- b. Remotely access R1 from PC-A using the Tera Term Telnet client.

Open Tera Term and enter the G0/1 interface IP address of R1 in the Host: field of the Tera Term: New Connection window. Ensure that the **Telnet** radio button is selected and then click **OK** to connect to the router.



Was remote access successful? _____ Yes

Why is the Telnet protocol considered to be a security risk?

A Telnet session can be seen in clear text. It is not encrypted. Passwords can easily be seen using a packet sniffer.

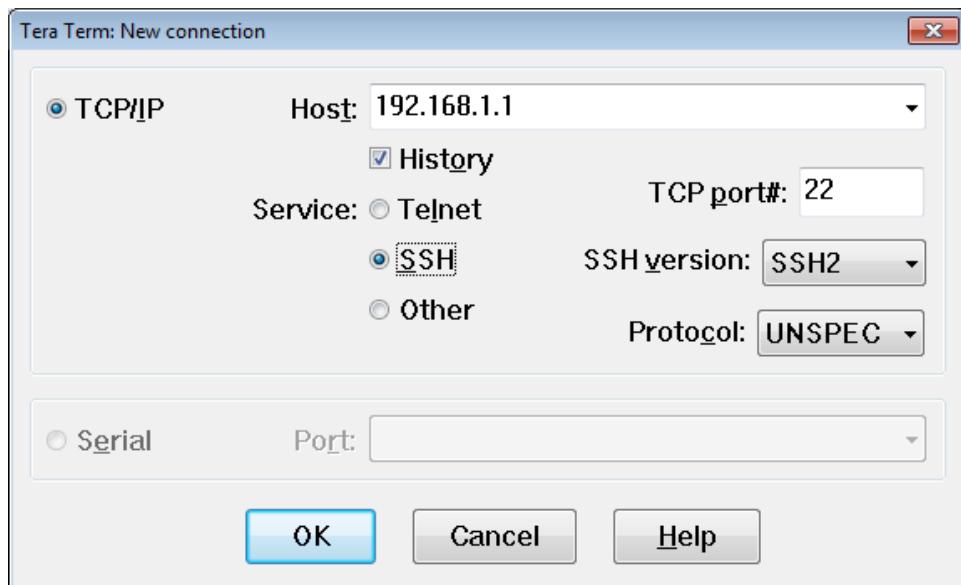
Step 4: Configure the router for SSH access.

- Enable SSH connections and create a user in the local database of the router.

```
R1# configure terminal
R1(config)# ip domain-name CCNA-lab.com
R1(config)# username admin privilege 15 secret adminpass1
R1(config)# line vty 0 4
R1(config-line)# transport input ssh
R1(config-line)# login local
R1(config-line)# exit
R1(config)# crypto key generate rsa modulus 1024
R1(config)# exit
```

- Remotely access R1 from PC-A using the Tera Term SSH client.

Open Tera Term and enter the G0/1 interface IP address of R1 in the Host: field of the Tera Term: New Connection window. Ensure that the **SSH** radio button is selected and then click **OK** to connect to the router.



Was remote access successful? _____ Yes

Part 3: Display Router Information

In Part 3, you will use **show** commands from an SSH session to retrieve information from the router.

Step 1: Establish an SSH session to R1.

Using Tera Term on PC-B, open an SSH session to R1 at IP address 192.168.0.1 and log in as **admin** with the password **adminpass1**.

Step 2: Retrieve important hardware and software information.

- Use the **show version** command to answer questions about the router.

```
R1# show version
Cisco IOS Software, C1900 Software (C1900-UNIVERSALK9-M), Version 15.2(4)M3, RELEASE
SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2012 by Cisco Systems, Inc.
Compiled Thu 26-Jul-12 19:34 by prod_rel_team
```

```
ROM: System Bootstrap, Version 15.0(1r)M15, RELEASE SOFTWARE (fc1)
```

```
R1 uptime is 10 minutes
System returned to ROM by power-on
System image file is "flash0:c1900-universalk9-mz.SPA.152-4.M3.bin"
Last reload type: Normal Reload
Last reload reason: power-on
```

```
This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
```

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Importers, exporters, distributors and users are responsible for compliance with U.S. and local country laws. By using this product you agree to comply with applicable laws and regulations. If you are unable to comply with U.S. and local laws, return this product immediately.

A summary of U.S. laws governing Cisco cryptographic products may be found at:
<http://www.cisco.com/wwl/export/crypto/tool/stqrg.html>

If you require further assistance please contact us by sending email to export@cisco.com.

```
Cisco CISCO1941/K9 (revision 1.0) with 446464K/77824K bytes of memory.  
Processor board ID FTX1636848Z  
2 Gigabit Ethernet interfaces  
2 Serial(sync/async) interfaces  
1 terminal line  
DRAM configuration is 64 bits wide with parity disabled.  
255K bytes of non-volatile configuration memory.  
250880K bytes of ATA System CompactFlash 0 (Read/Write)
```

License Info:

License UDI:

```
-----  
Device#      PID          SN  
-----  
*0          CISCO1941/K9      FTX1636848Z
```

Technology Package License Information for Module:'c1900'

```
-----  
Technology    Technology-package        Technology-package  
              Current       Type            Next reboot  
-----  
ipbase       ipbasek9      Permanent     ipbasek9  
security      None         None          None  
data         None         None          None
```

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

What is the name of the IOS image that the router is running?

Image version may vary, but answers should be something like c1900-universalk9-mz.SPA.152-4.M3.bin.

How much non-volatile random-access memory (NVRAM) does the router have?

Answers may vary, but the output from the **show version** on 1941 router is: 255K bytes of non-volatile configuration memory.

How much Flash memory does the router have?

Answers may vary, but the default output from the **show version** command on the 1941 router is 250880K bytes of ATA System CompactFlash 0 (Read/Write).

- b. The **show** commands often provide multiple screens of outputs. Filtering the output allows a user to display certain sections of the output. To enable the filtering command, enter a pipe (|) character after a **show** command, followed by a filtering parameter and a filtering expression. You can match the output to the filtering statement by using the **include** keyword to display all lines from the output that contain the filtering expression. Filter the **show version** command, using **show version | include register** to answer the following question.

```
R1# show version | include register
Configuration register is 0x2142
```

What is the boot process for the router on the next reload?

Answers may vary. In most cases (0x2102), the router will undergo a normal boot, load the IOS from the Flash memory, and load the startup configuration from the NVRAM if present. If the config register is 0x2142, the router will bypass the startup config and begin at the user-mode command prompt. If the initial boot fails, the router goes into ROMMON mode.

Step 3: Display the startup configuration.

Use the **show startup-config** command on the router to answer the following questions.

```
R1# show start
Using 1674 out of 262136 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
security passwords min-length 10
enable secret 4 3mxoP2KRPf3sFHYl6Vm6.ssJJi9tOJqqb6DMG/YH5No
!
no aaa new-model
!
no ipv6 cef
ip source-route
```

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```
!
no ip domain lookup
ip domain name CCNA-lab.com
ip cef
multilink bundle-name authenticated
!
!
!
license udi pid CISCO2911/K9 sn FTX1636848Z
!
!
username admin privilege 15 secret 7 1304131f020214B383779
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
description Connection to PC-B
ip address 192.168.0.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
description Connection to S1
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 200 0000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
!
banner motd ^CUnauthorized access prohibited!^C
!
line con 0
```

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```
exec-timeout 5 0
password 7 060506324F410A160B0713181F
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
exec-timeout 5 0
password 7 060506324F411F0D1C0713181F
logging synchronous
login local
transport input ssh
!
scheduler allocate 20000 1000
end
```

How are passwords presented in the output?

Passwords are encrypted due to the service password-encryption command. The line con password of ciscoconpass is encrypted as 060506324F410A160B0713181F. The line vty password of ciscovtypass is encrypted as 060506324F411F0D1C0713181F.

Use the **show startup-config | begin vty** command.

```
line vty 0 4
exec-timeout 5 0
password 7 060506324F411F0D1C0713181F
login local
transport input ssh
!
scheduler allocate 20000 1000
end
```

What is the result of using this command?

A user receives the startup configuration output beginning with the line that includes the first instance of the filtering expression.

Step 4: Display the routing table on the router.

Use the **show ip route** command on the router to answer the following questions.

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```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.0.0/24 is directly connected, GigabitEthernet0/0
L        192.168.0.1/32 is directly connected, GigabitEthernet0/0
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/1
```

What code is used in the routing table to indicate a directly connected network?

The C designates a directly connected subnet. An L designates a local interface. Both answers are correct.

How many route entries are coded with a C code in the routing table? _____ 2

Step 5: Display a summary list of the interfaces on the router.

Use the **show ip interface brief** command on the router to answer the following question.

```
R1# show ip interface brief
Interface          IP-Address      OK? Method Status      Protocol
Embedded-Service-Engine0/0 unassigned    YES unset  administratively down down
GigabitEthernet0/0     192.168.0.1    YES manual up       up
GigabitEthernet0/1     192.168.1.1    YES manual up       up
Serial0/0/0           unassigned     YES unset  administratively down down
Serial0/0/1           unassigned     YES unset  administratively down down
R1#
```

What command changed the status of the Gigabit Ethernet ports from administratively down to up?

no shutdown

Part 4: Configure IPv6 and Verify Connectivity

Step 1: Assign IPv6 addresses to R1 G0/0 and enable IPv6 routing.

Note: Assigning an IPv6 address in addition to an IPv4 address on an interface is known as dual stacking, because both the IPv4 and IPv6 protocol stacks are active. By enabling IPv6 unicast routing on R1, PC-B receives the R1 G0/0 IPv6 network prefix and can autoconfigure its IPv6 address and its default gateway.

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- a. Assign an IPv6 global unicast address to interface G0/0, assign the link-local address in addition to the unicast address on the interface, and enable IPv6 routing.

```
R1# configure terminal  
R1(config)# interface g0/0  
R1(config-if)# ipv6 address 2001:db8:acad:a::1/64  
R1(config-if)# ipv6 address fe80::1 link-local  
R1(config-if)# no shutdown  
R1(config-if)# exit  
R1(config)# ipv6 unicast-routing  
R1(config)# exit
```

- b. Use the **show ipv6 int brief** command to verify IPv6 settings on R1.

```
R1#show ipv6 int brief  
Em0/0 [administratively down/down]  
    unassigned  
GigabitEthernet0/0 [up/up]  
    FE80::1  
    2001:DB8:ACAD:A::1  
GigabitEthernet0/1 [up/up]  
    unassigned  
Serial0/0/0 [administratively down/down]  
    unassigned  
Serial0/0/1 [administratively down/down]  
    Unassigned
```

If no IPv6 address is assigned to G0/1, why is it listed as [up/up]?

The [up/up] status reflects the Layer 1 and Layer 2 status of the interface and does not rely on Layer 3 for status.

- c. Issue the **ipconfig** command on PC-B to examine the IPv6 configuration.

What is the IPv6 address assigned to PC-B?

Answers will vary. IPv6 address of 2001:db8:acad:a:d428:7de2:997c:b05a

What is the default gateway assigned to PC-B? _____ fe80::1

Issue a ping from PC-B to the R1 default gateway link local address. Was it successful? _____ Yes

Issue a ping from PC-B to the R1 IPv6 unicast address 2001:db8:acad:a::1. Was it successful? _____
Yes

Reflection

1. In researching a network connectivity issue, a technician suspects that an interface was not enabled. What **show** command could the technician use to troubleshoot this issue?

Answers may vary. However, **show ip interface brief** or **show startup-config** would provide the information.

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2. In researching a network connectivity issue, a technician suspects that an interface was assigned an incorrect subnet mask. What **show** command could the technician use to troubleshoot this issue?

show startup-config or show running-config

3. After configuring IPv6 on the R1 G0/0 PC-B LAN, if you were to ping from PC-A to the PC-B IPv6 address, would the ping succeed? Why or why not?

The ping would fail because R1 interface G0/1 was not configured with IPv6 and PC-A only has an IPv4 address.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Initializing and Reloading a Router and Switch

Step 1: Initialize and reload the router.

- a. Console into the router and enable privileged EXEC mode.

```
Router> enable  
Router#
```

- b. Type the **erase startup-config** command to remove the startup configuration from NVRAM.

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

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- c. Issue the **reload** command to remove an old configuration from memory. When prompted to **Proceed with reload**, press Enter to confirm the reload. (Pressing any other key aborts the reload.)

```
Router# reload  
Proceed with reload? [confirm]  
*Nov 29 18:28:09.923: %SYS-5-RELOAD: Reload requested by console. Reload Reason:  
Reload Command.
```

Note: You may be prompted to save the running configuration prior to reloading the router. Type **no** and press Enter.

```
System configuration has been modified. Save? [yes/no]: no
```

- d. After the router reloads, you are prompted to enter the initial configuration dialog. Enter **no** and press Enter.

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

- e. You are prompted to terminate autoinstall. Type **yes** and then press Enter.

```
Would you like to terminate autoinstall? [yes]: yes
```

Step 2: Initialize and reload the switch.

- a. Console into the switch and enter privileged EXEC mode.

```
Switch> enable  
Switch#
```

- b. Use the **show flash** command to determine if any VLANs have been created on the switch.

```
Switch# show flash  
Directory of flash:/  
  
2 -rwx 1919 Mar 1 1993 00:06:33 +00:00 private-config.text  
3 -rwx 1632 Mar 1 1993 00:06:33 +00:00 config.text  
4 -rwx 13336 Mar 1 1993 00:06:33 +00:00 multiple-fs  
5 -rwx 11607161 Mar 1 1993 02:37:06 +00:00 c2960-lanbasek9-mz.150-2.SE.bin  
6 -rwx 616 Mar 1 1993 00:07:13 +00:00 vlan.dat  
  
32514048 bytes total (20886528 bytes free)  
Switch#
```

- c. If the **vlan.dat** file was found in flash, then delete this file.

```
Switch# delete vlan.dat  
Delete filename [vlan.dat]?
```

- d. You are prompted to verify the filename. At this point, you can change the filename or just press Enter if you have entered the name correctly.

- e. You are prompted to confirm deleting this file. Press Enter to confirm deletion. (Pressing any other key aborts the deletion.)

```
Delete flash:/vlan.dat? [confirm]  
Switch#
```

- f. Use the **erase startup-config** command to erase the startup configuration file from NVRAM. You are prompted to confirm removing the configuration file. Press Enter to confirm to erase this file. (Pressing any other key aborts the operation.)

```
Switch# erase startup-config
```

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```
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Switch#  
g. Reload the switch to remove any old configuration information from memory. You are prompted to confirm
reloading the switch. Press Enter to proceed with the reload. (Pressing any other key aborts the reload.)
Switch# reload
Proceed with reload? [confirm]

Note: You may be prompted to save the running configuration prior to reloading the switch. Type no and
press Enter.

System configuration has been modified. Save? [yes/no]: no

h. After the switch reloads, you should be prompted to enter the initial configuration dialog. Type no and
press Enter.

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

Device Configs

Router R1

```
R1#show run
Building configuration...

Current configuration : 1742 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
security passwords min-length 10
enable secret 4 3mxoP2KRPf3sFHYl6Vm6.ssJJI9tOJqqb6DMG/YH5No
!
no aaa new-model
!
!
!
!
!
!
no ip domain lookup
```

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```
ip domain name CCNA-lab.com
ip cef
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
!
!
license udi pid CISCO1941/K9 sn FTX1636848Z
license accept end user agreement
!
!
username admin privilege 15 password 7 1304131F0202142B383779
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
description Connection to PC-B
ip address 192.168.0.1 255.255.255.0
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
!
interface GigabitEthernet0/1
description Connection to S1
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
```

Lab – Configuring Basic Router Settings with IOS CLI

```
no ip http secure-server
!
!
!
!
control-plane
!
!
banner motd ^CUnauthorized access prohibited!^C
!
line con 0
  exec-timeout 5 0
  password 7 03075218050022434019181604
  logging synchronous
  login
line aux 0
line 2
  no activation-character
  no exec
  transport preferred none
  transport input all
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
  stopbits 1
line vty 0 4
  exec-timeout 5 0
  password 7 14141B180F0B3C3F3D38322631
  logging synchronous
  login local
  transport input ssh
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring Basic Router Settings with CCP (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.0	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
S1	VLAN 1	N/A	N/A	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.0.3	255.255.255.0	192.168.0.1

Objectives

- Part 1: Set Up the Topology and Initialize Devices
- Part 2: Configure Devices and Verify Connectivity
- Part 3: Configure Router to Allow CCP Access
- Part 4: (Optional) Install and Set Up CCP on PC-A
- Part 5: Configure R1 Settings Using CCP
- Part 6: Use CCP Utilities

Background / Scenario

Cisco Configuration Professional (CCP) is a PC-based application that provides GUI-based device management for Integrated Services Routers (ISRs). It simplifies the configuration of routing, firewall, VPN, WAN, LAN, and other settings through menus and easy-to-use wizards.

In this lab, you will configure the router settings using the configuration from the previous lab in this chapter. Layer 3 connectivity must be established between the PC running CCP (PC-A) and R1 before CCP can establish a connection. In addition, HTTP access and authentication must be configured on R1.

You will download and install CCP on the PC and then use it to monitor R1's interface status, configure an interface, set the date and time, add a user to the local database, and edit vty settings. You will also use some of the utilities included in CCP.

Note: Router configurations performed using CCP generate IOS CLI commands. CCP can be very useful for configuring more complex router features because it does not require specific knowledge of the Cisco IOS command syntax.

Lab – Configuring Basic Router Settings with CCP

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Instructor Note: The instructor may opt to have CCP version 2.6 installed on Lab PCs prior to lab assignment.

Instructor Note: This lab is included in the CCNAv5 curriculum to provide the student exposure to the Cisco-developed GUI-based router management utility. Router configurations performed using CCP generate IOS CLI commands. The primary focus of the remaining labs will be on the use of IOS CLI.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Note: PC system requirements for CCP version 2.6 are:

- 2 GHz processor or faster
- 1 GB DRAM minimum; 2 GB recommended
- 400 MB of available hard disk space
- Internet Explorer 6.0 or above
- Screen resolution of 1024x768 or higher
- Java Runtime Environment (JRE) version 1.6.0_11 or later.
- Adobe Flash Player version 10.0 or later, with Debug set to No

Note: The Gigabit Ethernet interfaces on Cisco 1941 ISRs are autosensing and an Ethernet straight-through cable may be used between the router and PC-B. If using another model Cisco router, it may be necessary to use an Ethernet crossover cable.

Part 1: Set Up the Topology and Initialize Devices

Step 1: Cable the network as shown in the topology.

- a. Attach the devices shown in the topology diagram, and cable as necessary.
- b. Power on all the devices in the topology.

Step 2: Initialize and reload the router and switch.

Part 2: Configure Devices and Verify Connectivity

In Part 2, you will configure basic settings, such as the interface IP addresses (G0/1 only), secure device access, and passwords. Refer to the Topology and Addressing Table for device names and address information.

Step 1: Configure the PC interfaces.

- a. Configure the IP address, subnet mask, and default gateway settings on PC-A.
- b. Configure the IP address, subnet mask, and default gateway settings on PC-B.

Step 2: Configure the router.

Note: Do NOT configure interface G0/0 at this time. You will configure this interface using CCP later in the lab.

- a. Console into the router and enable privileged EXEC mode.
- b. Enter into global configuration mode.
- c. Disable DNS lookup.
- d. Assign a device name to the router.
- e. Require that a minimum of 10 characters be used for all passwords.
- f. Assign **cisco12345** as the privileged EXEC encrypted password.
- g. Assign **ciscoconpass** as the console password and enable login.
- h. Assign **ciscovtypass** as the vty password and enable login,
- i. Configure **logging synchronous** on the console and vty lines.
- j. Encrypt the clear text passwords.
- k. Create a banner that warns anyone accessing the device that unauthorized access is prohibited.
- l. Configure the IP addresses, an interface description, and activate G0/1 interface on the router.
- m. Save the running configuration to the startup configuration file.

Step 3: Verify network connectivity.

Verify that you can ping R1 G0/1 from PC-A.

Part 3: Configure the Router to Allow CCP Access

In Part 3, you will set up the router to allow CCP access by enabling HTTP and HTTPS server services. You will also enable HTTP authentication to use the local database.

Step 1: Enable HTTP and HTTPS server services on the router.

```
R1(config)# ip http server  
R1(config)# ip http secure-server
```

Step 2: Enable HTTP authentication to use the local database on the router.

```
R1(config)# ip http authentication local
```

Step 3: Configure the router for CCP access.

Assign a user in the router local database for accessing CCP using username **admin** and password **adminpass1**.

```
R1(config)# username admin privilege 15 secret adminpass1
```

Part 4: (Optional) Install and Set Up CCP on PC-A

Step 1: Install CCP.

Note: This step can be skipped if CCP is already installed on PC-A.

- a. Download CCP 2.6 from Cisco's website:

<http://software.cisco.com/download/release.html?mdfid=281795035&softwareid=282159854&release=2.6&rellifecycle=&relind=AVAILABLE&reltype=all>

- b. Choose the **cisco-config-pro-k9-pkg-2_6-en.zip** file.

Note: Verify that you select the correct CCP file and not CCP Express. If there is a more current release of CCP, you may choose to download it; however, this lab is based on CCP 2.6.

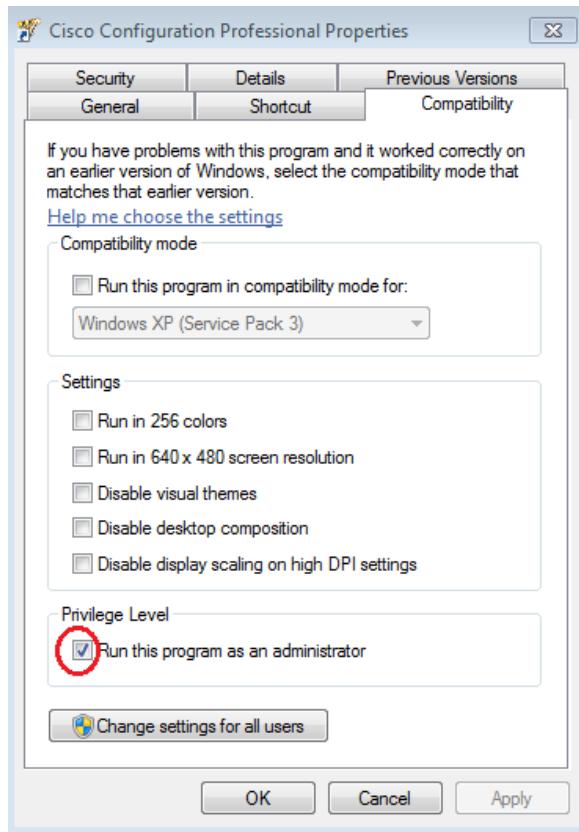
- c. Agree to the terms and conditions, and download and save the file to the desired location.
- d. Open the zip file and run the CCP executable.
- e. Follow the on-screen instructions to install CCP 2.6 on your PC.

Step 2: Change settings to run as the administrator.

CCP may fail to launch correctly if it is not run as an administrator. You can change the launch settings so that it automatically runs in administrator mode.

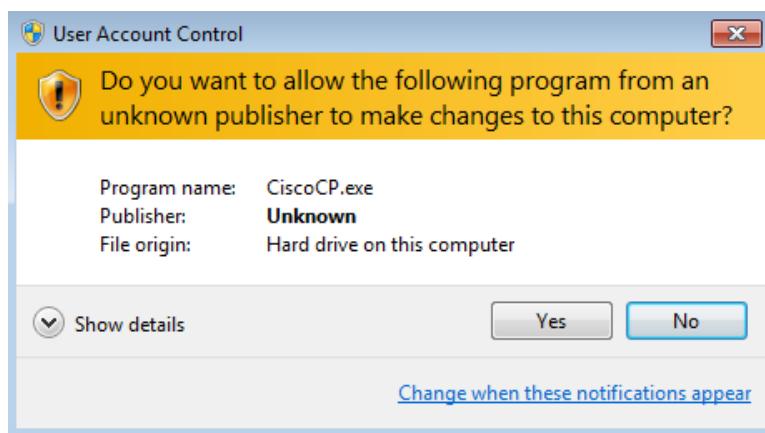
- a. Right-click the **CCP** desktop icon (or click the **Start** button) and then right-click **Cisco Configuration Professional**. In the drop-down list, select **Properties**.
- b. In the Properties dialog box, select the **Compatibility** tab. In the Privilege Level section, click the **Run this program as an administrator** checkbox, and then click **OK**.

Lab – Configuring Basic Router Settings with CCP



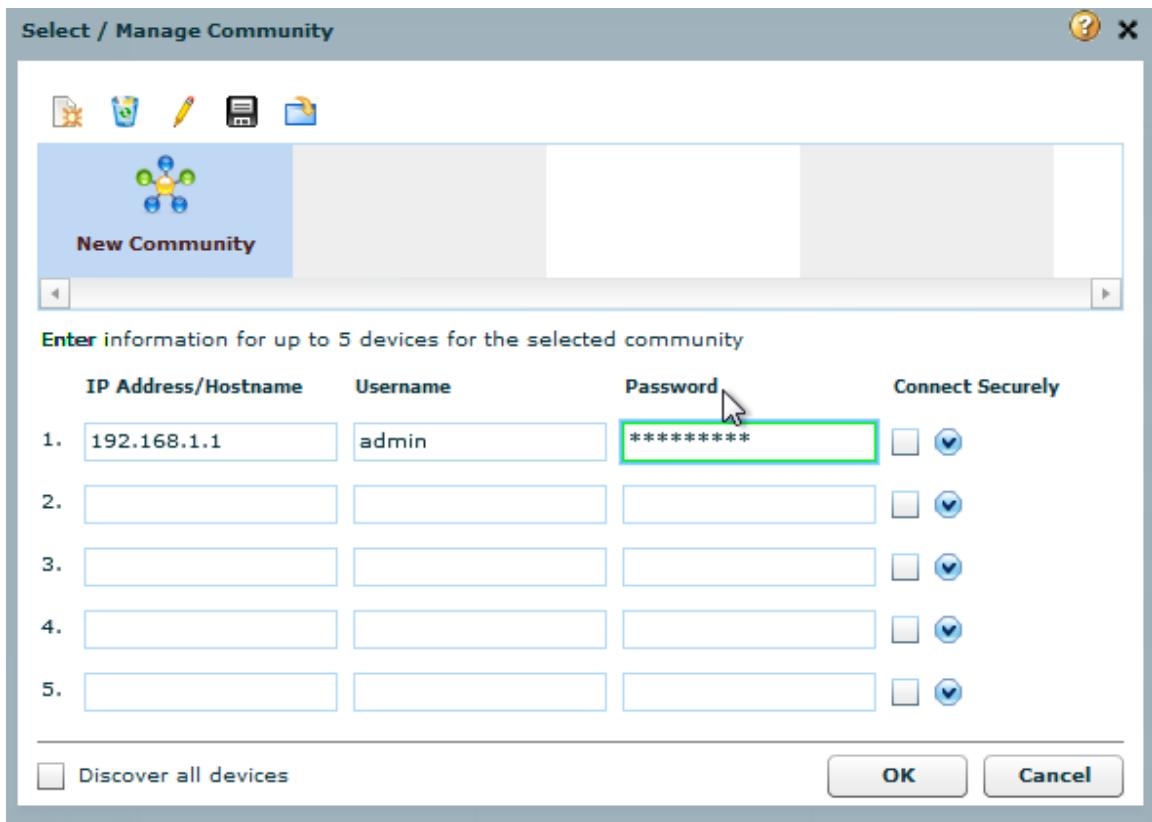
Step 3: Create or manage communities.

- On PC-A, start CCP. (Double-click the CCP desktop icon or click **Start > Cisco Configuration Professional.**)
- If you receive a security warning message prompting to allow the CiscoCP.exe program to make changes to the computer, click **Yes**.



- When CCP starts, the **Select / Mange Community** dialog box displays. Enter the IP address for R1 G0/1, and the username **admin** and password **adminpass1** that you added to the local database during the router configuration in Part 2. Click **OK**.

Lab – Configuring Basic Router Settings with CCP



- d. In the Community Information window, click **Discover**.

The screenshot shows the Cisco Configuration Professional interface. On the left, there's a sidebar with 'Community View' and 'Utilities' (Flash File Management, Configuration Editor, Save Configuration to PC). The main area is titled 'Community Information' and shows a table with one row:

IP address / Hostname	Router Hostname	Connection Type	Discovery Status
192.168.1.1		Non secure	Not discovered

At the bottom of the main area, there are buttons: 'Manage Devices', 'Delete', 'Discover' (which is circled in red), 'Discovery Details', 'Cancel Discovery', and 'Router Status'.

If you have configured the router correctly, the Discovery Status changes from **Not discovered** to **Discovered**, and R1 appears in the Router Hostname column.

Note: If there is a problem with your configuration, you will see a “Discovery failed” status. Click **Discovery Details** to determine why the discovery process failed and then troubleshoot the problem.

Part 5: Configure R1 Settings Using CCP

In Part 5, you will use CCP to display information about R1, configure interface G0/0, set the date and time, add a user to the local database, and change your vty settings.

Step 1: View the status of the interfaces on R1.

- On the CCP toolbar, click **Monitor**.



- In the left navigation pane, click **Router > Overview** to display the Monitor Overview screen in the right content pane.

- Use the up and down arrows to the right of the interface list to scroll through the list of interfaces for the router.

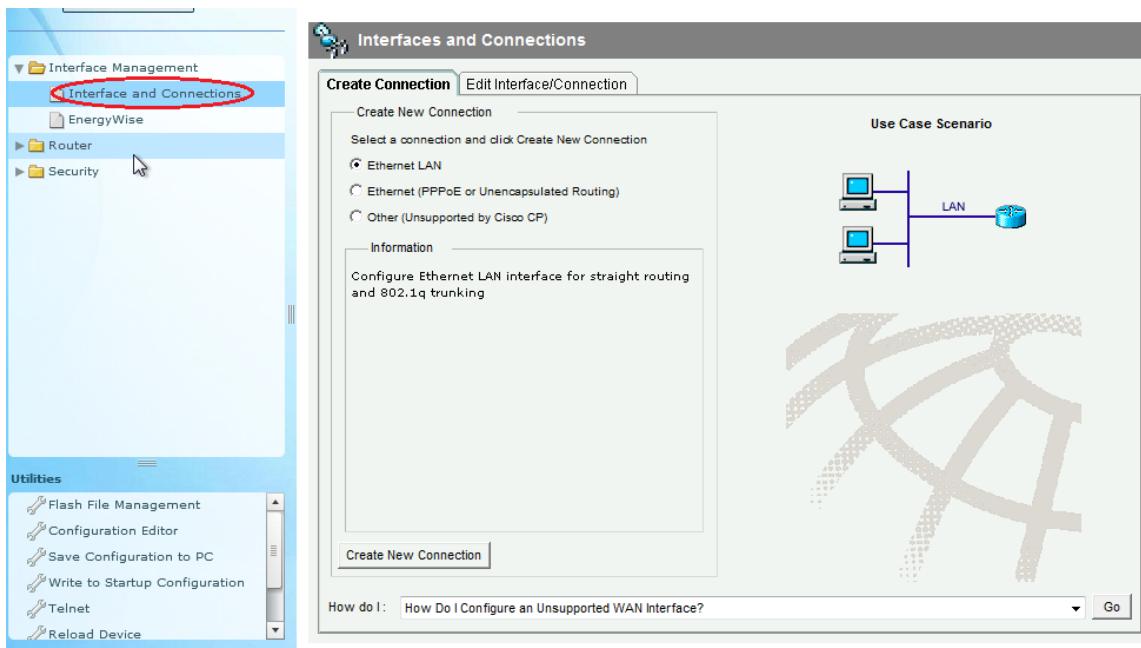
Interface Status					
Total Interface(s) Up:		1		Total Interface(s) Down: 4	
Interface	IP	Status	Bandwidth Usage	Description	
GigabitEthernet0/0	no ip address	Down	0 %		
GigabitEthernet0/1	192.168.1.1	Up	0 %		

Step 2: Use the Ethernet LAN wizard to configure interface G0/0.

- On the CCP toolbar, click **Configure**.



- In the left navigation pane, click **Interface Management > Interface and Connections** to display the Interfaces and Connections screen in the right content pane.



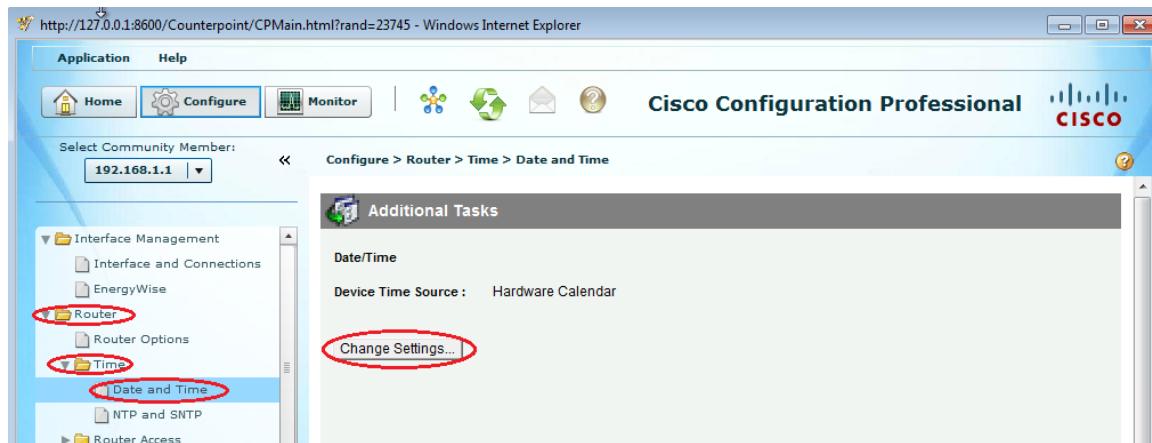
- Click **Create New Connection** to start the Ethernet LAN wizard.
- When you are prompted to enable AAA on the router, click **No**.
- Click **Next** to be guided through the Layer 3 Ethernet interface creation process.
- Keep the **Configure this interface for straight routing** radio button selected and click **Next**.
- Enter **192.168.0.1** in the IP address field and **255.255.255.0** in the Subnet mask field and click **Next**.
- Keep the **No** radio button selected on the DHCP server screen and click **Next**.
- Review the summary screen and click **Finish**.
- Click the **Save running config to device's startup config** check box, and then click **Deliver**. This adds the commands shown in the preview window to the running configuration, and then saves the running configuration to the startup configuration on the router.
- The Commands Delivery Status window displays. Click **OK** to close this window. You will be routed back to the Interfaces and Connections screen; G0/0 should have turned green and displayed as Up in the Status column.

Lab – Configuring Basic Router Settings with CCP

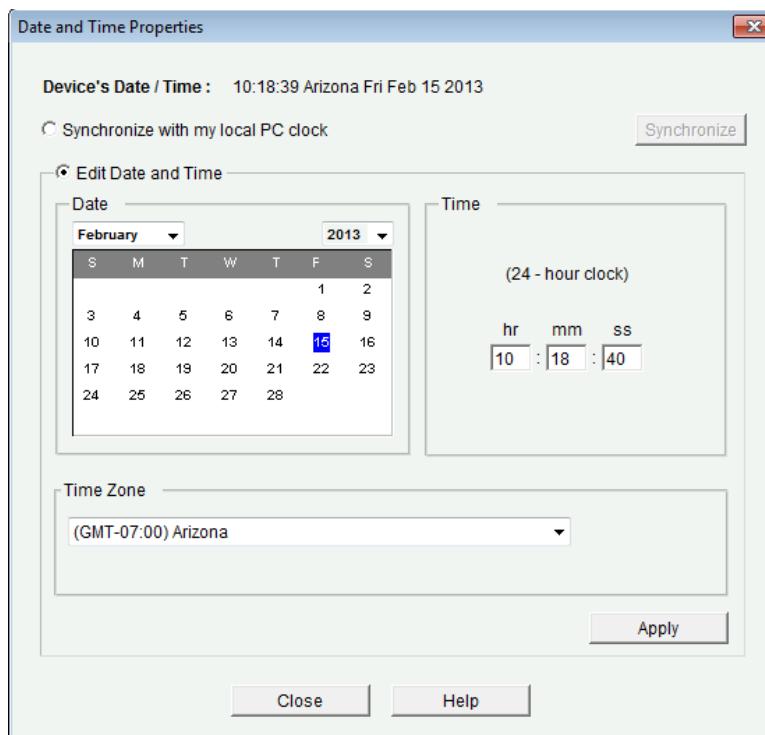
Interface	IP	Type	Slot	Status	Description
Embedded-Service-Engi	no IP address	Embedded-Service-Engine	0	Dow	
GigabitEthernet0/0	192.168.0.1	GigabitEthernet	0	Up	
GigabitEthernet0/1	192.168.1.1	GigabitEthernet	0	Up	Connection to S1 F0/5
Serial0/0/0	no IP address	Serial	0	Dow	
Serial0/0/1	no IP address	Serial	0	Dow	

Step 3: Set the date and time on the router.

- In the left navigation pane, select **Router > Time > Date and Time** to display the Additional Tasks > Date/Time screen in the right content pane. Click **Change Settings....**



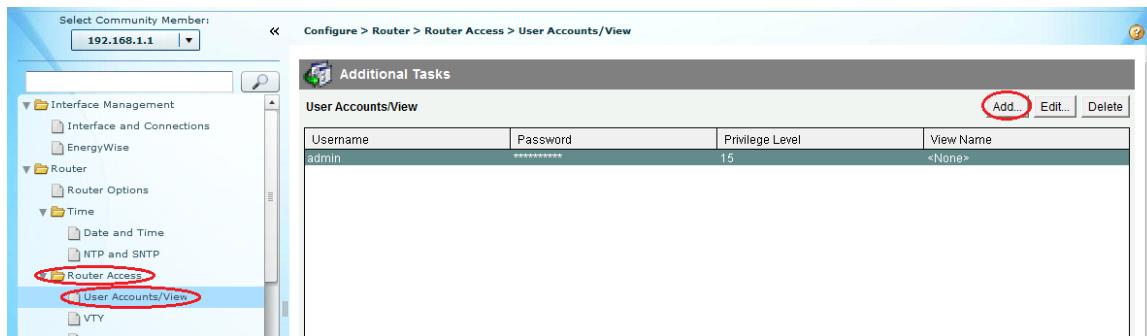
- In the Date and Time Properties window, edit the Date, Time, and Time Zone. Click **Apply**.



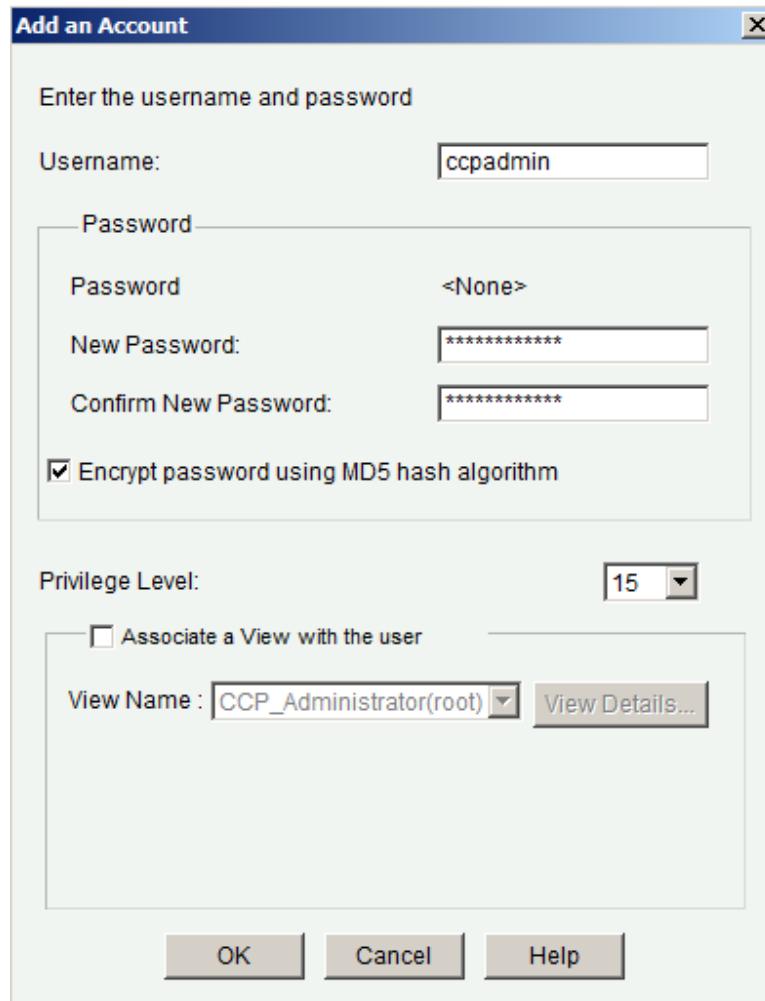
- In the Router's clock configured window, click **OK**. In the Date and Time Properties window, click **Close**.

Step 4: Add a new user account to the local database.

- In the left navigation pane, select **Router > Router Access > User Accounts/View** to display the Additional Tasks > User Accounts/View screen in the content pane on the right. Click the **Add...** button.



- Enter **ccpadmin** in the Username: field. Enter **ciscoccppass** in the New Password: and Confirm New Password: fields. Select **15** in the Privilege Level: drop-down list. Click **OK** to add this user to the local database.



Lab – Configuring Basic Router Settings with CCP

- c. In the Deliver Configuration to Device window, click the **Save running config to device's startup config** check box, and then click **Deliver**.
- d. Review the information in the Commands Delivery Status window, and click **OK**. The new user account should now appear in the content pane on the right.

Username	Password	Privilege Level	View Name
admin	*****	15	<None>
ccpadmin	*****	15	<None>

Step 5: Edit vty line settings.

- a. In the left navigation pane, select **Router Access > VTY** to display the Additional Tasks > VTYs screen in the content pane on the right. Click **Edit....**

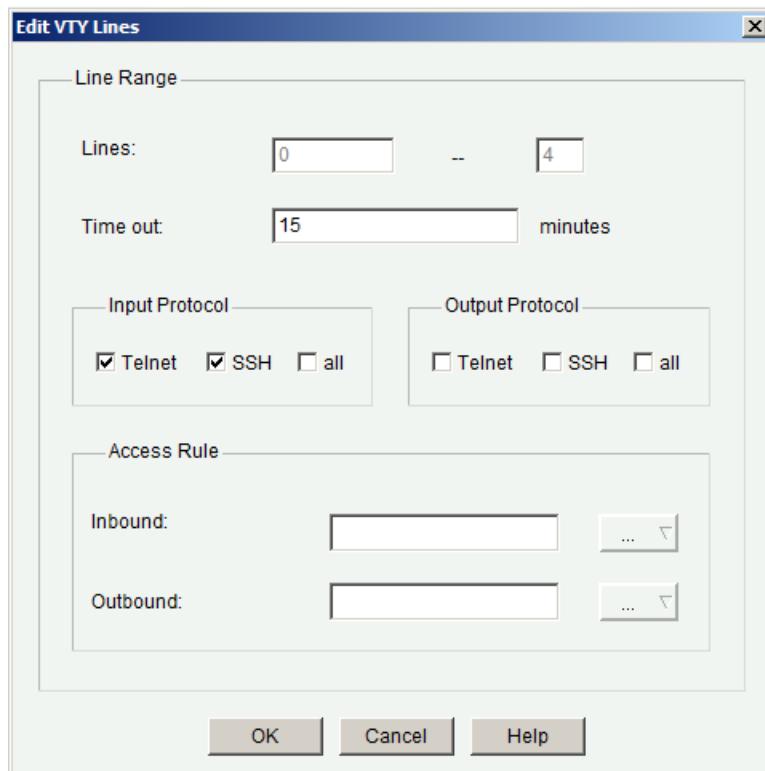
The screenshot shows the Cisco Management interface with the following details:

- Left Navigation Pane:** Shows a tree structure with **Select Community Member:** set to **192.168.1.1**. The **Router Access > VTY** node is highlighted and circled in red.
- Content Pane:** The title is **Configure > Router > Router Access > VTY**. It displays the **Additional Tasks > VTYs** table.
- Table Headers:** Item Name, Item Value
- Table Data:**

Item Name	Item Value
Line Range	0-4
Input Protocols Allowed	ssh
Output Protocols Allowed	None
EXEC timeout	5
Inbound Access-class	None
Outbound Access-class	None

- b. In the Edit VTY Lines window, change the Time out: field to **15** minutes. Click the **Input Protocol > Telnet** check box. Review the other options available. Also select the **SSH** checkbox. Then click **OK**.

Lab – Configuring Basic Router Settings with CCP



- c. Review the commands that will be delivered to the running configuration on the Deliver Configuration to Device screen and click **Deliver**. In the Commands Delivery Status window, click **OK**. The content pane on the right should reflect the changes to the EXEC timeout value.

Item Name	Item Value
Line Range	0-4
Input Protocols Allowed	ssh telnet
Output Protocols Allowed	None
EXEC timeout	15
Inbound Access-class	None
Outbound Access-class	None

Part 6: Use CCP Utilities

In Part 6, you will use the Utilities pane to save the router's running configuration to the startup configuration. The Ping utility will be used to test network connectivity, and the View utility will be used to show the router's running configuration. Finally, you will close CCP.

Step 1: Save the router's running configuration to the startup configuration.

- a. At the bottom of the left navigation pane, locate the Utilities pane. Click **Write to Startup Configuration**.

Lab – Configuring Basic Router Settings with CCP



- b. The content pane displays a confirmation screen. Click **Confirm**. An Information window displays, letting you know that the configuration was saved successfully. Click **OK**.

Step 2: Use the Ping utility to test connectivity to PC-B.

- a. In the Utilities pane, click **Ping and Traceroute** to display the Ping and Traceroute screen in the content pane. Enter **192.168.0.3** in the Destination*: field and then click **Ping**. Use the scrollbar to the right of the results box to view the results of your ping.

Utilities > Ping and Traceroute

Destination*: 192.168.0.3 (IP Address or Hostname)

Advanced

Ping Traceroute

Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

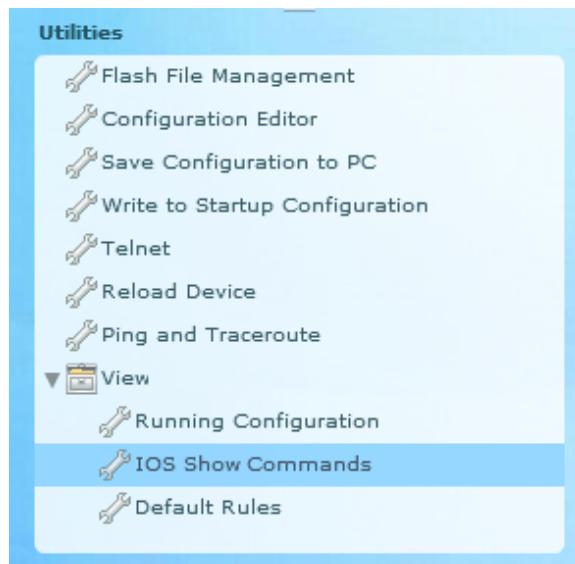
Clear

* - indicates mandatory field

Step 3: Use the View utility to show the running configuration for the router.

- a. In the Utilities pane, click **View > IOS Show Commands** to display the IOS Show Commands screen in the content pane.

Lab – Configuring Basic Router Settings with CCP



- b. Select **show run** from the drop-down list and click **Show**. The router's running configuration is displayed in the content pane.

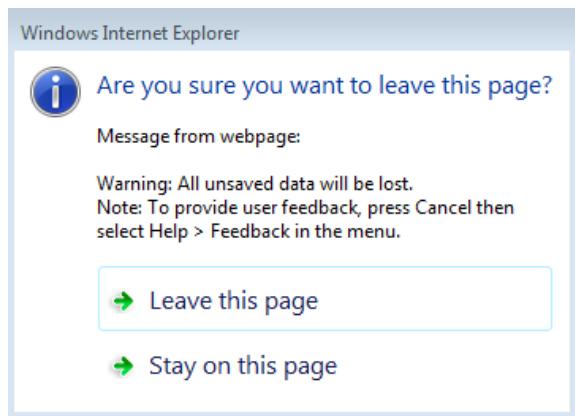
The screenshot shows the 'Utilities > View > IOS Show Commands' interface. A search bar contains 'show run'. Below it, the configuration text is displayed:

```
Building configuration...
Current configuration : 3576 bytes
!
! Last configuration change at 18:43:38 UTC Fri Feb 15 2013 by admin
! NVRAM config last updated at 18:57:31 UTC Fri Feb 15 2013 by admin
! NVRAM config last updated at 18:57:31 UTC Fri Feb 15 2013 by admin
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
no logging buffered
enable secret 5 $1$rej$9foNkH.43YVdrK2UA1iTk.
!
no aaa new-model
!
memory-size iomem 10
!
no ipv6 cef
ip auth-proxy max-login-attempts 5
ip admission max-login-attempts 5
!
!
```

Step 4: Close CCP.

Close the CCP window. When a Windows Internet Explorer confirmation window displays, click **Leave this page**.

Lab – Configuring Basic Router Settings with CCP



Reflection

1. What transport protocol does CCP use to access the router and what commands are used to allow access?

CCP uses the HTTP or HTTPS protocol to access the router. The **ip http server** or **ip http secure-server** are used to allow CCP access.

2. What router command tells CCP to use the local database to authenticate?

ip http authentication local

3. What other **show** commands are available in the Utilities pane of CCP?

Answers may vary, but include: show run, show flash, show startup-config, show access-lists, show diag, show interfaces, show version, show tech-support, show environment.

4. Why would you want to use CCP instead of the IOS CLI?

If configuring complex features such as a VPN or firewall, CCP can make the process easier with menus and wizards, while not requiring intimate knowledge of IOS commands. In addition, entering IOS commands can be prone to keystroke errors. CCP generates the equivalent IOS commands.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (After parts 1 and 2 of this lab)

```
R1#sh run
Building configuration...

Current configuration : 1794 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
security passwords min-length 10
enable secret 5 $1$z2a8$xZifGG09oPkH2emGuNFD0
!
no aaa new-model
!
no ipv6 cef
```

Lab – Configuring Basic Router Settings with CCP

```
ip source-route
ip cef
!
no ip domain lookup
ip domain name CCNA-lab.com
multilink bundle-name authenticated
!
crypto pki token default removal timeout 0
!
username admin privilege 15 secret 5 $1$MYCd$USPXpT5/TkHN6TZjZND4O/
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  description Connection to S1 F0/5
  ip address 192.168.1.1 255.255.255.0
  duplex auto
  speed auto
!
Interface Serial0/0/0
  no ip address
  shutdown
  clock rate 200 0000
!
Interface Serial0/0/1
  no ip address
  shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C

  Unauthorized access prohibited!

^C
!
line con 0
  exec-timeout 5 0
```

Lab – Configuring Basic Router Settings with CCP

```
password 7 060506324F410A160B0713181F
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
exec-timeout 5 0
password 7 104D000A0618041F15142B3837
login local
transport input ssh
!
scheduler allocate 20000 1000
end
```

Router R1 (Final)

```
R1#sh run
Building configuration...

Current configuration : 3576 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
security passwords min-length 10
enable secret 5 $1$z2a8$xBZifGG09oPkH2emGuNFd0
!
no aaa new-model
memory-size iomem 10
clock timezone Arizona -7 0
!
no ip domain lookup
ip domain name CCNA-lab.com
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
crypto pki trustpoint TP-self-signed-2463995903
```

Lab – Configuring Basic Router Settings with CCP

```
enrollment selfsigned
subject-name cn=IOS-Self-Signed-Certificate-2463995903
revocation-check none
rsakeypair TP-self-signed-2463995903
!
crypto pki certificate chain TP-self-signed-2463995903
certificate self-signed 01
3082022B 30820194 A0030201 02020101 300D0609 2A864886 F70D0101 05050030
31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
69666963 6174652D 32343633 39393539 3033301E 170D3133 30323139 31363538
35335A17 0D323030 31303130 30303030 305A3031 312F302D 06035504 03132649
4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 34363339
39353930 3330819F 300D0609 2A864886 F70D0101 01050003 818D0030 81890281
8100EACF 6CE8CF7D 97DAAF17 BA2F5368 A5529133 5184C2A5 2F3208C0 6A94B90B
5828FCBA 975BDAFC 02FB1AD7 28C8F900 12AC227E A0C5FC00 0659E501 0B9B350F
4A79BB3B A0D6AEF4 760ED122 EEB9BFAA C68E76DE 180C64AD 5B82F9DB 6A4CCEFE
8264BC03 4EDA5D1F B829762C B050E993 89B52977 008F8E87 14ABB782 38826D13
5BD70203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF 301F0603
551D2304 18301680 14ADC716 DB4F937D 4F4AF51B 8F0A6A03 83665A9A 7C301D06
03551D0E 04160414 ADC716DB 4F937D4F 4AF51B8F 0A6A0383 665A9A7C 300D0609
2A864886 F70D0101 05050003 81810084 5AF24507 9D50DC5E 57BC957D 500A590C
C5A93AD6 831A47E1 81CCD68E E24DCCF5 00B55F9A E65A630B FCBCFF0C E25AF701
A498CA1F F6DC675A CE12344F 6DC8457C D0C4C13A BFE8D951 ABB2C969 71F3100D
058CC8F1 D2CFDD9F 4848FD53 BA010956 10DADCC6 7A31FB89 DBEB1EDF 624AAF99
526BB3F5 60801F04 DD52971E 9AD735
quit
!
username admin privilege 15 secret 5 $1$MYCd$USPXpT5/TkHN6TZjZND4O/
username cccpadmin privilege 15 secret 5 $1$5oPi$xdns6VvP516JIqjQ4k/lH/
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
description $ETH-LAN$
ip address 192.168.0.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
description Connection to S1 F0/5
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
```

Lab – Configuring Basic Router Settings with CCP

```
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
ip http server
ip http authentication local
ip http secure-server
!
control-plane
!
banner motd ^C
```

```
Unauthorized access prohibited!
```

```
^C
!
line con 0
exec-timeout 5 0
password 7 060506324F410A160B0713181F
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
exec-timeout 15 0
password 7 104D000A0618041F15142B3837
login local
transport input telnet ssh
!
scheduler allocate 20000 1000
!
end
```



We Really Could Use a Map! (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Describe the three types of routes that are populated in a routing table (to include: directly-connected, static, and dynamic).

This modeling activity should help students feel more comfortable with reading a routing table. Two router tables will be presented to the students – they will read the tables, identify routing information, and reflect on how information was recorded in the table).

Scenario

Use the Ashland and Richmond routing tables shown below. With the help of a classmate, draw a network topology using the information from the tables. To assist you with this activity, follow these guidelines:

- Start with the Ashland router - use its routing table to identify ports and IP addresses/networks.
- Add the Richmond router - use its routing table to identify ports and IP addresses/networks.
- Add any other intermediary and end devices, as specified by the tables.

In addition, record answers from your group to the reflection questions provided with this activity.

Be prepared to share your work with another group or the class.

Resources

```
Ashland> show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2, 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

  192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
    C 192.168.1.0/24 is directly connected, GigabitEthernet0/1
    L 192.168.1.1/32 is directly connected, GigabitEthernet0/1
  192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
    C 192.168.2.0/24 is directly connected, Serial0/0/0
    L 192.168.2.1/32 is directly connected, Serial0/0/0
  D 192.168.3.0/24 [90/2170368] via 192.168.4.2, 01:53:50, GigabitEthernet0/0
  192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks
    C 192.168.4.0/24 is directly connected, GigabitEthernet0/0
    L 192.168.4.1/32 is directly connected, GigabitEthernet0/0
  D 192.168.5.0/24 [90/3072] via 192.168.4.2, 01:59:14, GigabitEthernet0/0
  S 192.168.6.0/24 [1/0] via 192.168.2.2

Ashland>
```

We Really Could Use a Map!

```
Richmond> show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2, 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

S 192.168.1.0/24 [1/0] via 192.168.3.1
D 192.168.2.0/24 [90/2170368] via 192.168.5.2, 01:55:09, GigabitEthernet0/1
  192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
    C 192.168.3.0/24 is directly connected, Serial0/0/0
    L 192.168.3.2/32 is directly connected, Serial0/0/0
D 192.168.4.0/24 [90/3072] via 192.168.5.2, 01:55:09, GigabitEthernet0/1
  192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks
    C 192.168.5.0/24 is directly connected, GigabitEthernet0/1
    L 192.168.5.1/32 is directly connected, GigabitEthernet0/1
  192.168.6.0/24 is variably subnetted, 2 subnets, 2 masks
    C 192.168.6.0/24 is directly connected, GigabitEthernet0/0
    L 192.168.6.1/32 is directly connected, GigabitEthernet0/0
Richmond>
```

Reflection

1. How many directly connected routes are listed on the Ashland router? What letter represents a direct connection to a network on a routing table?

The answer is C.

2. Find the route to the 192.168.6.0/24 network. What kind of route is this? Was it dynamically discovered by the Ashland router or manually configured by a network administrator on the Ashland router?

The answer is static route.

3. If you were configuring a default (static route) to any network from the Ashland router and wanted to send all data to 192.168.2.2 (the next hop) for routing purposes, how would you write it?

```
Ashland(config)# ip route 0.0.0.0 0.0.0.0 192.168.2.2
```

4. If you were configuring a default (static route) to any network from the Ashland router and wanted to send all data through your exit interface, how would you write it?

```
Ashland(config)# ip route 0.0.0.0 0.0.0.0 S0/0/0
```

5. When would you choose to use static routing, instead of letting dynamic routing take care of the routing paths for you?

If a router has a very reliable port to use, you may wish to route all traffic through (or to) that port, as this decreases processing load on the router. Also, sometimes network administrators will route traffic to certain network through certain ports to secure their networks.

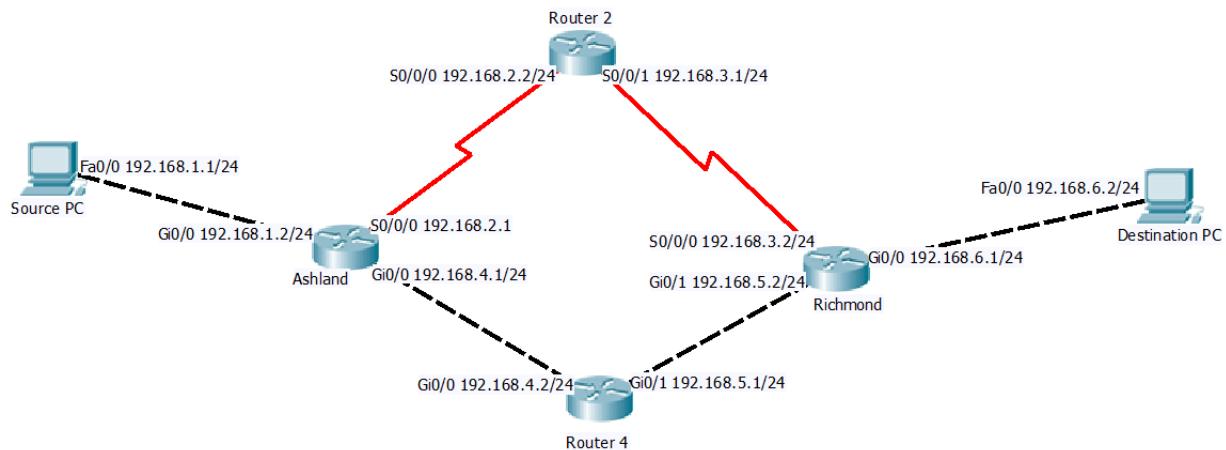
We Really Could Use a Map!

6. What is the significance of the L on the left side of the routing table?

It indicates the “link local” address of the port on the router which is configured by the network administrator.

Modeling Activity Graphic Representation (Instructor Resource Only)

Instructor Note: This is an example model that might be “built” as a result of this activity:



Identify elements of the model that map to IT-related content:

- Routes
- Routing Table
- Exit Interface
- Next Hop Interface
- Static Route
- Default Routing
- Static Routing
- Dynamic Routing
- Link Local



Switching to Local-Network Channels (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure routing between VLANs in a small to medium-sized business network.

This activity introduces students to the concept of using switches and routers to allow virtual networks to communicate with each other.

Scenario

You work for a small- to medium-sized business. As the network administrator, you are responsible for ensuring that your network operates efficiently and securely.

Several years ago, you created VLANs on your only switch for two of your departments, Accounting and Sales. As the business has grown, it has become apparent that sometimes these two departments must share company files and network resources.

You discuss this scenario with network administrators in a few branches of your company. They tell you to consider using inter-VLAN routing.

Research the concept of inter-VLAN routing. Design a simple presentation to show your manager how you would use inter-VLAN routing to allow the Accounting and Sales departments to remain separate, but share company files and network resources.

Resources

- Internet connection
- Software presentation program

Directions

Work with a partner to complete this activity.

Step 1: Use your Internet connection to research how inter-VLANs operate.

- a. Use a search engine to locate a few basic articles, or short videos, that discuss the concept of inter-VLAN routing.
- b. Read the articles, or view the videos, and take notes about how VLANs operate.
- c. Make sure you record where the information was found so that you can include the sources in Step 2 of this activity.

Step 2: Create a presentation for your manager.

- a. Design a small presentation for your manager listing how you would set up an inter-VLAN routing-based network for your small- to medium-sized business, using no more than five slides.
- b. Include slides which focus on:
 - 1) A synopsis of reasons you would change your current network to an inter-VLAN-switched network. Restate what you are trying to accomplish in your design proposal.
 - 2) A basic, easily understood definition and benefits of using inter-VLAN routing.
 - 3) A graphic depicting how you would modify your current network to use inter-VLAN routing.

Switching to Local-Network Channels

- a) Your current network utilizes one Cisco 2960 switch and one Cisco 1941 series router.
- b) Funding for new equipment is not negotiable.
- 4) How inter-VLANs could continue to assist with network traffic yet allow departments to communicate with each other.
- 5) How inter-VLAN routing would scale for the future.
- c. Make sure you quote the sources upon which you are basing your presentation.

Step 3: Present your proposal to the entire class.

Instructor Resource Information

Two possible sources of Internet information sites to support this activity might include:

- VLAN Guide for Networking Professionals - <http://www.computerweekly.com/tutorial/VLAN-guide-for-networking-professionals>
- InterVLAN Routing Tutorial – Premium Tutorial <http://www.9tut.com/intervlan-routing-tutorial>
- Chapter 5. Inter-VLAN Routing
http://www.informit.com/library/content.aspx?b=CCNP_Studies_Switching&seqNum=44
- Basic Configuration of VLANS, Switchports and InterVLAN Routing
http://www.youtube.com/watch?v=ojh8_BDcXyl

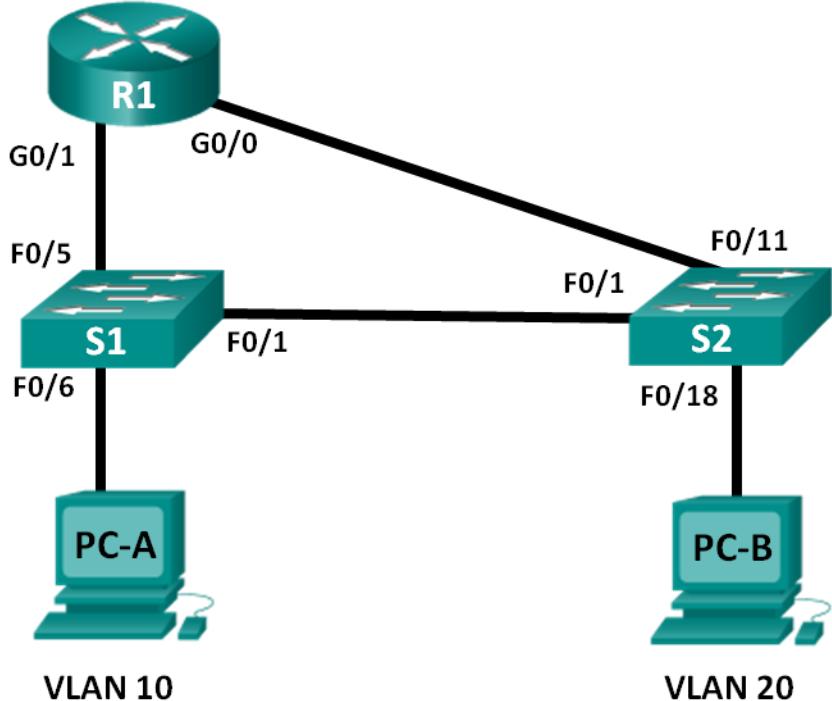
Identify elements of the model that map to IT-related content:

- Inter-VLAN routing definition
- Inter-VLAN design
- Inter-VLAN broadcast domains

Lab – Configuring Per-Interface Inter-VLAN Routing (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.20.1	255.255.255.0	N/A
	G0/1	192.168.10.1	255.255.255.0	N/A
S1	VLAN 10	192.168.10.11	255.255.255.0	192.168.10.1
S2	VLAN 10	192.168.10.12	255.255.255.0	192.168.10.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure Switches with VLANs and Trunking

Part 3: Verify Trunking, VLANs, Routing, and Connectivity

Background / Scenario

Legacy inter-VLAN routing is seldom used in today's networks; however, it is helpful to configure and understand this type of routing before moving on to router-on-a-stick (trunk-based) inter-VLAN routing or configuring Layer-3 switching. Also, you may encounter per-interface inter-VLAN routing in organizations with very small networks. One of the benefits of legacy inter-VLAN routing is ease of configuration.

In this lab, you will set up one router with two switches attached via the router Gigabit Ethernet interfaces. Two separate VLANs will be configured on the switches, and you will set up routing between the VLANs.

Note: This lab provides minimal assistance with the actual commands necessary to configure the router and switches. The required switch VLAN configuration commands are provided in Appendix A of this lab. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS, Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS, Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and clear any configurations, if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switches.

Step 3: Configure basic settings for R1.

- a. Disable DNS lookup.
- b. Assign the device name.
- c. Assign **class** as the privileged EXEC mode encrypted password.
- d. Assign **cisco** as the console and vty line password and enable login.
- e. Configure addressing on G0/0 and G0/1 and enable both interfaces.

Step 4: Configure basic settings on S1 and S2.

- a. Disable DNS lookup.
- b. Assign the device name.

Lab – Configuring Per-Interface Inter-VLAN Routing

- c. Assign **class** as the privileged EXEC mode encrypted password.
- d. Assign **cisco** as the console and vty line password and enable login.

Step 5: Configure basic settings on PC-A and PC-B.

Configure PC-A and PC-B with IP addresses and a default gateway address according to the Addressing Table.

Part 2: Configure Switches with VLANs and Trunking

In Part 2, you will configure the switches with VLANs and trunking.

Step 1: Configure VLANs on S1.

- a. On S1, create VLAN 10. Assign **Student** as the VLAN name.
- b. Create VLAN 20. Assign **Faculty-Admin** as the VLAN name.
- c. Configure F0/1 as a trunk port.
- d. Assign ports F0/5 and F0/6 to VLAN 10 and configure both F0/5 and F0/6 as access ports.
- e. Assign an IP address to VLAN 10 and enable it. Refer to the Addressing Table.
- f. Configure the default gateway according to the Addressing Table.

Step 2: Configure VLANs on S2.

- a. On S2, create VLAN 10. Assign **Student** as the VLAN name.
- b. Create VLAN 20. Assign **Faculty-Admin** as the VLAN name.
- c. Configure F0/1 as a trunk port.
- d. Assign ports F0/11 and F0/18 to VLAN 20 and configure both F0/11 and F0/18 as access ports.
- e. Assign an IP address to VLAN 10 and enable it. Refer to the Addressing Table.
- f. Configure the default gateway according to the Addressing Table.

Part 3: Verify Trunking, VLANs, Routing, and Connectivity

Step 1: Verify the R1 routing table.

- a. On R1, issue the **show ip route** command. What routes are listed on R1?

The 192.168.10.0/24 and 192.168.20.0/24 networks are listed on R1.

```
R1# show ip route
*Mar 25 15:05:00.003: %SYS-5-CONFIG_I: Configured from console by console
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
+ - replicated route, % - next hop override
Gateway of last resort is not set
    192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.10.0/24 is directly connected, GigabitEthernet0/1
L          192.168.10.1/32 is directly connected, GigabitEthernet0/1
    192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.20.0/24 is directly connected, GigabitEthernet0/0
L          192.168.20.1/32 is directly connected, GigabitEthernet0/0
```

- b. On both S1 and S2, issue the **show interface trunk** command. Is the F0/1 port on both switches set to trunk? _____ Yes

```
S1# show interface trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/1	1-4094			
Port	Vlans allowed and active in management domain			
Fa0/1	1,10,20			
Port	Vlans in spanning tree forwarding state and not pruned			
Fa0/1	1,10,20			

- c. Issue a **show vlan brief** command on both S1 and S2. Verify that VLANs 10 and 20 are active and that the proper ports on the switches are in the correct VLANs. Why is F0/1 not listed in any of the active VLANs?

It is a trunk port and is not assigned to a VLAN.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/7 Fa0/8, Fa0/9, Fa0/10, Fa0/11 Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10	Student	active	Fa0/5, Fa0/6
20	Faculty-Admin	active	
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdininet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S2# show vlan brief
```

Lab – Configuring Per-Interface Inter-VLAN Routing

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10	Student	active	
20	Faculty-Admin	active	Fa0/11, Fa0/18
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

- d. Ping from PC-A in VLAN 10 to PC-B in VLAN 20. If Inter-VLAN routing is functioning correctly, the pings between the 192.168.10.0 network and the 192.168.20.0 should be successful.

Note: It may be necessary to disable the PC firewall to ping between PCs.

- e. Verify connectivity between devices. You should be able to ping between all devices. Troubleshoot if you are not successful.

Reflection

What is an advantage of using legacy inter-VLAN routing?

Answers may vary. Configuration of both the router and switches is relatively easy and straightforward. No subinterfaces are required on the router and trunking does NOT have to be configured between the router and switch.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Configuration Commands

Switch S1

```
S1(config)# vlan 10
S1(config-vlan)# name Student
S1(config-vlan)# exit
S1(config)# vlan 20
S1(config-vlan)# name Faculty-Admin
S1(config-vlan)# exit
S1(config)# interface f0/1
S1(config-if)# switchport mode trunk
S1(config-if)# interface range f0/5 - 6
S1(config-if-range)# switchport mode access
S1(config-if-range)# switchport access vlan 10
S1(config-if-range)# interface vlan 10
S1(config-if)# ip address 192.168.10.11 255.255.255.0
S1(config-if)# no shut
S1(config-if)# exit
S1(config)# ip default-gateway 192.168.10.1
```

Switch S2

```
S2(config)# vlan 10
S2(config-vlan)# name Student
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
S2(config-vlan)# exit
S2(config)# vlan 20
S2(config-vlan)# name Faculty-Admin
S2(config-vlan)# exit
S2(config)# interface f0/1
S2(config-if)# switchport mode trunk
S2(config-if)# interface f0/11
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
S2(config-if)# interface f0/18
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
S2(config-if-range)# interface vlan 10
S2(config-if)#ip address 192.168.10.12 255.255.255.0
S2(config-if)# no shut
S2(config-if)# exit
S2(config)# ip default-gateway 192.168.10.1
```

Device Configs

Instructor Note: The VLANs configured do not display in the switch running configuration but are stored in the `vlan.dat` file.

Router R1

```
R1#show run
Building configuration...

Current configuration : 1640 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
!
!
no ip domain lookup
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
ip cef
no ipv6 cef
!
multilink bundle-name authenticated
!
!
!
!
!
redundancy
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
    no ip address
    shutdown
!
interface GigabitEthernet0/0
    ip address 192.168.20.1 255.255.255.0
    duplex auto
    speed auto
!
interface GigabitEthernet0/1
    ip address 192.168.10.1 255.255.255.0
    duplex auto
    speed auto
!
interface Serial0/0/0
    no ip address
    shutdown
    clock rate 2000000
!
interface Serial0/0/1
    no ip address
    shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
control-plane
!
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
!
!
line con 0
password cisco
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/7 Fa0/8, Fa0/9, Fa0/10, Fa0/11 Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10	Student	active	Fa0/5, Fa0/6
20	Faculty-Admin	active	
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdmynet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S1#show run
Building configuration...
```

```
Current configuration : 1644 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
no service password-encryption
!
hostname S1
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
interface FastEthernet0/1
switchport mode trunk
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/6
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
  no ip address
  shutdown
!
interface Vlan10
  ip address 192.168.10.11 255.255.255.0
!
  ip default-gateway 192.168.10.1
  ip http server
  ip http secure-server
!
!
line con 0
  password cisco
  login
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN	Name	Status	Ports
------	------	--------	-------

Lab – Configuring Per-Interface Inter-VLAN Routing

```
-----  
1     default                  active   Fa0/2, Fa0/3, Fa0/4, Fa0/5  
                                         Fa0/6, Fa0/7, Fa0/8, Fa0/9  
                                         Fa0/10, Fa0/12, Fa0/13, Fa0/14  
                                         Fa0/15, Fa0/16, Fa0/17, Fa0/19  
                                         Fa0/20, Fa0/21, Fa0/22, Fa0/23  
                                         Fa0/24, Gi0/1, Gi0/2  
10    Student                  active  
20    Faculty-Admin           active   Fa0/11, Fa0/18  
1002  fddi-default            act/unsup  
1003  token-ring-default     act/unsup  
1004  fddinet-default        act/unsup  
1005  trnet-default          act/unsup
```

```
S2#sh run  
Building configuration...
```

```
Current configuration : 1644 bytes  
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S2  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGh0lQM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
!  
no ip domain-lookup  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
<Output Omitted>  
interface FastEthernet0/10  
!  
interface FastEthernet0/11  
  switchport access vlan 20  
  switchport mode access  
!  
interface FastEthernet0/12  
!  
interface FastEthernet0/13  
!
```

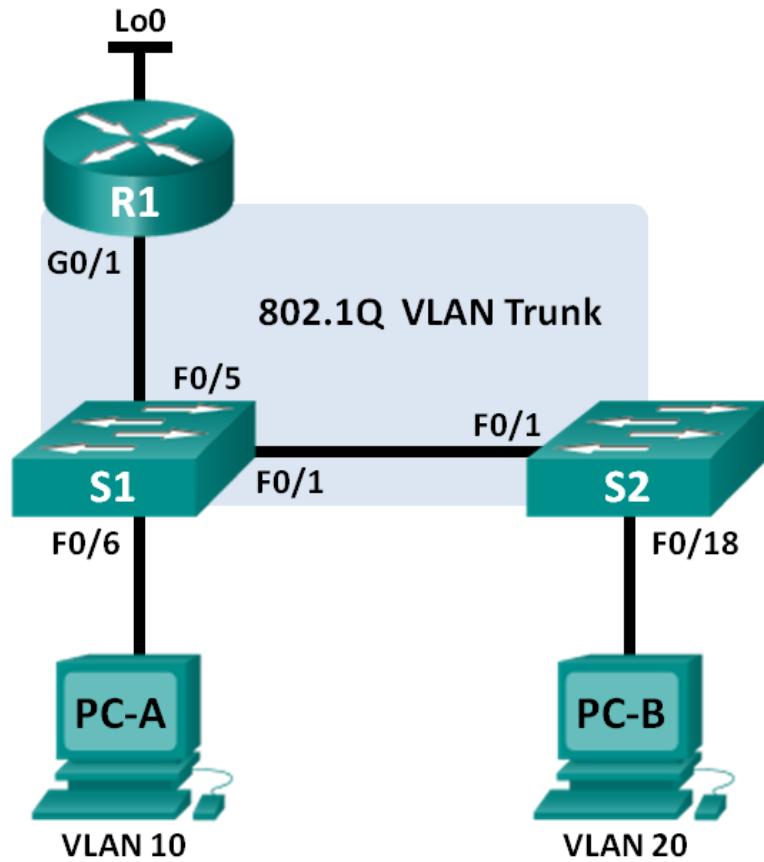
Lab – Configuring Per-Interface Inter-VLAN Routing

```
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
  switchport access vlan 20
  switchport mode access
!
!interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
  no ip address
  shutdown
!
interface Vlan10
  ip address 192.168.10.12 255.255.255.0
!
ip default-gateway 192.168.10.1
ip http server
ip http secure-server
!
line con 0
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
end
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1.1	192.168.1.1	255.255.255.0	N/A
	G0/1.10	192.168.10.1	255.255.255.0	N/A
	G0/1.20	192.168.20.1	255.255.255.0	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S2	VLAN 1	192.168.1.12	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Switch Port Assignment Specifications

Ports	Assignment	Network
S1 F0/1	802.1Q Trunk	N/A
S2 F0/1	802.1Q Trunk	N/A
S1 F0/5	802.1Q Trunk	N/A
S1 F0/6	VLAN 10 – Students	192.168.10.0/24
S2 F0/18	VLAN 20 – Faculty	192.168.20.0/24

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure Switches with VLANs and Trunking

Part 3: Configure Trunk-Based Inter-VLAN Routing

Background / Scenario

A second method of providing routing and connectivity for multiple VLANs is through the use of an 802.1Q trunk between one or more switches and a single router interface. This method is also known as router-on-a-stick inter-VLAN routing. In this method, the physical router interface is divided into multiple subinterfaces that provide logical pathways to all VLANs connected.

In this lab, you will configure trunk-based inter-VLAN routing and verify connectivity to hosts on different VLANs as well as with a loopback on the router.

Note: This lab provides minimal assistance with the actual commands necessary to configure trunk-based inter-VLAN routing. However, the required configuration commands are provided in Appendix A of this lab. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS, Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS, Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary.

from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS, release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS, release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the PC hosts, switches, and router.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the router and switches as necessary.

Step 4: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure device names as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure **logging synchronous** for the console line.
- f. Configure the IP address listed in the Addressing Table for VLAN 1 on both switches.
- g. Configure the default gateway on both switches.
- h. Administratively deactivate all unused ports on the switch.
- i. Copy the running configuration to the startup configuration.

Step 5: Configure basic settings for the router.

- a. Disable DNS lookup.
- b. Configure device names as shown in the topology.
- c. Configure the Lo0 IP address as shown in the Address Table. Do not configure subinterfaces at this time as they will be configured in Part 3.
- d. Assign **cisco** as the console and vty passwords.
- e. Assign **class** as the privileged EXEC password.

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

- f. Configure **logging synchronous** to prevent console messages from interrupting command entry.
- g. Copy the running configuration to the startup configuration.

Part 2: Configure Switches with VLANs and Trunking

In Part 2, you will configure the switches with VLANs and trunking.

Note: The required commands for Part 2 are provided in Appendix A. Test your knowledge by trying to configure S1 and S2 without referring to the appendix.

Step 1: Configure VLANs on S1.

- a. On S1, configure the VLANs and names listed in the Switch Port Assignment Specifications table. Write the commands you used in the space provided.

```
S1(config)# vlan 10
S1(config-vlan)# name Students
S1(config-vlan)# vlan 20
S1(config-vlan)# name Faculty
S1(config-vlan)# exit
```

- b. On S1, configure the interface connected to R1 as a trunk. Also configure the interface connected to S2 as a trunk. Write the commands you used in the space provided.

```
S1(config)# interface f0/5
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/1
S1(config-if)# switchport mode trunk
```

- c. On S1, assign the access port for PC-A to VLAN 10. Write the commands you used in the space provided.

```
S1(config)# interface f0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

Step 2: Configure VLANs on Switch 2.

- a. On S2, configure the VLANs and names listed in the Switch Port Assignment Specifications table.
- b. On S2, verify that the VLAN names and numbers match those on S1. Write the command you used in the space provided.

```
S2# show vlan brief
S2# show vlan brief

VLAN Name Status Ports
----- -- -----
1 default active Fa0/1, Fa0/2, Fa0/3, Fa0/4, Fa0/5
Fa0/6, Fa0/7, Fa0/8, Fa0/9
Fa0/10, Fa0/11, Fa0/12, Fa0/13
Fa0/14, Fa0/15, Fa0/16, Fa0/17
Fa0/18, Fa0/19, Fa0/20, Fa0/21
Fa0/22, Fa0/23, Fa0/24, Gi0/1
Gi0/2
10 Students active
20 Faculty active
1002 fddi-default active
1003 token-ring-default active
1004 fddinet-default active
1005 trnet-default active
```

- c. On S2, assign the access port for PC-B to VLAN 20.
- d. On S2, configure the interface connected to S1 as a trunk.

Part 3: Configure Trunk-Based Inter-VLAN Routing

In Part 3, you will configure R1 to route to multiple VLANs by creating subinterfaces for each VLAN. This method of inter-VLAN routing is called router-on-a-stick.

Note: The required commands for Part 3 are provided in Appendix A. Test your knowledge by trying to configure trunk-based or router-on-a-stick inter-VLAN routing without referring to the appendix.

Step 1: Configure a subinterface for VLAN 1.

- a. Create a subinterface on R1 G0/1 for VLAN 1 using 1 as the subinterface ID. Write the command you used in the space provided.

```
R1(config)# interface g0/1.1
```

- b. Configure the subinterface to operate on VLAN 1. Write the command you used in the space provided.

```
R1(config-subif)# encapsulation dot1Q 1
```

- c. Configure the subinterface with the IP address from the Address Table. Write the command you used in the space provided.

```
R1(config-subif)# ip address 192.168.1.1 255.255.255.0
```

Step 2: Configure a subinterface for VLAN 10.

- a. Create a subinterface on R1 G0/1 for VLAN 10 using 10 as the subinterface ID.
- b. Configure the subinterface to operate on VLAN 10.

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

- c. Configure the subinterface with the address from the Address Table.

Step 3: Configure a subinterface for VLAN 20.

- a. Create a subinterface on R1 G0/1 for VLAN 20 using 20 as the subinterface ID.
- b. Configure the subinterface to operate on VLAN 20.
- c. Configure the subinterface with the address from the Address Table.

Step 4: Enable the G0/1 interface.

Enable the G0/1 interface. Write the commands you used in the space provided.

```
R1(config)# interface g0/1
R1(config-if)# no shutdown
```

Step 5: Verify connectivity.

Enter the command to view the routing table on R1. What networks are listed?

```
192.168.1.0, 192.168.10.0, 192.168.20.0, and 209.165.200.224
```

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2, 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
```

```
    192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1.1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/1.1
    192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.10.0/24 is directly connected, GigabitEthernet0/1.10
L        192.168.10.1/32 is directly connected, GigabitEthernet0/1.10
    192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.20.0/24 is directly connected, GigabitEthernet0/1.20
L        192.168.20.1/32 is directly connected, GigabitEthernet0/1.20
    209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C        209.165.200.224/27 is directly connected, Loopback0
L        209.165.200.225/32 is directly connected, Loopback0
```

From PC-A, is it possible to ping the default gateway for VLAN 10? _____ Yes

From PC-A, is it possible to ping PC-B? _____ Yes

From PC-A, is it possible to ping Lo0? _____ Yes

From PC-A, is it possible to ping S2? _____ Yes

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

If the answer is **no** to any of these questions, troubleshoot the configurations and correct any errors.

Reflection

What are the advantages of trunk-based or router-on-a-stick inter-VLAN routing?

Router-on-a-stick inter-VLAN routing allows for one interface to route to multiple VLANs unlike the legacy inter-VLAN method which requires one port per VLAN.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A – Configuration Commands

Switch S1

```
S1(config)# vlan 10
S1(config-vlan)# name Students
S1(config-vlan)# vlan 20
S1(config-vlan)# name Faculty
S1(config-vlan)# exit
S1(config)# interface f0/1
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/5
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/6
S1(config-if)# switchport mode access
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
S1(config-if)# switchport access vlan 10
```

Switch S2

```
S2(config)# vlan 10
S2(config-vlan)# name Students
S2(config-vlan)# vlan 20
S2(config-vlan)# name Faculty
S2(config)# interface f0/1
S2(config-if)# switchport mode trunk
S2(config-if)# interface f0/18
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
```

Router R1

```
R1(config)# interface g0/1.1
R1(config-subif)# encapsulation dot1Q 1
R1(config-subif)# ip address 192.168.1.1 255.255.255.0
R1(config-subif)# interface g0/1.10
R1(config-subif)# encapsulation dot1Q 10
R1(config-subif)# ip address 192.168.10.1 255.255.255.0
R1(config-subif)# interface g0/1.20
R1(config-subif)# encapsulation dot1Q 20
R1(config-subif)# ip address 192.168.20.1 255.255.255.0
R1(config-subif)# exit
R1(config)# interface g0/1
R1(config-if)# no shutdown
```

Device Configs

Instructor Note: The VLANs configured do not display in the switch running configuration but are stored in the `vlan.dat` file. The output from the `show vlan brief` command is provided.

Router R1

```
R1# show run
Building configuration...

Current configuration : 1731 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
duplex auto
speed auto
!
interface GigabitEthernet0/1.1
encapsulation dot1Q 1
ip address 192.168.1.1 255.255.255.0
!
interface GigabitEthernet0/1.10
encapsulation dot1Q 10
ip address 192.168.10.1 255.255.255.0
!
interface GigabitEthernet0/1.20
encapsulation dot1Q 20
ip address 192.168.20.1 255.255.255.0
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Students	active	Fa0/6
20	Faculty	active	
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S1# show run
```

```
Building configuration...
```

```
Current configuration : 1627 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
no ip domain-lookup
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 switchport mode trunk
!
interface FastEthernet0/6
 switchport access vlan 10
 switchport mode access
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
interface Vlan1
  ip address 192.168.1.11 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
!
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
login
line vty 5 15
  password cisco
login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Students	active	
20	Faculty	active	Fa0/18
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdmynet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S2# show run
Building configuration...
```

```
Current configuration : 1633 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
switchport access vlan 20
switchport mode access
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
```

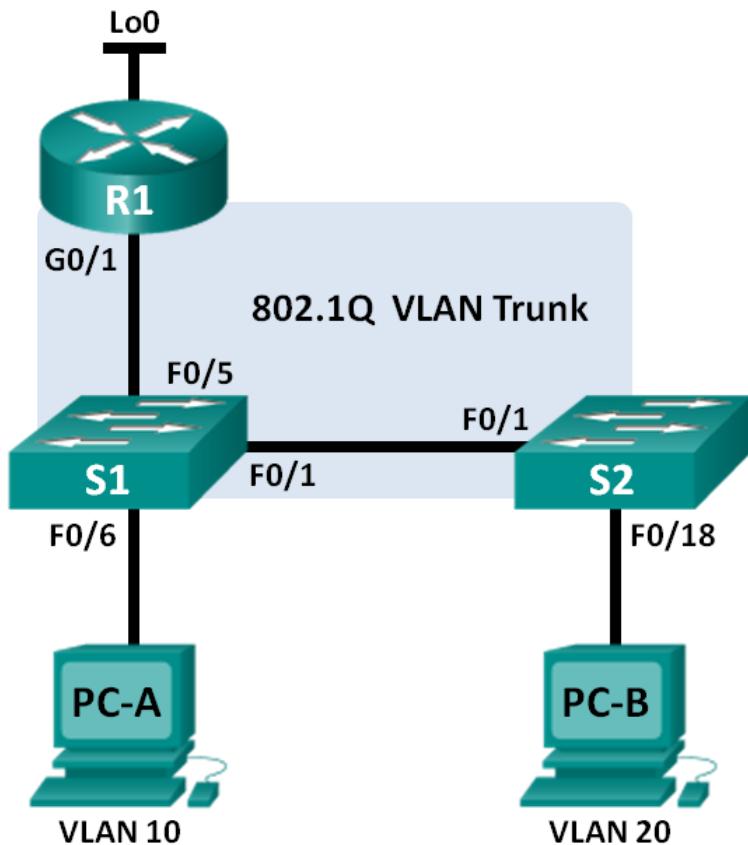
Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
 ip address 192.168.1.12 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Lab – Troubleshooting Inter-VLAN Routing (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1.1	192.168.1.1	255.255.255.0	N/A
	G0/1.10	192.168.10.1	255.255.255.0	N/A
	G0/1.20	192.168.20.1	255.255.255.0	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S2	VLAN 1	192.168.1.12	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Switch Port Assignment Specifications

Ports	Assignment	Network
S1 F0/1	802.1Q Trunk	N/A
S2 F0/1	802.1Q Trunk	N/A
S1 F0/5	802.1Q Trunk	N/A
S1 F0/6	VLAN 10 – R&D	192.168.10.0/24
S2 F0/18	VLAN 20 – Engineering	192.168.20.0/24

Objectives

Part 1: Build the Network and Load Device Configurations

Part 2: Troubleshoot the Inter-VLAN Routing Configuration

Part 3: Verify VLAN Configuration, Port Assignment, and Trunking

Part 4: Test Layer 3 Connectivity

Background / Scenario

The network has been designed and configured to support three VLANs. Inter-VLAN routing is provided by an external router using an 802.1Q trunk, also known as router-on-a-stick. Routing to a remote web server, which is simulated by Lo0, is also provided by R1. However, it is not working as designed, and user complaints have not given much insight into the source of the problems.

In this lab, you must first define what is not working as expected, and then analyze the existing configurations to determine and correct the source of the problems. This lab is complete when you can demonstrate IP connectivity between each of the user VLANs and the external web server network, and between the switch management VLAN and the web server network.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary

from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Load Device Configurations

In Part 1, you will set up the network topology and configure basic settings on the PC hosts, switches, and router.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 3: Load router and switch configurations.

Load the following configurations into the appropriate router or switch. All devices have the same passwords; the enable password is **class**, and the line password is **cisco**.

Router R1 Configuration:

```
hostname R1
enable secret class
no ip domain lookup
line con 0
  password cisco
  login
  logging synchronous
line vty 0 4
  password cisco
  login
interface loopback0
  ip address 209.165.200.225 255.255.255.224
interface gigabitEthernet0/1
  no ip address
! no shutdown
interface gigabitEthernet0/1.1
  encapsulation dot1q 11
! encapsulation dot1q 1
```

Lab – Troubleshooting Inter-VLAN Routing

```
ip address 192.168.1.1 255.255.255.0
interface gigabitEthernet0/1.10
  encapsulation dot1q 10
  ip address 192.168.11.1 255.255.255.0
! ip address 192.168.10.1 255.255.255.0
interface gigabitEthernet0/1.20
  encapsulation dot1q 20
  ip address 192.168.20.1 255.255.255.0
end
```

Switch S1 Configuration:

```
hostname S1
enable secret class
no ip domain-lookup
line con 0
  password cisco
  login
  logging synchronous
line vty 0 15
  password cisco
  login
vlan 10
  name R&D
  exit
!vlan 20
! name Engineering
! exit
interface fastethernet0/1
  switchport mode access
! switchport mode trunk
interface fastethernet0/5
  switchport mode trunk
!interface fastethernet0/6
! switchport access vlan 10
! switchport mode access
interface vlan1
  ip address 192.168.1.11 255.255.255.0
  ip default-gateway 192.168.1.1
end
```

Switch S2 Configuration:

```
hostname S2
enable secret class
no ip domain-lookup
line con 0
  password cisco
```

```
login
logging synchronous
line vty 0 15
password cisco
login
!vlan 10
! name R&D
! exit
vlan 20
name Engineering
exit
interface fastethernet0/1
switchport mode trunk
interface fastethernet0/18
switchport access vlan 10
switchport mode access
! switchport access vlan 20
interface vlan1
ip address 192.168.1.12 255.255.255.0
ip default-gateway 192.168.1.1
end
```

Step 4: Save the running configuration to the startup configuration.

Part 2: Troubleshoot the Inter-VLAN Routing Configuration

In Part 2, you will verify the inter-VLAN routing configuration.

- On R1, enter the **show ip route** command to view the routing table.

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C        209.165.200.224/27 is directly connected, Loopback0
L        209.165.200.225/32 is directly connected, Loopback0
```

Which networks are listed?

Only the 209.165.200.224 network.

Lab – Troubleshooting Inter-VLAN Routing

Are there any networks missing in the routing table? If so, which networks?

192.168.1.0, 192.168.10.0, 192.168.20.0

What is one possible reason that a route would be missing from the routing table?

Interface administratively down, no ip address

- b. On R1, issue the **show ip interface brief** command.

```
R1# show ip interface brief
Interface          IP-Address      OK? Method Status          Protocol
Embedded-Service-Engine0/0 unassigned    YES unset  administratively down down
GigabitEthernet0/0     unassigned    YES unset  administratively down down
GigabitEthernet0/1     unassigned    YES unset  administratively down down
GigabitEthernet0/1.1   192.168.1.1   YES manual administratively down down
GigabitEthernet0/1.10  192.168.11.1  YES manual administratively down down
GigabitEthernet0/1.20  192.168.20.1  YES manual administratively down down
Serial0/0/0           unassigned    YES unset  administratively down down
Serial0/0/1           unassigned    YES unset  administratively down down
Loopback0             209.165.200.225 YES manual up          up
```

Based on the output, are there any interface issues on the router? If so, what commands would resolve the issues?

```
R1(config)# interface g0/1
R1(config-if)# no shutdown
R1(config-if)# interface g0/1.10
R1(configs-if) ip address 192.168.10.1 255.255.255.0
```

- c. On R1, re-issue the **show ip route** command.

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.1.0/24 is directly connected, GigabitEthernet0/1.1
L      192.168.1.1/32 is directly connected, GigabitEthernet0/1.1
192.168.11.0/24 is variably subnetted, 2 subnets, 2 masks
```

Lab – Troubleshooting Inter-VLAN Routing

```
C      192.168.11.0/24 is directly connected, GigabitEthernet0/1.10
L      192.168.11.1/32 is directly connected, GigabitEthernet0/1.10
      192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.20.0/24 is directly connected, GigabitEthernet0/1.20
L      192.168.20.1/32 is directly connected, GigabitEthernet0/1.20
      209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C      209.165.200.224/27 is directly connected, Loopback0
L      209.165.200.225/32 is directly connected, Loopback0
```

Verify that all networks are available in the routing table. If not, continue to troubleshoot until all networks are present.

Part 3: Verify VLAN Configuration, Port Assignment, and Trunking

In Part 3, you will verify that the correct VLANs exist on both S1 and S2 and that trunking is configured correctly.

Step 1: Verify VLAN configuration and port assignments.

- On S1, enter the **show vlan brief** command to view the VLAN database.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10	R&D	active	
1002	fdci-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdininet-default	act/unsup	
1005	trnet-default	act/unsup	

Which VLANs are listed? Ignore VLANs 1002 to 1005.

VLAN 1, VLAN 10

Are there any VLAN numbers or names missing in the output? If so, list them.

VLAN 20 name Engineering

Are the access ports assigned to the correct VLANs? If not, list the missing or incorrect assignments.

Fa0/6 needs to be assigned to the VLAN 10

If required, what commands would resolve the VLAN issues?

Lab – Troubleshooting Inter-VLAN Routing

```
S1(config)# vlan 20
S1(config-vlan)# name Engineering
S1(config-vlan)# exit
S1(config)# interface fa0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

- b. On S1, re-issue the **show vlan brief** command to verify configuration.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	R&D	active	Fa0/6
20	Engineering	active	
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdmnet-default	act/unsup	
1005	trnet-default	act/unsup	

- c. On S2, enter the **show vlan brief** command to view the VLAN database.

```
S2# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	VLAN0010	active	Fa0/18
20	Engineering	active	
1002	fdmi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdmnet-default	act/unsup	
1005	trnet-default	act/unsup	

Which VLANs are listed? Ignore VLANs 1002 to 1005.

VLAN 1, VLAN 10, VLAN 20

Lab – Troubleshooting Inter-VLAN Routing

Are there any VLANs numbers or names missing in the output? If so, list them.

VLAN 10 missing name R&D

Are the access ports assigned to the correct VLANs? If not, list the missing or incorrect assignments.

F0/18 needs to be assigned to the VLAN 20 instead of 10

If required, what commands would resolve the VLAN issues?

```
S2(config)# vlan 10
S2(config-vlan)# name R&D
S2(config-vlan)# exit
S2(config)# interface fa0/18
S2(config-if)# switchport access vlan 20
```

- d. On S2, re-issue the **show vlan brief** command to verify any configuration changes.

```
S2# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	R&D	active	
20	Engineering	active	Fa0/18
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdtnet-default	act/unsup	
1005	trnet-default	act/unsup	

Step 2: Verify trunking interfaces.

- a. On S1, enter the **show interface trunk** command to view the trunking interfaces.

```
S1# show interface trunk
```

```
Port      Mode          Encapsulation  Status       Native vlan
Fa0/5     on           802.1q        trunking    1

Port      Vlans allowed on trunk
Fa0/5     1-4094

Port      Vlans allowed and active in management domain
```

Lab – Troubleshooting Inter-VLAN Routing

Fa0/5 1,10,20

Port Vlans in spanning tree forwarding state and not pruned
Fa0/5 1,10,20

Which ports are in trunking mode?

F0/5

Are there any ports missing in the output? If so, list them.

F0/1

If required, what commands would resolve the port trunking issues?

```
S1(config)# interface fa0/1
S1(configs-if)# switchport mode trunk
```

- b. On S1, re-issue the **show interface trunk** command to verify any configuration changes.

S1# show interface trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1
Fa0/5	on	802.1q	trunking	1

Port Vlans allowed on trunk
Fa0/1 1-4094
Fa0/5 1-4094

Port Vlans allowed and active in management domain
Fa0/1 1,10,20
Fa0/5 1,10,20

Port Vlans in spanning tree forwarding state and not pruned
Fa0/1 none
Fa0/5 1,10,20

- c. On S2, enter the **show interface trunk** command to view the trunking interfaces.

S2# show interface trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1

Port Vlans allowed on trunk
Fa0/1 1-4094

Port Vlans allowed and active in management domain
Fa0/1 1,10,20

Lab – Troubleshooting Inter-VLAN Routing

Port Vlans in spanning tree forwarding state and not pruned
Fa0/1 1,10,20

Which ports are in trunking mode?

F0/1

Are there any ports missing in the output? If so, list them.

None

If required, what commands would resolve the port trunking issues?

All trunk ports configured correctly

Part 4: Test Layer 3 Connectivity

- Now that you have corrected multiple configuration issues, let's test connectivity.

From PC-A, is it possible to ping the default gateway for VLAN 10? _____ Yes.

From PC-A, is it possible to ping PC-B? _____ Yes.

From PC-A, is it possible to ping Lo0? _____ Yes.

If the answer is **no** to any of these questions, troubleshoot the configurations and correct the error.

Note: It may be necessary to disable the PC firewall for pings between PCs to be successful.

From PC-A, is it possible to ping S1? _____ No.

From PC-A, is it possible to ping S2? _____ No.

List some of the issues that could still be preventing successful pings to the switches.

Incorrect VLAN assignment on router subinterface, incorrect IP address on switch, no default gateway on switch

- One way to help resolve where the error is occurring is to do a **tracert** from PC-A to S1.

```
C:\Users\User1> tracert 192.168.1.11
Tracing route to 192.168.1.11 over a maximum of 30 hops
  1    <1 ms      <1 ms      <1 ms  192.168.10.1
  2      *          *          *      Request timed out.
  3      *          *          *      Request timed out.

<output omitted>
```

This output shows that the request from PC-A is reaching the default gateway on R1 g0/1.10, but the packet stops at the router.

- You have already verified the routing table entries for R1, now execute the **show run | section interface** command to verify VLAN configuration. List any configuration errors.
-

Lab – Troubleshooting Inter-VLAN Routing

Interface g0/1.1 is assigned to VLAN 11 instead of VLAN 1

```
R1# show run | section interface
interface Loopback0
  ip address 209.165.200.225 255.255.255.224
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
interface GigabitEthernet0/1
  no ip address
  duplex auto
  speed auto
interface GigabitEthernet0/1.1
  encapsulation dot1Q 11
  ip address 192.168.1.1 255.255.255.0
interface GigabitEthernet0/1.10
  encapsulation dot1Q 10
  ip address 192.168.10.1 255.255.255.0
interface GigabitEthernet0/1.20
  encapsulation dot1Q 20
  ip address 192.168.20.1 255.255.255.0
interface Serial0/0/0
  no ip address
  shutdown
  clock rate 2000000
interface Serial0/0/1
  no ip address
  shutdown
```

What commands would resolve any issues found?

```
R1(config)# interface g0/1.1
R1(config-if)# encapsulation dot1q 1
```

- d. Verify that that pings from PC-A now reach both S1 and S2.

From PC-A, is it possible to ping S1? _____ Yes.

From PC-A, is it possible to ping S2? _____ Yes.

Reflection

What are the advantages of viewing the routing table for troubleshooting purposes?

Lab – Troubleshooting Inter-VLAN Routing

All configured interfaces and subinterfaces are listed and can be easily examined for errors.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Instructor Note: The VLANs configured do not display in the switch running configuration but are stored in the `vlan.dat` file.

Router R1

```
R1# show run
Building configuration...

Current configuration : 1522 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
!
!
!
!
!
!
no ip domain lookup
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.224
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
!
interface GigabitEthernet0/1.1
 encapsulation dot1Q 1
 ip address 192.168.1.1 255.255.255.0
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
interface GigabitEthernet0/1.10
encapsulation dot1Q 10
ip address 192.168.10.1 255.255.255.0
!
interface GigabitEthernet0/1.20
encapsulation dot1Q 20
ip address 192.168.20.1 255.255.255.0
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
```

```
end
```

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	R&D	active	Fa0/6
20	Engineering	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fdдинet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S1# show run
```

```
Building configuration...
```

```
Current configuration : 1453 bytes
!
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
 switchport mode trunk
!
interface FastEthernet0/6
 switchport access vlan 10
 switchport mode access
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.11 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN	Name	Status	Ports

1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9

Lab – Troubleshooting Inter-VLAN Routing

		Fa0/10, Fa0/11, Fa0/12, Fa0/13
		Fa0/14, Fa0/15, Fa0/16, Fa0/17
		Fa0/19, Fa0/20, Fa0/21, Fa0/22
		Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	R&D	active
20	Engineering	active Fa0/18
1002	fdmi-default	act/unsup
1003	token-ring-default	act/unsup
1004	fddinet-default	act/unsup
1005	trnet-default	act/unsup

```
S2# show run
Building configuration...

Current configuration : 1458 bytes
!
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
!
!
!
!
interface FastEthernet0/1
    switchport mode trunk
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
    switchport access vlan 20
    switchport mode access
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
    ip address 192.168.1.12 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
line con 0
    password cisco
    logging synchronous
    login
line vty 0 4
    password cisco
    login
line vty 5 15
    password cisco
    login
!
end
```



The Inside Track (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain how Layer 3 switches forward data in a small- to medium-sized business LAN.

Students will choose which type of inter-VLAN routing they would prefer if designing a network for local area network communications.

Scenario

Your company has just purchased a three-level building. You are the network administrator and must design the company inter-VLAN routing network scheme to serve a few employees on each floor.

Floor 1 is occupied by the HR Department, Floor 2 is occupied by the IT Department, and Floor 3 is occupied by the Sales Department. All Departments must be able to communicate with each other, but at the same time have their own separate working networks.

You brought three Cisco 2960 switches and a Cisco 1941 series router from the old office location to serve network connectivity in the new building. New equipment is non-negotiable.

Refer to the PDF for this activity for further instructions.

Resources

- Software presentation program

Directions

Work with a partner to complete this activity.

Step 1: Design your topology.

- a. Use one 2960 switch per floor of your new building.
- b. Assign one department to each switch.
- c. Pick one of the switches to connect to the 1941 series router.

Step 2: Plan the VLAN scheme.

- a. Devise VLAN names and numbers for the HR, IT, and Sales Departments.
- b. Include a management VLAN, possibly named Management or Native, numbered to your choosing.
- c. Use either IPv4 or v6 as your addressing scheme for the LANs. If using IPv4, you must also use VLSM.

Step 3: Design a graphic to show your VLAN design and address scheme.

Step 4: Choose your inter-VLAN routing method.

- a. Legacy (per interface)
- b. Router-on-a-Stick
- c. Multilayer switching

Step 5: Create a presentation justifying your inter-VLAN routing method of choice.

- a. No more than eight slides can be created for the presentation.
- b. Present your group's design to the class or to your instructor.
 - 1) Be able to explain the method you chose. What makes it different or more desirable to your business than the other two methods?
 - 2) Be able to show how data moves throughout your network. Verbally explain how the networks are able to communicate using your inter-VLAN method of choice.

Instructor Resource Information

- All students should be able to differentiate between the three inter-VLAN routing methods
- All students should be able to explain how they chose the method of inter-VLAN routing for their business
- All students should be able to explain how data flows on their chosen inter-VLAN routing method

Identify elements of the model that map to IT-related content:

- Legacy or per-interface inter-VLAN routing
- Router-on-a-Stick inter-VLAN routing
- Multi-layer switching inter-VLAN routing



Which Way Should We Go? (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Explain the benefits of using static routes.

This chapter focuses on static routing and dynamic routing. This modeling activity helps students to think about how they can choose a path different from the best path for network communication.

Scenario

A huge sporting event is about to take place in your city. To attend the event, you make concise plans to arrive at the sports arena on time to see the entire game.

There are two routes you can take to drive to the event:

- Highway route - It is easy to follow and fast driving speeds are allowed.
- Alternative, direct route - You found this route using a city map. Depending on conditions, such as the amount of traffic or congestion, this just may be the way to get to the arena on time!

With a partner, discuss these options. Choose a preferred route to arrive at the arena in time to see every second of the huge sporting event.

Compare your optional preferences to network traffic, which route would you choose to deliver data communications for your small- to medium-sized business? Would it be the fastest, easiest route or the alternative, direct route? Justify your choice.

Complete the modeling activity .pdf and be prepared to justify your answers to the class or with another group.

Required Resources

None

Reflection

1. Which route did you choose as your first preference? On what criteria did you base your decision?

Students' answers will vary. Some will choose the fastest, easiest route and some will choose the alternate, direct-route. Criteria mentioned may include time constraints, speed of the route, traffic congestion on the route, and ease of following the route.

2. If traffic congestion were to occur on either route, would this change the path you would take to the arena? Explain your answer.

Most students would change their path in order to arrive at the sports arena on time. Others will decide to keep on the same path to the arena hoping that traffic congestion will subside. In either case, most will appreciate having a choice of routes.

3. A popular phrase that can be argued is "the shortest distance between two points is a straight line." Is this always true with delivery of network data? How do you compare your answer to this modeling activity scenario?
-

Which Way Should We Go?

Again, traffic can impact the route chosen. Sometimes it may be necessary to choose an alternate path for data delivery. Sometimes the alternate path will allow your data to be delivered more quickly than using the fastest path.

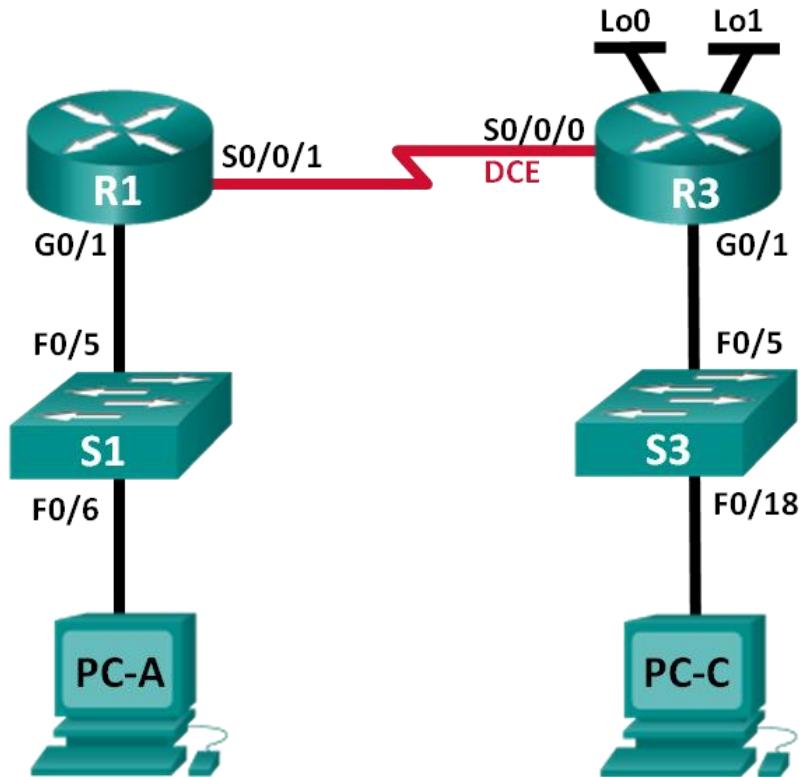
Identify elements of the model that map to IT-related content:

- Routers use routing protocols to record dynamic routes in their routing tables to indicate best-path delivery.
- The best-path delivery method can be changed to a manually configured path called a static route.
- A floating static route can be configured on a router to provide an alternate or backup path if the dynamic route becomes inoperable at any time.

Lab – Configuring IPv4 Static and Default Routes (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	192.168.0.1	255.255.255.0	N/A
	S0/0/1	10.1.1.1	255.255.255.252	N/A
R3	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.2	255.255.255.252	N/A
PC-A	Lo0	209.165.200.225	255.255.255.224	N/A
	Lo1	198.133.219.1	255.255.255.0	N/A
PC-A	NIC	192.168.0.10	255.255.255.0	192.168.0.1
PC-C	NIC	192.168.1.10	255.255.255.0	192.168.1.1

Objectives

Part 1: Set Up the Topology and Initialize Devices

Part 2: Configure Basic Device Settings and Verify Connectivity

Part 3: Configure Static Routes

- Configure a recursive static route.
- Configure a directly connected static route.
- Configure and remove static routes.

Part 4: Configure and Verify a Default Route

Background / Scenario

A router uses a routing table to determine where to send packets. The routing table contains a set of routes that describe which gateway or interface the router uses to reach a specified network. Initially, the routing table contains only directly connected networks. To communicate with distant networks, routes must be specified and added to the routing table.

In this lab, you will manually configure a static route to a specified distant network based on a next-hop IP address or exit interface. You will also configure a static default route. A default route is a type of static route that specifies a gateway to use when the routing table does not contain a path for the destination network.

Note: This lab provides minimal assistance with the actual commands necessary to configure static routing. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Set Up the Topology and Initialize Devices

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switch.

Part 2: Configure Basic Device Settings and Verify Connectivity

In Part 2, you will configure basic settings, such as the interface IP addresses, device access, and passwords. You will verify LAN connectivity and identify routes listed in the routing tables for R1 and R3.

Step 1: Configure the PC interfaces.

Step 2: Configure basic settings on the routers.

- a. Configure device names, as shown in the Topology and Addressing Table.
- b. Disable DNS lookup.
- c. Assign **class** as the enable password and assign **cisco** as the console and vty password.
- d. Save the running configuration to the startup configuration file.

Step 3: Configure IP settings on the routers.

- a. Configure the R1 and R3 interfaces with IP addresses according to the Addressing Table.
- b. The S0/0/0 connection is the DCE connection and requires the **clock rate** command. The R3 S0/0/0 configuration is displayed below.

Instructor Note: For Cisco 1941 routers, DCE is automatically detected and the clock rate is automatically set to 2000000, and does not need to be configured.

```
R3(config)# interface s0/0/0
R3(config-if)# ip address 10.1.1.2 255.255.255.252
R3(config-if)# clock rate 128000
R3(config-if)# no shutdown
```

Step 4: Verify connectivity of the LANs.

- a. Test connectivity by pinging from each PC to the default gateway that has been configured for that host.
From PC-A, is it possible to ping the default gateway? _____ Yes
From PC-C, is it possible to ping the default gateway? _____ Yes
- b. Test connectivity by pinging between the directly connected routers.
From R1, is it possible to ping the S0/0/0 interface of R3? _____ Yes

Lab – Configuring IPv4 Static and Default Routes

If the answer is **no** to any of these questions, troubleshoot the configurations and correct the error.

- c. Test connectivity between devices that are not directly connected.

From PC-A, is it possible to ping PC-C? _____ **No**

From PC-A, is it possible to ping Lo0? _____ **No**

From PC-A, is it possible to ping Lo1? _____ **No**

Were these pings successful? Why or why not?

No, the router does not contain routes to the distant networks.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Step 5: Gather information.

- a. Check the status of the interfaces on R1 with the **show ip interface brief** command.

R1# **show ip interface brief**

Interface	IP-Address	OK?	Method	Status	Protocol
Embedded-Service-Engine0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/1	192.168.0.1	YES	manual	up	up
Serial0/0/0	unassigned	YES	unset	administratively down	down
Serial0/0/1	10.1.1.1	YES	manual	up	up

How many interfaces are activated on R1? _____ **Two**

- b. Check the status of the interfaces on R3.

R3# **show ip interface brief**

Interface	IP-Address	OK?	Method	Status	Protocol
Embedded-Service-Engine0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/1	192.168.1.1	YES	manual	up	up
Serial0/0/0	10.1.1.2	YES	manual	up	up
Serial0/0/1	unassigned	YES	unset	administratively down	down
Loopback0	209.165.200.225	YES	manual	up	up
Loopback1	198.133.219.1	YES	manual	up	up

How many interfaces are activated on R3? _____ **Four**

- c. View the routing table information for R1 using the **show ip route** command.

R1# **show ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Lab – Configuring IPv4 Static and Default Routes

Gateway of last resort is not set

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.0/30 is directly connected, Serial0/0/1
L      10.1.1.1/32 is directly connected, Serial0/0/1
192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.0.0/24 is directly connected, GigabitEthernet0/1
L      192.168.0.1/32 is directly connected, GigabitEthernet0/1
```

What networks are present in the Addressing Table of this lab, but not in the routing table for R1?

192.168.1.0, 198.133.219.0, 209.165.200.224

- d. View the routing table information for R3.

```
R3# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.0/30 is directly connected, Serial0/0/0
L      10.1.1.2/32 is directly connected, Serial0/0/0
192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.1.0/24 is directly connected, GigabitEthernet0/1
L      192.168.1.1/32 is directly connected, GigabitEthernet0/1
198.133.219.0/24 is variably subnetted, 2 subnets, 2 masks
C      198.133.219.0/24 is directly connected, Loopback1
L      198.133.219.1/32 is directly connected, Loopback1
209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C      209.165.200.224/27 is directly connected, Loopback0
L      209.165.200.225/32 is directly connected, Loopback0
```

What networks are present in the Addressing Table in this lab, but not in the routing table for R3?

192.168.0.0

Why are all the networks not in the routing tables for each of the routers?

The routers are not configured with static or dynamic routing; therefore, the routers only know about the directly connected networks.

Part 3: Configure Static Routes

In Part 3, you will employ multiple ways to implement static and default routes, you will confirm that the routes have been added to the routing tables of R1 and R3, and you will verify connectivity based on the introduced routes.

Note: This lab provides minimal assistance with the actual commands necessary to configure static routing. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Step 1: Configure a recursive static route.

With a recursive static route, the next-hop IP address is specified. Because only the next-hop IP is specified, the router must perform multiple lookups in the routing table before forwarding packets. To configure recursive static routes, use the following syntax:

```
Router(config)# ip route network-address subnet-mask ip-address
```

- On the R1 router, configure a static route to the 192.168.1.0 network using the IP address of the Serial 0/0/0 interface of R3 as the next-hop address. Write the command you used in the space provided.

```
R1(config)# ip route 192.168.1.0 255.255.255.0 10.1.1.2
```

- View the routing table to verify the new static route entry.

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

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

```
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.1.1.0/30 is directly connected, Serial0/0/1
L        10.1.1.1/32 is directly connected, Serial0/0/1
    192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.0.0/24 is directly connected, GigabitEthernet0/1
L        192.168.0.1/32 is directly connected, GigabitEthernet0/1
S        192.168.1.0/24 [1/0] via 10.1.1.2
```

How is this new route listed in the routing table?

```
S    192.168.1.0/24 [1/0] via 10.1.1.2
```

From host PC-A, is it possible to ping the host PC-C? _____ No

These pings should fail. If the recursive static route is correctly configured, the ping arrives at PC-C. PC-C sends a ping reply back to PC-A. However, the ping reply is discarded at R3 because R3 does not have a return route to the 192.168.0.0 network in the routing table.

Step 2: Configure a directly connected static route.

With a directly connected static route, the `exit-interface` parameter is specified, which allows the router to resolve a forwarding decision in one lookup. A directly connected static route is typically used with a point-to-point serial interface. To configure directly connected static routes with an exit interface specified, use the following syntax:

```
Router(config) # ip route network-address subnet-mask exit-intf
```

- a. On the R3 router, configure a static route to the 192.168.0.0 network using S0/0/0 as the exit interface. Write the command you used in the space provided.

```
R3(config) # ip route 192.168.0.0 255.255.255.0 s0/0/0
```

- b. View the routing table to verify the new static route entry.

```
R3# show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP  
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area  
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2  
E1 - OSPF external type 1, E2 - OSPF external type 2  
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2  
ia - IS-IS inter area, * - candidate default, U - per-user static route  
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP  
+ - replicated route, % - next hop override
```

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

```
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks  
C      10.1.1.0/30 is directly connected, Serial0/0/0  
L      10.1.1.2/32 is directly connected, Serial0/0/0  
S      192.168.0.0/24 is directly connected, Serial0/0/0  
        192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.1.0/24 is directly connected, GigabitEthernet0/1  
L      192.168.1.1/32 is directly connected, GigabitEthernet0/1  
        198.133.219.0/24 is variably subnetted, 2 subnets, 2 masks  
C      198.133.219.0/24 is directly connected, Loopback1  
L      198.133.219.1/32 is directly connected, Loopback1  
        209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks  
C      209.165.200.224/27 is directly connected, Loopback0  
L      209.165.200.225/32 is directly connected, Loopback0
```

How is this new route listed in the routing table?

```
S 192.168.0.0/24 is directly connected, Serial0/0/0
```

- c. From host PC-A, is it possible to ping the host PC-C? _____ Yes

This ping should be successful.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Step 3: Configure a static route.

- a. On the R1 router, configure a static route to the 198.133.219.0 network using one of the static route configuration options from the previous steps. Write the command you used in the space provided.

```
R1(config)# ip route 198.133.219.0 255.255.255.0 s0/0/1
```

or

```
R1(config)# ip route 198.133.219.0 255.255.255.0 10.1.1.2
```

- b. On the R1 router, configure a static route to the 209.165.200.224 network on R3 using the other static route configuration option from the previous steps. Write the command you used in the space provided.

```
R1(config)# ip route 209.165.200.224 255.255.255.224 s0/0/1
```

or

```
R1(config)# ip route 209.165.200.224 255.255.255.224 10.1.1.2
```

- c. View the routing table to verify the new static route entry.

Note: The students may have different routing table outputs depending on the type of configured static routes.

```
R1# show ip route
```

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

```
          10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.1.1.0/30 is directly connected, Serial0/0/1
L        10.1.1.1/32 is directly connected, Serial0/0/1
          192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.0.0/24 is directly connected, GigabitEthernet0/1
L        192.168.0.1/32 is directly connected, GigabitEthernet0/1
S        192.168.1.0/24 [1/0] via 10.1.1.2
S        198.133.219.0/24 is directly connected, Serial0/0/1
          209.165.200.0/27 is subnetted, 1 subnets
S        209.165.200.224 [1/0] via 10.1.1.2
```

How is this new route listed in the routing table?

```
S      198.133.219.0/24 is directly connected, Serial0/0/1
```

or

```
S      198.133.219.0/24 [1/0] via 10.1.1.2
```

Lab – Configuring IPv4 Static and Default Routes

- d. From host PC-A, is it possible to ping the R1 address 198.133.219.1? _____ Yes
This ping should be successful.

Step 4: Remove static routes for loopback addresses.

- a. On R1, use the **no** command to remove the static routes for the two loopback addresses from the routing table. Write the commands you used in the space provided.

```
R1(config)# no ip route 209.165.200.224 255.255.255.224 10.1.1.2
R1(config)# no ip route 198.133.219.0 255.255.255.0 s0/0/1
```

Note: A static route can be removed with the **no** command without specifying the exit interface or next-hop ip address as displayed below.

```
R1(config)# no ip route 209.165.200.224 255.255.255.224
R1(config)# no ip route 198.133.219.0 255.255.255.0
```

- b. View the routing table to verify the routes have been removed.

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.1.1.0/30 is directly connected, Serial0/0/1
L       10.1.1.1/32 is directly connected, Serial0/0/1
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.0.0/24 is directly connected, GigabitEthernet0/1
L       192.168.0.1/32 is directly connected, GigabitEthernet0/1
S       192.168.1.0/24 [1/0] via 10.1.1.2
```

How many network routes are listed in the routing table on R1? _____ Three

Is the Gateway of last resort set? _____ No

Part 4: Configure and Verify a Default Route

In Part 4, you will implement a default route, confirm that the route has been added to the routing table, and verify connectivity based on the introduced route.

A default route identifies the gateway to which the router sends all IP packets for which it does not have a learned or static route. A default static route is a static route with 0.0.0.0 as the destination IP address and subnet mask. This is commonly referred to as a “quad zero” route.

In a default route, either the next-hop IP address or exit interface can be specified. To configure a default static route, use the following syntax:

Lab – Configuring IPv4 Static and Default Routes

```
Router(config) # ip route 0.0.0.0 0.0.0.0 {ip-address or exit-intf}
```

- a. Configure the R1 router with a default route using the exit interface of S0/0/1. Write the command you used in the space provided.

```
R1(config) # ip route 0.0.0.0 0.0.0.0 s0/0/1
```

- b. View the routing table to verify the new static route entry.

```
R1#show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP  
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area  
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2  
E1 - OSPF external type 1, E2 - OSPF external type 2  
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2  
ia - IS-IS inter area, * - candidate default, U - per-user static route  
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP  
+ - replicated route, % - next hop override
```

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

```
S*    0.0.0.0/0 is directly connected, Serial0/0/1  
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks  
C      10.1.1.0/30 is directly connected, Serial0/0/1  
L      10.1.1.1/32 is directly connected, Serial0/0/1  
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.0.0/24 is directly connected, GigabitEthernet0/1  
L      192.168.0.1/32 is directly connected, GigabitEthernet0/1  
S      192.168.1.0/24 [1/0] via 10.1.1.2
```

How is this new route listed in the routing table?

```
S*    0.0.0.0/0 is directly connected, Serial0/0/1
```

What is the Gateway of last resort?

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

- c. From host PC-A, is it possible to ping the 209.165.200.225? _____ Yes
d. From host PC-A, is it possible to ping the 198.133.219.1? _____ Yes

These pings should be successful.

Reflection

1. A new network 192.168.3.0/24 is connected to interface G0/0 on R1. What commands could be used to configure a static route to that network from R3?

```
Answers will vary. ip route 192.168.3.0 255.255.255.0 10.1.1.1, ip route 192.168.3.0 255.255.255.0 s0/0/0, or  
ip route 0.0.0.0 0.0.0.0 s0/0/0.
```

Lab – Configuring IPv4 Static and Default Routes

2. Is there a benefit to configuring a directly connected static route instead of a recursive static route?

Configuring a directly attached static route allows the routing table to resolve the exit interface in a single search instead of in two searches as needed for recursive static routes.

3. Why is it important to configure a default route on a router?

A default route prevents the router from dropping packets to unknown destinations.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Configuration Commands for Parts 2, 3, and 4

The commands listed in Appendix A are for reference only. This Appendix does not include all the specific commands necessary to complete this lab.

Basic Device Settings

Configure IP settings on the router.

```
R3(config)# interface s0/0/0
R3(config-if)# ip address 10.1.1.2 255.255.255.252
R3(config-if)# clock rate 128000
R3(config-if)# no shutdown
```

Static Route Configurations

Configure a recursive static route.

Lab – Configuring IPv4 Static and Default Routes

```
R1(config)# ip route 192.168.1.0 255.255.255.0 10.1.1.2
```

Configure a directly connected static route.

```
R3(config)# ip route 192.168.0.0 255.255.255.0 s0/0/0
```

Remove static routes.

```
R1(config)# no ip route 209.165.200.224 255.255.255.224 serial0/0/1
```

or

```
R1(config)# no ip route 209.165.200.224 255.255.255.224 10.1.1.2
```

or

```
R1(config)# no ip route 209.165.200.224 255.255.255.224
```

Default Route Configuration

```
R1(config)# ip route 0.0.0.0 0.0.0.0 s0/0/1
```

Device Configs - R1 and R3

Router R1 (after Part 4)

```
R1#show run
Building configuration...

Current configuration : 1547 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
!
```

Lab – Configuring IPv4 Static and Default Routes

```
multilink bundle-name authenticated
!
!
!
!
!
!
redundancy
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.0.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
ip address 10.1.1.1 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 Serial0/0/1
ip route 192.168.1.0 255.255.255.0 10.1.1.2
!
!
!
!
control-plane
```

Lab – Configuring IPv4 Static and Default Routes

```
!
!
banner motd ^CUnauthorized access prohibited!^C
!
line con 0
password 7 01100F175804
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 01100F175804
logging synchronous
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3

```
R3#show run
Building configuration...

Current configuration : 1700 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
```

Lab – Configuring IPv4 Static and Default Routes

```
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
!
multilink bundle-name authenticated
!
!
!
!
!
!
vtp domain TSHOOT
vtp mode transparent
!
redundancy
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.224
!
interface Loopback1
 ip address 198.133.219.1 255.255.255.0
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
```

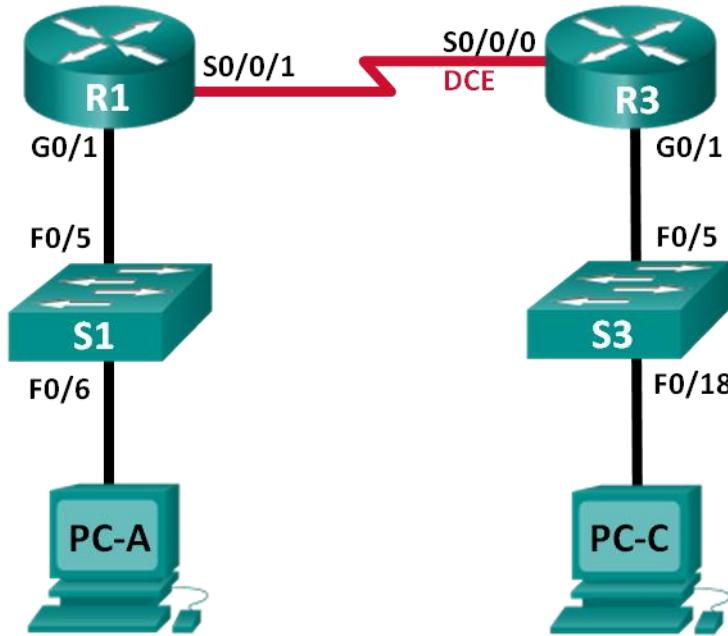
Lab – Configuring IPv4 Static and Default Routes

```
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 10.1.1.2 255.255.255.252
 clock rate 256000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.0.0 255.255.255.0 Serial0/0/0
!
!
!
!
control-plane
!
!
!
banner motd ^CUnauthorized access prohibited!^C
!
line con 0
 password 7 110A1016141D
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password 7 00071A150754
logging synchronous
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring IPv6 Static and Default Routes (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IPv6 Address / Prefix Length	Default Gateway
R1	G0/1	2001:DB8:ACAD:A::/64 eui-64	N/A
	S0/0/1	FC00::1/64	N/A
R3	G0/1	2001:DB8:ACAD:B::/64 eui-64	N/A
	S0/0/0	FC00::2/64	N/A
PC-A	NIC	SLAAC	SLAAC
PC-C	NIC	SLAAC	SLAAC

Objectives

Part 1: Build the Network and Configure Basic Device Settings

- Enable IPv6 unicast routing and configure IPv6 addressing on the routers.
- Disable IPv4 addressing and enable IPv6 SLAAC for the PC network interfaces.
- Use **ipconfig** and **ping** to verify LAN connectivity.
- Use **show** commands to verify IPv6 settings.

Part 2: Configure IPv6 Static and Default Routes

Lab – Configuring IPv6 Static and Default Routes

- Configure a directly attached IPv6 static route.
- Configure a recursive IPv6 static route.
- Configure a default IPv6 static route.

Background / Scenario

In this lab, you will configure the entire network to communicate using only IPv6 addressing, including configuring the routers and PCs. You will use stateless address auto-configuration (SLAAC) for configuring the IPv6 addresses for the hosts. You will also configure IPv6 static and default routes on the routers to enable communication to remote networks that are not directly connected.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will cable and configure the network to communicate using IPv6 addressing.

Step 1: Cable the network as shown in the topology diagram.

Step 2: Initialize and reload the routers and switches.

Step 3: Enable IPv6 unicast routing and configure IPv6 addressing on the routers.

- a. Using Tera Term, console into the router labeled R1 in the topology diagram and assign the router the name R1.
- b. Within global configuration mode, enable IPv6 routing on R1.

```
R1(config)# ipv6 unicast-routing
```
- c. Configure the network interfaces on R1 with IPv6 addresses. Notice that IPv6 is enabled on each interface. The G0/1 interface has a globally routable unicast address and EUI-64 is used to create the interface identifier portion of the address. The S0/0/1 interface has a privately routable, unique-local address, which is recommended for point-to-point serial connections.

```
R1(config)# interface g0/1
R1(config-if)# ipv6 address 2001:DB8:ACAD:A::/64 eui-64
```

Lab – Configuring IPv6 Static and Default Routes

```
R1(config-if) # no shutdown
R1(config-if) # interface serial 0/0/1
R1(config-if) # ipv6 address FC00::1/64
R1(config-if) # no shutdown
R1(config-if) # exit
```

- d. Assign a device name to router R3.
- e. Within global configuration mode, enable IPv6 routing on R3.

```
R3(config) # ipv6 unicast-routing
```

- f. Configure the network interfaces on R3 with IPv6 addresses. Notice that IPv6 is enabled on each interface. The G0/1 interface has a globally routable unicast address and EUI-64 is used to create the interface identifier portion of the address. The S0/0/0 interface has a privately routable, unique-local address, which is recommended for point-to-point serial connections. The clock rate is set because it is the DCE end of the serial cable.

```
R3(config) # interface gigabit 0/1
R3(config-if) # ipv6 address 2001:DB8:ACAD:B::/64 eui-64
R3(config-if) # no shutdown
R3(config-if) # interface serial 0/0/0
R3(config-if) # ipv6 address FC00::2/64
R3(config-if) # clock rate 128000
R3(config-if) # no shutdown
R3(config-if) # exit
```

Step 4: Disable IPv4 addressing and enable IPv6 SLAAC for the PC network interfaces.

- a. On both PC-A and PC-C, navigate to the **Start menu > Control Panel**. Click the **Network and Sharing Center** link while viewing with icons. In the Network and Sharing Center window, click the **Change adapter settings** link on the left side of the window to open the Network Connections window.
- b. In the Network Connections window, you see the icons for your network interface adapters. Double-click the Local Area Connection icon for the PC network interface that is connected to the switch. Click the **Properties** to open the Local Area Connection Properties dialogue window.
- c. With the Local Area Connection Properties window open, scroll down through the items and uncheck the item **Internet Protocol Version 4 (TCP/IPv4)** check box to disable the IPv4 protocol on the network interface.
- d. With the Local Area Connection Properties window still open, click the **Internet Protocol Version 6 (TCP/IPv6)** check box, and then click **Properties**.
- e. With the Internet Protocol Version 6 (TCP/IPv6) Properties window open, check to see if the radio buttons for **Obtain an IPv6 address automatically** and **Obtain DNS server address automatically** are selected. If not, select them.
- f. With the PCs configured to obtain an IPv6 address automatically, they will contact the routers to obtain the network subnet and gateway information, and auto-configure their IPv6 address information. In the next step, you will verify the settings.

Step 5: Use ipconfig and ping to verify LAN connectivity.

- a. From PC-A, open a command prompt, type **ipconfig /all** and press Enter. The output should look similar to that shown below. In the output, you should see that the PC now has an IPv6 global unicast address, a link-local IPv6 address, and a link-local IPv6 default gateway address. You may also see a temporary IPv6 address and under the DNS server addresses, three site-local addresses that start with FEC0. Site-

Lab – Configuring IPv6 Static and Default Routes

local addresses are private addresses that were meant to be backwards compatible with NAT. However, they are not supported in IPv6 and are replaced by unique-local addresses.

```
C:\Users\User1> ipconfig /all
Windows IP Configuration

<Output omitted>

Ethernet adapter Local Area Connection:

  Connection-specific DNS Suffix . :
  Description . . . . . : Intel(R) 82577LC Gigabit Network Connection
  Physical Address. . . . . : 1C-C1-DE-91-C3-5D
  DHCP Enabled. . . . . : No
  Autoconfiguration Enabled . . . . . : Yes
  IPv6 Address. . . . . : 2001:db8:acad:a:7c0c:7493:218d:2f6c(Preferred)
  Temporary IPv6 Address. . . . . : 2001:db8:acad:a:bc40:133a:54e7:d497(Preferred)
  Link-local IPv6 Address . . . . . : fe80::7c0c:7493:218d:2f6c%13(Preferred)
  Default Gateway . . . . . : fe80::6273:5cff:fe0d:1a61%13
  DNS Servers . . . . . . . . . : fec0:0:0:ffff::1%1
                                 fec0:0:0:ffff::2%1
                                 fec0:0:0:ffff::3%1
  NetBIOS over Tcpip. . . . . : Disabled
```

Based on your network implementation and the output of the **ipconfig /all** command, did PC-A receive IPv6 addressing information from R1?

If the router has its Gigabit Ethernet interface and IPv6 unicast-routing configured, then the answer should be yes. Note: It may take a few seconds for the PC to auto-negotiate the IPv6 address information from the router.

- b. What is the PC-A global unicast IPv6 address?

Answers will vary due to the unique nature of the eui-64 host identifier. In the sample in Step 5a, 2001:db8:acad:a:7c0c:7493:218d:2f6c(Preferred) is global unicast address.

- c. What is the PC-A link-local IPv6 address?

Answers will vary due to the unique nature of the link-local address. In the sample in step 5a, fe80::7c0c:7493:218d:2f6c%13(Preferred) is link-local address.

- d. What is the PC-A default gateway IPv6 address?

Answers will vary due to the unique nature of the link-local default gateway address.

- e. From PC-A, use the **ping -6** command to issue an IPv6 ping to the link-local default gateway address. You should see replies from the R1 router.

```
C:\Users\User1> ping -6 <default-gateway-address>
```

Lab – Configuring IPv6 Static and Default Routes

```
C:\Users\User1> ping -6 fe80::6273:5cff:fe0d:1a61%13

Pinging fe80::6273:5cff:fe0d:1a61%13 with 32 bytes of data:
Reply from fe80::6273:5cff:fe0d:1a61%13: time<1ms
Reply from fe80::6273:5cff:fe0d:1a61%13: time<1ms
Reply from fe80::6273:5cff:fe0d:1a61%13: time<1ms
Reply from fe80::6273:5cff:fe0d:1a61%13: time<1ms

Ping statistics for fe80::6273:5cff:fe0d:1a61%13:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Did PC-A receive replies to the ping from PC-A to R1?

If the PC was able to receive IP address information from the router, then answer should be yes.

- f. Repeat Step 5a from PC-C.

Did PC-C receive IPv6 addressing information from R3?

If the router has its Gigabit Ethernet interface and ipv6 unicast-routing configured, then the answer should be yes. Note: It may take a few seconds for the PC to auto-negotiate the IPv6 address information from the router.

- g. What is the PC-C global unicast IPv6 address?
-

Answers will vary due to the unique nature of the eui-64 host identifier.

- h. What is the PC-C link-local IPv6 address?
-

Answers will vary due to the unique nature of the link-local address.

- i. What is the PC-C default gateway IPv6 address?
-

Answers will vary due to the unique nature of the link-local default gateway address.

- j. From PC-C, use the **ping -6** command to ping the PC-C default gateway.

Did PC-C receive replies to the pings from PC-C to R3?

If the PC was able to receive IP address information from the router, then answer should be yes.

- k. Attempt an IPv6 **ping -6** from PC-A to the PC-C IPv6 address.

```
C:\Users\User1> ping -6 PC-C-IPv6-address
```

Was the ping successful? Why or why not?

The answer should be no because the routers have not been configured with static or dynamic routing and know only about the directly connected networks. Without the proper routes, the routers will drop packets destined for unknown networks.

Step 6: Use show commands to verify IPv6 settings.

- Check the status of the interfaces on R1 with the **show ipv6 interface brief** command.

```
R1# show ipv6 interface brief
Em0/0                  [administratively down/down]
    unassigned
GigabitEthernet0/0      [administratively down/down]
    unassigned
GigabitEthernet0/1      [up/up]
    FE80::6273:5CFF:FE0D:1A61
    2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61
Serial0/0/0             [administratively down/down]
    unassigned
Serial0/0/1             [up/up]
    FE80::6273:5CFF:FE0D:1A60
    FC00::1
```

What are the two IPv6 addresses for the G0/1 interface and what kind of IPv6 addresses are they?

Answers will vary on the interface identifier portion of the address. Using the command output depicted above, the answer is: a link-local address at FE80::6273:5CFF:FE0D:1A61 and a global unicast address at 2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61

What are the two IPv6 addresses for the S0/0/1 interface and what kind of IPv6 addresses are they?

Answers will vary on the interface identifier portion of the address. Using the command output depicted above, the answer is: a link-local address at FE80::6273:5CFF:FE0D:1A60 and a unique-local address at FC00::1.

- To see more detailed information on the IPv6 interfaces, type a **show ipv6 interface** command on R1 and press Enter.

```
R1# show ipv6 interface
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::6273:5CFF:FE0D:1A61
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61, subnet is 2001:DB8:ACAD:A::/64 [EUI]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF0D:1A61
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
```

Lab – Configuring IPv6 Static and Default Routes

```
ICMP unreachables are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
ND advertised default router preference is Medium
Hosts use stateless autoconfig for addresses.
Serial0/0/1 is up, line protocol is up
IPv6 is enabled, link-local address is FE80::6273:5CFF:FE0D:1A60
No Virtual link-local address(es):
Global unicast address(es):
    FC00::1, subnet is FC00::/64
Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
    FF02::1:FF0D:1A60
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ICMP unreachables are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND RAs are suppressed (periodic)
Hosts use stateless autoconfig for addresses.
```

What are the multicast group addresses for the Gigabit Ethernet 0/1 interface?

Answers will vary slightly. Based on the command output above:

FF02::1, FF02::2, FF02::1:FF0D:1A61

What are the multicast group addresses for the S0/0/1 interface?

Answers will vary slightly. Based on the command output above:

FF02::1, FF02::2, FF02::1:FF00:1, FF02::1:FF0D:1A60

What is an FF02::1 multicast address used for?

Multicasting to all nodes on the local network segment.

What is an FF02::2 multicast address used for?

Multicasting to all routers on the local network segment.

What kind of multicast addresses are FF02::1:FF00:1 and FF02::1:FF0D:1A60, and what are they used for?

Lab – Configuring IPv6 Static and Default Routes

Solicited-node multicast addresses. Each interface unicast or anycast address has to have a solicited-node multicast address for resolving neighbor addresses on the local-link.

- c. View the IPv6 routing table information for R1 using the **show ipv6 route** command. The IPv6 routing table should have two connected routes, one for each interface, and three local routes, one for each interface and one for multicast traffic to a Null0 interface.

```
R1# show ipv6 route
IPv6 Routing Table - default - 5 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
      B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
      IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
      O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
      ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C  2001:DB8:ACAD:A::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L  2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61/128 [0/0]
    via GigabitEthernet0/1, receive
C  FC00::/64 [0/0]
    via Serial0/0/1, directly connected
L  FC00::1/128 [0/0]
    via Serial0/0/1, receive
L  FF00::/8 [0/0]
    via Null0, receive
```

In what way does the routing table output of R1 reveal why you were unable to ping PC-C from PC-A?

The ping to PC-C was unsuccessful because there is no route to the 2001:DB8:ACAD:B::/64 network in the routing table.

Part 2: Configure IPv6 Static and Default Routes

In Part 2, you will configure IPv6 static and default routes three different ways. You will confirm that the routes have been added to the routing tables, and you will verify successful connectivity between PC-A and PC-C.

You will configure three types of IPv6 static routes:

- **Directly Connected IPv6 Static Route** – A directly connected static route is created when specifying the outgoing interface.
- **Recursive IPv6 Static Route** – A recursive static route is created when specifying the next-hop IP address. This method requires the router to execute a recursive lookup in the routing table in order to identify the outgoing interface.
- **Default IPv6 Static Route** – Similar to a quad zero IPv4 route, a default IPv6 static route is created by making the destination IPv6 prefix and prefix length all zeros, ::/0.

Step 1: Configure a directly connected IPv6 static route.

In a directly connected IPv6 static route, the route entry specifies the router outgoing interface. A directly connected static route is typically used with a point-to-point serial interface. To configure a directly attached IPv6 static route, use the following command format:

Lab – Configuring IPv6 Static and Default Routes

```
Router(config) # ipv6 route <ipv6-prefix/prefix-length> <outgoing-interface-type> <outgoing-interface-number>
```

- a. On router R1, configure an IPv6 static route to the 2001:DB8:ACAD:B::/64 network on R3, using the R1 outgoing S0/0/1 interface.

```
R1(config) # ipv6 route 2001:DB8:ACAD:B::/64 serial 0/0/1  
R1(config) #
```

- b. View the IPv6 routing table to verify the new static route entry.

```
R1# show ipv6 route  
IPv6 Routing Table - default - 6 entries  
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route  
      B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2  
      IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external  
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect  
      O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2  
      ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2  
C  2001:DB8:ACAD:A::/64 [0/0]  
    via GigabitEthernet0/1, directly connected  
L  2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61/128 [0/0]  
    via GigabitEthernet0/1, receive  
S  2001:DB8:ACAD:B::/64 [1/0]  
    via Serial0/0/1, directly connected  
C  FC00::/64 [0/0]  
    via Serial0/0/1, directly connected  
L  FC00::1/128 [0/0]  
    via Serial0/0/1, receive  
L  FF00::/8 [0/0]  
    via Null0, receive
```

What is the code letter and routing table entry for the newly added route in the routing table?

```
S  2001:DB8:ACAD:B::/64 [1/0]  
  via Serial0/0/1, directly connected
```

- c. Now that the static route has been configured on R1, is it now possible to ping the host PC-C from PC-A?

The answer is no, not yet.

These pings should fail. If the recursive static route is correctly configured, the ping arrives at PC-C. PC-C sends a ping reply back to PC-A. However, the ping reply is discarded at R3 because R3 does not have a return route to the 2001:DB8:ACAD:A::/64 network in the routing table. To successfully ping across the network, you must also create a static route on R3.

- d. On router R3, configure an IPv6 static route to the 2001:DB8:ACAD:A::/64 network, using the R3 outgoing S0/0/0 interface.

```
R3(config) # ipv6 route 2001:DB8:ACAD:A::/64 serial 0/0/0  
R3(config) #
```

- e. Now that both routers have static routes, attempt an IPv6 **ping -6** from PC-A to the PC-C global unicast IPv6 address.

Lab – Configuring IPv6 Static and Default Routes

```
C:\Users\User1>ping -6 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8

Pinging 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8 with 32 bytes of data:
Reply from 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8: time=17ms
Reply from 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8: time=6ms
Reply from 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8: time=6ms
Reply from 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8: time=6ms

Ping statistics for 2001:db8:acad:b:8cf0:f8ab:f36e:dfa8:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 6ms, Maximum = 17ms, Average = 8ms
```

Was the ping successful? Why?

With static routes configured on both R1 and R3, the ping should be successful.

Step 2: Configure a recursive IPv6 static route.

In a recursive IPv6 static route, the route entry has the next-hop router IPv6 address. To configure a recursive IPv6 static route, use the following command format:

```
Router(config)# ipv6 route <ipv6-prefix/prefix-length> <next-hop-ipv6-address>
```

- On router R1, delete the directly attached static route and add a recursive static route.

```
R1(config)# no ipv6 route 2001:DB8:ACAD:B::/64 serial 0/0/1
R1(config)# ipv6 route 2001:DB8:ACAD:B::/64 FC00::2
R1(config)# exit
```

- On router R3, delete the directly attached static route and add a recursive static route.

```
R3(config)# no ipv6 route 2001:DB8:ACAD:A::/64 serial 0/0/0
R3(config)# ipv6 route 2001:DB8:ACAD:A::/64 FC00::1
R3(config)# exit
```

- View the IPv6 routing table on R1 to verify the new static route entry.

```
R1# show ipv6 route
IPv6 Routing Table - default - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
      B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
      IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
      O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
      ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C  2001:DB8:ACAD:A::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L  2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61/128 [0/0]
    via GigabitEthernet0/1, receive
S  2001:DB8:ACAD:B::/64 [1/0]
    via FC00::2
```

Lab – Configuring IPv6 Static and Default Routes

```
C  FC00::/64 [0/0]
    via Serial0/0/1, directly connected
L  FC00::1/128 [0/0]
    via Serial0/0/1, receive
L  FF00::/8 [0/0]
    via Null0, receive
```

What is the code letter and routing table entry for the newly added route in the routing table?

```
S  2001:DB8:ACAD:B::/64 [1/0]
    via FC00::2
```

- d. Verify connectivity by issuing a **ping -6** command from PC-A to PC-C.

Was the ping successful? _____ Yes

Note: It may be necessary to disable the PC firewall to ping between PCs.

Step 3: Configure a default IPv6 static route.

In a default static route, the destination IPv6 prefix and prefix length are all zeros.

```
Router(config) # ipv6 route ::/0 <outgoing-interface-type> <outgoing-interface-number> {and/or} <next-hop-ipv6-address>
```

- a. On router R1, delete the recursive static route and add a default static route.

```
R1(config) # no ipv6 route 2001:DB8:ACAD:B::/64 FC00::2
R1(config) # ipv6 route ::/0 serial 0/0/1
R1(config) #
```

- b. Delete the recursive static route and add a default static route on R3.

```
R3(config) # no ipv6 route 2001:DB8:ACAD:A::/64 FC00::1
R3(config) # ipv6 route ::/0 serial 0/0/0
R3(config) #
```

- c. View the IPv6 routing table on R1 to verify the new static route entry.

```
R1# show ipv6 route
IPv6 Routing Table - default - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
      B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
      IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
      O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
      ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S  ::/0 [1/0]
    via Serial0/0/1, directly connected
C  2001:DB8:ACAD:A::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L  2001:DB8:ACAD:A:6273:5CFF:FE0D:1A61/128 [0/0]
    via GigabitEthernet0/1, receive
C  FC00::/64 [0/0]
    via Serial0/0/1, directly connected
L  FC00::1/128 [0/0]
```

Lab – Configuring IPv6 Static and Default Routes

```
via Serial0/0/1, receive  
L FF00::/8 [0/0]  
via Null0, receive
```

What is the code letter and routing table entry for the newly added default route in the routing table?

```
S ::/0 [1/0]  
via Serial0/0/1, directly connected
```

- d. Verify connectivity by issuing a **ping -6** command from PC-A to PC-C.

Was the ping successful? _____ Yes

Note: It may be necessary to disable the PC firewall to ping between PCs.

Reflection

1. This lab focuses on configuring IPv6 static and default routes. Can you think of a situation where you would need to configure both IPv6 and IPv4 static and default routes on a router?

Many Internet service providers (ISPs) are implementing IPv6 networks, and in the near future may require their clients to connect to their networks using IPv6 addressing. In this situation, network administrators may decide to implement both IPv4 and IPv6 networks and would therefore need to configure both IPv6 and IPv4 routing.

2. In practice, configuring an IPv6 static and default route is very similar to configuring an IPv4 static and default route. Aside from the obvious differences between the IPv6 and IPv4 addressing, what are some other differences when configuring and verifying an IPv6 static route as compared to an IPv4 static route?

When configuring a static IPv6 route, the **ipv6 route** command is used instead of the **ip route** command. Another important difference is the need to use the **show ipv6 route** command to view the IPv6 routing table as compared to the IPv4 routing table with the **show ip route** command.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1

```
R1#show run
Building configuration...

Current configuration : 1222 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
no aaa new-model
!
ipv6 unicast-routing
ipv6 cef
!
ip cef
multilink bundle-name authenticated
```

Lab – Configuring IPv6 Static and Default Routes

```
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
duplex auto
speed auto
ipv6 address 2001:DB8:ACAD:A::/64 eui-64
ipv6 enable
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
ipv6 address FC00::1/64
ipv6 enable
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 route ::/0 Serial0/0/1
!
control-plane
!
line con 0
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
login
```

Lab – Configuring IPv6 Static and Default Routes

```
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3

```
R3#show run
Building configuration...

Current configuration : 1241 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
no aaa new-model
!
ipv6 unicast-routing
ipv6 cef
!
ip cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  no ip address
  duplex auto
  speed auto
  ipv6 address 2001:DB8:ACAD:B::/64 eui-64
  ipv6 enable
!
interface Serial0/0/0
```

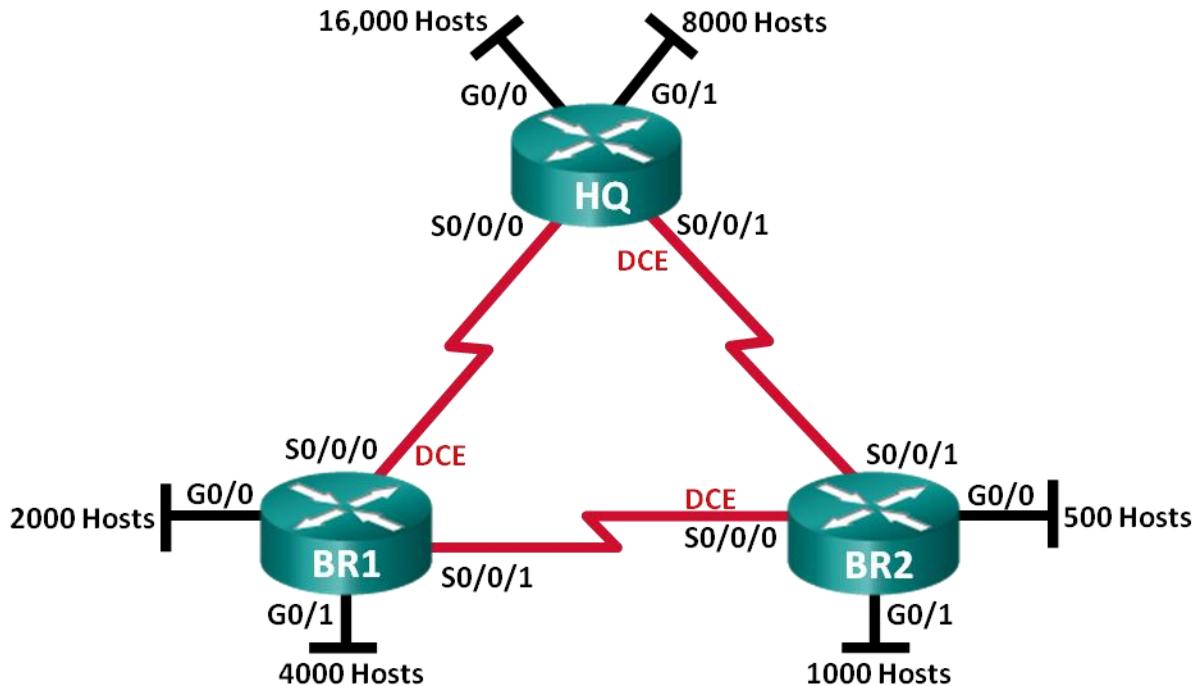
Lab – Configuring IPv6 Static and Default Routes

```
no ip address
ipv6 address FC00::2/64
ipv6 enable
clock rate 256000
!
interface Serial0/0/1
no ip address
shutdown
clock rate 2000000
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 route ::/0 Serial0/0/0
!
control-plane
!
line con 0
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Designing and Implementing IPv4 Addressing with VLSM (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Objectives

- Part 1: Examine the Network Requirements
- Part 2: Design the VLSM Address Scheme
- Part 3: Cable and Configure the IPv4 Network

Background / Scenario

The Variable Length Subnet Mask (VLSM) was designed to help conserve IP addresses. With VLSM, a network is subnetted and then subnetted again. This process can be repeated multiple times to create subnets of various sizes based on the number of hosts required in each subnet. Effective use of VLSM requires address planning.

In this lab, you are given the network address 172.16.128.0/17 to develop an address scheme for the network shown in the Topology diagram. VLSM will be used so that the addressing requirements can be met. After you have designed the VLSM address scheme, you will configure the interfaces on the routers with the appropriate IP address information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Instructor Note: This lab is a review of VLSM concepts covered in the previous CCNA course. The lab can be performed in multiple sessions if time is an issue. Parts 1 and 2 are paper-based and can be assigned as homework. Part 3 is Hands-on and requires lab equipment.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 PC (with terminal emulation program, such as Tera Term, to configure routers)
- Console cable to configure the Cisco IOS devices via the console ports
- Ethernet (optional) and serial cables as shown in the topology
- Windows Calculator (optional)

Part 1: Examine the Network Requirements

In Part 1, you will examine the network requirements to develop a VLSM address scheme for the network shown in the Topology diagram using the network address of 172.16.128.0/17.

Note: You may use the Windows Calculator application and the www.ipcalc.org IP subnet calculator to help with your calculations.

Step 1: Determine how many host addresses are available and how many subnets are needed.

How many host addresses are available in a /17 network? _____ 32,766

What is the total number of host addresses needed in the topology diagram? _____ 31,506

How many subnets are needed in the network topology? _____ 9

Step 2: Determine the largest subnet needed.

Subnet description (e.g. BR1 G0/1 LAN or BR1-HQ WAN link) _____ HQ G0/0 LAN

How many IP addresses are needed in the largest subnet? _____ 16,000

What is the smallest subnet that supports that many addresses?

_____ /18 or 255.255.192.0

How many host addresses does that subnet support? _____ 16,382

Can the 172.16.128.0/17 network be subnetted to support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.128.0/18

_____ 172.16.192.0/18

Use the first network address for this subnet.

Step 3: Determine the second largest subnet needed.

Subnet description _____ HQ G0/1 LAN

How many IP addresses are needed for the second largest subnet? _____ 8,000

What is the smallest subnet that supports that many hosts?

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_____ /19 or 255.255.224.0

How many host addresses does that subnet support? _____ 8,190

Can the remaining subnet be subnetted again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.192.0/19

_____ 172.16.224.0/19

Use the first network address for this subnet.

Step 4: Determine the next largest subnet needed.

Subnet description _____ BR1 G0/1 LAN

How many IP addresses are needed for the next largest subnet? _____ 4,000

What is the smallest subnet that supports that many hosts?

_____ /20 or 255.255.240.0

How many host addresses does that subnet support? _____ 4,094

Can the remaining subnet be subnetted again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.224.0/20

_____ 172.16.240.0/20

Use the first network address for this subnet.

Step 5: Determine the next largest subnet needed.

Subnet description _____ BR1 G0/0 LAN

How many IP addresses are needed for the next largest subnet? _____ 2,000

What is the smallest subnet that supports that many hosts?

_____ /21 or 255.255.248.0

How many host addresses does that subnet support? _____ 2,046

Can the remaining subnet be subnetted again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.240.0/21

_____ 172.16.248.0/21

Use the first network address for this subnet.

Step 6: Determine the next largest subnet needed.

Subnet description _____ BR2 G0/1 LAN

How many IP addresses are needed for the next largest subnet? _____ 1,000

What is the smallest subnet that supports that many hosts?

_____ /22 or 255.255.252.0

How many host addresses does that subnet support? _____ 1,022

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Can the remaining subnet be subnetted again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.248.0/22

_____ 172.16.252.0/22

Use the first network address for this subnet.

Step 7: Determine the next largest subnet needed.

Subnet description _____ BR2 G0/0 LAN

How many IP addresses are needed for the next largest subnet? _____ 500

What is the smallest subnet that supports that many hosts?

_____ /23 or 255.255.254.0

How many host addresses does that subnet support? _____ 510

Can the remaining subnet be subnetted again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.252.0/23

_____ 172.16.254.0/23

Use the first network address for this subnet.

Step 8: Determine the subnets needed to support the serial links.

How many host addresses are needed for each serial subnet link? _____ 2

What is the smallest subnet that supports that many host addresses?

_____ /30 or 255.255.255.252

a. Subnet the remaining subnet and write the network addresses that result from this subnetting below.

_____ 172.16.254.0/24

_____ 172.16.255.0/24

b. Continue subnetting the first subnet of each new subnet until you have four /30 subnets. Write the first three network addresses of these /30 subnets below.

_____ 172.16.254.0/30

_____ 172.16.254.4/30

_____ 172.16.254.8/30

c. Enter the subnet descriptions for these three subnets below.

_____ HQ - BR1 Serial Link

_____ HQ - BR2 Serial Link

_____ BR1 - BR2 Serial Link

Part 2: Design the VLSM Address Scheme

Step 1: Calculate the subnet information.

Use the information that you obtained in Part 1 to fill in the table below.

Subnet Description	Number of Hosts Needed	Network Address /CIDR	First Host Address	Broadcast Address
HQ G0/0	16,000	172.16.128.0/18	172.16.128.1	172.16.191.255
HQ G0/1	8,000	172.16.192.0/19	172.16.192.1	172.16.223.255
BR1 G0/1	4,000	172.16.224.0/20	172.16.224.1	172.16.239.255
BR1 G0/0	2,000	172.16.240.0/21	172.16.240.1	172.16.247.255
BR2 G0/1	1,000	172.16.248.0/22	172.16.248.1	172.16.251.255
BR2 G0/0	500	172.16.252.0/23	172.16.252.1	172.16.253.255
HQ S0/0/0 – BR1 S0/0/0	2	172.16.254.0/30	172.16.254.1	172.16.254.3
HQ S0/0/1 – BR2 S0/0/1	2	172.16.254.4/30	172.16.254.5	172.16.254.7
BR1 S0/0/1 – BR2 S0/0/0	2	172.16.254.8/30	172.16.254.9	172.168.254.11

Step 2: Complete the device interface address table.

Assign the first host address in the subnet to the Ethernet interfaces. HQ should be given the first host address on the serial links to BR1 and BR2. BR1 should be given the first host address for the serial link to BR2.

Device	Interface	IP Address	Subnet Mask	Device Interface
HQ	G0/0	172.16.128.1	255.255.192.0	16,000 Host LAN
	G0/1	172.16.192.1	255.255.224.0	8,000 Host LAN
	S0/0/0	172.16.254.1	255.255.255.252	BR1 S0/0/0
	S0/0/1	172.16.254.5	255.255.255.252	BR2 S0/0/1
BR1	G0/0	172.16.240.1	255.255.248.0	2,000 Host LAN
	G0/1	172.16.224.1	255.255.240.0	4,000 Host LAN
	S0/0/0	172.16.254.2	255.255.255.252	HQ S0/0/0
	S0/0/1	172.16.254.9	255.255.255.252	BR2 S0/0/0
BR2	G0/0	172.16.252.1	255.255.254.0	500 Host LAN
	G0/1	172.16.248.1	255.255.252.0	1,000 Host LAN
	S0/0/0	172.16.254.10	255.255.255.252	BR1 S0/0/1
	S0/0/1	172.16.254.6	255.255.255.252	HQ S0/0/1

Part 3: Cable and Configure the IPv4 Network

In Part 3, you will cable the network topology and configure the three routers using the VLSM address scheme that you developed in Part 2.

Step 1: Cable the network as shown in the topology.

Step 2: Configure basic settings on each router.

- a. Assign the device name to the router.
- b. Disable DNS lookup to prevent the router from attempting to translate incorrectly entered commands as though they were hostnames.
- c. Assign **class** as the privileged EXEC encrypted password.
- d. Assign **cisco** as the console password and enable login.
- e. Assign **cisco** as the vty password and enable login.
- f. Encrypt the clear text passwords.
- g. Create a banner that warns anyone accessing the device that unauthorized access is prohibited.

Step 3: Configure the interfaces on each router.

- a. Assign an IP address and subnet mask to each interface using the table that you completed in Part 2.
- b. Configure an interface description for each interface.
- c. Set the clocking rate on all DCE serial interfaces to 128000.
`HQ(config-if)# clock rate 128000`
- d. Activate the interfaces.

Step 4: Save the configuration on all devices.

Step 5: Test Connectivity.

- a. From HQ, ping BR1's S0/0/0 interface address.
- b. From HQ, ping BR2's S0/0/1 interface address.
- c. From BR1, ping BR2's S0/0/0 interface address.
- d. Troubleshoot connectivity issues if pings were not successful.

Note: Pings to the GigabitEthernet interfaces on other routers are unsuccessful. The LANs defined for the GigabitEthernet interfaces are simulated. Because no devices are attached to these LANs, they are in a down/down state. A routing protocol must be in place for other devices to be aware of those subnets. The GigabitEthernet interfaces must also be in an up/up state before a routing protocol can add the subnets to the routing table. These interfaces remain in a down/down state until a device is connected to the other end of the Ethernet interface cable. The focus of this lab is on VLSM and configuring the interfaces.

Reflection

Can you think of a shortcut for calculating the network addresses of consecutive /30 subnets?

Answers may vary. A /30 network has 4 address spaces: the network address, 2 host addresses, and a broadcast address. Another technique for obtaining the next /30 network address would be to take the network address of the previous /30 network and add 4 to the last octet.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (Final Configuration)

```
BR1#sh run
Building configuration...

Current configuration : 1555 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname BR1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 15
!
!
```

Lab – Designing and Implementing IPv4 Addressing with VLSM

```
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
description LAN with 2,000 hosts.
ip address 172.16.240.1 255.255.248.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
description LAN with 4,000 hosts.
ip address 172.16.224.1 255.255.240.0
duplex auto
speed auto
!
interface Serial0/0/0
description Connection to HQ S0/0/0.
ip address 172.16.254.2 255.255.255.252
clock rate 128000
!
interface Serial0/0/1
description Connection to BR2 S0/0/0.
ip address 172.16.254.9 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
control-plane
!
!
banner motd ^C
Warning: Unauthorized access is prohibited!
^C
!
line con 0
password 7 14141B180F0B
login
line aux 0
line 2
```

```
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 094F471A1A0A
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2 (Final Configuration)

```
HQ#sh run
Building configuration...

Current configuration : 1554 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname HQ
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
```

Lab – Designing and Implementing IPv4 Addressing with VLSM

```
description LAN with 16,000 hosts.
ip address 172.16.128.1 255.255.192.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
description LAN with 8,000 hosts.
ip address 172.16.192.1 255.255.224.0
duplex auto
speed auto
!
interface Serial0/0/0
description Connection to BR1 S0/0/0.
ip address 172.16.254.1 255.255.255.252
!
interface Serial0/0/1
description Connection to BR2 S0/0/1.
ip address 172.16.254.5 255.255.255.252
clock rate 128000
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
control-plane
!
!
banner motd ^C
Warning: Unauthorized access is prohibited!
^C
!
line con 0
password 7 02050D480809
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 00071A150754
login
transport input all
!
```

```
scheduler allocate 20000 1000
!
end
```

Router R3 (Final Configuration)

```
BR2#sh run
Building configuration...

Current configuration : 1593 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname BR2
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  description LAN with 500 hosts.
  ip address 172.16.252.1 255.255.254.0
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  description LAN with 1,000 hosts.
  ip address 172.16.248.1 255.255.252.0
  duplex auto
  speed auto
!
```

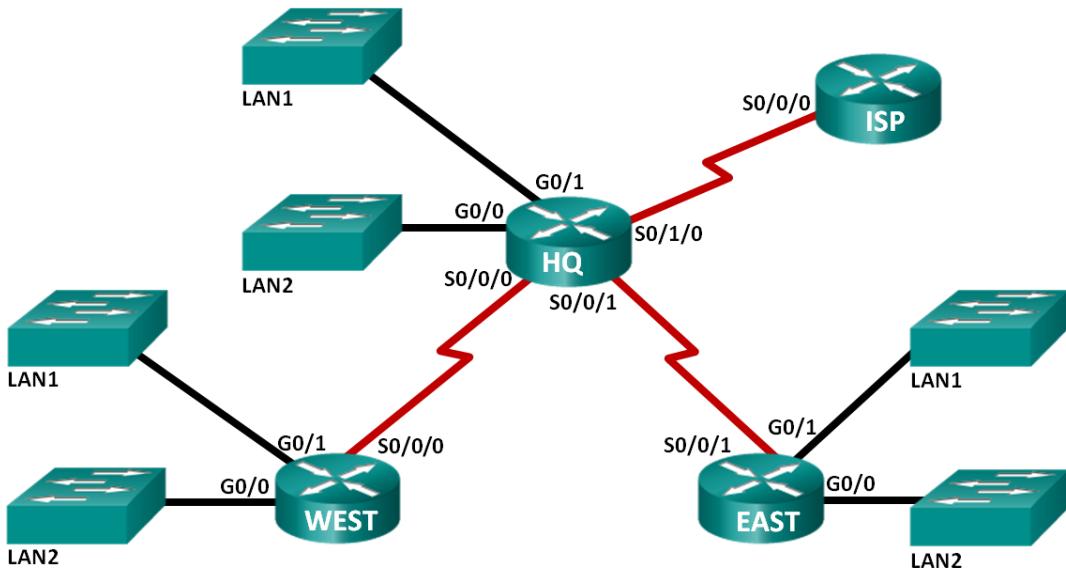
Lab – Designing and Implementing IPv4 Addressing with VLSM

```
interface Serial0/0/0
description Connection to BR1 S0/0/1.
ip address 172.16.254.10 255.255.255.252
clock rate 128000
!
interface Serial0/0/1
description Connection to HQ S0/0/1.
ip address 172.16.254.6 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
!
banner motd ^C
Warning: Unauthorized access is prohibited!
^C
!
line con 0
password 7 070C285F4D06
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 0822455D0A16
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Calculating Summary Routes with IPv4 and IPv6 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Subnet	IPv4 Address	IPv6 Address
HQ LAN1	192.168.64.0/23	2001:DB8:ACAD:E::/64
HQ LAN2	192.168.66.0/23	2001:DB8:ACAD:F::/64
EAST LAN1	192.168.68.0/24	2001:DB8:ACAD:1::/64
EAST LAN2	192.168.69.0/24	2001:DB8:ACAD:2::/64
WEST LAN1	192.168.70.0/25	2001:DB8:ACAD:9::/64
WEST LAN2	192.168.70.128/25	2001:DB8:ACAD:A::/64
Link from HQ to EAST	192.168.71.4/30	2001:DB8:ACAD:1000::/64
Link from HQ to WEST	192.168.71.0/30	2001:DB8:ACAD:2000::/64
Link from HQ to ISP	209.165.201.0/30	2001:DB8:CC1E:1::/64

Objectives

Part 1: Calculate IPv4 Summary Routes

- Determine the summary route for the HQ LANs.
- Determine the summary route for the EAST LANs.
- Determine the summary route for the WEST LANs.

Lab – Calculating Summary Routes with IPv4 and IPv6

- Determine the summary route for the HQ, EAST, and WEST LANs.

Part 2: Calculate IPv6 Summary Routes

- Determine the summary route for the HQ LANs.
- Determine the summary route for the EAST LANs.
- Determine the summary route for the WEST LANs.
- Determine the summary route for the HQ, EAST, and WEST LANs.

Background / Scenario

Summary routes reduce the number of entries in routing tables and make the routing table lookup process more efficient. This process also reduces the memory requirements for the router. A single static route can be used to represent a few routes or thousands of routes.

In this lab, you will determine the summary routes for different subnets of a network. You will then determine the summary route for the entire network. Summary routes will be determined for both IPv4 and IPv6 addresses. Because IPv6 uses hexadecimal (hex) values, you will be required to convert hex to binary.

Instructor Note: This activity can be done in class or assigned as homework. If the assignment is done in class, you may wish to have students work alone or in teams of two students each. It is suggested that the first problem be done together in class to give students guidance as to how to proceed for the rest of the assignment.

Required Resources

- 1 PC (Windows 7, Vista, or XP with Internet access)
- Optional: calculator for converting hex and decimal to binary

Part 1: Calculate IPv4 Summary Routes

In Part 1, you will determine summarized routes that can be used to reduce the size of routing tables. Fill in the tables, after each set of steps, with the appropriate IPv4 addressing information.

Step 1: List the HQ LAN1 and HQ LAN2 IP subnet mask in decimal form.

Step 2: List the HQ LAN1 and HQ LAN2 IP address in binary form.

Step 3: Count the number of far left matching bits to determine the subnet mask for the summary route.

- a. How many far left matching bits are present in the two networks? _____ **22**
- b. List the subnet mask for the summary route in decimal form.

Step 4: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- a. List the matching binary bits for HQ LAN1 and HQ LAN2 subnets.
- b. Add zeros to comprise the remainder of the network address in binary form.
- c. List the summarized network address in decimal form.

Lab – Calculating Summary Routes with IPv4 and IPv6

Subnet	IPv4 Address	Subnet Mask	Subnet IP Address in Binary Form
HQ LAN1	192.168.64.0	255.255.254.0	11000000.10101000.01000000.00000000
HQ LAN2	192.168.66.0	255.255.254.0	11000000.10101000.01000010.00000000
HQ LANs Summary Address	192.168.64.0	255.255.252.0	11000000.10101000.01000000.00000000

Step 5: List the EAST LAN1 and EAST LAN2 IP subnet mask in decimal form.

Step 6: List the EAST LAN1 and EAST LAN2 IP address in binary form.

Step 7: Count the number of far left matching bits to determine the subnet mask for the summary route.

- How many far left matching bits are present in the two networks? _____ 23
- List the subnet mask for the summary route in decimal form.

Step 8: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- List the matching binary bits for EAST LAN1 and EAST LAN2 subnets.
- Add zeros to comprise the remainder of the network address in binary form.
- List the summarized network address in decimal form.

Subnet	IPv4 Address	Subnet Mask	Subnet Address in Binary Form
EAST LAN1	192.168.68.0	255.255.255.0	11000000.10101000.01000100.00000000
EAST LAN2	192.168.69.0	255.255.255.0	11000000.10101000.01000101.00000000
EAST LANs Summary Address	192.168.68.0	255.255.254.0	11000000.10101000.01000100.00000000

Step 9: List the WEST LAN1 and WEST LAN2 IP subnet mask in decimal form.

Step 10: List the WEST LAN1 and WEST LAN2 IP address in binary form.

Step 11: Count the number of far left matching bits to determine the subnet mask for the summary route.

- How many far left matching bits are present in the two networks? _____ 24
- List the subnet mask for the summary route in decimal form.

Step 12: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- List the matching binary bits for WEST LAN1 and WEST LAN2 subnets.

Lab – Calculating Summary Routes with IPv4 and IPv6

- b. Add zeros to comprise the remainder of the network address in binary form.
- c. List the summarized network address in decimal form.

Subnet	IPv4 Address	Subnet Mask	Subnet IP Address in Binary Form
WEST LAN1	192.168.70.0	255.255.255.128	11000000.10101000.01000110.00000000
WEST LAN2	192.168.70.128	255.255.255.128	11000000.10101000.01000110.10000000
WEST LANs Summary Address	192.168.70.0	255.255.255.0	11000000.10101000.01000110.00000000

Step 13: List the HQ, EAST, and WEST summary route IP address and subnet mask in decimal form.

Step 14: List the HQ, EAST, and WEST summary route IP address in binary form.

Step 15: Count the number of far left matching bits to determine the subnet mask for the summary route.

- a. How many far left matching bits are present in the three networks? _____ **21**
- b. List the subnet mask for the summary route in decimal form.

Step 16: Copy the matching binary bits and then add all zeros to determine the summarized network address.

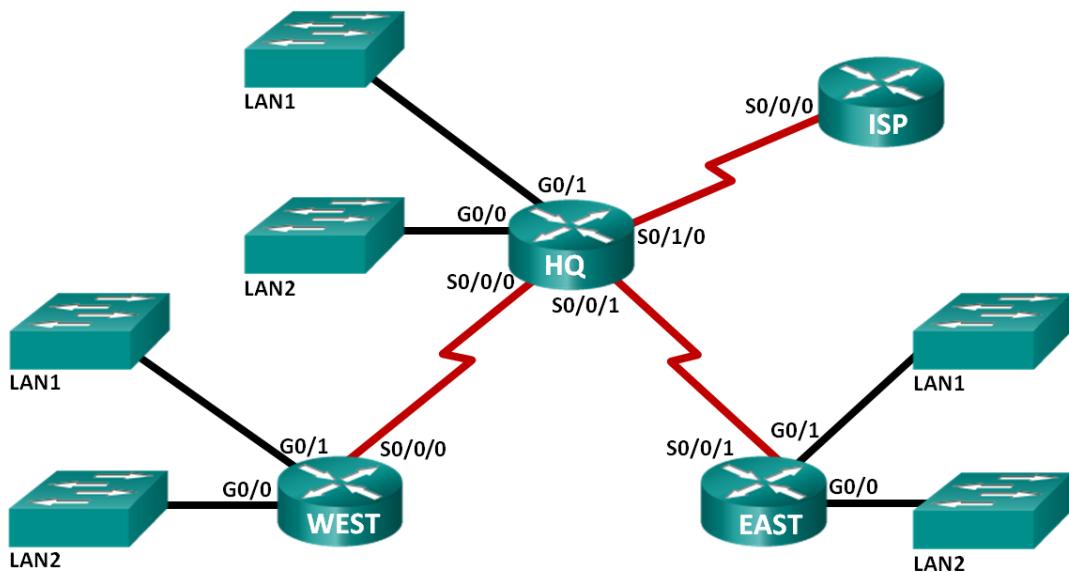
- a. List the matching binary bits for HQ, EAST, and WEST subnets.
- b. Add zeros to comprise the remainder of the network address in binary form.
- c. List the summarized network address in decimal form.

Subnet	IPv4 Address	Subnet Mask	Subnet IP Address in Binary Form
HQ	192.168.64.0	255.255.252.0	11000000.10101000.01000000.00000000
EAST	192.168.68.0	255.255.254.0	11000000.10101000.01000100.00000000
WEST	192.168.70.0	255.255.255.0	11000000.10101000.01000110.00000000
Network Address Summary Route	192.168.64.0	255.255.248.0	11000000.10101000.01000000.00000000

Part 2: Calculate IPv6 Summary Routes

In Part 2, you will determine summarized routes that can be used to reduce the size of routing tables. Complete the tables after each set of steps, with the appropriate IPv6 addressing information.

Topology



Addressing Table

Subnet	IPv6 Address
HQ LAN1	2001:DB8:ACAD:E::/64
HQ LAN2	2001:DB8:ACAD:F::/64
EAST LAN1	2001:DB8:ACAD:1::/64
EAST LAN2	2001:DB8:ACAD:2::/64
WEST LAN1	2001:DB8:ACAD:9::/64
WEST LAN2	2001:DB8:ACAD:A::/64
Link from HQ to EAST	2001:DB8:ACAD:1000::/64
Link from HQ to WEST	2001:DB8:ACAD:2000::/64
Link from HQ to ISP	2001:DB8:CC1E:1::/64

Step 1: List the first 64 bits of the HQ LAN1 and HQ LAN2 IP subnet mask in hexadecimal form.

Step 2: List the HQ LAN1 and HQ LAN2 subnet ID (bits 48-64) in binary form.

Step 3: Count the number of far left matching bits to determine the subnet mask for the summary route.

- a. How many far left matching bits are present in the two subnet IDs? _____ **63**
- b. List the subnet mask for the first 64 bits of the summary route in decimal form.

Step 4: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- a. List the matching subnet ID binary bits for HQ LAN1 and HQ LAN2 subnets.
- b. Add zeros to comprise the remainder of the subnet ID address in binary form.
- c. List the summarized network address in decimal form.

Subnet	IPv6 Address	Subnet Mask for First 64 bits	Subnet ID in Binary Form
HQ LAN1	2001:DB8:ACAD:E::/64	FFFF:FFFF:FFFF:FFFF	00000000000001110
HQ LAN2	2001:DB8:ACAD:F::/64	FFFF:FFFF:FFFF:FFFF	00000000000001111
HQ LANs Summary Address	2001:DB8:ACAD:E::/63	FFFF:FFFF:FFFF:FFFE	00000000000001110

Step 5: List the first 64 bits of the EAST LAN1 and EAST LAN2 IP subnet mask in hexadecimal form.

Step 6: List the EAST LAN1 and EAST LAN2 subnet ID (bits 48-64) in binary form.

Step 7: Count the number of far left matching bits to determine the subnet mask for the summary route.

- a. How many far left matching bits are present in the two subnet IDs? _____ 62
- b. List the subnet mask for the first 64 bits of the summary route in decimal form.

Step 8: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- a. List the matching binary bits for EAST LAN1 and EAST LAN2 subnets.
- b. Add zeros to comprise the remainder of the subnet ID address in binary form.
- c. List the summarized network address in decimal form.

Lab – Calculating Summary Routes with IPv4 and IPv6

Subnet	IPv6 Address	Subnet Mask for First 64 bits	Subnet ID in Binary Form
EAST LAN1	2001:DB8:ACAD:1::/64	FFFF:FFFF:FFFF:FFFF	00000000000000000001
EAST LAN2	2001:DB8:ACAD:2::/64	FFFF:FFFF:FFFF:FFFF	00000000000000000010
EAST LANs Summary Address	2001:DB8:ACAD::/62	FFFF:FFFF:FFFF:FFFC	00000000000000000000

Step 9: List the first 64 bits of the WEST LAN1 and WEST LAN2 IP subnet mask in decimal form.

Step 10: List the WEST LAN1 and WEST LAN2 subnet ID (bits 48-64) in binary form.

Step 11: Count the number of far left matching bits to determine the subnet mask for the summary route.

- How many far left matching bits are present in the two subnet IDs? _____ 62
- List the subnet mask for the first 64 bits of the summary route in decimal form.

Step 12: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- List the matching binary bits for WEST LAN1 and WEST LAN2 subnets.
- Add zeros to comprise the remainder of the subnet ID address in binary form.
- List the summarized network address in decimal form.

Subnet	IPv6 Address	Subnet Mask for First 64 bits	Subnet ID in Binary Form
WEST LAN1	2001:DB8:ACAD:9::/64	FFFF:FFFF:FFFF:FFFF	00000000000000001001
WEST LAN2	2001:DB8:ACAD:A::/64	FFFF:FFFF:FFFF:FFFF	00000000000000001010
WEST LANs Summary Address	2001:DB8:ACAD:8::/62	FFFF:FFFF:FFFF:FFFC	00000000000000001000

Step 13: List the HQ, EAST, and WEST summary route IP address and the first 64 bits of the subnet mask in decimal form.

Step 14: List the HQ, EAST, and WEST summary route subnet ID in binary form.

Step 15: Count the number of far left matching bits to determine the subnet mask for the summary route.

- How many far left matching bits are present in the three subnet IDs? _____ 60
- List the subnet mask for the first 64 bits of the summary route in decimal form.

Step 16: Copy the matching binary bits and then add all zeros to determine the summarized network address.

- a. List the matching binary bits for HQ, EAST, and WEST subnets.
- b. Add zeros to comprise the remainder of the subnet ID address in binary form.
- c. List the summarized network address in decimal form.

Subnet	IPv6 Address	Subnet Mask for first 64 bits	Subnet ID in Binary Form
HQ	2001:DB8:ACAD:E::/63	FFFF:FFFF:FFFF:FFFE	00000000000000001110
EAST	2001:DB8:ACAD::/62	FFFF:FFFF:FFFF:FFFC	00000000000000000000
WEST	2001:DB8:ACAD:8::/62	FFFF:FFFF:FFFF:FFFC	00000000000000001000
Network Address Summary Route	2001:DB8:ACAD::/60	FFFF:FFFF:FFFF:FFF0	00000000000000000000

Reflection

1. How is determining the summary route for IPv4 different from IPv6?

There is no major difference except that IPv4 is 32 bit and IPv6 is 128 bit. Also, IPv4 is converted from decimal to binary and IPv6 is converted from hex to binary.

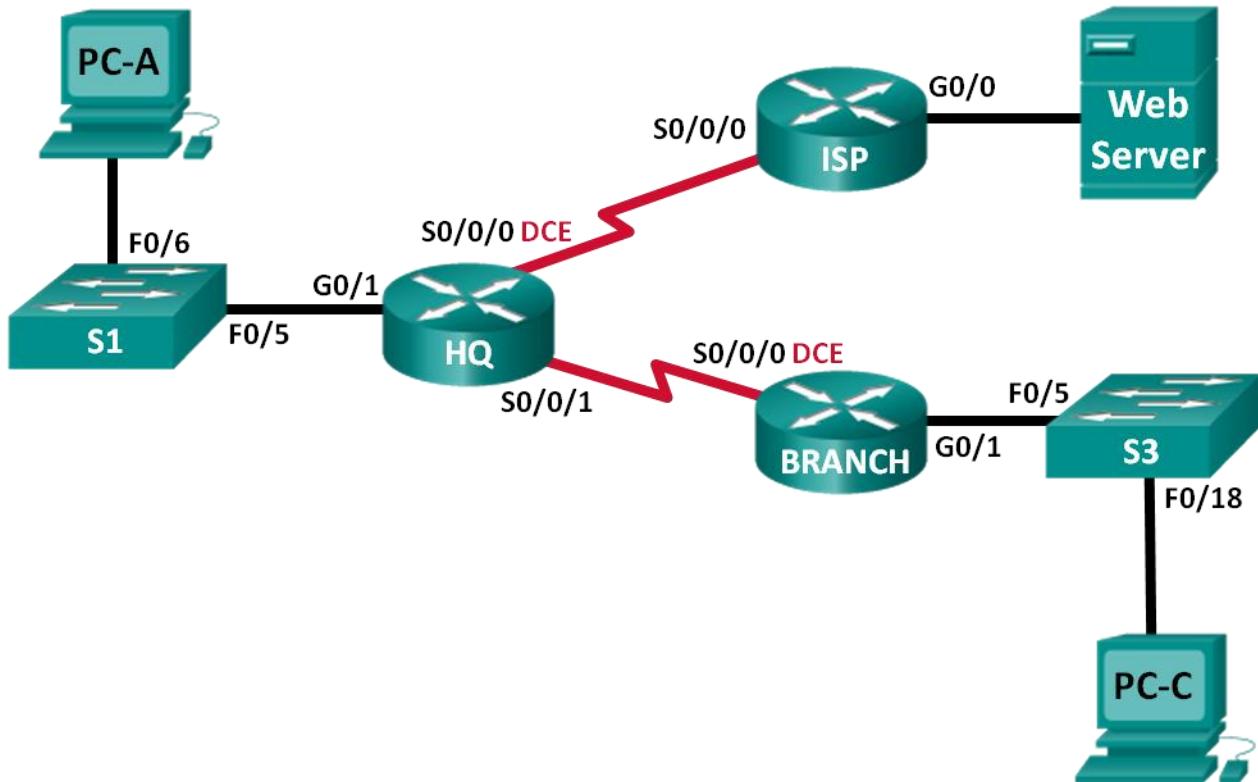
2. Why are summary routes beneficial to a network?

Makes the routing table lookup process more efficient and reduces the memory requirements for the router.

Lab – Troubleshooting IPv4 and IPv6 Static Routes (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Default Gateway
HQ	G0/1	192.168.0.1/25 2001:DB8:ACAD::1/64 FE80::1 link-local	N/A
	S0/0/0 (DCE)	10.1.1.2/30 2001:DB8:ACAD::20:2/64	N/A
	S0/0/1	192.168.0.253/30 2001:DB8:ACAD:2::1/30	N/A
ISP	G0/0	172.16.3.1/24 2001:DB8:ACAD:30::1/64 FE80::1 link-local	N/A
	S0/0/0	10.1.1.1/30 2001:DB8:ACAD:20::/64	N/A
BRANCH	G0/1	192.168.1.1/24 2001:DB8:ACAD:1::1/64 FE80::1 link-local	N/A
	S0/0/0 (DCE)	192.168.0.254/30 2001:DB8:ACAD:2::2/64	N/A
S1	VLAN 1	N/A	N/A
S3	VLAN 1	N/A	N/A
PC-A	NIC	192.168.0.3/25 2001:DB8:ACAD::3/64	192.168.0.1 FE80::1
Web Server	NIC	172.16.3.3/24 2001:DB8:ACAD:30::3/64	172.16.3.1 FE80::1
PC-C	NIC	192.168.1.3/24 2001:DB8:ACAD:1::3/64	192.168.1.1 FE80::1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot Static Routes in an IPv4 Network

Part 3: Troubleshoot Static Routes in an IPv6 Network

Background / Scenario

As a network administrator, you must be able to configure routing of traffic using static routes. Understanding how to configure and troubleshoot static routing is a requirement. Static routes are commonly used for stub networks and default routes. Your company's ISP has hired you to troubleshoot connectivity issues on the network. You will have access to the HQ, BRANCH, and the ISP routers.

Lab – Troubleshooting IPv4 and IPv6 Static Routes

In this lab, you will begin by loading configuration scripts on each of the routers. These scripts contain errors that will prevent end-to-end communication across the network. You will need to troubleshoot each router to determine the configuration errors, and then use the appropriate commands to correct the configurations. When you have corrected all of the configuration errors, the hosts on the network should be able to communicate with each other.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the routers and switches with some basic settings, such as passwords and IP addresses. Preset configurations are also provided for you for the initial router configurations. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram and cable, as necessary.

Step 2: Initialize and reload the routers and switches.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Assign **class** as the privileged EXEC mode password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 4: Configure hosts and Web Server.

- a. Configure IP addresses for IPv4 and IPv6.
- b. Configure IPv4 default gateway.

Step 5: Load router configurations.

Router HQ

```
hostname HQ
ipv6 unicast-routing
interface GigabitEthernet0/1
  ipv6 address 2001:DB8:ACAD::1/64
  ip address 192.168.0.1 255.255.255.128
  ipv6 address FE80::1 link-local
!no shutdown
interface Serial0/0/0
  ipv6 address 2001:DB8:ACAD:20::2/64
  ip address 10.1.1.2 255.255.255.252
  clock rate 800000
  no shutdown
interface Serial0/0/1
  ipv6 address 2001:DB8:ACAD:2::3/64
!ipv6 address 2001:DB8:ACAD:2::1/64
  ip address 192.168.0.253 255.255.255.252
  no shutdown
  ip route 172.16.3.0 255.255.255.0 10.1.1.1
  ip route 192.168.1.0 255.255.255.0 192.16.0.254
!ip route 192.168.1.0 255.255.255.0 192.168.0.254
  ipv6 route 2001:DB8:ACAD:1::/64 2001:DB8:ACAD:2::2
  ipv6 route 2001:DB8:ACAD:30::/64 2001:DB8:ACAD::20:1
!ipv6 route 2001:DB8:ACAD:30::/64 2001:DB8:ACAD:20::1
```

Router ISP

```
hostname ISP
ipv6 unicast-routing
interface GigabitEthernet0/0
  ipv6 address 2001:DB8:ACAD:30::1/64
  ip address 172.16.3.11 255.255.255.0
!ip address 172.16.3.1 255.255.255.0
  ipv6 address FE80::1 link-local
  no shutdown
interface Serial0/0/0
  ipv6 address 2001:DB8::ACAD:20:1/64
!ipv6 address 2001:DB8:ACAD:20::1/64
  ip address 10.1.1.1 255.255.255.252
  no shutdown
  ip route 192.168.1.0 255.255.255.0 10.1.1.2
!ip route 192.168.0.0 255.255.254.0 10.1.1.2
  ipv6 route 2001:DB8:ACAD::/62 2001:DB8:ACAD:20::2
```

Router BRANCH

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
hostname BRANCH
ipv6 unicast-routing
interface GigabitEthernet0/1
  ipv6 address 2001:DB8:ACAD:1::1/64
  ip address 192.168.1.1 255.255.255.0
  ipv6 address FE80::1 link-local
  no shutdown
interface Serial0/0/0
  ipv6 address 2001:DB8:ACAD:2::2/64
  clock rate 128000
  ip address 192.168.0.249 255.255.255.252
!ip address 192.168.0.254 255.255.255.252
  clock rate 128000
  no shutdown
  ip route 0.0.0.0 0.0.0.0 10.1.1.2
!ip route 0.0.0.0 0.0.0.0 192.168.0.253
!ipv6 unicast-routing
  ipv6 route ::/0 2001:DB8:ACAD::1
!ipv6 route ::/0 2001:DB8:ACAD:2::1
```

Part 2: Troubleshoot Static Routes in an IPv4 Network

IPv4 Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
HQ	G0/1	192.168.0.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.2	255.255.255.252	N/A
	S0/0/1	192.168.0.253	255.255.255.252	N/A
ISP	G0/0	172.16.3.1	255.255.255.0	N/A
	S0/0/0	10.1.1.1	255.255.255.252	N/A
BRANCH	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.0.254	255.255.255.252	N/A
S1	VLAN 1	192.168.0.11	255.255.255.128	192.168.0.1
S3	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.0.3	255.255.255.128	192.168.0.1
Web Server	NIC	172.16.3.3	255.255.255.0	172.16.3.1
PC-C	NIC	192.168.1.3	255.255.255.0	192.168.1.1

Step 1: Troubleshoot the HQ router.

The HQ router is the link between the ISP router and the BRANCH router. The ISP router represents the outside network while the BRANCH router represents the corporate network. The HQ router is configured with static routes to ISP and BRANCH networks.

- Display the status of the interfaces on HQ. Enter **show ip interface brief**. Record and resolve any issues as necessary.
-

The interface g0/1 is status administratively down and protocol down. Issue the **no shutdown** command on interface g0/1 to resolve the issue.

```
HQ# show ip interface brief
Interface          IP-Address      OK? Method Status      Protocol
Embedded-Service-Engine0/0 unassigned    YES unset   administratively down down
GigabitEthernet0/0     unassigned    YES unset   administratively down down
GigabitEthernet0/1     192.168.0.1   YES manual  administratively down down
Serial0/0/0           10.1.1.2      YES manual  up          up
Serial0/0/1           192.168.0.253 YES manual  up          up
```

- Ping from HQ router to BRANCH router (192.168.0.254). Were the pings successful? _____ No
- Ping from HQ router to ISP router (10.1.1.1). Were the pings successful? _____ Yes
- Ping from PC-A to the default gateway. Were the pings successful? _____ Yes
- Ping from PC-A to PC-C. Were the pings successful? _____ No

Lab – Troubleshooting IPv4 and IPv6 Static Routes

- f. Ping from PC-A to Web Server. Were the pings successful? _____ No
g. Display the routing table on HQ. What non-directly connected routes are shown in the routing table?

```
static route to 172.16.3.0/24 via 10.1.1.1.
```

```
no route to 192.168.1.0/24
```

```
HQ# show ip route
```

```
<Output omitted>
```

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

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.0/30 is directly connected, Serial0/0/0
L      10.1.1.2/32 is directly connected, Serial0/0/0
      172.16.0.0/24 is subnetted, 1 subnets
S      172.16.3.0 [1/0] via 10.1.1.1
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.0.252/30 is directly connected, Serial0/0/1
L      192.168.0.253/32 is directly connected, Serial0/0/1
```

- h. Based on the results of the pings, routing table output, and static routes in the running configuration, what can you conclude about network connectivity?
-
-

```
There is a static route to PC-C's network but it does not show in the route table, need to re-enter route with correct destination IP. There is a static route to the 172.16.3.0 network but the Web Server is not reachable.
```

```
HQ# show run | include ip route
ip route 172.16.3.0 255.255.255.0 10.1.1.1
ip route 192.168.1.0 255.255.255.0 192.16.0.254
```

- i. What commands (if any) need to be entered to resolve routing issues? Record the command(s).
-
-

```
HQ(config)# no ip route 192.168.1.0 255.255.255.0 192.16.0.254
HQ(config)# ip route 192.168.1.0 255.255.255.0 192.168.0.254
```

- j. Repeat any of the steps from b to f to verify whether the problems have been resolved. Record your observations and possible next steps in troubleshooting connectivity.
-
-

Lab – Troubleshooting IPv4 and IPv6 Static Routes

The routing problems have not been resolved. The HQ router still cannot ping the BRANCH router. This may indicate there is an issue on BRANCH router that is preventing PC-A from pinging PC-C successfully. The HQ router can reach ISP router, but PC-A cannot ping Web Server. There may be an issue on the ISP router.

```
HQ# show ip route
```

```
<Output omitted>
```

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

```
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.1.1.0/30 is directly connected, Serial0/0/0
L        10.1.1.2/32 is directly connected, Serial0/0/0
    172.16.0.0/24 is subnetted, 1 subnets
S            172.16.3.0 [1/0] via 10.1.1.1
        192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C            192.168.0.252/30 is directly connected, Serial0/0/1
L            192.168.0.253/32 is directly connected, Serial0/0/1
S            192.168.1.0/24 [1/0] via 192.168.0.254
```

Step 2: Troubleshoot the ISP router.

For the ISP router, there should be a route to HQ and BRANCH routers. One static route is configured on ISP router to reach the 192.168.1.0/24, 192.168.0.0/25, and 192.168.0.252/30 networks.

- Display the status of interfaces on ISP. Enter **show ip interface brief**. Record and resolve any issues as necessary.

The IP address for G0/0 is incorrectly configured.

```
ISP(config)# interface GigabitEthernet0/0
ISP(config-if)# ip address 172.16.3.1 255.255.255.0
```

```
ISP# show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Embedded-Service-Engine0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/0	172.16.3.11	YES	manual	up	up
GigabitEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0/0	10.1.1.1	YES	manual	up	up
Serial0/0/1	unassigned	YES	unset	administratively down	down

- Ping from the ISP router to the HQ router (10.1.1.2). Were the pings successful? _____ Yes
- Ping from Web Server to the default gateway. Were the pings successful? _____ Yes
- Ping from Web Server to PC-A. Were the pings successful? _____ No
- Ping from Web Server to PC-C. Were the pings successful? _____ No
- Display the routing table on ISP. What non-directly connected routes are shown in the routing table?

Lab – Troubleshooting IPv4 and IPv6 Static Routes

Static route to 192.168.1.0/24 via 10.1.1.2

No route to 192.168.0.252/30

ISP# **show ip route**

<Output omitted>

Gateway of last resort is not set

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.0/30 is directly connected, Serial0/0/0
L      10.1.1.1/32 is directly connected, Serial0/0/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C      172.16.3.0/24 is directly connected, GigabitEthernet0/0
L      172.16.3.1/32 is directly connected, GigabitEthernet0/0
S      192.168.1.0/24 [1/0] via 10.1.1.2
```

- g. Based on the results of the pings, routing table output, and static routes in the running configuration, what can you conclude about network connectivity?

A summary route to 192.168.0.0/23 is needed to reach both 192.168.1.0/24 and 192.168.0.252/30 network.

- h. What commands (if any) need to be entered to resolve routing issues? Record the command(s).

(Hint: ISP only requires one summarized route to the company's networks 192.168.1.0/24, 192.168.0.0/25, and 192.168.0.252/32.)

```
ISP(config)# no ip route 192.168.1.0 255.255.255.0 10.1.1.2
ISP(config)# ip route 192.168.0.0 255.255.254.0 10.1.1.2
```

- i. Repeat any of the steps from b to e to verify whether the problems have been resolved. Record your observations and possible next steps in troubleshooting connectivity.

After the correction, Web Server can reach PC-A. However, Web Server still cannot ping PC-C. There are still more unresolved issues in the network.

ISP# **show ip route**

<Output omitted>

Gateway of last resort is not set

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.0/30 is directly connected, Serial0/0/0
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
L      10.1.1.1/32 is directly connected, Serial0/0/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C      172.16.3.0/24 is directly connected, GigabitEthernet0/0
L      172.16.3.1/32 is directly connected, GigabitEthernet0/0
S      192.168.0.0/23 [1/0] via 10.1.1.2
```

Step 3: Troubleshoot the BRANCH router.

For the BRANCH router, a default route is set to reach the rest of the network and ISP.

- Display the status of the interfaces on BRANCH. Enter **show ip interface brief**. Record and resolve any issues, as necessary.

The IP address for S0/0/1 is incorrectly configured.

```
BRANCH(config)# interface s0/0/0
BRANCH(config-if)# ip address 192.168.0.254 255.255.255.252
```

```
BRANCH# show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Embedded-Service-Engine0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/1	192.168.1.1	YES	manual	up	up
Serial0/0/0	192.168.0.249	YES	manual	up	up
Serial0/0/1	unassigned	YES	unset	administratively down	down

- Ping from the BRANCH router to the HQ router (192.168.0.253). Were the pings successful? _____
Yes
- Ping from PC-C to the default gateway. Were the pings successful? _____ Yes
- Ping from PC-C to PC-A. Were the pings successful? _____ No
- Ping from PC-C to Web Server. Were the pings successful? _____ No
- Display the routing table on BRANCH. What non-directly connected routes are shown in the routing table?

None.

```
BRANCH# show ip route
<Output omitted>
```

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

```
192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.0.252/30 is directly connected, Serial0/0/0
L      192.168.0.254/32 is directly connected, Serial0/0/0
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.1.0/24 is directly connected, GigabitEthernet0/1
L      192.168.1.1/32 is directly connected, GigabitEthernet0/1
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

- g. Based on the results of the pings, routing table output, and static routes in the running configuration, what can you conclude about network connectivity?

No static routes are displayed in the routing table. The default route was configured incorrectly.

```
BRANCH# show run | include ip route  
ip route 0.0.0.0 0.0.0.0 10.1.1.2
```

- h. What commands (if any) need to be entered to resolve routing issues? Record the command(s).

```
BRANCH(config)# no ip route 0.0.0.0 0.0.0.0 10.1.1.2  
BRANCH(config)# ip route 0.0.0.0 0.0.0.0 192.168.0.253
```

- i. Repeat any of the steps from b to e to verify whether the problems have been resolved. Record your observations and possible next steps in troubleshooting connectivity.

```
BRANCH# show ip route  
<Output omitted>
```

```
Gateway of last resort is 192.168.0.253 to network 0.0.0.0
```

```
S*    0.0.0.0/0 [1/0] via 192.168.0.253  
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.0.252/30 is directly connected, Serial0/0/0  
L      192.168.0.254/32 is directly connected, Serial0/0/0  
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.1.0/24 is directly connected, GigabitEthernet0/1  
L      192.168.1.1/32 is directly connected, GigabitEthernet0/1
```

Part 3: Troubleshoot Static Routes in an IPv6 Network

Device	Interface	IPv6 Address	Prefix Length	Default Gateway
HQ	G0/1	2001:DB8:ACAD::1	64	N/A
	S0/0/0 (DCE)	2001:DB8:ACAD::20:2	64	N/A
	S0/0/1	2001:DB8:ACAD:2::1	64	N/A
ISP	G0/0	2001:DB8:ACAD:30::1	64	N/A
	S0/0/0	2001:DB8:ACAD:20::1	64	N/A
BRANCH	G0/1	2001:DB8:ACAD:1::1	64	N/A
	S0/0/0 (DCE)	2001:DB8:ACAD:2::2	64	N/A
PC-A	NIC	2001:DB8:ACAD::3	64	FE80::1
Web Server	NIC	2001:DB8:ACAD:30::3	64	FE80::1
PC-C	NIC	2001:DB8:ACAD:1::3	64	FE80::1

Step 1: Troubleshoot the HQ router.

The HQ router is the link between the ISP router and the BRANCH router. The ISP router represents the outside network while the BRANCH router represents the corporate network. The HQ router is configured with static routes to both the ISP and the BRANCH networks.

- Display the status of the interfaces on HQ. Enter **show ipv6 interface brief**. Record and resolve any issues, as necessary.
-
-

The IPv6 address for S0/0/1 is incorrectly configured.

```
HQ(config)# interface s0/0/1
HQ(config-if)# no ipv6 address 2001:DB8:ACAD:2::3/64
HQ(config-if)# ipv6 address 2001:DB8:ACAD:2::1/64
HQ# show ipv6 interface brief
Em0/0 [administratively down/down]
    unassigned
GigabitEthernet0/0 [administratively down/down]
    unassigned
GigabitEthernet0/1 [up/up]
    FE80::1
    2001:DB8:ACAD::1
Serial0/0/0 [up/up]
    FE80::D68C:B5FF:FECE:A0C0
    2001:DB8:ACAD:20::2
Serial0/0/1 [up/up]
    FE80::D68C:B5FF:FECE:A0C0
    2001:DB8:ACAD:2::3ping
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

- b. Ping from the HQ router to the BRANCH router (2001:DB8:ACAD:2::2). Were the pings successful? _____ **Yes**
- c. Ping from the HQ router to the ISP router (2001:DB8:ACAD:20::1). Were the pings successful? _____ **No**
- d. Ping from PC-A to the default gateway. Were the pings successful? _____ **Yes**
- e. Ping from PC-A to Web Server. Were the pings successful? _____ **No**
- f. Ping from PC-A to PC-C. Were the pings successful? _____ **No**
- g. Display the routing table by issuing a **show ipv6 route** command. What non-directly connected routes are shown in the routing table?

Static route to 2001:DB8:ACAD:1::/64 via 2001:DB8:ACAD:2::2

Static route to 2001:DB8:ACAD:30::/64 via 2001:DB8:ACAD::20:1

```
HQ# show ipv6 route
IPv6 Routing Table - default - 9 entries
<Output omitted>
C 2001:DB8:ACAD::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L 2001:DB8:ACAD::1/128 [0/0]
    via GigabitEthernet0/1, receive
S 2001:DB8:ACAD:1::/64 [1/0]
    via 2001:DB8:ACAD:2::2
C 2001:DB8:ACAD:2::/64 [0/0]
    via Serial0/0/1, directly connected
L 2001:DB8:ACAD:2::1/128 [0/0]
    via Serial0/0/1, receive
C 2001:DB8:ACAD:20::/64 [0/0]
    via Serial0/0/0, directly connected
L 2001:DB8:ACAD:20::2/128 [0/0]
    via Serial0/0/0, receive
S 2001:DB8:ACAD:30::/64 [1/0]
    via 2001:DB8:ACAD::20:1
L FF00::/8 [0/0]
    via Null0, receive
```

- h. Based on the results of the pings, routing table output, and static routes in the running configuration, what can you conclude about network connectivity?

Static route to 2001:DB8:ACAD:30::/64 has an incorrectly configured next hop address.

- i. What commands (if any) need to be entered to resolve routing issues? Record the command(s).

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
HQ(config)# no ipv6 route 2001:DB8:ACAD:30::/64 2001:DB8:ACAD::20:1
HQ(config)# ipv6 route 2001:DB8:ACAD:30::/64 2001:DB8:ACAD:20::1
```

- j. Repeat any of the steps from b to f to verify whether the problems have been resolved. Record your observations and possible next steps in troubleshooting connectivity.
-
-

The routing problems have not been resolved. The HQ router still cannot ping ISP router. The ISP router probably has IP address issue. PC-A still cannot ping PC-C and Web Server.

```
HQ# show ipv6 route
IPv6 Routing Table - default - 9 entries
<Output omitted>
C 2001:DB8:ACAD::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L 2001:DB8:ACAD::1/128 [0/0]
    via GigabitEthernet0/1, receive
S 2001:DB8:ACAD:1::/64 [1/0]
    via 2001:DB8:ACAD:2::2
C 2001:DB8:ACAD:2::/64 [0/0]
    via Serial0/0/1, directly connected
L 2001:DB8:ACAD:2::1/128 [0/0]
    via Serial0/0/1, receive
C 2001:DB8:ACAD:20::/64 [0/0]
    via Serial0/0/0, directly connected
L 2001:DB8:ACAD:20::2/128 [0/0]
    via Serial0/0/0, receive
S 2001:DB8:ACAD:30::/64 [1/0]
    via 2001:DB8:ACAD:20::1
L FF00::/8 [0/0]
    via Null0, receive
```

Step 2: Troubleshoot the ISP router.

- On the ISP router, one static route is configured to reach all the networks on HQ and BRANCH routers.
- a. Display the status of the interfaces on ISP. Enter **show ipv6 interface brief**. Record and resolve any issues, as necessary.
-
-

The IPv6 address for S0/0/0 is incorrectly configured.

```
ISP(config)# interface s0/0/0
ISP(config-if)# no ipv6 address 2001:DB8::ACAD:20:1/64
ISP(config-if)# ipv6 address 2001:DB8:ACAD:20::1/64
ISP# show ipv6 interface brief
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
Em0/0 [administratively down/down]
      unassigned
GigabitEthernet0/0 [up/up]
      FE80::1
      2001:DB8:ACAD:30::1
GigabitEthernet0/1 [administratively down/down]
      unassigned
Serial0/0/0 [up/up]
      FE80::FE99:47FF:FE71:78A0
      2001:DB8::ACAD:20::1
Serial0/0/1 [administratively down/down]
      unassigned
```

- b. Ping from the ISP router to the HQ router (2001:DB8:ACAD:20::2). Were the pings successful? _____
Yes
- c. Ping from Web Server to the default gateway. Were the pings successful? _____ **Yes**
- d. Ping from Web Server to PC-A. Were the pings successful? _____ **Yes**
- e. Ping from Web Server to PC-C. Were the pings successful? _____ **No**
- f. Display the routing table. What non-directly connected routes are shown in the routing table?
-
-

Static route to 2001:DB8:ACAD::/62 via 2001:DB8:ACAD:20::2

```
ISP# show ipv6 route
IPv6 Routing Table - default - 6 entries
<Output omitted>
S 2001:DB8:ACAD::/62 [1/0]
  via 2001:DB8:ACAD:20::2
C 2001:DB8:ACAD:20::/64 [0/0]
  via Serial0/0/0, directly connected
L 2001:DB8:ACAD:20::1/128 [0/0]
  via Serial0/0/0, receive
C 2001:DB8:ACAD:30::/64 [0/0]
  via GigabitEthernet0/0, directly connected
L 2001:DB8:ACAD:30::1/128 [0/0]
  via GigabitEthernet0/0, receive
L FF00::/8 [0/0]
  via Null0, receive
```

- g. Based on the results of the pings, routing table output, and static routes in the running configuration, what can you conclude about network connectivity?
-
-

No issues with the static route

- h. What commands (if any) need to be entered to resolve routing issues? Record the command(s).
-

Lab – Troubleshooting IPv4 and IPv6 Static Routes

None

- i. Repeat any of the steps from b to e to verify whether the problems have been resolved. Record your observations and possible next steps in troubleshooting connectivity.
-
-
-

Not all routing issues have been resolved. Web Server still cannot ping PC-C.

Step 3: Troubleshoot the BRANCH router.

For the BRANCH routers, there is a default route to the HQ router. This default route allows the BRANCH network to the ISP router and Web Server.

- a. Display the status of the interfaces on BRANCH. Enter **show ipv6 interface brief**. Record and resolve any issues, as necessary.
-
-

All interfaces were configured correctly according to the Addressing Table.

```
BRANCH# show ipv6 interface brief
Em0/0 [administratively down/down]
    unassigned
GigabitEthernet0/0 [administratively down/down]
    unassigned
GigabitEthernet0/1 [up/up]
    FE80::1
    2001:DB8:ACAD:1::1
Serial0/0/0 [up/up]
    FE80::FE99:47FF:FE71:7A20
    2001:DB8:ACAD:2::2
Serial0/0/1 [administratively down/down]
    unassigned
```

- b. Ping from the BRANCH router to the HQ router (2001:DB8:ACAD:2::1). Were the pings successful?
_____ Yes
- c. Ping from the BRANCH router to the ISP router (2001:DB8:ACAD:20::1). Were the pings successful?
_____ No
- d. Ping from PC-C to the default gateway. Were the pings successful? _____ Yes
- e. Ping from PC-C to PC-A. Were the pings successful? _____ No
- f. Ping from PC-C to Web Server. Were the pings successful? _____ No
- g. Display the routing table. What non-directly connected routes are shown in the routing table?
-
-

None

```
BRANCH# show ipv6 route
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
IPv6 Routing Table - default - 5 entries
<Output omitted>
C 2001:DB8:ACAD:1::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L 2001:DB8:ACAD:1::1/128 [0/0]
    via GigabitEthernet0/1, receive
C 2001:DB8:ACAD:2::/64 [0/0]
    via Serial0/0/0, directly connected
L 2001:DB8:ACAD:2::2/128 [0/0]
    via Serial0/0/0, receive
L FF00::/8 [0/0]
    via Null0, receive
```

- h. Based on the results of the pings, routing table output, and static routes in the running configuration, what can you conclude about network connectivity?

No default route is displayed in the table. The next-hop address was incorrectly configured.

- i. What commands (if any) need to be entered to resolve routing issues? Record the command(s).

```
BRANCH(config)# no ipv6 route ::/0 2001:DB8:ACAD::1
BRANCH(config)# ipv6 route ::/0 2001:DB8:ACAD:2::1
```

- j. Repeat any of the steps from b to f to verify whether the problems have been resolved. Record your observations and possible next steps in troubleshooting connectivity.

```
BRANCH# show ipv6 route
IPv6 Routing Table - default - 6 entries
<Output omitted>
S ::/0 [1/0]
    via 2001:DB8:ACAD:2::1
C 2001:DB8:ACAD:1::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L 2001:DB8:ACAD:1::1/128 [0/0]
    via GigabitEthernet0/1, receive
C 2001:DB8:ACAD:2::/64 [0/0]
    via Serial0/0/0, directly connected
L 2001:DB8:ACAD:2::2/128 [0/0]
    via Serial0/0/0, receive
L FF00::/8 [0/0]
    via Null0, receive
```

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs**Router HQ (Corrected)**

```
HQ# show run
Building configuration...

Current configuration : 1652 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname HQ
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 15
!
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
!
!
!
!
!
ip cef
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.0.1 255.255.255.128
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD::1/64
!
interface Serial0/0/0
ip address 10.1.1.2 255.255.255.252
ipv6 address 2001:DB8:ACAD:20::2/64
clock rate 2000000
!
interface Serial0/0/1
ip address 192.168.0.253 255.255.255.252
ipv6 address 2001:DB8:ACAD:2::1/64
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
!
ip route 172.16.3.0 255.255.255.0 10.1.1.1
ip route 192.168.1.0 255.255.255.0 192.168.0.254
!
ipv6 route 2001:DB8:ACAD:1::/64 2001:DB8:ACAD:2::2
ipv6 route 2001:DB8:ACAD:30::/64 2001:DB8:ACAD:20::1
!
!
!
control-plane
!
!
!
!
line con 0
password cisco
logging synchronous
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router ISP (Corrected)

```
ISP# show run
Building configuration...

Current configuration : 1493 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
!
!
!
ip cef
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
ip address 172.16.3.1 255.255.255.0
duplex auto
speed auto
ipv6 address Fe80::1 link-local
ipv6 address 2001:DB8:ACAD:30::1/64
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 10.1.1.1 255.255.255.252
ipv6 address 2001:DB8:ACAD:20::1/64
!
interface Serial0/0/1
no ip address
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
shutdown
clock rate 2000000
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.0.0 255.255.254.0 10.1.1.2
!
ipv6 route 2001:DB8:ACAD::/62 2001:DB8:ACAD:20::2
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router BRANCH (Corrected)

```
BRANCH# show run
Building configuration...

Current configuration : 1522 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
!
hostname BRANCH
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
!
!
!
!
!
ip cef
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:1::1/64
!
interface Serial0/0/0
```

Lab – Troubleshooting IPv4 and IPv6 Static Routes

```
ip address 192.168.0.254 255.255.255.252
ipv6 address 2001:DB8:ACAD:2::2/64
clock rate 128000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 192.168.0.253
!
ipv6 route ::/0 2001:DB8:ACAD:2::1
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Make It Static! (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Configure a static route.

This modeling activity reviews content from the curriculum regarding how default static routes are written and configured for IPv6 network addresses.

As the use of IPv6 addressing becomes more prevalent, it is important for network administrators to be able to direct network traffic between routers.

To prove that you are able to direct IPv6 traffic correctly and review the IPv6 default static route curriculum concepts, use the topology as shown in the .pdf file provided, specifically for this activity. Work with a partner to write an IPv6 statement for each of the three scenarios. Try to write the route statements without the assistance of completed labs, Packet Tracer files, etc.

- **Scenario 1**

IPv6 default static route from R2 directing all data through your S0/0/0 interface to the next hop address on R1.

- **Scenario 2**

IPv6 default static route from R3 directing all data through your S0/0/1 interface to the next hop address on R2.

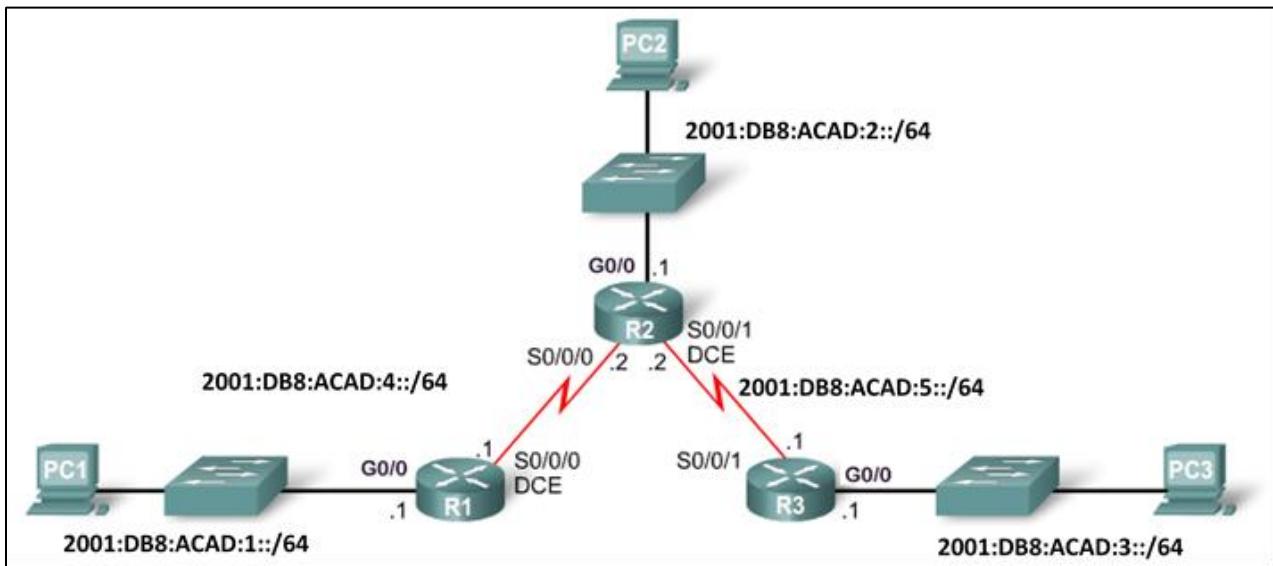
- **Scenario 3**

IPv6 default static route from R2 directing all data through your S0/0/1 interface to the next hop address on R3.

When complete, get together with another group and compare your written answers. Discuss any differences found in your comparisons.

Resources

Topology Diagram



Make It Static!

- **Scenario 1**

IPv6 default static route from R2 directing all data to the next hop address on R1.

Configuration Command	IPv6 Network to Route	Next Hop IPv6 Address
R2(config)# ipv6 route		

- **Scenario 2**

IPv6 default static route from R3 directing all data to the next hop address on R2.

Configuration Command	IPv6 Network to Route	Next Hop IPv6 Address
R3(config)# ipv6 route		

- **Scenario 3**

IPv6 default static route from R2 directing all data to the next hop address on R3.

Configuration Command	IPv6 Network to Route	Next Hop IPv6 Address
R2(config)# ipv6 route		

Instructor Activity Reference

- **Scenario 1**

IPv6 default static route from R2 directing all data to the next hop address on R1.

Configuration Command	IPv6 Network to Route	Next Hop IPv6 Address
R2(config)# ipv6 route	::/0	2001:DB8:ACAD:4::1

Make It Static!

- **Scenario 2**

IPv6 default static route from R3 directing all data to the next hop address on R2

Configuration Command	IPv6 Network to Route	Next Hop IPv6 Address
R3 (config) # ipv6 route	<code>::/0</code>	<code>2001:DB8:ACAD:5::2</code>

- **Scenario 3**

IPv6 default static route from R2 directing all data to the next hop address on R3

Configuration Command	IPv6 Network to Route	Next Hop IPv6 Address
R2 (config) # ipv6 route	<code>::/0</code>	<code>2001:DB8:ACAD:5::1</code>

Identify elements of the model that map to IT-related content:

- IPv6 address
- Next hop address
- Exit interface
- Default route
- Static route

How Much Does This Cost? (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Explain the operation of dynamic routing protocols.

To prepare for the concepts to be learned in this chapter, students will create physical routes, record progress of travel on the physical routes, and compare/contrast recorded results. Emphasis in this activity will be: number of hops, or steps used, data time recorded to start and finish the complete route, and dropped data, if the route finish is not reached within certain parameters.

Scenario

This modeling activity illustrates the network concept of routing cost.

You will be a member of a team of five students who travel routes to complete the activity scenarios. One digital camera or bring your own device (BYOD) with camera, a stopwatch, and the student file for this activity will be required per group. One person will function as the photographer and event recorder, as selected by each group. The remaining four team members will actively participate in the scenarios below.

A school or university classroom, hallway, outdoor track area, school parking lot, or any other location can serve as the venue for these activities.

Activity 1

The tallest person in the group establishes a start and finish line by marking 15 steps from start to finish, indicating the distance of the team route. Each student will take 15 steps from the start line toward the finish line and then stop on the 15th step—no further steps are allowed.

Note: Not all of the students may reach the same distance from the start line due to their height and stride differences. The photographer will take a group picture of the entire team's final location after taking the 15 steps required.

Activity 2

A new start and finish line will be established; however, this time, a longer distance for the route will be established than the distance specified in Activity 1. No maximum steps are to be used as a basis for creating this particular route. One at a time, students will “walk the new route from beginning to end twice”.

Each team member will count the steps taken to complete the route. The recorder will time each student and at the end of each team member's route, record the time that it took to complete the full route and how many steps were taken, as recounted by each team member and recorded on the team's student file.

Once both activities have been completed, teams will use the digital picture taken for Activity 1 and their recorded data from Activity 2 file to answer the reflection questions.

Group answers can be discussed as a class, time permitting.

Required Resources

- Digital or BYOD camera to record Activity 1's team results. Activity 2's data is based solely upon number of steps taken and the time it took to complete the route and no camera is necessary for Activity 2.

How Much Does This Cost?

- Stopwatch
- Student file accompanying this modeling activity so that Activity 2 results can be recorded as each student finishes the route.

Scenario – Part 2 Recording Matrix

Student Team Member Name	Time Used to Finish the Route	Number of Steps Taken to Finish the Route

Reflection Questions

1. The photographer took a picture of the team's progress after taking 15 steps for Activity 1. Most likely, some team members did not reach the finish line on their 15th step due to height and stride differences. What do you think would happen if network data did not reach the finish line, or destination, in the allowed number of hops or steps?

The data would not be successfully delivered. It would be dropped from the network route.

2. What could be done to help team members reach the finish line if they did not reach it in Activity 1?

Answers will vary, but students should mention increasing the number of steps (hops) allowed or removing the 15-step restriction.

3. Which person would best be selected to deliver data using the network route completed in Activity 2? Justify your answer.

The data took different amounts of time to be delivered, but it was delivered by all team members. The team member taking the shortest amount of time would be the best person to deliver the data.

4. Using the data recorded in Activity 2 and a limit of 255 steps, or hops, did all members of the team take more than 255 steps to finish their route? What would happen if they had to stop on the 254th step, or hop?

The route would not be finished (see same result from Activity 1 and 15 hop limit) and therefore, the route would not be finished – data would be dropped)

5. Use the data that was recorded in Activity 2. Would you say the parameters for the route were enough to finish it successfully if all team members reached the finish line with 255 or less steps, or hops? Justify your answer.

Yes, the numbers of steps allowed were not exceeded, therefore allowing the data to be delivered successfully.

How Much Does This Cost?

6. In network routing, different parameters are set for routing protocols. Use the data recorded for Activity 2. Would you select time, or number of steps, or hops, or a combination of both as your preferred routing type? List at least three reasons for your answers.

Answers will vary, but students could mention:

- Time – the shortest amount of time taken by a team member might be the preferred route.
- Hops – if all team members finished the route within the 255 step, or hop, limit, this might be selected as the preferred route.
- Both – the lowest number of hops taken by a particular team member in the shortest period of time might be the preferred route.

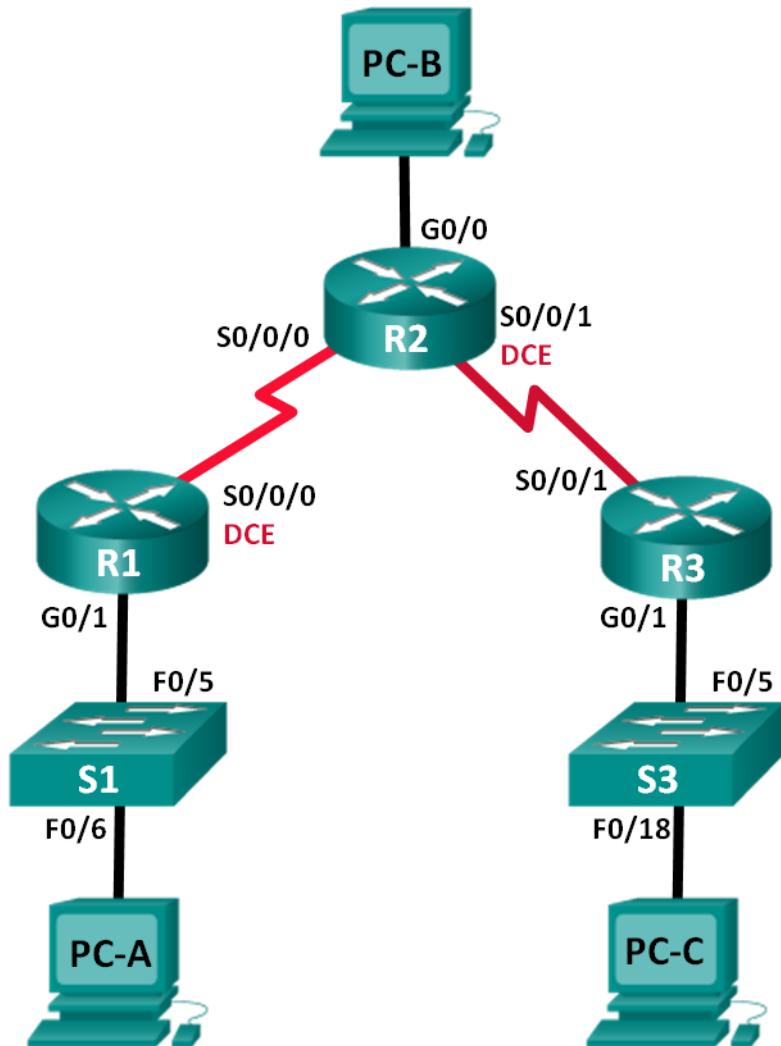
Identify elements of the model that map to IT-related content:

- Routers use number of hops, bandwidth, delay and cost metrics to determine the best path for network communication.
- Routing tables show records of the best routes for data delivery using the protocols configured for and reported by network traffic.
- Network administrators have a choice as to which types of routing protocols to use for network data delivery.
- As long as the parameters of a particular routing protocol are followed, data will be delivered successfully from source to destination.

Lab – Configuring Basic RIPv2 and RIPng (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	172.30.10.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A
R2	G0/0	209.165.201.1	255.255.255.0	N/A
	S0/0/0	10.1.1.2	255.255.255.252	N/A
R3	S0/0/1 (DCE)	10.2.2.2	255.255.255.252	N/A
	G0/1	172.30.30.1	255.255.255.0	N/A
S1	S0/0/1	10.2.2.1	255.255.255.252	N/A
	N/A	VLAN 1	N/A	N/A
S3	N/A	VLAN 1	N/A	N/A
	NIC	172.30.10.3	255.255.255.0	172.30.10.1
PC-A	NIC	209.165.201.2	255.255.255.0	209.165.201.1
PC-B	NIC	172.30.30.3	255.255.255.0	172.30.30.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify RIPv2 Routing

- Configure and verify RIPv2 is running on routers.
- Configure a passive interface.
- Examine routing tables.
- Disable automatic summarization.
- Configure a default route.
- Verify end-to-end connectivity.

Part 3: Configure IPv6 on Devices

Part 4: Configure and Verify RIPng Routing

- Configure and verify RIPng is running on routers.
- Examine routing tables.
- Configure a default route.
- Verify end-to-end connectivity.

Background / Scenario

RIP version 2 (RIPv2) is used for routing of IPv4 addresses in small networks. RIPv2 is a classless, distance-vector routing protocol, as defined by RFC 1723. Because RIPv2 is a classless routing protocol, subnet masks are included in the routing updates. By default, RIPv2 automatically summarizes networks at major network boundaries. When automatic summarization has been disabled, RIPv2 no longer summarizes networks to their classful address at boundary routers.

Lab – Configuring Basic RIPv2 and RIPng

RIPng (RIP Next Generation) is a distance-vector routing protocol for routing IPv6 addresses, as defined by RFC 2080. RIPng is based on RIPv2 and has the same administrative distance and 15-hop limitation.

In this lab, you will configure the network topology with RIPv2 routing, disable automatic summarization, propagate a default route, and use CLI commands to display and verify RIP routing information. You will then configure the network topology with IPv6 addresses, configure RIPng, propagate a default route, and use CLI commands to display and verify RIPng routing information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and Serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switch.

Step 3: Configure basic settings for each router and switch.

- a. Disable DNS lookup.
- b. Configure device names as shown in the topology.
- c. Configure password encryption.
- d. Assign **class** as the privileged EXEC password.
- e. Assign **cisco** as the console and vty passwords.
- f. Configure a MOTD banner to warn users that unauthorized access is prohibited.
- g. Configure **logging synchronous** for the console line.
- h. Configure the IP address listed in the Addressing Table for all interfaces.
- i. Configure a description to each interface with an IP address.
- j. Configure the clock rate if applicable to the DCE serial interface.
- k. Copy the running-configuration to the startup-configuration.

Step 4: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 5: Test connectivity.

At this point, the PCs are unable to ping each other.

- a. Each workstation should be able to ping the attached router. Verify and troubleshoot if necessary.
- b. The routers should be able to ping one another. Verify and troubleshoot if necessary.

Part 2: Configure and Verify RIPv2 Routing

In Part 2, you will configure RIPv2 routing on all routers in the network and then verify that routing tables are updated correctly. After RIPv2 has been verified, you will disable automatic summarization, configure a default route, and verify end-to-end connectivity.

Step 1: Configure RIPv2 routing.

- a. On R1, configure RIPv2 as the routing protocol and advertise the appropriate networks.

```
R1# config t  
R1(config)# router rip  
R1(config-router)# version 2  
R1(config-router)# passive-interface g0/1  
R1(config-router)# network 172.30.0.0  
R1(config-router)# network 10.0.0.0
```

The **passive-interface** command stops routing updates out the specified interface. This process prevents unnecessary routing traffic on the LAN. However, the network that the specified interface belongs to is still advertised in routing updates that are sent out across other interfaces.

- b. Configure RIPv2 on R3 and use the **network** statement to add appropriate networks and prevent routing updates on the LAN interface.
- c. Configure RIPv2 on R2. Do not advertise the 209.165.201.0 network.

Note: It is not necessary to make the G0/0 interface passive on R2 because the network associated with this interface is not being advertised.

Step 2: Examine current state of network.

- a. The status of the two serial links can quickly be verified using the **show ip interface brief** command on R2.

```
R2# show ip interface brief  
Interface          IP-Address      OK? Method Status      Protocol  
Embedded-Service-Engine0/0 unassigned    YES unset  administratively down down  
GigabitEthernet0/0     209.165.201.1  YES manual up       up  
GigabitEthernet0/1     unassigned    YES unset  administratively down down  
Serial0/0/0           10.1.1.2      YES manual up       up  
Serial0/0/1           10.2.2.2      YES manual up       up
```

- b. Check connectivity between PCs.

From PC-A, is it possible to ping PC-B? _____ Why?

No, R2 is not advertising the route to PC-B.

Lab – Configuring Basic RIPv2 and RIPng

From PC-A, is it possible to ping PC-C? _____ Why?

No, R1 and R3 do not have routes to the specific subnets on the remote router.

From PC-C, is it possible to ping PC-B? _____ Why?

No, R2 is not advertising the route to PC-B.

From PC-C, is it possible to ping PC-A? _____ Why?

No, R1 and R3 do not have routes to the specific subnets on the remote router.

- c. Verify that RIPv2 is running on the routers.

You can use the **debug ip rip**, **show ip protocols**, and **show run** commands to confirm that RIPv2 is running. The **show ip protocols** command output for R1 is shown below.

```
R1# show ip protocols
Routing Protocol is "rip"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Sending updates every 30 seconds, next due in 7 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Redistributing: rip
Default version control: send version 2, receive 2
  Interface          Send   Recv   Triggered RIP  Key-chain
    Serial0/0/0        2       2
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
  10.0.0.0
  172.30.0.0
Passive Interface(s):
  GigabitEthernet0/1
Routing Information Sources:
  Gateway          Distance      Last Update
  10.1.1.2          120
Distance: (default is 120)
```

When issuing the **debug ip rip** command on R2, what information is provided that confirms RIPv2 is running?

RIP: sending v2 updates to 224.0.0.9 via Serial 0/0/0 (10.1.1.2).

When you are finished observing the debugging outputs, issue the **undebbug all** command at the privileged EXEC prompt.

When issuing the **show run** command on R3, what information is provided that confirms RIPv2 is running?

router rip
version 2

- d. Examine the automatic summarization of routes.
-
-

Lab – Configuring Basic RIPv2 and RIPng

The LANs connected to R1 and R3 are composed of discontiguous networks. R2 displays two equal-cost paths to the 172.30.0.0/16 network in the routing table. R2 displays only the major classful network address of 172.30.0.0 and does not display any of the subnets for this network.

```
R2# show ip route
<Output omitted>
    10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C        10.1.1.0/30 is directly connected, Serial0/0/0
L        10.1.1.2/32 is directly connected, Serial0/0/0
C        10.2.2.0/30 is directly connected, Serial0/0/1
L        10.2.2.2/32 is directly connected, Serial0/0/1
R        172.30.0.0/16 [120/1] via 10.2.2.1, 00:00:23, Serial0/0/1
                  [120/1] via 10.1.1.1, 00:00:09, Serial0/0/0
    209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks
C        209.165.201.0/24 is directly connected, GigabitEthernet0/0
L        209.165.201.1/32 is directly connected, GigabitEthernet0/0
```

R1 displays only its own subnets for the 172.30.0.0 network. R1 does not have any routes for the 172.30.0.0 subnets on R3.

```
R1# show ip route
<Output omitted>
    10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        10.1.1.0/30 is directly connected, Serial0/0/0
L        10.1.1.1/32 is directly connected, Serial0/0/0
R        10.2.2.0/30 [120/1] via 10.1.1.2, 00:00:21, Serial0/0/0
    172.30.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.30.10.0/24 is directly connected, GigabitEthernet0/1
L        172.30.10.1/32 is directly connected, GigabitEthernet0/1
```

R3 only displays its own subnets for the 172.30.0.0 network. R3 does not have any routes for the 172.30.0.0 subnets on R1.

```
R3# show ip route
<Output omitted>
    10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        10.2.2.0/30 is directly connected, Serial0/0/1
L        10.2.2.1/32 is directly connected, Serial0/0/1
R        10.1.1.0/30 [120/1] via 10.2.2.2, 00:00:23, Serial0/0/1
    172.30.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.30.30.0/24 is directly connected, GigabitEthernet0/1
L        172.30.30.1/32 is directly connected, GigabitEthernet0/1
```

Use the **debug ip rip** command on R2 to determine the routes received in the RIP updates from R3 and list them here.

172.30.0.0/16

R3 is not sending any of the 172.30.0.0 subnets, only the summarized route of 172.30.0.0/16, including the subnet mask. Therefore, the routing tables on R1 and R2 do not display the 172.30.0.0 subnets on R3.

Step 3: Disable automatic summarization.

- a. The **no auto-summary** command is used to turn off automatic summarization in RIPv2. Disable auto summarization on all routers. The routers will no longer summarize routes at major classful network boundaries. R1 is shown here as an example.

```
R1(config)# router rip  
R1(config-router)# no auto-summary
```

- b. Issue the **clear ip route *** command to clear the routing table.

```
R1(config-router)# end  
R1# clear ip route *
```

- c. Examine the routing tables. Remember will it take some time to converge the routing tables after clearing them.

The LAN subnets connected to R1 and R3 should now be included in all three routing tables.

```
R2# show ip route  
<Output omitted>  
Gateway of last resort is not set  
  
    10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks  
C        10.1.1.0/30 is directly connected, Serial0/0/0  
L        10.1.1.2/32 is directly connected, Serial0/0/0  
C        10.2.2.0/30 is directly connected, Serial0/0/1  
L        10.2.2.2/32 is directly connected, Serial0/0/1  
    172.30.0.0/16 is variably subnetted, 3 subnets, 2 masks  
R        172.30.0.0/16 [120/1] via 10.2.2.1, 00:01:01, Serial0/0/1  
                [120/1] via 10.1.1.1, 00:01:15, Serial0/0/0  
R        172.30.10.0/24 [120/1] via 10.1.1.1, 00:00:21, Serial0/0/0  
R        172.30.30.0/24 [120/1] via 10.2.2.1, 00:00:04, Serial0/0/1  
    209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks  
C        209.165.201.0/24 is directly connected, GigabitEthernet0/0  
L        209.165.201.1/32 is directly connected, GigabitEthernet0/0  
R1# show ip route  
<Output omitted>  
Gateway of last resort is not set  
  
    10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks  
C        10.1.1.0/30 is directly connected, Serial0/0/0  
L        10.1.1.1/32 is directly connected, Serial0/0/0  
R        10.2.2.0/30 [120/1] via 10.1.1.2, 00:00:12, Serial0/0/0  
    172.30.0.0/16 is variably subnetted, 3 subnets, 2 masks  
C        172.30.10.0/24 is directly connected, GigabitEthernet0/1  
L        172.30.10.1/32 is directly connected, GigabitEthernet0/1  
R        172.30.30.0/24 [120/2] via 10.1.1.2, 00:00:12, Serial0/0/0  
R3# show ip route  
<Output omitted>  
    10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks  
C        10.2.2.0/30 is directly connected, Serial0/0/1  
L        10.2.2.1/32 is directly connected, Serial0/0/1
```

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```
R      10.1.1.0/30 [120/1] via 10.2.2.2, 00:00:23, Serial0/0/1
    172.30.0.0/16 is variably subnetted, 2 subnets, 2 masks
C      172.30.30.0/24 is directly connected, GigabitEthernet0/1
L      172.30.30.1/32 is directly connected, GigabitEthernet0/1
R      172.30.10.0 [120/2] via 10.2.2.2, 00:00:16, Serial0/0/1
```

- d. Use the **debug ip rip** command on R2 to exam the RIP updates.

```
R2# debug ip rip
```

After 60 seconds, issue the **no debug ip rip** command.

What routes are in the RIP updates that are received from R3?

172.30.30.0/24

Are the subnet masks now included in the routing updates? _____ yes

Step 4: Configure and redistribute a default route for Internet access.

- a. From R2, create a static route to network 0.0.0.0 0.0.0.0, using the **ip route** command. This forwards any unknown destination address traffic to the R2 G0/0 toward PC-B, simulating the Internet by setting a Gateway of Last Resort on the R2 router.

```
R2(config)# ip route 0.0.0.0 0.0.0.0 209.165.201.2
```

- b. R2 will advertise a route to the other routers if the **default-information originate** command is added to its RIP configuration.

```
R2(config)# router rip
```

```
R2(config-router)# default-information originate
```

Step 5: Verify the routing configuration.

- a. View the routing table on R1.

```
R1# show ip route
```

<Output omitted>

Gateway of last resort is 10.1.1.2 to network 0.0.0.0

```
R*   0.0.0.0/0 [120/1] via 10.1.1.2, 00:00:13, Serial0/0/0
    10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C     10.1.1.0/30 is directly connected, Serial0/0/0
L     10.1.1.1/32 is directly connected, Serial0/0/0
R     10.2.2.0/30 [120/1] via 10.1.1.2, 00:00:13, Serial0/0/0
    172.30.0.0/16 is variably subnetted, 3 subnets, 2 masks
C     172.30.10.0/24 is directly connected, GigabitEthernet0/1
L     172.30.10.1/32 is directly connected, GigabitEthernet0/1
R     172.30.30.0/24 [120/2] via 10.1.1.2, 00:00:13, Serial0/0/0
```

How can you tell from the routing table that the subnetted network shared by R1 and R3 has a pathway for Internet traffic?

There is a Gateway of Last Resort, and the default route shows up in the table as being learned via RIP.

Lab – Configuring Basic RIPv2 and RIPng

- b. View the routing table on R2.

How is the pathway for Internet traffic provided in its routing table?

R2 has a static default route to 0.0.0.0 via 209.165.201.2, which is directly connected to G0/0.

Step 6: Verify connectivity.

- a. Simulate sending traffic to the Internet by pinging from PC-A and PC-C to 209.165.201.2.

Were the pings successful? _____ Yes

- b. Verify that hosts within the subnetted network can reach each other by pinging between PC-A and PC-C.

Were the pings successful? _____ Yes

Note: It may be necessary to disable the PCs firewall.

Part 3: Configure IPv6 on Devices

In Part 3, you will configure all interfaces with IPv6 addresses and verify connectivity.

Addressing Table

Device	Interface	IPv6 Address / Prefix Length	Default Gateway
R1	G0/1	2001:DB8:ACAD:A::1/64 FE80::1 link-local	N/A
	S0/0/0	2001:DB8:ACAD:12::1/64 FE80::1 link-local	N/A
R2	G0/0	2001:DB8:ACAD:B::2/64 FE80::2 link-local	N/A
	S0/0/0	2001:DB8:ACAD:12::2/64 FE80::2 link-local	N/A
R3	S0/0/1	2001:DB8:ACAD:23::2/64 FE80::2 link-local	N/A
	G0/1	2001:DB8:ACAD:C::3/64 FE80::3 link-local	N/A
PC-A	NIC	2001:DB8:ACAD:A::A/64	FE80::1
	NIC	2001:DB8:ACAD:B::B/64	FE80::2
PC-C	NIC	2001:DB8:ACAD:C::C/64	FE80::3

Step 1: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 2: Configure IPv6 on routers.

Note: Assigning an IPv6 address in addition to an IPv4 address on an interface is known as dual stacking. This is because both IPv4 and IPv6 protocol stacks are active.

- a. For each router interface, assign the global and link local address from the Addressing Table.
- b. Enable IPv6 routing on each router.
- c. Enter the appropriate command to verify IPv6 addresses and link status. Write the command in the space below.

```
show ipv6 interface brief
R1# show ipv6 interface brief
GigabitEthernet0/0          [administratively down/down]
GigabitEthernet0/1          [up/up]
    FE80::1
    2001:DB8:ACAD:A::1
Serial0/0/0                 [up/up]
    FE80::1
```

```
2001:DB8:ACAD:12::1  
Serial0/0/1 [administratively down/down]
```

- d. Each workstation should be able to ping the attached router. Verify and troubleshoot if necessary.
- e. The routers should be able to ping one another. Verify and troubleshoot if necessary.

Part 4: Configure and Verify RIPng Routing

In Part 4, you will configure RIPng routing on all routers, verify that routing tables are updated correctly, configure and distribute a default route, and verify end-to-end connectivity.

Step 1: Configure RIPng routing.

With IPv6, it is common to have multiple IPv6 addresses configured on an interface. The network statement has been eliminated in RIPng. RIPng routing is enabled at the interface level instead, and is identified by a locally significant process name as multiple processes can be created with RIPng.

- a. Issue the **ipv6 rip Test1 enable** command for each interface on R1 that is to participate in RIPng routing, where **Test1** is the locally significant process name.

```
R1(config)# interface g0/1  
R1(config)# ipv6 rip Test1 enable  
R1(config)# interface s0/0/0  
R1(config)# ipv6 rip Test1 enable
```

- b. Configure RIPng for the serial interfaces on R2 with **Test2** as the process name. Do not configure for the G0/0 interface.

```
R2(config)# interface s0/0/0  
R2(config)# ipv6 rip Test2 enable  
R2(config)# interface s0/0/1  
R2(config)# ipv6 rip Test2 enable
```

- c. Configure RIPng for each interface on R3 with **Test3** as the process name.

```
R3(config)# interface g0/1  
R3(config)# ipv6 rip Test3 enable  
R3(config)# interface s0/0/1  
R3(config)# ipv6 rip Test3 enable
```

- d. Verify that RIPng is running on the routers.

The **show ipv6 protocols**, **show run**, **show ipv6 rip database**, and **show ipv6 rip process name** commands can all be used to confirm that RIPng is running. On R1, issue the **show ipv6 protocols** command.

```
R1# show ipv6 protocols  
IPv6 Routing Protocol is "connected"  
IPv6 Routing Protocol is "ND"  
IPv6 Routing Protocol is "rip Test1"  
  Interfaces:  
    Serial0/0/0  
    GigabitEthernet0/1  
  Redistribution:  
    None
```

How is the RIPng listed in the output?

RIPng is listed by process name.

- e. Issue the **show ipv6 rip Test1** command.

```
R1# show ipv6 rip Test1
RIP process "Test1", port 521, multicast-group FF02::9, pid 314
    Administrative distance is 120. Maximum paths is 16
    Updates every 30 seconds, expire after 180
    Holddown lasts 0 seconds, garbage collect after 120
    Split horizon is on; poison reverse is off
    Default routes are not generated
    Periodic updates 1, trigger updates 0
    Full Advertisement 0, Delayed Events 0
Interfaces:
    GigabitEthernet0/1
    Serial0/0/0
Redistribution:
    None
```

How are RIPv2 and RIPng similar?

Answers will vary. Both RIPv2 and RIPng have an administrative distance of 120, use hop count as the metric, and send updates every 30 seconds.

- f. Inspect the IPv6 routing table on each router. Write the appropriate command used to view the routing table in the space below.
-

```
show ipv6 route
R1# show ipv6 route
IPv6 Routing Table - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
        U - Per-user Static route, M - MIPv6
        I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
        O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
        ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
        D - EIGRP, EX - EIGRP external
C  2001:DB8:ACAD:A::/64 [0/0]
    via ::, GigabitEthernet0/1
L  2001:DB8:ACAD:A::1/128 [0/0]
    via ::, GigabitEthernet0/1
R  2001:DB8:ACAD:C::/64 [120/3]
    via FE80::2, Serial0/0/0
C  2001:DB8:ACAD:12::/64 [0/0]
    via ::, Serial0/0/0
L  2001:DB8:ACAD:12::1/128 [0/0]
    via ::, Serial0/0/0
R  2001:DB8:ACAD:23::/64 [120/2]
    via FE80::2, Serial0/0/0
```

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```
L FF00::/8 [0/0]
via ::, Null0
```

On R1, how many routes have been learned by RIPng? _____ 2

On R2, how many routes have been learned by RIPng? _____ 2

On R3, how many routes have been learned by RIPng? _____ 2

- g. Check connectivity between PCs.

From PC-A, is it possible to ping PC-B? _____ no

From PC-A, is it possible to ping PC-C? _____ yes

From PC-C, is it possible to ping PC-B? _____ no

From PC-C, is it possible to ping PC-A? _____ yes

Why are some pings successful and others not?

No route has been advertised to the 2001:DB8:ACAD:B::/64 network.

Step 2: Configure and redistribute a default route.

- a. From R2, create a static default route to network ::0/64 using the **ipv6 route** command, and the IP address of exit interface G0/0. This forwards any unknown destination address traffic to the R2 G0/0 interface toward PC-Bs, simulating the Internet. Write the command used in the space below.

```
R2(config)# ipv6 route ::0/64 2001:db8:acad:b::b
```

- b. Static routes can be included in RIPng updates by using the **ipv6 rip process name default-information originate** command in interface configuration mode. Configure the serial links on R2 to send the default route in RIPng updates.

```
R2(config)# int s0/0/0
R2(config-rtr)# ipv6 rip Test2 default-information originate
R2(config)# int s0/0/1
R2(config-rtr)# ipv6 rip Test2 default-information originate
```

Step 3: Verify the routing configuration.

- a. View the IPv6 routing table on R2.

```
R2# show ipv6 route
IPv6 Routing Table - 10 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
      U - Per-user Static route, M - MIPv6
      I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
      O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
      ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
      D - EIGRP, EX - EIGRP external
S    ::/64 [1/0]
      via 2001:DB8:ACAD:B::B
R    2001:DB8:ACAD:A::/64 [120/2]
      via FE80::1, Serial0/0/0
C    2001:DB8:ACAD:B::/64 [0/0]
```

Lab – Configuring Basic RIPv2 and RIPng

```
    via ::, GigabitEthernet0/1
L 2001:DB8:ACAD:B::2/128 [0/0]
    via ::, GigabitEthernet0/1
R 2001:DB8:ACAD:C::/64 [120/2]
    via FE80::3, Serial0/0/1
C 2001:DB8:ACAD:12::/64 [0/0]
    via ::, Serial0/0/0
L 2001:DB8:ACAD:12::2/128 [0/0]
    via ::, Serial0/0/0
C 2001:DB8:ACAD:23::/64 [0/0]
    via ::, Serial0/0/1
L 2001:DB8:ACAD:23::2/128 [0/0]
    via ::, Serial0/0/1
L FF00::/8 [0/0]
    via ::, Null0
```

How can you tell from the routing table that R2 has a pathway for Internet traffic?

The static default route shows up in the R2 routing table.

```
S ::/64 [1/0]
    via 2001:DB8:ACAD:B::B
```

- b. View the routing tables on R1 and R3.

How is the pathway for Internet traffic provided in their routing tables?

The default route shows up as a distributed RIPng route with a metric of 2.

R1:

```
R ::/0 [120/2]
    via FE80::2, Serial0/0/0
```

R3:

```
R ::/0 [120/2]
    via FE80::2, Serial0/0/1
```

Step 4: Verify connectivity.

Simulate sending traffic to the Internet by pinging from PC-A and PC-C to 2001:DB8:ACAD:B::B/64.

Were the pings successful? _____ Yes

Reflection

1. Why would you turn off automatic summarization for RIPv2?
-

So the routers will no longer summarize routes at major classful network boundaries.

2. In both scenarios, how did R1 and R3 learn the pathway to the Internet?
-

From RIP routing updates received from the router where the default route was configured (R2).

3. How are configuring RIPv2 and RIPng different?

Answers may vary. RIPv2 is configured through network statements where RIPng is configured on interfaces.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs - Final

Router R1

```
R1# show run
Building configuration...

Current configuration : 1787 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUg.2
!
```

Lab – Configuring Basic RIPv2 and RIPng

```
no aaa new-model
!
no ip domain lookup
ip cef
ipv6 unicast-routing
ipv6 cef
!
multilink bundle-name authenticated
!
!
redundancy
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  description R1 LAN
  ip address 172.30.10.1 255.255.255.0
  duplex auto
  speed auto
  ipv6 address FE80::1 link-local
  ipv6 address 2001:DB8:ACAD:A::1/64
  ipv6 rip Test1 enable
!
interface Serial0/0/0
  description Link to R2
  ip address 10.1.1.1 255.255.255.252
  ipv6 address FE80::1 link-local
  ipv6 address 2001:DB8:ACAD:12::1/64
  ipv6 rip Test1 enable
  clock rate 2000000
!
interface Serial0/0/1
  no ip address
  shutdown
!
router rip
  version 2
  passive-interface GigabitEthernet0/1
  network 10.0.0.0
  network 172.30.0.0
  no auto-summary
```

Lab – Configuring Basic RIPv2 and RIPng

```
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 router rip Test1
!
control-plane
!
banner motd ^CUnauthorized access is strictly prohibited.^C
!
line con 0
password 7 045802150C2E
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 060506324F41
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2#show run
Building configuration...

Current configuration : 2073 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
```

Lab – Configuring Basic RIPv2 and RIPng

```
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
!
no ip domain lookup
ip cef
ipv6 unicast-routing
ipv6 cef
!
!
!
!
!
redundancy
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
description R2 LAN
ip address 209.165.201.1 255.255.255.0
duplex auto
speed auto
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:B::1/64
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
description Link to R1
ip address 10.1.1.2 255.255.255.252
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:12::2/64
ipv6 rip Test2 enable
ipv6 rip Test2 default-information originate
!
interface Serial0/0/1
description Link to R3
ip address 10.2.2.2 255.255.255.252
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:23::2/64
ipv6 rip Test2 enable
ipv6 rip Test2 default-information originate
clock rate 2000000
!
```

Lab – Configuring Basic RIPv2 and RIPng

```
router rip
version 2
network 10.0.0.0
default-information originate
no auto-summary
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 209.165.201.2
!
ipv6 route ::/64 2001:DB8:ACAD:B::B
ipv6 router rip Test2
!
control-plane
!
banner motd ^CUnauthorized access is strictly prohibited.^C
!
line con 0
password 7 0822455D0A16
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 110A1016141D
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3

```
R3#show run
Building configuration...

Current configuration : 1847 bytes
!
version 15.2
service timestamps debug datetime msec
```

Lab – Configuring Basic RIPv2 and RIPng

```
service timestamps log datetime msec
no service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
ip cef
ipv6 unicast-routing
ipv6 cef
!
multilink bundle-name authenticated
!
!
redundancy
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
description R3 LAN
ip address 172.30.30.1 255.255.255.0
duplex auto
speed auto
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:C::3/64
ipv6 rip Test3 enable
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
description Link to R2
```

Lab – Configuring Basic RIPv2 and RIPng

```
ip address 10.2.2.1 255.255.255.252
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:23::3/64
ipv6 rip Test3 enable
!
router rip
version 2
passive-interface GigabitEthernet0/1
network 10.0.0.0
network 172.30.0.0
no auto-summary
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 router rip Test3
!
control-plane
!
banner motd ^CUnauthorized access is strictly prohibited.^C
!
line con 0
password 7 02050D480809
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 14141B180F0B
login
transport input all
!
scheduler allocate 20000 1000
!
end
```



IPv6 - Details, Details... (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Analyze a routing table to determine the route source, administrative distance, and metric for a given route to include IPv4/IPv6.

The focus of this activity is to review IPv6 routing table entries and concepts.

Scenario

After studying the concepts presented in this chapter concerning IPv6, you should be able to read a routing table easily and interpret the IPv6 routing information listed within it.

With a partner, use the IPv6 routing table diagram and the .pdf provided with this activity. Record your answers to the Reflection questions. Then compare your answers with, at least, one other group from the class.

Required Resources

- Routing Table Diagram (as shown below)
- Two PCs or bring your own devices (BYODs): one PC or BYOD will display the Routing Table Diagram for your group to access while recording answers to the Reflection questions on the other PC or BYOD.

Routing Table Diagram

```
R3# show ipv6 route
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
        B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
        IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
        ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
        O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
        ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
R    2001:DB8:CAFE:1::/64 [120/3]
      via FE80::FE99:47FF:FE71:78A0, Serial0/0/1
R    2001:DB8:CAFE:2::/64 [120/2]
      via FE80::FE99:47FF:FE71:78A0, Serial0/0/1
C    2001:DB8:CAFE:3::/64 [0/0]
      via GigabitEthernet0/0, directly connected
L    2001:DB8:CAFE:3::1/128 [0/0]
      via GigabitEthernet0/0, receive
      (output omitted)
```

Reflection

1. How many different IPv6 networks are shown on the routing table diagram? List them in the table provided below.

Three; you do not count the L route as it is already accounted for in the C route.

Routing Table IPv6 Networks
2001:DB8:CAFE:1::/64
2001:DB8:CAFE:2::/64
2001:DB8:CAFE:3::/64

2. The 2001:DB8:CAFE:3:: route is listed twice on the routing table, once with a /64 and once with a /128. What is the significance of this dual network entry?

The 2001:DB8:CAFE:3::/64 indicates a specific IPv6 network as represented by the first 64 network bits. The 2001:DB8:CAFE:3::1/128 indicates a local route entry. The /128 prefix assists with route lookup-up processes for packages destined for the interfaces.

3. How many routes in this table are RIP routes? What type of RIP routes are listed: RIP, RIPv2, or RIPng?

Two routes are RIP routes, both are RIPng because they show IPv6 network addresses.

4. Use the first RIP route, as listed on the routing table, as a reference. What is the administrative distance of this route? What is the cost? What is the significance of these two values?

The administrative distance is 120. This value is automatically assigned when RIP is configured without making specific changes. The cost for this route is 3 which indicates how many hops it would take to get to the specified network.

5. Use the second RIP route, as referenced by the routing table diagram. How many hops would it take to get to the 2001:DB8:CAFE:2::/64 network? What would happen to this routing table entry if the cost for this route exceeded 15 hops?

Two hops would be necessary to reach 2001:DB8:CAFE:2::/64. The route would disappear if the hop count increased to a cost of 16.

6. You are designing an IPv6 addressing scheme to add another router to your network's physical topology. Use the /64 prefix for this addressing scheme and an IPv6 network base of 2001:DB8:CAFF:2::/64,. What would

IPv6 – Details, Details...

be the next, numerical network assignment you could use if the first three hexets remained the same?
Justify your answer.

The next physical addressing space could possibly be assigned as 2001:DB8:CAFF:3::/64. If the first three hexets stayed the same, increments would be applied to the fourth hexet. The last 64 bits would be reserved for host addressing unless the prefix of /64 changes.

Identify elements of the model that map to IT-related content:

- IPv6 addresses
- RIPng routing protocol
- Administrative distance
- Cost
- Link local addresses
- Hextets
- Network prefixes

Can Submarines Swim? (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Explain the process by which link-state routers learn about other networks.

This modeling activity focuses students' thoughts on the basic idea of using the shortest path to find the best network path for data communications.

Scenario

Edsger Wybe Dijkstra was a famous computer programmer and theoretical physicist. One of his most famous quotes was: "The question of whether computers can think is like the question of whether submarines can swim." Dijkstra's work has been applied, among other things, to routing protocols. He created the Shortest Path First (SPF) algorithm for network routing.

- Visit the Association for Computing Machinery's (ACM) website at http://amturing.acm.org/award_winners/dijkstra_1053701.cfm. Read the article about the life of Dijkstra. List five facts from the article you found interesting about him and his work.
- Next, view Dijkstra's animation of how to find the shortest path first located at http://upload.wikimedia.org/wikipedia/commons/5/57/Dijkstra_Animation.gif. While viewing the animation, pay close attention to what is occurring in it. Note three observations about the animation.
- Lastly, view the graphic located at http://upload.wikimedia.org/wikipedia/commons/3/37/Ricerca_operativa_percorso_minimo_01.gif. Take a few moments to view the visual and note three observations you have made about the visual. (Note: Use a web translator if you do not know the Italian words "Casa" and "Ufficio".)

Now, open the PDF provided with this activity and answer the reflection questions. Save your work.

Get together with two of your classmates to compare your answers.

Resources

- Internet connection
- Internet browser

Reflection

1. List five facts you found interesting about Edsger Wybe Dijkstra's life.

Answers will vary based on student preference after reading the site information. Some answers may include: Dijkstra was originally from the Netherlands. He was a computer programmer. His workforce title changed from programmer to theoretical physicist when he was denied a marriage license by the Netherlands. He worked for Burroughs Corporation. He spent 20 years of his life at the University of Texas/Austin in the Computer Science Department. It took only 20 minutes to develop the algorithm for shortest path first, this algorithm was based on a square diagram.

2. List three observations about the animation found at http://upload.wikimedia.org/wikipedia/commons/5/57/Dijkstra_Animation.gif.

Different paths are shown from source to destination. Numbers are shown to calculate path cost from one place to another. Some paths are shorter than others; therefore, finding the shortest path is key to find the shortest path from source to destination.

Can Submarines Swim?

3. List three observations about the visual shown at
http://commons.wikimedia.org/wiki/File:Ricerca_operativa_percorso_minimo_01.gif.

Casa and Ufficio indicate source and destination locations on the diagram. Numbers are provided to indicate cost on each line to travel from source to destination. Some costs (when added) will be lower or higher than others when travelling from source to destination.

4. Distance vector routing protocols basically depend on number of hops to find the best route from source to destination. If you apply the information you learned from this introductory activity to routing, would hops be the main factor in finding the best path from source to destination? If compared to network communication, could it possibly be better to find the best path using a different metric than hop count? Justify your answer.

Using the information found in this research activity, it appears that the metric of the path can vary from source to destination. Hop count can be used to find the best path for network communications, or a different metric can be used. Calculations can be based on numbers – these numbers can be added to find the best route from source to destination. Therefore, numbers or cost, instead of hops, can provide an alternative metric to finding the best path from source to destination.

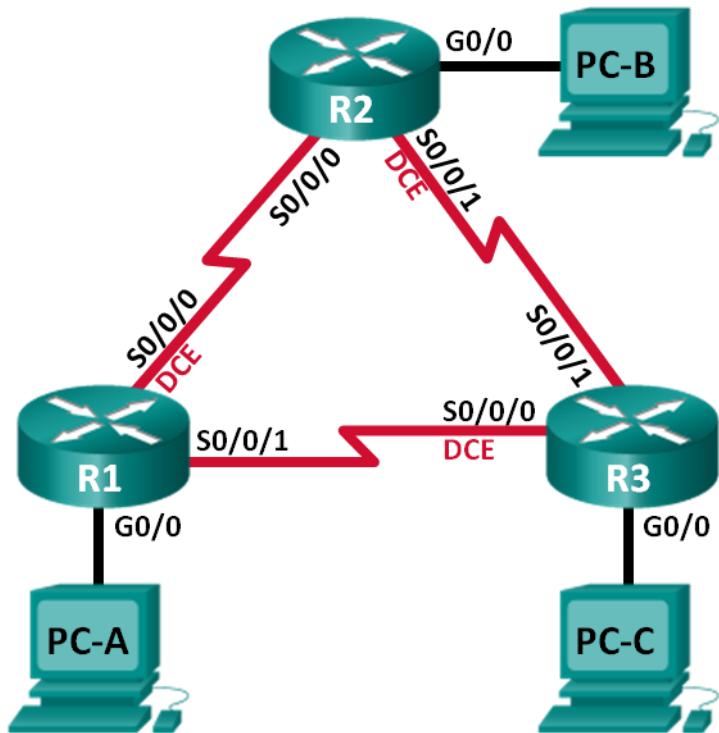
Identify elements of the model that map to IT-related content:

- Routes
- Dijkstra
- Shortest path first
- Metrics

Lab - Configuring Basic Single-Area OSPFv2 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.12.1	255.255.255.252	N/A
	S0/0/1	192.168.13.1	255.255.255.252	N/A
R2	G0/0	192.168.2.1	255.255.255.0	N/A
	S0/0/0	192.168.12.2	255.255.255.252	N/A
	S0/0/1 (DCE)	192.168.23.1	255.255.255.252	N/A
R3	G0/0	192.168.3.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.13.2	255.255.255.252	N/A
	S0/0/1	192.168.23.2	255.255.255.252	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.2.3	255.255.255.0	192.168.2.1
PC-C	NIC	192.168.3.3	255.255.255.0	192.168.3.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify OSPF Routing

Part 3: Change Router ID Assignments

Part 4: Configure OSPF Passive Interfaces

Part 5: Change OSPF Metrics

Background / Scenario

Open Shortest Path First (OSPF) is a link-state routing protocol for IP networks. OSPFv2 is defined for IPv4 networks, and OSPFv3 is defined for IPv6 networks. OSPF detects changes in the topology, such as link failures, and converges on a new loop-free routing structure very quickly. It computes each route using Dijkstra's algorithm, a shortest path first algorithm.

In this lab, you will configure the network topology with OSPFv2 routing, change the router ID assignments, configure passive interfaces, adjust OSPF metrics, and use a number of CLI commands to display and verify OSPF routing information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you set up the network topology and configure basic settings on the PC hosts and routers.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers as necessary.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure a message of the day (MOTD) banner to warn users that unauthorized access is prohibited.
- f. Configure **logging synchronous** for the console line.
- g. Configure the IP address listed in the Addressing Table for all interfaces.
- h. Set the clock rate for all DCE serial interfaces at **128000**.
- i. Copy the running configuration to the startup configuration.

Step 4: Configure PC hosts.

Step 5: Test connectivity.

The routers should be able to ping one another, and each PC should be able to ping its default gateway. The PCs are unable to ping other PCs until OSPF routing is configured. Verify and troubleshoot if necessary.

Part 2: Configure and Verify OSPF Routing

In Part 2, you will configure OSPFv2 routing on all routers in the network and then verify that routing tables are updated correctly. After OSPF has been verified, you will configure OSPF authentication on the links for added security.

Step 1: Configure OSPF on R1.

- a. Use the **router ospf** command in global configuration mode to enable OSPF on R1.

```
R1(config)# router ospf 1
```

Note: The OSPF process id is kept locally and has no meaning to other routers on the network.

- b. Configure the **network** statements for the networks on R1. Use an area ID of 0.

```
R1(config-router)# network 192.168.1.0 0.0.0.255 area 0
```

Lab - Configuring Basic Single-Area OSPFv2

```
R1(config-router)# network 192.168.12.0 0.0.0.3 area 0
R1(config-router)# network 192.168.13.0 0.0.0.3 area 0
```

Step 2: Configure OSPF on R2 and R3.

Use the **router ospf** command and add the **network** statements for the networks on R2 and R3. Neighbor adjacency messages display on R1 when OSPF routing is configured on R2 and R3.

```
R1#
00:22:29: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.1 on Serial0/0/0 from LOADING to
FULL, Loading Done
R1#
00:23:14: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.2 on Serial0/0/1 from LOADING to
FULL, Loading Done
R1#
```

Step 3: Verify OSPF neighbors and routing information.

- Issue the **show ip ospf neighbor** command to verify that each router lists the other routers in the network as neighbors.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.23.2	0	FULL/ -	00:00:33	192.168.13.2	Serial0/0/1
192.168.23.1	0	FULL/ -	00:00:30	192.168.12.2	Serial0/0/0

- Issue the **show ip route** command to verify that all networks display in the routing table on all routers.

```
R1# show ip route
```

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, 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

```
192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.1.0/24 is directly connected, GigabitEthernet0/0
L      192.168.1.1/32 is directly connected, GigabitEthernet0/0
O      192.168.2.0/24 [110/65] via 192.168.12.2, 00:32:33, Serial0/0/0
O      192.168.3.0/24 [110/65] via 192.168.13.2, 00:31:48, Serial0/0/1
          192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.12.0/30 is directly connected, Serial0/0/0
L      192.168.12.1/32 is directly connected, Serial0/0/0
          192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.13.0/30 is directly connected, Serial0/0/1
L      192.168.13.1/32 is directly connected, Serial0/0/1
          192.168.23.0/30 is subnetted, 1 subnets
O      192.168.23.0/30 [110/128] via 192.168.12.2, 00:31:38, Serial0/0/0
                                [110/128] via 192.168.13.2, 00:31:38, Serial0/0/1
```

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What command would you use to only see the OSPF routes in the routing table?

show ip route ospf

Step 4: Verify OSPF protocol settings.

The **show ip protocols** command is a quick way to verify vital OSPF configuration information. This information includes the OSPF process ID, the router ID, networks the router is advertising, the neighbors the router is receiving updates from, and the default administrative distance, which is 110 for OSPF.

```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.13.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.1.0 0.0.0.255 area 0
    192.168.12.0 0.0.0.3 area 0
    192.168.13.0 0.0.0.3 area 0
  Routing Information Sources:
    Gateway          Distance      Last Update
    192.168.23.2      110          00:19:16
    192.168.23.1      110          00:20:03
  Distance: (default is 110)
```

Step 5: Verify OSPF process information.

Use the **show ip ospf** command to examine the OSPF process ID and router ID. This command displays the OSPF area information, as well as the last time the SPF algorithm was calculated.

```
R1# show ip ospf
Routing Process "ospf 1" with ID 192.168.13.1
  Start time: 00:20:23.260, Time elapsed: 00:25:08.296
  Supports only single TOS(TOS0) routes
  Supports opaque LSA
  Supports Link-local Signaling (LLS)
  Supports area transit capability
  Supports NSSA (compatible with RFC 3101)
  Event-log enabled, Maximum number of events: 1000, Mode: cyclic
  Router is not originating router-LSAs with maximum metric
  Initial SPF schedule delay 5000 msec
  Minimum hold time between two consecutive SPFs 10000 msec
  Maximum wait time between two consecutive SPFs 10000 msec
  Incremental-SPF disabled
  Minimum LSA interval 5 secs
  Minimum LSA arrival 1000 msec
  LSA group pacing timer 240 secs
```

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```
Interface flood pacing timer 33 msec
Retransmission pacing timer 66 msec
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm last executed 00:22:53.756 ago
    SPF algorithm executed 7 times
    Area ranges are
    Number of LSA 3. Checksum Sum 0x019A61
    Number of opaque link LSA 0. Checksum Sum 0x000000
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

Step 6: Verify OSPF interface settings.

- Issue the **show ip ospf interface brief** command to display a summary of OSPF-enabled interfaces.

```
R1# show ip ospf interface brief
Interface      PID   Area          IP Address/Mask     Cost   State Nbrs F/C
Se0/0/1        1      0             192.168.13.1/30    64     P2P   1/1
Se0/0/0        1      0             192.168.12.1/30    64     P2P   1/1
Gi0/0          1      0             192.168.1.1/24     1      DR    0/0
```

- For a more detailed list of every OSPF-enabled interface, issue the **show ip ospf interface** command.

```
R1# show ip ospf interface
Serial0/0/1 is up, line protocol is up
    Internet Address 192.168.13.1/30, Area 0, Attached via Network Statement
    Process ID 1, Router ID 192.168.13.1, Network Type POINT_TO_POINT, Cost: 64
    Topology-MTID      Cost      Disabled      Shutdown      Topology Name
                    0          64          no           no           Base
    Transmit Delay is 1 sec, State POINT_TO_POINT
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
        oob-resync timeout 40
        Hello due in 00:00:01
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    Index 3/3, flood queue length 0
    Next 0x0(0)/0x0(0)
```

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```
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 192.168.23.2
    Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
    Internet Address 192.168.12.1/30, Area 0, Attached via Network Statement
    Process ID 1, Router ID 192.168.13.1, Network Type POINT_TO_POINT, Cost: 64
    Topology-MTID      Cost      Disabled      Shutdown      Topology Name
        0            64          no           no           Base
    Transmit Delay is 1 sec, State POINT_TO_POINT
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
        oob-resync timeout 40
        Hello due in 00:00:03
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    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 192.168.23.1
        Suppress hello for 0 neighbor(s)
GigabitEthernet0/0 is up, line protocol is up
    Internet Address 192.168.1.1/24, Area 0, Attached via Network Statement
    Process ID 1, Router ID 192.168.13.1, Network Type BROADCAST, Cost: 1
    Topology-MTID      Cost      Disabled      Shutdown      Topology Name
        0            1          no           no           Base
    Transmit Delay is 1 sec, State DR, Priority 1
    Designated Router (ID) 192.168.13.1, Interface address 192.168.1.1
    No backup designated router on this network
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
        oob-resync timeout 40
        Hello due in 00:00:01
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    Index 1/1, flood queue length 0
    Next 0x0(0)/0x0(0)
    Last flood scan length is 0, maximum is 0
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 0, Adjacent neighbor count is 0
    Suppress hello for 0 neighbor(s)
```

Step 7: Verify end-to-end connectivity.

Each PC should be able to ping the other PCs in the topology. Verify and troubleshoot if necessary.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Part 3: Change Router ID Assignments

The OSPF router ID is used to uniquely identify the router in the OSPF routing domain. Cisco routers derive the router ID in one of three ways and with the following precedence:

- 1) IP address configured with the OSPF **router-id** command, if present
- 2) Highest IP address of any of the router's loopback addresses, if present
- 3) Highest active IP address on any of the router's physical interfaces

Because no router IDs or loopback interfaces have been configured on the three routers, the router ID for each router is determined by the highest IP address of any active interface.

In Part 3, you will change the OSPF router ID assignment using loopback addresses. You will also use the **router-id** command to change the router ID.

Step 1: Change router IDs using loopback addresses.

- a. Assign an IP address to loopback 0 on R1.

```
R1(config)# interface lo0  
R1(config-if)# ip address 1.1.1.1 255.255.255.255  
R1(config-if)# end
```

- b. Assign IP addresses to Loopback 0 on R2 and R3. Use IP address 2.2.2.2/32 for R2 and 3.3.3.3/32 for R3.

- c. Save the running configuration to the startup configuration on all three routers.

- d. You must reload the routers in order to reset the router ID to the loopback address. Issue the **reload** command on all three routers. Press Enter to confirm the reload.

Instructor Note: The **clear ip ospf process** command does not reset the router IDs with the loopback address. Reloading the router will reset the router ID to the loopback address.

- e. After the router completes the reload process, issue the **show ip protocols** command to view the new router ID.

```
R1# show ip protocols  
*** IP Routing is NSF aware ***  
  
Routing Protocol is "ospf 1"  
    Outgoing update filter list for all interfaces is not set  
    Incoming update filter list for all interfaces is not set  
    Router ID 1.1.1.1  
    Number of areas in this router is 1. 1 normal 0 stub 0 nssa  
    Maximum path: 4  
    Routing for Networks:  
        192.168.1.0 0.0.0.255 area 0  
        192.168.12.0 0.0.0.3 area 0  
        192.168.13.0 0.0.0.3 area 0  
    Routing Information Sources:  
        Gateway          Distance      Last Update  
            3.3.3.3           110          00:01:00  
            2.2.2.2           110          00:01:14  
    Distance: (default is 110)
```

- f. Issue the **show ip ospf neighbor** command to display the router ID changes for the neighboring routers.

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```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/ -	00:00:35	192.168.13.2	Serial0/0/1
2.2.2.2	0	FULL/ -	00:00:32	192.168.12.2	Serial0/0/0

```
R1#
```

Step 2: Change the router ID on R1 using the **router-id** command.

The preferred method for setting the router ID is with the **router-id** command.

- Issue the **router-id 11.11.11.11** command on R1 to reassign the router ID. Notice the informational message that appears when issuing the **router-id** command.

```
R1(config)# router ospf 1
R1(config-router)# router-id 11.11.11.11
Reload or use "clear ip ospf process" command, for this to take effect
R1(config)# end
```

- You will receive an informational message telling you that you must either reload the router or use the **clear ip ospf process** command for the change to take effect. Issue the **clear ip ospf process** command on all three routers. Type **yes** to reply to the reset verification message, and press ENTER.
- Set the router ID for R2 to **22.22.22.22** and the router ID for R3 to **33.33.33.33**. Then use **clear ip ospf process** command to reset ospf routing process.
- Issue the **show ip protocols** command to verify that the router ID changed on R1.

```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 11.11.11.11
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.1.0 0.0.0.255 area 0
    192.168.12.0 0.0.0.3 area 0
    192.168.13.0 0.0.0.3 area 0
  Passive Interface(s):
    GigabitEthernet0/1
  Routing Information Sources:
    Gateway          Distance      Last Update
    33.33.33.33      110          00:00:19
    22.22.22.22      110          00:00:31
    3.3.3.3          110          00:00:41
    2.2.2.2          110          00:00:41
  Distance: (default is 110)
```

- Issue the **show ip ospf neighbor** command on R1 to verify that new router ID for R2 and R3 is listed.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
33.33.33.33	0	FULL/ -	00:00:36	192.168.13.2	Serial0/0/1
22.22.22.22	0	FULL/ -	00:00:32	192.168.12.2	Serial0/0/0

Part 4: Configure OSPF Passive Interfaces

The **passive-interface** command prevents routing updates from being sent through the specified router interface. This is commonly done to reduce traffic on the LANs as they do not need to receive dynamic routing protocol communication. In Part 4, you will use the **passive-interface** command to configure a single interface as passive. You will also configure OSPF so that all interfaces on the router are passive by default, and then enable OSPF routing advertisements on selected interfaces.

Step 1: Configure a passive interface.

- Issue the **show ip ospf interface g0/0** command on R1. Notice the timer indicating when the next Hello packet is expected. Hello packets are sent every 10 seconds and are used between OSPF routers to verify that their neighbors are up.

```
R1# show ip ospf interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 11.11.11.11, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0              1            no            no          Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 11.11.11.11, Interface address 192.168.1.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:02
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

- Issue the **passive-interface** command to change the G0/0 interface on R1 to passive.

```
R1(config)# router ospf 1
R1(config-router)# passive-interface g0/0
```

- Re-issue the **show ip ospf interface g0/0** command to verify that G0/0 is now passive.

```
R1# show ip ospf interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 11.11.11.11, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0              1            no            no          Base
  Transmit Delay is 1 sec, State DR, Priority 1
```

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```
Designated Router (ID) 11.11.11.11, Interface address 192.168.1.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
        No Hellos (Passive interface)
Supports Link-local Signaling (LLS)
Cisco NSF helper support enabled
IETF NSF helper support enabled
Index 1/1, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 0, maximum is 0
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
```

- d. Issue the **show ip route** command on R2 and R3 to verify that a route to the 192.168.1.0/24 network is still available.

```
R2# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      2.0.0.0/32 is subnetted, 1 subnets
C        2.2.2.2 is directly connected, Loopback0
O  192.168.1.0/24 [110/65] via 192.168.12.1, 00:58:32, Serial0/0/0
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.2.0/24 is directly connected, GigabitEthernet0/0
L          192.168.2.1/32 is directly connected, GigabitEthernet0/0
O  192.168.3.0/24 [110/65] via 192.168.23.2, 00:58:19, Serial0/0/1
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.12.0/30 is directly connected, Serial0/0/0
L          192.168.12.2/32 is directly connected, Serial0/0/0
      192.168.13.0/30 is subnetted, 1 subnets
O          192.168.13.0 [110/128] via 192.168.23.2, 00:58:19, Serial0/0/1
                  [110/128] via 192.168.12.1, 00:58:32, Serial0/0/0
      192.168.23.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.23.0/30 is directly connected, Serial0/0/1
L          192.168.23.1/32 is directly connected, Serial0/0/1
```

Step 2: Set passive interface as the default on a router.

- a. Issue the **show ip ospf neighbor** command on R1 to verify that R2 is listed as an OSPF neighbor.

```
R1# show ip ospf neighbor
```

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Neighbor ID	Pri	State	Dead Time	Address	Interface
33.33.33.33	0	FULL/ -	00:00:31	192.168.13.2	Serial0/0/1
22.22.22.22	0	FULL/ -	00:00:32	192.168.12.2	Serial0/0/0

- b. Issue the **passive-interface default** command on R2 to set the default for all OSPF interfaces as passive.

```
R2(config)# router ospf 1
R2(config-router)# passive-interface default
R2(config-router)#
*Apr  3 00:03:00.979: %OSPF-5-ADJCHG: Process 1, Nbr 11.11.11.11 on Serial0/0/0 from
FULL to DOWN, Neighbor Down: Interface down or detached
*Apr  3 00:03:00.979: %OSPF-5-ADJCHG: Process 1, Nbr 33.33.33.33 on Serial0/0/1 from
FULL to DOWN, Neighbor Down: Interface down or detached
```

- c. Re-issue the **show ip ospf neighbor** command on R1. After the dead timer expires, R2 will no longer be listed as an OSPF neighbor.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
33.33.33.33	0	FULL/ -	00:00:34	192.168.13.2	Serial0/0/1

- d. Issue the **show ip ospf interface S0/0/0** command on R2 to view the OSPF status of interface S0/0/0.

```
R2# show ip ospf interface s0/0/0
Serial0/0/0 is up, line protocol is up
  Internet Address 192.168.12.2/30, Area 0, Attached via Network Statement
  Process ID 1, Router ID 22.22.22.22, Network Type POINT_TO_POINT, Cost: 64
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
          0          64          no          no          Base
  Transmit Delay is 1 sec, State POINT_TO_POINT
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    No Hellos (Passive interface)
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

- e. If all interfaces on R2 are passive, then no routing information is being advertised. In this case, R1 and R3 should no longer have a route to the 192.168.2.0/24 network. You can verify this by using the **show ip route** command.
- f. On R2, issue the **no passive-interface** command so the router will send and receive OSPF routing updates. After entering this command, you will see an informational message that a neighbor adjacency has been established with R1.

```
R2(config)# router ospf 1
R2(config-router)# no passive-interface s0/0/0
```

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```
R2 (config-router)#
*Apr 3 00:18:03.463: %OSPF-5-ADJCHG: Process 1, Nbr 11.11.11.11 on Serial0/0/0 from
LOADING to FULL, Loading Done
```

- g. Re-issue the **show ip route** and **show ipv6 ospf neighbor** commands on R1 and R3, and look for a route to the 192.168.2.0/24 network.

O 192.168.2.0/24 [110/129] via 192.168.13.1, 00:00:04, Serial0/0/0

What interface is R3 using to route to the 192.168.2.0/24 network? _____ S0/0/0

What is the accumulated cost metric for the 192.168.2.0/24 network on R3? _____ 129

Does R2 show up as an OSPF neighbor on R1? _____ Yes

Does R2 show up as an OSPF neighbor on R3? _____ No

What does this information tell you?

Answers will vary, but all traffic to the 192.168.2.0/24 network from R3 will be routed through R1. The S0/0/1 interface on R2 is still configured as a passive interface, so OSPF routing information is not being advertised across this interface. The 129 accumulated cost results from the fact that traffic from R3 to the 192.168.2.0/24 network must pass through two T1 (1.544 Mb/s) serial links (at a cost of 64 each) plus the R2 Gigabit 0/0 LAN link (at a cost of 1).

- h. Change interface S0/0/1 on R2 to allow it to advertise OSPF routes. Record the commands used below.

```
R2 (config)# router ospf 1
```

```
R2 (config-router)#! no passive-interface s0/0/1
```

- i. Re-issue the **show ip route** command on R3.

O 192.168.2.0/24 [110/65] via 192.168.23.1, 00:00:00, Serial0/0/1

What interface is R3 using to route to the 192.168.2.0/24 network? _____ S0/0/1

What is the accumulated cost metric for the 192.168.2.0/24 network on R3 now and how is this calculated?

65 (One T1 (1.544 Mb/s) serial link (at a cost of 64) plus the R2 Gigabit 0/0 LAN link (at a cost of 1)).

Is R2 listed as an OSPF neighbor to R3? _____ Yes

Part 5: Change OSPF Metrics

In Part 3, you will change OSPF metrics using the **auto-cost reference-bandwidth** command, the **bandwidth** command, and the **ip ospf cost** command.

Note: All DCE interfaces should have been configured with a clocking rate of 128000 in Part 1.

Step 1: Change the reference bandwidth on the routers.

The default reference-bandwidth for OSPF is 100Mb/s (Fast Ethernet speed). However, most modern infrastructure devices have links that are faster than 100Mb/s. Because the OSPF cost metric must be an integer, all links with transmission speeds of 100Mb/s or higher have a cost of 1. This results in Fast Ethernet, Gigabit Ethernet and 10G Ethernet interfaces all having the same cost. Therefore, the reference-bandwidth must be changed to a higher value to accommodate networks with links faster than 100Mb/s.

- a. Issue the **show interface** command on R1 to view the default bandwidth setting for the G0/0 interface.

```
R1# show interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is c471.fe45.7520 (bia c471.fe45.7520)
  MTU 1500 bytes, BW 1000000 Kbit/sec, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full Duplex, 100Mbps, media type is RJ45
  output flow-control is unsupported, input flow-control is unsupported
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output 00:17:31, 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 queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    0 packets input, 0 bytes, 0 no buffer
    Received 0 broadcasts (0 IP multicasts)
    0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    0 watchdog, 0 multicast, 0 pause input
    279 packets output, 89865 bytes, 0 underruns
    0 output errors, 0 collisions, 1 interface resets
    0 unknown protocol drops
    0 babbles, 0 late collision, 0 deferred
    1 lost carrier, 0 no carrier, 0 pause output
    0 output buffer failures, 0 output buffers swapped out
```

Note: The bandwidth setting on G0/0 may differ from what is shown above if the PC host interface can only support Fast Ethernet speed. If the PC host interface is not capable of supporting gigabit speed, then the bandwidth will most likely be displayed as 100000 Kbit/sec.

- b. Issue the **show ip route ospf** command on R1 to determine the route to the 192.168.3.0/24 network.

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
```

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+ - replicated route, % - next hop override

Gateway of last resort is not set

```
O    192.168.3.0/24 [110/65] via 192.168.13.2, 00:00:57, Serial0/0/1
      192.168.23.0/30 is subnetted, 1 subnets
O        192.168.23.0 [110/128] via 192.168.13.2, 00:00:57, Serial0/0/1
          [110/128] via 192.168.12.2, 00:01:08, Serial0/0/0
```

Note: The accumulated cost to the 192.168.3.0/24 network from R1 is 65.

- c. Issue the **show ip ospf interface** command on R3 to determine the routing cost for G0/0.

```
R3# show ip ospf interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet Address 192.168.3.1/24, Area 0, Attached via Network Statement
  Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
              0          1          no          no          Base
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.23.2, Interface address 192.168.3.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:05
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

- d. Issue the **show ip ospf interface s0/0/1** command on R1 to view the routing cost for S0/0/1.

```
R1# show ip ospf interface s0/0/1
Serial0/0/1 is up, line protocol is up
  Internet Address 192.168.13.1/30, Area 0, Attached via Network Statement
  Process ID 1, Router ID 1.1.1.1, Network Type POINT_TO_POINT, Cost: 64
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
              0          64          no          no          Base
  Transmit Delay is 1 sec, State POINT_TO_POINT
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:04
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
```

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```
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 192.168.23.2
    Suppress hello for 0 neighbor(s)
```

The sum of the costs of these two interfaces is the accumulated cost for the route to the 192.168.3.0/24 network on R3 (1 + 64 = 65), as can be seen in the output from the **show ip route** command.

- e. Issue the **auto-cost reference-bandwidth 10000** command on R1 to change the default reference bandwidth setting. With this setting, 10Gb/s interfaces will have a cost of 1, 1 Gb/s interfaces will have a cost of 10, and 100Mb/s interfaces will have a cost of 100.

```
R1(config)# router ospf 1
R1(config-router)# auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
    Please ensure reference bandwidth is consistent across all routers.
```

- f. Issue the **auto-cost reference-bandwidth 10000** command on routers R2 and R3.
- g. Re-issue the **show ip ospf interface** command to view the new cost of G0/0 on R3, and S0/0/1 on R1.

```
R3# show ip ospf interface g0/0
GigabitEthernet0/0 is up, line protocol is up
    Internet Address 192.168.3.1/24, Area 0, Attached via Network Statement
    Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 10
    Topology-MTID      Cost      Disabled      Shutdown      Topology Name
        0          10          no          no          Base
    Transmit Delay is 1 sec, State DR, Priority 1
    Designated Router (ID) 192.168.23.2, Interface address 192.168.3.1
    No backup designated router on this network
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
        oob-resync timeout 40
        Hello due in 00:00:02
    Supports Link-local Signaling (LLS)
    Cisco NSF helper support enabled
    IETF NSF helper support enabled
    Index 1/1, flood queue length 0
    Next 0x0(0)/0x0(0)
    Last flood scan length is 0, maximum is 0
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 0, Adjacent neighbor count is 0
    Suppress hello for 0 neighbor(s)
```

Note: If the device connected to the G0/0 interface does not support Gigabit Ethernet speed, the cost will be different than the output display. For example, the cost will be 100 for Fast Ethernet speed (100Mb/s).

```
R1# show ip ospf interface s0/0/1
Serial0/0/1 is up, line protocol is up
    Internet Address 192.168.13.1/30, Area 0, Attached via Network Statement
    Process ID 1, Router ID 1.1.1.1, Network Type POINT_TO_POINT, Cost: 6476
    Topology-MTID      Cost      Disabled      Shutdown      Topology Name
        0          6476          no          no          Base
    Transmit Delay is 1 sec, State POINT_TO_POINT
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

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```
oob-resync timeout 40
Hello due in 00:00:05
Supports Link-local Signaling (LLS)
Cisco NSF helper support enabled
IETF NSF helper support enabled
Index 3/3, 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 192.168.23.2
    Suppress hello for 0 neighbor(s)
```

- h. Re-issue the **show ip route ospf** command to view the new accumulated cost for the 192.168.3.0/24 route (10 + 6476 = 6486).

Note: If the device connected to the G0/0 interface does not support Gigabit Ethernet speed, the total cost will be different than the output display. For example, the accumulated cost will be 6576 if G0/0 is operating at Fast Ethernet speed (100Mb/s).

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
O  192.168.2.0/24 [110/6486] via 192.168.12.2, 00:05:40, Serial0/0/0
O  192.168.3.0/24 [110/6486] via 192.168.13.2, 00:01:08, Serial0/0/1
    192.168.23.0/30 is subnetted, 1 subnets
O        192.168.23.0 [110/12952] via 192.168.13.2, 00:05:17, Serial0/0/1
                           [110/12952] via 192.168.12.2, 00:05:17, Serial0/0/0
```

Note: Changing the default reference-bandwidth on the routers from 100 to 10,000 in effect changed the accumulated costs of all routes by a factor of 100, but the cost of each interface link and route is now more accurately reflected.

- i. To reset the reference-bandwidth back to its default value, issue the **auto-cost reference-bandwidth 100** command on all three routers.

```
R1(config)# router ospf 1
R1(config-router)# auto-cost reference-bandwidth 100
% OSPF: Reference bandwidth is changed.
Please ensure reference bandwidth is consistent across all routers.
```

Why would you want to change the OSPF default reference-bandwidth?

Answers may vary, but today's equipment supports link speeds that are faster than 100 Mb/s. To obtain a more accurate cost calculation for these faster links, a higher default reference-bandwidth setting is needed.

Step 2: Change the bandwidth for an interface.

On most serial links, the bandwidth metric will default to 1544 Kbits (that of a T1). If this is not the actual speed of the serial link, the bandwidth setting will need to be changed to match the actual speed to allow the route cost to be calculated correctly in OSPF. Use the **bandwidth** command to adjust the bandwidth setting on an interface.

Note: A common misconception is to assume that the **bandwidth** command will change the physical bandwidth, or speed, of the link. The command modifies the bandwidth metric used by OSPF to calculate routing costs, and does not modify the actual bandwidth (speed) of the link.

- a. Issue the **show interface s0/0/0** command on R1 to view the current bandwidth setting on S0/0/0. Even though the clock rate, link speed on this interface was set to 128Kb/s, the bandwidth is still showing 1544Kb/s.

```
R1# show interface s0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is WIC MBRD Serial
  Internet address is 192.168.12.1/30
    MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
      reliability 255/255, txload 1/255, rxload 1/255
    Encapsulation HDLC, loopback not set
    Keepalive set (10 sec)
<Output omitted>
```

- b. Issue the **show ip route ospf** command on R1 to view the accumulated cost for the route to network 192.168.23.0/24 using S0/0/0. Note that there are two equal-cost (128) routes to the 192.168.23.0/24 network, one via S0/0/0 and one via S0/0/1.

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

```
Gateway of last resort is not set

O      192.168.3.0/24 [110/65] via 192.168.13.2, 00:00:26, Serial0/0/1
      192.168.23.0/30 is subnetted, 1 subnets
O          192.168.23.0 [110/128] via 192.168.13.2, 00:00:26, Serial0/0/1
                  [110/128] via 192.168.12.2, 00:00:42, Serial0/0/0
```

- c. Issue the **bandwidth 128** command to set the bandwidth on S0/0/0 to 128Kb/s.

```
R1(config)# interface s0/0/0
R1(config-if)# bandwidth 128
```

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- d. Re-issue the **show ip route ospf** command. The routing table no longer displays the route to the 192.168.23.0/24 network over the S0/0/0 interface. This is because the best route, the one with the lowest cost, is now via S0/0/1.

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

O    192.168.3.0/24 [110/65] via 192.168.13.2, 00:04:51, Serial0/0/1
    192.168.23.0/30 is subnetted, 1 subnets
O    192.168.23.0 [110/128] via 192.168.13.2, 00:04:51, Serial0/0/1
```

- e. Issue the **show ip ospf interface brief** command. The cost for S0/0/0 has changed from 64 to 781 which is an accurate cost representation of the link speed.

```
R1# show ip ospf interface brief
Interface     PID   Area          IP Address/Mask   Cost   State  Nbrs F/C
Se0/0/1        1     0             192.168.13.1/30   64     P2P    1/1
Se0/0/0        1     0             192.168.12.1/30   781    P2P    1/1
Gi0/0          1     0             192.168.1.1/24    1      DR     0/0
```

- f. Change the bandwidth for interface S0/0/1 to the same setting as S0/0/0 on R1.

```
R1(config)# interface s0/0/1
R1(config-if) # bandwidth 128
```

- g. Re-issue the **show ip route ospf** command to view the accumulated cost of both routes to the 192.168.23.0/24 network. Note that there are again two equal-cost (845) routes to the 192.168.23.0/24 network, one via S0/0/0 and one via S0/0/1.

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

O    192.168.3.0/24 [110/782] via 192.168.13.2, 00:00:09, Serial0/0/1
    192.168.23.0/30 is subnetted, 1 subnets
O    192.168.23.0 [110/845] via 192.168.13.2, 00:00:09, Serial0/0/1
                [110/845] via 192.168.12.2, 00:00:09, Serial0/0/0
```

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Explain how the costs to the 192.168.3.0/24 and 192.168.23.0/30 networks from R1 were calculated.

The cost to 192.168.3.0/24: R1 S0/0/1 + R3 G0/0 ($781+1=782$). The cost to 192.168.23.0/30: R1 S0/0/1 and R3 S0/0/1 ($781+64=845$).

- h. Issue the **show ip route ospf** command on R3. The accumulated cost of the 192.168.1.0/24 is still showing as 65. Unlike the **clock rate** command, the **bandwidth** command needs to be applied on each side of a serial link.

R3# **show ip route ospf**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

O 192.168.1.0/24 [110/**65**] via 192.168.13.1, 00:30:58, Serial0/0/0
192.168.12.0/30 is subnetted, 1 subnets
O 192.168.12.0 [110/128] via 192.168.23.1, 00:30:58, Serial0/0/1
[110/128] via 192.168.13.1, 00:30:58, Serial0/0/0

- i. Issue the **bandwidth 128** command on all remaining serial interfaces in the topology.

What is the new accumulated cost to the 192.168.23.0/24 network on R1? Why?

1,562. Each serial link now has a cost of 781, and the route to the 192.168.23.0/24 network travels over two serial links. $781 + 781 = 1,562$.

Step 3: Change the route cost.

OSPF uses the bandwidth setting to calculate the cost for a link by default. However, you can override this calculation by manually setting the cost of a link using the **ip ospf cost** command. Like the **bandwidth** command, the **ip ospf cost** command only affects the side of the link where it was applied.

- a. Issue the **show ip route ospf** on R1.

R1# **show ip route ospf**

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

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+ - replicated route, % - next hop override

Gateway of last resort is not set

```
O 192.168.2.0/24 [110/782] via 192.168.12.2, 00:00:26, Serial0/0/0
O 192.168.3.0/24 [110/782] via 192.168.13.2, 00:02:50, Serial0/0/1
    192.168.23.0/30 is subnetted, 1 subnets
O     192.168.23.0 [110/1562] via 192.168.13.2, 00:02:40, Serial0/0/1
        [110/1562] via 192.168.12.2, 00:02:40, Serial0/0/0
```

- b. Apply the **ip ospf cost 1565** command to the S0/0/1 interface on R1. A cost of 1565 is higher than the accumulated cost of the route through R2 which is 1562.

```
R1(config)# int s0/0/1
R1(config-if)# ip ospf cost 1565
```

- c. Re-issue the **show ip route ospf** command on R1 to display the effect this change has made on the routing table. All OSPF routes for R1 are now being routed through R2.

```
R1# show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
O 192.168.2.0/24 [110/782] via 192.168.12.2, 00:02:06, Serial0/0/0
O 192.168.3.0/24 [110/1563] via 192.168.12.2, 00:05:31, Serial0/0/0
    192.168.23.0/30 is subnetted, 1 subnets
O     192.168.23.0 [110/1562] via 192.168.12.2, 01:14:02, Serial0/0/0
```

Note: Manipulating link costs using the **ip ospf cost** command is the easiest and preferred method for changing OSPF route costs. In addition to changing the cost based on bandwidth, a network administrator may have other reasons for changing the cost of a route, such as preference for a particular service provider or the actual monetary cost of a link or route.

Explain why the route to the 192.168.3.0/24 network on R1 is now going through R2?

OSPF will choose the route with the least accumulated cost. The route with the lowest accumulated cost is: R1-S0/0/0 + R2-S0/0/1 + R3-G0/0, or $781 + 781 + 1 = 1,563$. This metric is smaller than the accumulated cost of R1-S0/0/1 + R3-G0/0, or $1565 + 1 = 1,566$.

Reflection

1. Why is it important to control the router ID assignment when using the OSPF protocol?
-

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Router ID assignments control the Designated Router (DR) and Backup Designated Router (BDR) election process on a multi-access network. If the router ID is associated with an active interface, it can change if the interface goes down. For this reason it should be set using the IP address of a loopback interface (which cannot go down) or set using the **router-id** command.

2. Why is the DR/BDR election process not a concern in this lab?

The DR/BDR election process is only an issue on a multi-access network such as Ethernet or Frame Relay. The serial links used in this lab are point-to-point links, so no DR/BDR election is performed.

3. Why would you want to set an OSPF interface to passive?

Answers will vary, but configuring a LAN interface as passive eliminates unnecessary OSPF routing information on that interface, freeing up bandwidth. The router will still advertise the network to its neighbors.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs - Final

Router R1

```
R1#sh run
Building configuration...

Current configuration : 1794 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
```

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```
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 bandwidth 128
 ip address 192.168.12.1 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 bandwidth 128
 ip address 192.168.13.1 255.255.255.252
 ip ospf cost 1565
!
router ospf 1
 router-id 11.11.11.11
 passive-interface GigabitEthernet0/0
 network 192.168.1.0 0.0.0.255 area 0
 network 192.168.12.0 0.0.0.3 area 0
 network 192.168.13.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
!
banner motd ^C
 Unauthorized Access is Prohibited!
```

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```
^C
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0
password cisco
login
transport input all
line vty 1 4
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2#sh run
Building configuration...

Current configuration : 1912 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
ip cef
```

Lab - Configuring Basic Single-Area OSPFv2

```
no ipv6 cef
multilink bundle-name authenticated
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.2.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 bandwidth 128
 ip address 192.168.12.2 255.255.255.252
!
interface Serial0/0/1
 bandwidth 128
 ip address 192.168.23.1 255.255.255.252
 clock rate 128000
!
router ospf 1
 router-id 22.22.22.22
 passive-interface default
 no passive-interface Serial0/0/0
 no passive-interface Serial0/0/1
 network 192.168.2.0 0.0.0.255 area 0
 network 192.168.12.0 0.0.0.3 area 0
 network 192.168.23.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C
 Unauthorized Access is Prohibited!
^C
```

```
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0
password cisco
login
transport input all
line vty 1 4
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3

```
R3#sh run
Building configuration...

Current configuration : 1674 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
no ip domain lookup
ip cef
no ipv6 cef
```

Lab - Configuring Basic Single-Area OSPFv2

```
multilink bundle-name authenticated
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.3.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 bandwidth 128
 ip address 192.168.13.2 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 bandwidth 128
 ip address 192.168.23.2 255.255.255.252
!
router ospf 1
 router-id 33.33.33.33
 network 192.168.3.0 0.0.0.255 area 0
 network 192.168.13.0 0.0.0.3 area 0
 network 192.168.23.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C
 Unauthorized Access is Prohibited!
^C
!
line con 0
 password cisco
 logging synchronous
```

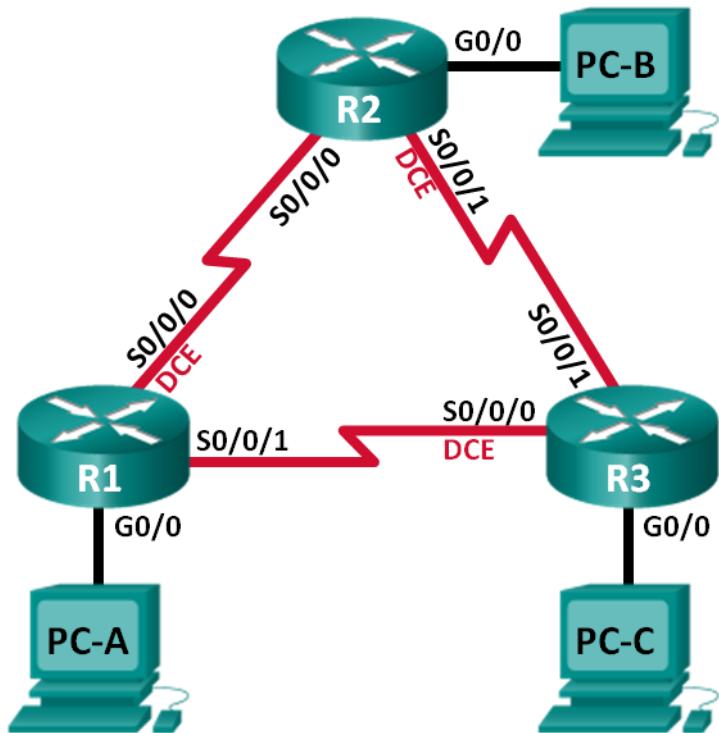
Lab - Configuring Basic Single-Area OSPFv2

```
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab - Configuring Basic Single-Area OSPFv3 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IPv6 Address	Default Gateway
R1	G0/0	2001:DB8:ACAD:A::1/64 FE80::1 link-local	N/A
	S0/0/0 (DCE)	2001:DB8:ACAD:12::1/64 FE80::1 link-local	N/A
	S0/0/1	2001:DB8:ACAD:13::1/64 FE80::1 link-local	N/A
R2	G0/0	2001:DB8:ACAD:B::2/64 FE80::2 link-local	N/A
	S0/0/0	2001:DB8:ACAD:12::2/64 FE80::2 link-local	N/A
	S0/0/1 (DCE)	2001:DB8:ACAD:23::2/64 FE80::2 link-local	N/A
R3	G0/0	2001:DB8:ACAD:C::3/64 FE80::3 link-local	N/A
	S0/0/0 (DCE)	2001:DB8:ACAD:13::3/64 FE80::3 link-local	N/A
	S0/0/1	2001:DB8:ACAD:23::3/64 FE80::3 link-local	N/A
PC-A	NIC	2001:DB8:ACAD:A::A/64	FE80::1
PC-B	NIC	2001:DB8:ACAD:B::B/64	FE80::2
PC-C	NIC	2001:DB8:ACAD:C::C/64	FE80::3

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify OSPFv3 Routing

Part 3: Configure OSPFv3 Passive Interfaces

Background / Scenario

Open Shortest Path First (OSPF) is a link-state routing protocol for IP networks. OSPFv2 is defined for IPv4 networks, and OSPFv3 is defined for IPv6 networks.

In this lab, you will configure the network topology with OSPFv3 routing, assign router IDs, configure passive interfaces, and use a number of CLI commands to display and verify OSPFv3 routing information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used.

Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the PC hosts and routers.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers as necessary.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the vty password.
- e. Configure a MOTD banner to warn users that unauthorized access is prohibited.
- f. Configure **logging synchronous** for the console line.
- g. Encrypt plain text passwords.
- h. Configure the IPv6 unicast and link-local addresses listed in the Addressing Table for all interfaces.
- i. Enable IPv6 unicast routing on each router.
- j. Copy the running configuration to the startup configuration.

Step 4: Configure PC hosts.

Step 5: Test connectivity.

The routers should be able to ping one another, and each PC should be able to ping its default gateway. The PCs are unable to ping other PCs until OSPFv3 routing is configured. Verify and troubleshoot if necessary.

Part 2: Configure OSPFv3 Routing

In Part 2, you will configure OSPFv3 routing on all routers in the network and then verify that routing tables are updated correctly.

Step 1: Assign router IDs.

OSPFv3 continues to use a 32 bit address for the router ID. Because there are no IPv4 addresses configured on the routers, you will manually assign the router ID using the **router-id** command.

Lab - Configuring Basic Single-Area OSPFv3

- a. Issue the **ipv6 router ospf** command to start an OSPFv3 process to the router.

```
R1(config)# ipv6 router ospf 1
```

Note: The OSPF process ID is kept locally and has no meaning to other routers on the network.

- b. Assign the OSPFv3 router ID **1.1.1.1** to the R1.

```
R1(config-rtr)# router-id 1.1.1.1
```

- c. Start the OSPFv3 routing process and assign a router ID of **2.2.2.2** to R2 and a router ID of **3.3.3.3** to R3.

- d. Issue the **show ipv6 ospf** command to verify the router IDs on all routers.

```
R2# show ipv6 ospf
```

```
Routing Process "ospfv3 1" with ID 2.2.2.2
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
Router is not originating router-LSAs with maximum metric
<output omitted>
```

Step 2: Configure OSPFv6 on R1.

With IPv6, it is common to have multiple IPv6 addresses configured on an interface. The **network** statement has been eliminated in OSPFv3. OSPFv3 routing is enabled at the interface level instead.

- a. Issue the **ipv6 ospf 1 area 0** command for each interface on R1 that is to participate in OSPFv3 routing.

```
R1(config)# interface g0/0
R1(config-if)# ipv6 ospf 1 area 0
R1(config-if)# interface s0/0/0
R1(config-if)# ipv6 ospf 1 area 0
R1(config-if)# interface s0/0/1
R1(config-if)# ipv6 ospf 1 area 0
```

Note: The process ID must match the process ID you used in Step1a.

- b. Assign the interfaces on R2 and R3 to OSPFv3 area 0. You should see neighbor adjacency messages display when adding the interfaces to area 0.

```
R1#
*Mar 19 22:14:43.251: %OSPFv3-5-ADJCHG: Process 1, Nbr 2.2.2.2 on Serial0/0/0 from
LOADING to FULL, Loading Done
R1#
*Mar 19 22:14:46.763: %OSPFv3-5-ADJCHG: Process 1, Nbr 3.3.3.3 on Serial0/0/1 from
LOADING to FULL, Loading Done
```

Step 3: Verify OSPFv3 neighbors.

Issue the **show ipv6 ospf neighbor** command to verify that the router has formed an adjacency with its neighboring routers. If the router ID of the neighboring router is not displayed, or if its state does not show as **FULL**, the two routers have not formed an OSPF adjacency.

```
R1# show ipv6 ospf neighbor
```

```
OSPFv3 Router with ID (1.1.1.1) (Process ID 1)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
3.3.3.3	0	FULL/ -	00:00:39	6	Serial0/0/1
2.2.2.2	0	FULL/ -	00:00:36	6	Serial0/0/0

Step 4: Verify OSPFv3 protocol settings.

The **show ipv6 protocols** command is a quick way to verify vital OSPFv3 configuration information, including the OSPF process ID, the router ID, and the interfaces enabled for OSPFv3.

```
R1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
Router ID 1.1.1.1
Number of areas: 1 normal, 0 stub, 0 nssa
Interfaces (Area 0):
    Serial0/0/1
    Serial0/0/0
    GigabitEthernet0/0
Redistribution:
    None
```

Step 5: Verify OSPFv3 interfaces.

- Issue the **show ipv6 ospf interface** command to display a detailed list for every OSPF-enabled interface.

```
R1# show ipv6 ospf interface
Serial0/0/1 is up, line protocol is up
    Link Local Address FE80::1, Interface ID 7
    Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
    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 00:00:05
    Graceful restart helper support enabled
    Index 1/3/3, flood queue length 0
    Next 0x0(0)/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 3.3.3.3
    Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
    Link Local Address FE80::1, Interface ID 6
    Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
    Network Type POINT_TO_POINT, Cost: 64
    Transmit Delay is 1 sec, State POINT_TO_POINT
    Timer intervals configured, Hello 10, Dead 40, Retransmit 5
        Hello due in 00:00:00
    Graceful restart helper support enabled
    Index 1/2/2, flood queue length 0
    Next 0x0(0)/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 1, Adjacent neighbor count is 1
```

Lab - Configuring Basic Single-Area OSPFv3

```
Adjacent with neighbor 2.2.2.2
Suppress hello for 0 neighbor(s)
GigabitEthernet0/0 is up, line protocol is up
  Link Local Address FE80::1, Interface ID 3
  Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 1.1.1.1, local address FE80::1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Graceful restart helper support enabled
  Index 1/1/1, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

- b. To display a summary of OSPFv3-enabled interfaces, issue the **show ipv6 ospf interface brief** command.

```
R1# show ipv6 ospf interface brief
```

Interface	PID	Area	Intf ID	Cost	State	Nbrs	F/C
Se0/0/1	1	0	7	64	P2P	1/1	
Se0/0/0	1	0	6	64	P2P	1/1	
Gi0/0	1	0	3	1	DR	0/0	

Step 6: Verify the IPv6 routing table.

Issue the **show ipv6 route** command to verify that all networks are appearing in the routing table.

```
R2# show ipv6 route
IPv6 Routing Table - default - 10 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
      B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
      IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
      O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
      ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
O  2001:DB8:ACAD:A::/64 [110/65]
  via FE80::1, Serial0/0/0
C  2001:DB8:ACAD:B::/64 [0/0]
  via GigabitEthernet0/0/0, directly connected
L  2001:DB8:ACAD:B::2/128 [0/0]
  via GigabitEthernet0/0/0, receive
O  2001:DB8:ACAD:C::/64 [110/65]
  via FE80::3, Serial0/0/1
C  2001:DB8:ACAD:12::/64 [0/0]
  via Serial0/0/0/0, directly connected
L  2001:DB8:ACAD:12::2/128 [0/0]
  via Serial0/0/0/0, receive
```

Lab - Configuring Basic Single-Area OSPFv3

```
O 2001:DB8:ACAD:13::/64 [110/128]
  via FE80::3, Serial0/0/1
  via FE80::1, Serial0/0/0
C 2001:DB8:ACAD:23::/64 [0/0]
  via Serial0/0/1, directly connected
L 2001:DB8:ACAD:23::2/128 [0/0]
  via Serial0/0/1, receive
L FF00::/8 [0/0]
  via Null0, receive
```

What command would you use to only see the OSPF routes in the routing table?

```
show ipv6 route ospf
```

Step 7: Verify end-to-end connectivity.

Each PC should be able to ping the other PCs in the topology. Verify and troubleshoot if necessary.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Part 3: Configure OSPFv3 Passive Interfaces

The **passive-interface** command prevents routing updates from being sent through the specified router interface. This is commonly done to reduce traffic on the LANs as they do not need to receive dynamic routing protocol communication. In Part 3, you will use the **passive-interface** command to configure a single interface as passive. You will also configure OSPFv3 so that all interfaces on the router are passive by default, and then enable OSPF routing advertisements on selected interfaces.

Step 1: Configure a passive interface.

- Issue the **show ipv6 ospf interface g0/0** command on R1. Notice the timer indicating when the next Hello packet is expected. Hello packets are sent every 10 seconds and are used between OSPF routers to verify that their neighbors are up.

```
R1# show ipv6 ospf interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Link Local Address FE80::1, Interface ID 3
  Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 1.1.1.1, local address FE80::1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:05
  Graceful restart helper support enabled
  Index 1/1/1, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

- Issue the **passive-interface** command to change the G0/0 interface on R1 to passive.

Lab - Configuring Basic Single-Area OSPFv3

```
R1(config)# ipv6 router ospf 1
```

```
R1(config-rtr) # passive-interface g0/0
```

- c. Re-issue the **show ipv6 ospf interface g0/0** command to verify that G0/0 is now passive.

```
R1# show ipv6 ospf interface g0/0
```

```
GigabitEthernet0/0 is up, line protocol is up
```

```
Link Local Address FE80::1, Interface ID 3
```

```
Area 0, Process ID 1, Instance ID 0, Router ID 1.1.1.1
```

```
Network Type BROADCAST, Cost: 1
```

```
Transmit Delay is 1 sec, State WAITING, Priority 1
```

```
No designated router on this network
```

```
No backup designated router on this network
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
No Hellos (Passive interface)
```

```
Wait time before Designated router selection 00:00:34
```

```
Graceful restart helper support enabled
```

```
Index 1/1/1, flood queue length 0
```

```
Next 0x0(0)/0x0(0)/0x0(0)
```

```
Last flood scan length is 0, maximum is 0
```

```
Last flood scan time is 0 msec, maximum is 0 msec
```

```
Neighbor Count is 0, Adjacent neighbor count is 0
```

```
Suppress hello for 0 neighbor(s)
```

- d. Issue the **show ipv6 route ospf** command on R2 and R3 to verify that a route to the 2001:DB8:ACAD:A::/64 network is still available.

```
R2# show ipv6 route ospf
```

```
IPv6 Routing Table - default - 10 entries
```

```
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
```

```
B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
```

```
IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
```

```
ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
```

```
O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
```

```
ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
```

```
O 2001:DB8:ACAD:A::/64 [110/65]
```

```
    via FE80::1, Serial0/0/0
```

```
O 2001:DB8:ACAD:C::/64 [110/65]
```

```
    via FE80::3, Serial0/0/1
```

```
O 2001:DB8:ACAD:13::/64 [110/128]
```

```
    via FE80::3, Serial0/0/1
```

```
    via FE80::1, Serial0/0/0
```

Step 2: Set passive interface as the default on the router.

- a. Issue the **passive-interface default** command on R2 to set the default for all OSPFv3 interfaces as passive.

```
R2(config)# ipv6 router ospf 1
```

```
R2(config-rtr) # passive-interface default
```

- b. Issue the **show ipv6 ospf neighbor** command on R1. After the dead timer expires, R2 is no longer listed as an OSPF neighbor.

Lab - Configuring Basic Single-Area OSPFv3

```
R1# show ipv6 ospf neighbor
```

```
OSPFv3 Router with ID (1.1.1.1) (Process ID 1)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
3.3.3.3	0	FULL/ -	00:00:37	6	Serial0/0/1

- c. On R2, issue the **show ipv6 ospf interface s0/0/0** command to view the OSPF status of interface S0/0/0.

```
R2# show ipv6 ospf interface s0/0/0
```

```
Serial0/0/0 is up, line protocol is up
```

```
Link Local Address FE80::2, Interface ID 6
```

```
Area 0, Process ID 1, Instance ID 0, Router ID 2.2.2.2
```

```
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
```

```
No Hellos (Passive interface)
```

```
Graceful restart helper support enabled
```

```
Index 1/2/2, flood queue length 0
```

```
Next 0x0(0)/0x0(0)/0x0(0)
```

```
Last flood scan length is 2, maximum is 3
```

```
Last flood scan time is 0 msec, maximum is 0 msec
```

```
Neighbor Count is 0, Adjacent neighbor count is 0
```

```
Suppress hello for 0 neighbor(s)
```

- d. If all OSPFv3 interfaces on R2 are passive, then no routing information is being advertised. If this is the case, then R1 and R3 should no longer have a route to the 2001:DB8:ACAD:B::/64 network. You can verify this by using the **show ipv6 route** command.
- e. Change S0/0/1 on R2 by issuing the **no passive-interface** command, so that it sends and receives OSPFv3 routing updates. After entering this command, an informational message displays stating that a neighbor adjacency has been established with R3.

```
R2(config)# ipv6 router ospf 1
```

```
R2(config-rtr)# no passive-interface s0/0/1
```

```
*Apr 8 19:21:57.939: %OSPFv3-5-ADJCHG: Process 1, Nbr 3.3.3.3 on Serial0/0/1  
from LOADING to FULL, Loading Done
```

- f. Re-issue the **show ipv6 route** and **show ipv6 ospf neighbor** commands on R1 and R3, and look for a route to the 2001:DB8:ACAD:B::/64 network.

O 2001:DB8:ACAD:B::/64 [110/129]

via FE80::3, Serial0/0/1

What interface is R1 using to route to the 2001:DB8:ACAD:B::/64 network? _____ S0/0/1

What is the accumulated cost metric for the 2001:DB8:ACAD:B::/64 network on R1? _____ 129

Does R2 show up as an OSPFv3 neighbor on R1? _____ No

Does R2 show up as an OSPFv3 neighbor on R3? _____ Yes

What does this information tell you?

Answers will vary, but all traffic to the 2001:DB8:ACAD:B::/64 network from R1 will be routed through R3. The S0/0/0 interface on R2 is still configured as a passive interface, so OSPFv3 routing information is not being advertised across this interface. The 129 accumulated cost results from the fact that traffic from R3 to the 192.168.2.0/24 network must pass through two T1 (1.544 Mb/s) serial links (at a cost of 64 each) plus the R2 Gigabit 0/0 LAN link (at a cost of 1).

- g. On R2, issue the **no passive-interface S0/0/0** command to allow OSPFv3 routing updates to be advertised on that interface.
- h. Verify that R1 and R2 are now OSPFv3 neighbors.

Reflection

1. If the OSPFv6 configuration for R1 had a process ID of 1, and the OSPFv3 configuration for R2 had a process ID of 2, can routing information be exchanged between the two routers? Why?
-
-

Yes. The OSPFv3 process ID is only used locally on the router, it does not need to match the process ID used on the other routers in the OSPFv3 area.

2. What may have been the reasoning for removing the **network** command in OSPFv3?
-
-
-

Answers will vary, but removing the network statement helps prevent IPv6 address typo errors. Also, an IPv6 interface can have multiple IPv6 addresses assigned to it. By assigning an Interface to an OSPFv3 Area, all the multicast networks on that interface will automatically be assigned to the OSPFv6 area and have a route created in the IPv6 routing table.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs - Final

Router R1

```
R1#sh run
Building configuration...

Current configuration : 1673 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
```

Lab - Configuring Basic Single-Area OSPFv3

```
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
ipv6 ospf 1 area 0
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:12::1/64
ipv6 ospf 1 area 0
clock rate 2000000
!
interface Serial0/0/1
no ip address
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:13::1/64
ipv6 ospf 1 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
ipv6 router ospf 1
router-id 1.1.1.1
passive-interface GigabitEthernet0/0
!
control-plane
!
banner motd ^C
```

Lab - Configuring Basic Single-Area OSPFv3

```
Unauthorized Access is Prohibited!
^C
!
line con 0
 exec-timeout 0 0
 logging synchronous
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password 7 030752180500
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2#sh run
Building configuration...

Current configuration : 1736 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
```

Lab - Configuring Basic Single-Area OSPFv3

```
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
duplex auto
speed auto
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:B::2/64
ipv6 ospf 1 area 0
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:12::2/64
ipv6 ospf 1 area 0
!
interface Serial0/0/1
no ip address
ipv6 address FE80::2 link-local
ipv6 address 2001:DB8:ACAD:23::2/64
ipv6 ospf 1 area 0
clock rate 2000000
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 router ospf 1
router-id 2.2.2.2
passive-interface default
no passive-interface Serial0/0/0
no passive-interface Serial0/0/1
!
control-plane
!
banner motd ^C
Unauthorized Access is Prohibited!
^C
```

Lab - Configuring Basic Single-Area OSPFv3

```
!
line con 0
logging synchronous
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 045802150C2E
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3

```
R3#sh run
Building configuration...

Current configuration : 1680 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh0lQM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
```

Lab - Configuring Basic Single-Area OSPFv3

```
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
duplex auto
speed auto
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:C::3/64
ipv6 ospf 1 area 0
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:13::3/64
ipv6 ospf 1 area 0
clock rate 2000000
!
interface Serial0/0/1
no ip address
ipv6 address FE80::3 link-local
ipv6 address 2001:DB8:ACAD:23::3/64
ipv6 ospf 1 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 router ospf 1
router-id 3.3.3.3
!
control-plane
!
banner motd ^C
Unauthorized Access is Prohibited!
^C
!
line con 0
logging synchronous
line aux 0
line 2
no activation-character
```

Lab - Configuring Basic Single-Area OSPFv3

```
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 1511021F0725
login
transport input all
!
scheduler allocate 20000 1000
!
end
```



Stepping Through OSPFv3 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Explain the process by which link-state routers learn about other networks.

This class activity is designed for groups of three students. Its objective is to review the shortest path first routing process.

Scenario

This class activity is designed for groups of three students. The objective is to review the Shortest Path First (SPF) routing process.

You will design and address a network, communicate the network address scheme and operation of network links to your group members, and compute the SPF.

Complete the steps as shown on the PDF for this class activity. If you have time, share your network design and Open Shortest Path First (OSPF) process with another group.

Resources

In preparation of this activity, you will need two different IPv6 network and cost numbers. The IPv6 network numbers must be chosen with the following format: 2002:DB8:AAAA:?:0/64, where? is a student-selected network number. You have two choices for cost – 10 (Fast Ethernet network), or 1 (Gigabit Ethernet network).

Bring your two IPv6 network and cost numbers to the group setting. One student in your group will act as the recorder, will draw three circles, and connect them on paper. Each circle will represent a student's router and the connecting lines will represent the networks and links to be agreed upon.

Each group member should follow Steps 1 to 4 (below) in the order listed. As the group progresses through the activity, you should keep personal notes about your own router, including information about neighbor adjacency, link-state advertisements, topology table entries, and the SPF algorithm.

Directions

Step 1:

- a. Speak to the classmate to your left. Compare network and cost numbers brought to the group. Agree upon an IPv6 network, links, and cost numbers you would like to use between your two routers. Remember, you may only use 1 (Gigabit Ethernet) or 10 (Fast Ethernet) for cost. When you have agreed upon your network, link numbers, and determined the cost of the route, record the information on the paper graphic created by the recorder.
- b. Complete the same process with the classmate to your right.
- c. After speaking with both of your direct neighbors, you have agreed upon two networks with link addresses and the cost of the route. Record the information you agreed upon on the paper graphic.

Step 2:

- a. Each student will speak only to their direct neighbors. They will share all of their IPv6 network and link numbers and the cost of the networks to which they are connected. Almost immediately, everyone in the group will know about all networks, their links, and the cost of the individual networks between neighbors.
- b. Check with the group members to ascertain all group members have the same information with which to work for Step 3.

Step 3:

- a. On your own paper, create a table listing possible paths to all other networks. Use the formula supplied with this chapter $n(n - 1)/2$. You will have a total of four possible routes to list on your table.
- b. On the table created in the Step 3 a., add a column with the headings, IPv6 Network Number and Cost.
- c. Fill in the table with information you know about the networks on your group's topology.

Step 4:

- a. Go back to the table created in Step 3.
- b. Place a star by the lowest-cost routes to all other routers.

When these four steps are complete, you have established neighbor adjacencies, exchanged link-state advertisements, built a topology table, and created a routing table with the best cost to all other networks within your group or area.

If you have the time, refer to your topology table and build the network on real equipment or Packet Tracer. Use some or all of the commands listed below to prove OSPF's operation:

```
R1# show ipv6 interface brief  
R1# show ipv6 protocols  
R1# show ip protocols  
R1# show ipv6 route
```

Reflection

1. Which OSPFv3 processing step is reviewed in Step 1 of this activity?

Step 1 reviews creating adjacencies with direct neighbors.

2. Which OSPFv3 processing step is reviewed in Step 2 of this activity?

Step 2 is a review of the OSPFv3 link state advertisement process.

3. Which process for OSPFv3 is reviewed in Step 3 of this activity?

Step 3 is a review of how to build a topology table for the entire network.

4. Which process step for OSPFv3 is reviewed in Step 4 of this activity?

Step 4 reviews using the SPF process for calculating the routing table entries.

Identify elements of the model that map to IT-related content:

- Physical topology
- OSPFv3 process and verification commands
- IPv6 network and link addressing
- Cost
- Neighbor adjacencies
- Link state advertisements
- Topology table
- IPv6 routing table
- OSPFv3 operation commands



Permit Me to Assist You (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain the purpose and operation of ACLs.

Students will design a process for selecting a candidate for security clearance. Groups will be formed and “applicants” will be permitted or denied the job.

Scenario

- Each individual in the class will record five questions they would ask a candidate who is applying for a security clearance for a network assistant position within a small- to medium-sized business. The list of questions should be listed in order of importance to selecting a good candidate for the job. The preferred answers will also be recorded.
- After three minutes of brainstorming the list of questions, the instructor will ask two students to serve as interviewers. These two students will use only their list of questions and answers for the next part of this activity. The instructor will explain to only the two interviewers that they have the discretion, at any time, to stop the process and state “you are all permitted to the next level of interviews” or “I am sorry, but you do not have the qualifications to continue to the next level of interviews.” The interviewer does not need to complete all of the questions on the list.
- The rest of the class will be split in half and assigned to one of the interviewers.
- Once everyone is settled into their group with an interviewer, the group application interviews will begin.
- The two selected interviewers will ask the first question on the list that they created; an example would be “are you over the age of 18?” If the applicant does not meet the age requirement, as specified by the interviewer’s original questions and answers, the applicant will be eliminated from the pool of applicants and must move to another area within the room where they will observe the rest of the application process.

At this point, or later in the process, instructors may wish to state: “You have 2 minutes to complete the interview process.” This is to provide time management to the activity.

The next question will then be asked by the interviewer. If applicants answer correctly, they may stay with the applicant group. The entire class will then get together and discuss their observations regarding the process to permit or deny them the opportunity to continue on to the next level of interviews.

Reflection

1. What factors did you consider when devising your list of criteria for network assistant security clearance?

Answers will vary – age, experience, knowledge of networking, etc.

2. How difficult was it to devise five security questions to deliver during the interviews? Why were you asked to list your questions in order of importance to selecting a good candidate?

All of the students should mention that the most important qualifications should be listed first in order to eliminate those candidates who do not meet their criteria, quickly.

3. Why would the process of elimination be stopped, even if there were still a few applicants available?

Permit Me to Assist You

Answers will vary, but the most likely answer would be to provide a pool of applicants who will be permitted or denied the opportunity to move to the next level of employment application process.

4. How could this scenario and the results be applied to network traffic?
-

Some traffic can be permitted on networks, and some will be denied.

Packet Tracer Example (answers will vary)

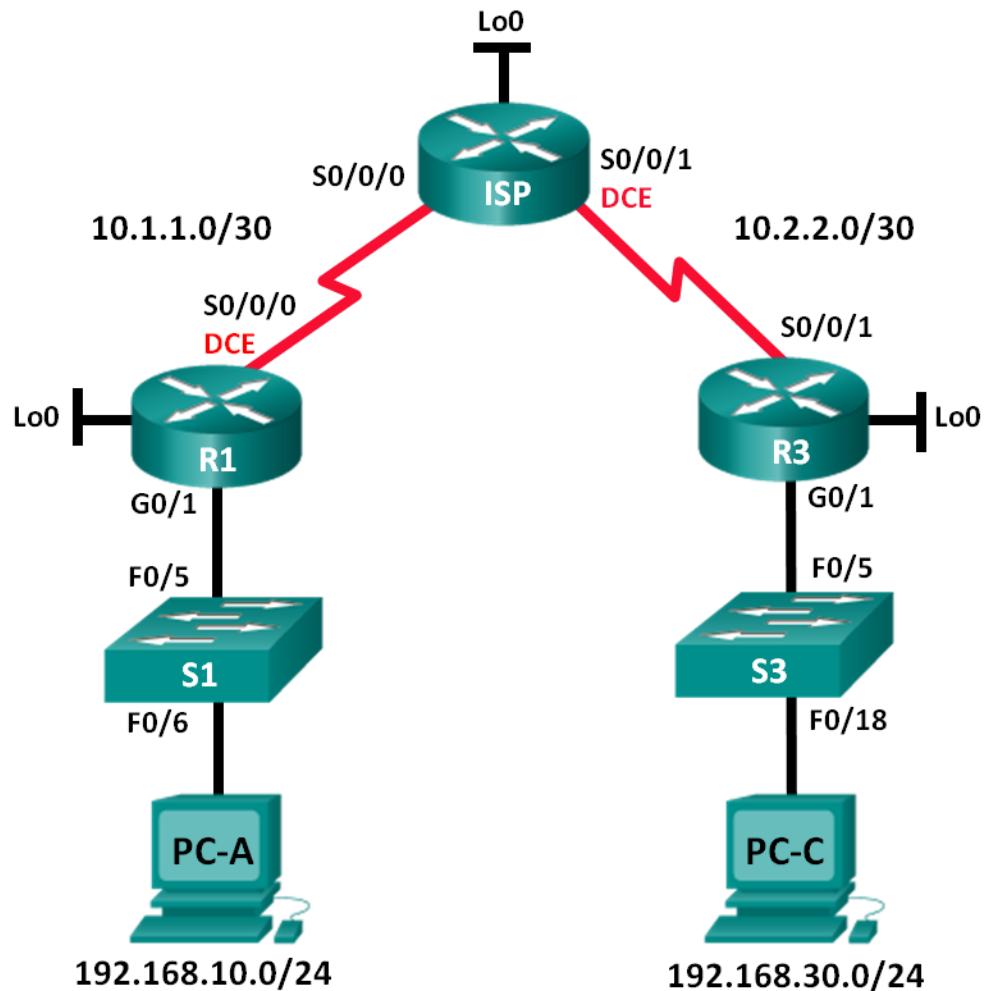
Instructor Note: Identify elements of the model that map to IT-related content:

- ACLs are processes that determine desirable and undesirable network traffic.
- Criteria must be established in advance of permitting or denying network traffic.
- The order of importance must be established when developing criteria for permitting or denying network participation.
- At the end of the process, more than one host may be denied or permitted network participation, based on the criteria specified.

Lab – Configuring and Verifying Standard ACLs (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	192.168.10.1	255.255.255.0	N/A
	Lo0	192.168.20.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A
ISP	S0/0/0	10.1.1.2	255.255.255.252	N/A
	S0/0/1 (DCE)	10.2.2.2	255.255.255.252	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
R3	G0/1	192.168.30.1	255.255.255.0	N/A
	Lo0	192.168.40.1	255.255.255.0	N/A
	S0/0/1	10.2.2.1	255.255.255.252	N/A
S1	VLAN 1	192.168.10.11	255.255.255.0	192.168.10.1
S3	VLAN 1	192.168.30.11	255.255.255.0	192.168.30.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-C	NIC	192.168.30.3	255.255.255.0	192.168.30.1

Objectives

Part 1: Set Up the Topology and Initialize Devices

- Set up equipment to match the network topology.
- Initialize and reload the routers and switches.

Part 2: Configure Devices and Verify Connectivity

- Assign a static IP address to PCs.
- Configure basic settings on routers.
- Configure basic settings on switches.
- Configure EIGRP routing on R1, ISP, and R3.
- Verify connectivity between devices.

Part 3: Configure and Verify Standard Numbered and Named ACLs

- Configure, apply, and verify a numbered standard ACL.
- Configure, apply, and verify a named ACL.

Part 4: Modify a Standard ACL

- Modify and verify a named standard ACL.
- Test the ACL.

Background / Scenario

Network security is an important issue when designing and managing IP networks. The ability to configure proper rules to filter packets, based on established security policies, is a valuable skill.

Lab – Configuring and Verifying Standard ACLs

In this lab, you will set up filtering rules for two offices represented by R1 and R3. Management has established some access policies between the LANs located at R1 and R3, which you must implement. The ISP router sitting between R1 and R3 will not have any ACLs placed on it. You would not be allowed any administrative access to an ISP router because you can only control and manage your own equipment.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Set Up the Topology and Initialize Devices

In Part 1, you set up the network topology and clear any configurations, if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Part 2: Configure Devices and Verify Connectivity

In Part 2, you configure basic settings on the routers, switches, and PCs. Refer to the Topology and Addressing Table for device names and address information.

Step 1: Configure IP addresses on PC-A and PC-C.

Step 2: Configure basic settings for the routers.

- a. Disable DNS lookup.
- b. Configure the device names as shown in the topology.
- c. Create loopback interfaces on each router as shown in the Addressing Table.
- d. Configure interface IP addresses as shown in the Topology and Addressing Table.
- e. Configure a privileged EXEC mode password of **class**.
- f. Assign a clock rate of **128000** to the DCE serial interfaces.
- g. Assign **cisco** as the console password.
- h. Assign **cisco** as the vty password and enable Telnet access.

Step 3: (Optional) Configure basic settings on the switches.

- a. Disable DNS lookup.
- b. Configure the device names as shown in the topology.
- c. Configure the management interface IP address as shown in the Topology and Addressing Table.
- d. Configure a privileged EXEC mode password of **class**.
- e. Configure a default gateway.
- f. Assign **cisco** as the console password.
- g. Assign **cisco** as the vty password and enable Telnet access.

Step 4: Configure EIGRP routing on R1, ISP, and R3.

- a. Configure autonomous system (AS) number 10 and advertise all networks on R1, ISP, and R3. Disable automatic summarization.
- b. After configuring EIGRP on R1, ISP, and R3, verify that all routers have complete routing tables listing all networks. Troubleshoot if this is not the case.

Step 5: Verify connectivity between devices.

Note: It is very important to test whether connectivity is working **before** you configure and apply access lists! You want to ensure that your network is properly functioning before you start to filter traffic.

- a. From PC-A, ping PC-C and the loopback interface on R3. Were your pings successful? _____ Yes
- b. From R1, ping PC-C and the loopback interface on R3. Were your pings successful? _____ Yes
- c. From PC-C, ping PC-A and the loopback interface on R1. Were your pings successful? _____ Yes
- d. From R3, ping PC-A and the loopback interface on R1. Were your pings successful? _____ Yes

Part 3: Configure and Verify Standard Numbered and Named ACLs

Step 1: Configure a numbered standard ACL.

Standard ACLs filter traffic based on the source IP address only. A typical best practice for standard ACLs is to configure and apply it as close to the destination as possible. For the first access list, create a standard numbered ACL that allows traffic from all hosts on the 192.168.10.0/24 network and all hosts on the 192.168.20.0/24 network to access all hosts on the 192.168.30.0/24 network. The security policy also states that a **deny any** access control entry (ACE), also referred to as an ACL statement, should be present at the end of all ACLs.

What wildcard mask would you use to allow all hosts on the 192.168.10.0/24 network to access the 192.168.30.0/24 network?

0.0.0.255

Following Cisco's recommended best practices, on which router would you place this ACL? _____ R3

On which interface would you place this ACL? In what direction would you apply it?

G0/1. The ACL should be applied going out. Students may answer with placing the ACL on the S0/0/1 interface on R3 going **in**. Emphasize to them that this would effectively block the LANs on R1 from getting to the 192.168.40.0/24 network as well!

Lab – Configuring and Verifying Standard ACLs

- a. Configure the ACL on R3. Use 1 for the access list number.

```
R3(config)# access-list 1 remark Allow R1 LANs Access
R3(config)# access-list 1 permit 192.168.10.0 0.0.0.255
R3(config)# access-list 1 permit 192.168.20.0 0.0.0.255
R3(config)# access-list 1 deny any
```

- b. Apply the ACL to the appropriate interface in the proper direction.

```
R3(config)# interface g0/1
R3(config-if)# ip access-group 1 out
```

- c. Verify a numbered ACL.

The use of various **show** commands can aid you in verifying both the syntax and placement of your ACLs in your router.

To see access list 1 in its entirety with all ACEs, which command would you use?

```
R3# show access-lists 1
```

or

```
R3# show access-lists
```

What command would you use to see where the access list was applied and in what direction?

```
R3# show ip interface g0/1
```

or

```
R3# show ip interface
```

- 1) On R3, issue the **show access-lists 1** command.

```
R3# show access-list 1
Standard IP access list 1
  10 permit 192.168.10.0, wildcard bits 0.0.0.255
  20 permit 192.168.20.0, wildcard bits 0.0.0.255
  30 deny   any
```

- 2) On R3, issue the **show ip interface g0/1** command.

```
R3# show ip interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 192.168.30.1/24
  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 disabled
  Multicast reserved groups joined: 224.0.0.10
  Outgoing access list is 1
  Inbound access list is not set
  Output omitted
```

Lab – Configuring and Verifying Standard ACLs

- 3) Test the ACL to see if it allows traffic from the 192.168.10.0/24 network access to the 192.168.30.0/24 network. From the PC-A command prompt, ping the PC-C IP address. Were the pings successful? _____ Yes
- 4) Test the ACL to see if it allows traffic from the 192.168.20.0/24 network access to the 192.168.30.0/24 network. You must do an extended ping and use the loopback 0 address on R1 as your source. Ping PC-C's IP address. Were the pings successful? _____ Yes

```
R1# ping
Protocol [ip]:
Target IP address: 192.168.30.3
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.20.1
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 192.168.30.3, timeout is 2 seconds:
Packet sent with a source address of 192.168.20.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
```

- d. From the R1 prompt, ping PC-C's IP address again.

```
R1# ping 192.168.3.3
```

Was the ping successful? Why or why not?

No, the pings failed. When you ping from the router, it uses the closest interface to the destination as its source address. The pings had a source address of 10.1.1.1. The access list on R3 only allows the 192.168.10.0/24 and the 192.168.20.0/24 networks access.

Step 2: Configure a named standard ACL.

Create a named standard ACL that conforms to the following policy: allow traffic from all hosts on the 192.168.40.0/24 network access to all hosts on the 192.168.10.0/24 network. Also, only allow host PC-C access to the 192.168.10.0/24 network. The name of this access list should be called BRANCH-OFFICE-POLICY.

Following Cisco's recommended best practices, on which router would you place this ACL? _____ R1

On which interface would you place this ACL? In what direction would you apply it?

Lab – Configuring and Verifying Standard ACLs

G0/1. The ACL should be applied going out. Students may answer with placing the ACL on the S0/0/0 interface on R1 going in. Emphasize to them that this would effectively block all traffic from the LANs on R3 from getting to the 192.168.20.0/24 network.

- a. Create the standard named ACL BRANCH-OFFICE-POLICY on R1.

```
R1(config)# ip access-list standard BRANCH-OFFICE-POLICY
R1(config-std-nacl)# permit host 192.168.30.3
R1(config-std-nacl)# permit 192.168.40.0 0.0.0.255
R1(config-std-nacl)# end
R1#
*Feb 15 15:56:55.707: %SYS-5-CONFIG_I: Configured from console by console
```

Looking at the first permit ACE in the access list, what is another way to write this?

```
R1(config-std-nacl)# permit 192.168.30.3 0.0.0.0
```

- b. Apply the ACL to the appropriate interface in the proper direction.

```
R1# config t
R1(config)# interface g0/1
R1(config-if)# ip access-group BRANCH-OFFICE-POLICY out
```

- c. Verify a named ACL.

- 1) On R1, issue the **show access-lists** command.

```
R1# show access-lists
Standard IP access list BRANCH-OFFICE-POLICY
    10 permit 192.168.30.3
    20 permit 192.168.40.0, wildcard bits 0.0.0.255
```

Is there any difference between this ACL on R1 with the ACL on R3? If so, what is it?

Although there is no line 30 with a **deny any** on R1, it is implied. You may wish to emphasize this to your students. Having them actually configure the **deny any** ACE is a good practice and reinforces the concept as it shows up in the ACL when issuing a **show access-lists** command. It is easy to forget the implicit **deny any** when troubleshooting ACLs. This could easily result in traffic being denied that should have been allowed in.

- 2) On R1, issue the **show ip interface g0/1** command.

```
R1# show ip interface g0/1
GigabitEthernet0/1 is up, line protocol is up
    Internet address is 192.168.10.1/24
    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 disabled
```

Lab – Configuring and Verifying Standard ACLs

```
Multicast reserved groups joined: 224.0.0.10
Outgoing access list is BRANCH-OFFICE-POLICY
Inbound access list is not set
<Output omitted>
```

- 3) Test the ACL. From the command prompt on PC-C, ping PC-A's IP address. Were the pings successful? _____ **Yes**
- 4) Test the ACL to ensure that only the PC-C host is allowed access to the 192.168.10.0/24 network. You must do an extended ping and use the G0/1 address on R3 as your source. Ping PC-A's IP address. Were the pings successful? _____ **No**

```
R3# ping
Protocol [ip]:
Target IP address: 192.168.10.3
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.30.1
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 192.168.10.3, timeout is 2 seconds:
Packet sent with a source address of 192.168.30.1
U.U.U
```

- 5) Test the ACL to see if it allows traffic from the 192.168.40.0/24 network access to the 192.168.10.0/24 network. You must perform an extended ping and use the loopback 0 address on R3 as your source. Ping PC-A's IP address. Were the pings successful? _____ **Yes**

```
R3# ping
Protocol [ip]:
Target IP address: 192.168.10.3
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.40.1
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 192.168.10.3, timeout is 2 seconds:
```

```
Packet sent with a source address of 192.168.40.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/40/60 ms
```

Part 4: Modify a Standard ACL

It is common in business for security policies to change. For this reason, ACLs may need to be modified. In Part 4, you will change one of the previous ACLs you configured, to match a new management policy being put in place.

Management has decided that users from the 209.165.200.224/27 network should be allowed full access to the 192.168.10.0/24 network. Management also wants ACLs on all of their routers to follow consistent rules. A **deny any** ACE should be placed at the end of all ACLs. You must modify the BRANCH-OFFICE-POLICY ACL.

You will add two additional lines to this ACL. There are two ways you could do this:

OPTION 1: Issue a **no ip access-list standard BRANCH-OFFICE-POLICY** command in global configuration mode. This would effectively take the whole ACL out of the router. Depending upon the router IOS, one of the following scenarios would occur: all filtering of packets would be cancelled and all packets would be allowed through the router; or, because you did not take off the **ip access-group** command on the G0/1 interface, filtering is still in place. Regardless, when the ACL is gone, you could retype the whole ACL, or cut and paste it in from a text editor.

OPTION 2: You can modify ACLs in place by adding or deleting specific lines within the ACL itself. This can come in handy, especially with ACLs that have many lines of code. The retying of the whole ACL or cutting and pasting can easily lead to errors. Modifying specific lines within the ACL is easily accomplished.

Note: For this lab, use Option 2.

Step 1: Modify a named standard ACL.

- From R1 privilege EXEC mode, issue a **show access-lists** command.

```
R1# show access-lists
Standard IP access list BRANCH-OFFICE-POLICY
    10 permit 192.168.30.3 (8 matches)
    20 permit 192.168.40.0, wildcard bits 0.0.0.255 (5 matches)
```

- Add two additional lines at the end of the ACL. From global config mode, modify the ACL, BRANCH-OFFICE-POLICY.

```
R1#(config)# ip access-list standard BRANCH-OFFICE-POLICY
R1(config-std-nacl)# 30 permit 209.165.200.224 0.0.0.31
R1(config-std-nacl)# 40 deny any
R1(config-std-nacl)# end
```

- Verify the ACL.

- On R1, issue the **show access-lists** command.

```
R1# show access-lists
Standard IP access list BRANCH-OFFICE-POLICY
    10 permit 192.168.30.3 (8 matches)
    20 permit 192.168.40.0, wildcard bits 0.0.0.255 (5 matches)
    30 permit 209.165.200.224, wildcard bits 0.0.0.31
    40 deny any
```

Do you have to apply the BRANCH-OFFICE-POLICY to the G0/1 interface on R1?

No, the **ip access-group BRANCH-OFFICE-POLICY out** command is still in place on G0/1.

- 2) From the ISP command prompt, issue an extended ping. Test the ACL to see if it allows traffic from the 209.165.200.224/27 network access to the 192.168.10.0/24 network. You must do an extended ping and use the loopback 0 address on ISP as your source. Ping PC-A's IP address. Were the pings successful? _____ Yes

Reflection

1. As you can see, standard ACLs are very powerful and work quite well. Why would you ever have the need for using extended ACLs?

Standard ACLs can only filter based on the source address. Also, they are not granular. They allow or deny EVERYTHING (protocols and services). Extended ACLs, while harder to write, are well-suited to complex networks where you may need to allow only certain ports access to networks while denying others.

2. Typically, more typing is required when using a named ACL as opposed to a numbered ACL. Why would you choose named ACLs over numbered?

Students could list two reasons here. The first reason is that using named ACLs gives you the ability to modify specific lines within the ACL itself, without retyping the whole thing. NOTE: Newer versions of the IOS allows numbered ACLs to be modified just like named ACLs. Secondly, having a named ACL is a good best practice as it helps to document the purpose of the ACL with a descriptive name.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs**Router R1**

```
R1#sh run
Building configuration...

Current configuration : 1590 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
enable secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrbp4RFmfqY
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
```

Lab – Configuring and Verifying Standard ACLs

```
!
interface Loopback0
 ip address 192.168.20.1 255.255.255.0
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.10.1 255.255.255.0
 ip access-group BRANCH-OFFICE-POLICY out
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 10.1.1.1 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 no ip address
 shutdown
 clock rate 128000
!
!
router eigrp 10
 network 10.1.1.0 0.0.0.3
 network 192.168.10.0
 network 192.168.20.0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
ip access-list standard BRANCH-OFFICE-POLICY
 permit 192.168.30.3
 permit 192.168.40.0 0.0.0.255
 permit 209.165.200.224 0.0.0.31
 deny any
control-plane
!
!
!
line con 0
line aux 0
```

Lab – Configuring and Verifying Standard ACLs

```
line vty 0 4
password class
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3

```
R3#sh run
Building configuration...

Current configuration : 1506 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
enable secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrbp4RFmfqY
!
no aaa new-model
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
interface Loopback0
 ip address 192.168.40.1 255.255.255.0
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.30.1 255.255.255.0
```

Lab – Configuring and Verifying Standard ACLs

```
ip access-group 1 out
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
ip address 10.2.2.1 255.255.255.252
!
!
router eigrp 10
network 10.2.2.0 0.0.0.3
network 192.168.30.0
network 192.168.40.0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
access-list 1 remark Allow R1 LANs Access
access-list 1 permit 192.168.10.0 0.0.0.255
access-list 1 permit 192.168.20.0 0.0.0.255
access-list 1 deny any
!
!
!
control-plane
!
!
!
line con 0
line aux 0
line vty 0 4
password class
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router ISP

```
ISP#sh run
Building configuration...
```

Lab – Configuring and Verifying Standard ACLs

```
Current configuration : 1313 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encrypt
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrb4RFmfqY
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.224
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 10.1.1.2 255.255.255.252
!
interface Serial0/0/1
 ip address 10.2.2.2 255.255.255.252
 clock rate 128000
!
!
router eigrp 10
 network 209.165.200.224 0.0.0.31
 network 10.1.1.0 0.0.0.3
```

Lab – Configuring and Verifying Standard ACLs

```
network 10.2.2.0 0.0.0.3
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
!
line con 0
line aux 0
line vty 0 4
password class
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1# show run
Building configuration...

Current configuration : 2990 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrbp4RFmfqY
!
no aaa new-model
system mtu routing 1500
!
!
```

Lab – Configuring and Verifying Standard ACLs

```
no ip domain-lookup
!
!<output omitted>
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
  ip address 192.168.10.11 255.255.255.0
!
ip default-gateway 192.168.10.1
ip http server
ip http secure-server
!
!
line con 0
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

Switch S3

```
S3# show start
Using 1696 out of 65536 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S3
!
boot-start-marker
boot-end-marker
!
enable secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrbp4RFmfqY
!
no aaa new-model
system mtu routing 1500
!
!
```

Lab – Configuring and Verifying Standard ACLs

```
no ip domain-lookup
!
!<output omitted>
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
    ip address 192.168.30.11 255.255.255.0
!
ip default-gateway 192.168.30.1
ip http server
ip http secure-server
!
!
line con 0
line vty 0 4
    password cisco
    login
line vty 5 15
    password cisco
    login
!
end
```

Lab – Configuring and Verifying VTY Restrictions (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.0	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
S1	VLAN 1	192.168.1.2	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.0.3	255.255.255.0	192.168.0.1

Objectives

- Part 1: Configure Basic Device Settings
- Part 2: Configure and Apply the Access Control List on R1
- Part 3: Verify the Access Control List Using Telnet
- Part 4: Challenge - Configure and Apply the Access Control List on S1

Background / Scenario

It is a good practice to restrict access to the router management interfaces, such as the console and vty lines. An access control list (ACL) can be used to allow access for specific IP addresses, ensuring that only the administrator PCs have permission to telnet or SSH into the router.

Note: In the Cisco device outputs, ACL are abbreviated as access-list.

In this lab, you will create and apply a named standard ACL to restrict remote access to the router vty lines.

After the ACL has been created and applied, you will test and verify the ACL by accessing the router from different IP addresses using Telnet.

This lab will provide the commands necessary for creating and applying the ACL.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Lab – Configuring and Verifying VTY Restrictions

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Note: The Gigabit Ethernet interfaces on Cisco 1941 routers are autosensing and an Ethernet straight-through cable may be used between the router and PC-B. If using another model Cisco router, it may be necessary to use an Ethernet crossover cable.

Part 1: Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the interface IP addresses, device access, and passwords on the router.

Step 1: Cable the network as shown in the topology diagram.

Step 2: Configure the PC-A and PC-B network settings according to the Addressing Table.

Step 3: Initialize and reload the router and switch.

- a. Disable DNS lookup.
- b. Configure device names according to the Topology diagram.
- c. Assign **class** as the privileged EXEC encrypted password.
- d. Assign **cisco** as the console password, activate logging synchronous, and enable login.
- e. Assign **cisco** as the vty password, activate logging synchronous, and enable login.
- f. Encrypt the plain text passwords.
- g. Create a banner that warns anyone accessing the device that unauthorized access is prohibited.
- h. Configure IP addresses on the interfaces listed in the Addressing Table.
- i. Configure the default gateway for the switch.
- j. Save the running configuration to the startup configuration file.

Part 2: Configure and Apply the Access Control List on R1

In Part 2, you will configure a named standard ACL and apply it to the router virtual terminal lines to restrict remote access to the router.

Step 1: Configure and apply a standard named ACL.

- a. Console into the router R1 and enable privileged EXEC mode.
- b. From global configuration mode, view the command options under **ip access-list** by using a space and a question mark.

Lab – Configuring and Verifying VTY Restrictions

```
R1(config)# ip access-list ?
extended      Extended Access List
helper        Access List acts on helper-address
log-update    Control access list log updates
logging       Control access list logging
resequence   Resequence Access List
standard     Standard Access List
```

- c. View the command options under **ip access-list standard** by using a space and a question mark.

```
R1(config)# ip access-list standard ?
<1-99>        Standard IP access-list number
<1300-1999>   Standard IP access-list number (expanded range)
WORD           Access-list name
```

- d. Add **ADMIN-MGT** to the end of the **ip access-list standard** command and press Enter. You are now in the standard named access-list configuration mode (config-std-nacl).

```
R1(config)# ip access-list standard ADMIN-MGT
R1(config-std-nacl) #
```

- e. Enter your ACL permit or deny access control entry (ACE), also known as an ACL statement, one line at a time. Remember that there is an implicit **deny any** at the end of the ACL, which effectively denies all traffic. Enter a question mark to view your command options.

```
R1(config-std-nacl) # ?
Standard Access List configuration commands:
<1-2147483647> Sequence Number
default        Set a command to its defaults
deny          Specify packets to reject
exit          Exit from access-list configuration mode
no            Negate a command or set its defaults
permit         Specify packets to forward
remark        Access list entry comment
```

- f. Create a permit ACE for Administrator PC-A at 192.168.1.3, and an additional permit ACE to allow other reserved administrative IP addresses from 192.168.1.4 to 192.168.1.7. Notice how the first permit ACE signifies a single host, by using the **host** keyword, the ACE **permit 192.168.1.3 0.0.0.0** could have been used instead. The second permit ACE allows hosts 192.168.1.4 through 192.168.1.7, by using the 0.0.0.3 wildcard, which is the inverse of a 255.255.255.252 subnet mask.

```
R1(config-std-nacl) # permit host 192.168.1.3
R1(config-std-nacl) # permit 192.168.1.4 0.0.0.3
R1(config-std-nacl) # exit
```

You do not need to enter a deny ACE because there is an implicit **deny any** ACE at the end of the ACL.

- g. Now that the named ACL is created, apply it to the vty lines.

```
R1(config)# line vty 0 4
R1(config-line) # access-class ADMIN-MGT in
R1(config-line) # exit
```

Part 3: Verify the Access Control List Using Telnet

In Part 3, you will use Telnet to access the router, verifying that the named ACL is functioning correctly.

Lab – Configuring and Verifying VTY Restrictions

Note: SSH is more secure than Telnet; however, SSH requires that the network device be configured to accept SSH connections. Telnet is used with this lab for convenience.

- a. Open a command prompt on PC-A and verify that you can communicate with the router by issuing a **ping** command.

```
C:\Users\user1> ping 192.168.1.1
```

```
Pinging 192.168.1.1 with 32 bytes of data:  
Reply from 192.168.1.1: bytes=32 time=5ms TTL=64  
Reply from 192.168.1.1: bytes=32 time=1ms TTL=64  
Reply from 192.168.1.1: bytes=32 time=1ms TTL=64  
Reply from 192.168.1.1: bytes=32 time=1ms TTL=64
```

```
Ping statistics for 192.168.1.1:  
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
    Approximate round trip times in milli-seconds:  
        Minimum = 1ms, Maximum = 5ms, Average = 2ms
```

```
C:\Users\user1>
```

- b. Using the command prompt on PC-A, launch the Telnet client program to telnet into the router. Enter the login and then the enable passwords. You should be successfully logged in, see the banner message, and receive an R1 router command prompt.

```
C:\Users\user1> telnet 192.168.1.1
```

Unauthorized access is prohibited!

User Access Verification

Password:

R1>enable

Password:

R1#

Was the Telnet connection successful? _____

The Telnet connection should be successful, and the student should be prompted for a password from router R1.

- c. Type **exit** at the command prompt and press Enter to exit the Telnet session.
- d. Change your IP address to test if the named ACL blocks non-permitted IP addresses. Change the IPv4 address to 192.168.1.100 on PC-A.
- e. Attempt to telnet into R1 at 192.168.1.1 again. Was the Telnet session successful?

If the IP address on PC-A was changed, the Telnet connection should not be successful.

What message was received? _____

Connecting To 192.168.1.1...Could not open connection to the host, on port 23: Connect failed

- f. Change the IP address on PC-A to test if the named ACL permits a host with an IP address from the 192.168.1.4 to 192.168.1.7 range to telnet into the router. After changing the IP address on PC-A, open a Windows command prompt and attempt to telnet into router R1.

Was the Telnet session successful?

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If the IP address on PC-A was changed to an address from 192.168.1.4 to 192.168.1.7, then the telnet connection should be successful.

- g. From privileged EXEC mode on R1, type the **show ip access-lists** command and press Enter. From the command output, notice how the Cisco IOS automatically assigns line numbers to the ACL ACEs in increments of 10 and shows the number of times each permit ACE has been successfully matched (in parenthesis).

```
R1# show ip access-lists
Standard IP access list ADMIN-MGT
  10 permit 192.168.1.3 (2 matches)
  20 permit 192.168.1.4, wildcard bits 0.0.0.3 (2 matches)
```

Because two successful Telnet connections to the router were established, and each Telnet session was initiated from an IP address that matches one of the permit ACEs, there are matches for each permit ACE.

Why do you think that there are two matches for each permit ACE when only one connection from each IP address was initiated?

Answer will vary. The students may recognize that the two matches to the permit ACEs correspond to how the Telnet protocol operates while establishing the telnet connections. The fact that there are two matches per single connection refers to how many times control information is sent to the router generating a match to the router permit ACE.

How would you determine at what point the Telnet protocol causes the two matches during the Telnet connection?

Answers will vary, but students should recognize that a protocol analyzer like Wireshark, would allow them to capture and analyze the Telnet protocol packets, to determine when the ACL permit ACE matches are generated.

- h. On R1, enter into global configuration mode.
- i. Enter into access-list configuration mode for the ADMIN-MGT named access list and add a **deny any** ACE to the end of the access list.

```
R1(config)# ip access-list standard ADMIN-MGT
R1(config-std-nacl)# deny any
R1(config-std-nacl)# exit
```

Note: Because there is an implicit **deny any** ACE at the end of all ACLs, adding an explicit **deny any** ACE is unnecessary, yet can still be useful to the network administrator to log or simply know how many times the **deny any** access-list ACE was matched.

- j. Try to telnet from PC-B to R1. This creates a match to the **deny any** ACE in the ADMIN-MGT named access list.

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- k. From privileged EXEC mode, type **show ip access-lists** command and press Enter. You should now see multiple matches to the **deny any** ACE.

```
R1# show ip access-lists
Standard IP access list ADMIN-MGT
  10 permit 192.168.1.3 (2 matches)
  20 permit 192.168.1.4, wildcard bits 0.0.0.3 (2 matches)
  30 deny any (3 matches)
```

The failed Telnet connection produces more matches to the explicit deny ACE than a successful one. Why do you think this happens?

Answers may vary, but students may recognize that the Telnet protocol must make three attempts to create a Telnet session.

Part 4: Challenge - Configure and Apply the Access Control List on S1

Step 1: Configure and apply a standard named ACL for the vty lines on S1.

- a. Without referring back to the R1 configuration commands, try to configure the ACL on S1, allowing only the PC-A IP address.
- b. Apply the ACL to the S1 vty lines. Remember that there are more vty lines on a switch than a router.

Step 2: Test the vty ACL on S1.

Telnet from each of the PCs to verify that the vty ACL is working properly. You should be able to telnet to S1 from PC-A, but not from PC-B.

Reflection

1. As evidenced by the remote vty access, ACLs are powerful content filters that can be applied to more than just inbound and outbound network interfaces. In what other ways might ACLs be applied?
-
-

Answers may vary. Students may recognize that ACLs can be applied to network applications like server applications as well.

2. Does an ACL applied to a vty remote management interface improve the security of Telnet connection? Does this make Telnet a more viable remote access management tool?
-
-

Answers may vary, but students should recognize that even though ACLs help restrict remote management access to network devices, they do nothing to encrypt the actual data that is sent over the network. If that information is captured or sniffed by a third party program by a different host on the network the network is not secure.

3. Why does it make sense to apply an ACL to vty lines instead of specific interfaces?
-

Answers may vary, but students should recognize that, by applying the ACL to the logical vty lines, it does not make any difference what interface the Telnet or SSH request comes in on. The vty ACLs are interface independent. In addition, the vty ACL can be applied once instead of applying it to multiple interfaces.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1

Building configuration...

```
Current configuration : 1467 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
```

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```
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
ip address 192.168.0.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
```

Lab – Configuring and Verifying VTY Restrictions

```
!
no ip http server
no ip http secure-server
!
!
ip access-list standard ADMIN-MGT
permit 192.168.1.3
permit 192.168.1.4 0.0.0.3
deny any
!
!
!
!
control-plane
!
!
!
banner motd ^CNo unauthorized access allowed!^C
!
line con 0
password 7 070C285F4D06
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
access-class ADMIN-MGT in
password 7 13061E010803
logging synchronous
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

Building configuration...

```
Current configuration : 1782 bytes
!
!
version 15.0
no service pad
```

Lab – Configuring and Verifying VTY Restrictions

Lab – Configuring and Verifying VTY Restrictions

```
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.2 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
ip access-list standard ADMIN-MGT
 permit 192.168.1.3
!
banner motd ^CNo unauthorized access allowed!^C
!
```

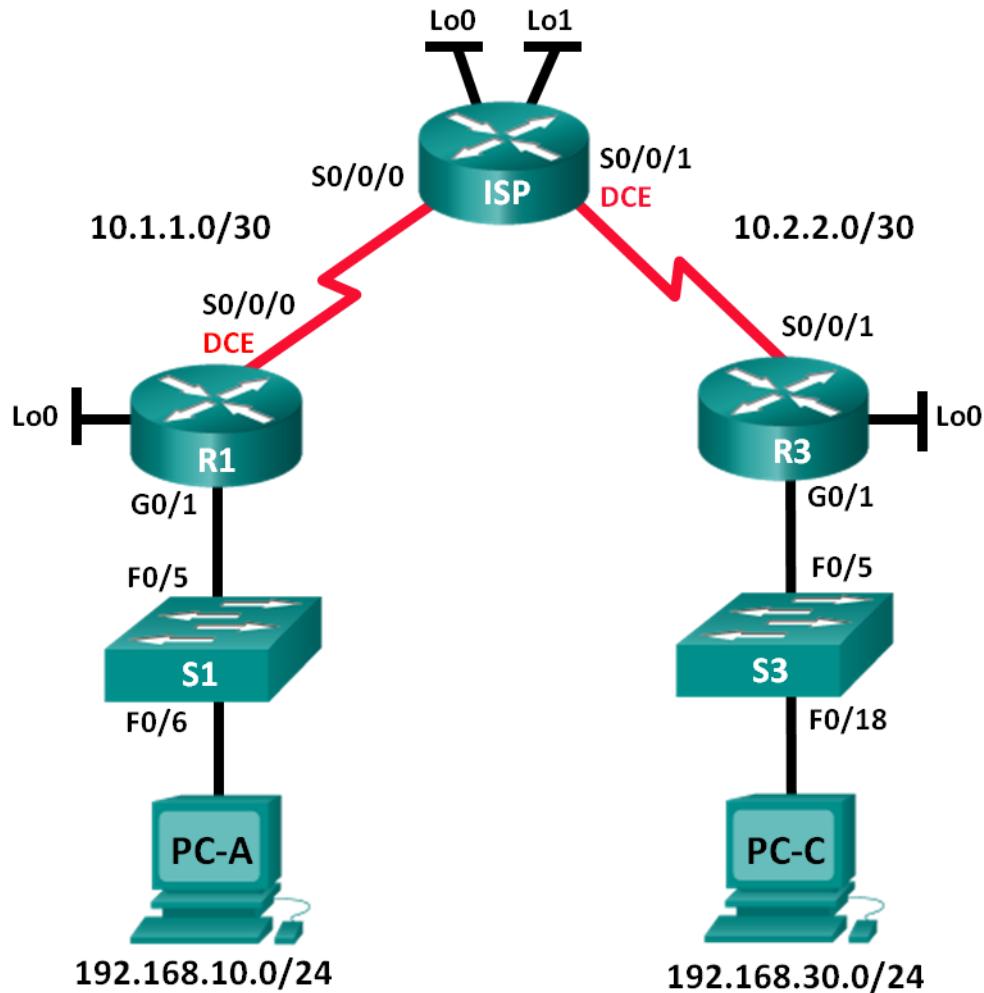
Lab – Configuring and Verifying VTY Restrictions

```
line con 0
password 7 01100F175804
logging synchronous
login
line vty 0 4
access-class ADMIN-MGT in
password 7 01100F175804
logging synchronous
login
line vty 5 14
access-class ADMIN-MGT in
password 7 01100F175804
logging synchronous
login
line vty 15
password 7 0822455D0A16
login
!
end
```

Lab – Configuring and Verifying Extended ACLs (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	192.168.10.1	255.255.255.0	N/A
	Lo0	192.168.20.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A
ISP	S0/0/0	10.1.1.2	255.255.255.252	N/A
	S0/0/1 (DCE)	10.2.2.2	255.255.255.252	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
R3	Lo1	209.165.201.1	255.255.255.224	N/A
	G0/1	192.168.30.1	255.255.255.0	N/A
	Lo0	192.168.40.1	255.255.255.0	N/A
S1	S0/0/1	10.2.2.1	255.255.255.252	N/A
	VLAN 1	192.168.10.11	255.255.255.0	192.168.10.1
	VLAN 1	192.168.30.11	255.255.255.0	192.168.30.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-C	NIC	192.168.30.3	255.255.255.0	192.168.30.1

Objectives

Part 1: Set Up the Topology and Initialize Devices

Part 2: Configure Devices and Verify Connectivity

- Configure basic settings on PCs, routers, and switches.
- Configure EIGRP routing on R1, ISP, and R3.

Part 3: Configure and Verify Extended Numbered and Named ACLs

- Configure, apply, and verify a numbered extended ACL.
- Configure, apply, and verify a named extended ACL.

Part 4: Modify and Verify Extended ACLs

Background / Scenario

Extended access control lists (ACLs) are extremely powerful. They offer a much greater degree of control than standard ACLs as to the types of traffic that can be filtered, as well as where the traffic originated and where it is going.

In this lab, you will set up filtering rules for two offices represented by R1 and R3. Management has established some access policies between the LANs located at R1 and R3, which you must implement. The ISP router between R1 and R3 does not have any ACLs placed on it. You would not be allowed any administrative access to an ISP router as you can only control and manage your own equipment.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used.

Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Set Up the Topology and Initialize Devices

In Part 1, you will set up the network topology and clear any configurations if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Part 2: Configure Devices and Verify Connectivity

In Part 2, you will configure basic settings on the routers, switches, and PCs. Refer to the Topology and Addressing Table for device names and address information.

Step 1: Configure IP addresses on PC-A and PC-C.

Step 2: Configure basic settings on R1.

- a. Disable DNS lookup.
- b. Configure the device name as shown in the topology.
- c. Create a loopback interface on R1.
- d. Configure interface IP addresses as shown in the Topology and Addressing Table.
- e. Configure a privileged EXEC mode password of **class**.
- f. Assign a clock rate of **128000** to the S0/0/0 interface.
- g. Assign **cisco** as the console and vty password and enable Telnet access. Configure **logging synchronous** for both the console and vty lines.
- h. Enable web access on R1 to simulate a web server with local authentication for user **admin**.

```
R1(config)# ip http server  
R1(config)# ip http authentication local  
R1(config)# username admin privilege 15 secret class
```

Step 3: Configure basic settings on ISP.

- a. Configure the device name as shown in the topology.
- b. Create the loopback interfaces on ISP.
- c. Configure interface IP addresses as shown in the Topology and Addressing Table.
- d. Disable DNS lookup.
- e. Assign **class** as the privileged EXEC mode password.
- f. Assign a clock rate of **128000** to the S0/0/1 interface.
- g. Assign **cisco** as the console and vty password and enable Telnet access. Configure **logging synchronous** for both console and vty lines.
- h. Enable web access on the ISP. Use the same parameters as in Step 2h.

Step 4: Configure basic settings on R3.

- a. Configure the device name as shown in the topology.
- b. Create a loopback interface on R3.
- c. Configure interface IP addresses as shown in the Topology and Addressing Table.
- d. Disable DNS lookup.
- e. Assign **class** as the privileged EXEC mode password.
- f. Assign **cisco** as the console password and configure **logging synchronous** on the console line.
- g. Enable SSH on R3.

```
R3(config)# ip domain-name cisco.com
R3(config)# crypto key generate rsa modulus 1024
R3(config)# line vty 0 4
R3(config-line)# login local
R3(config-line)# transport input ssh
```

- h. Enable web access on R3. Use the same parameters as in Step 2h.

Step 5: (Optional) Configure basic settings on S1 and S3.

- a. Configure the hostnames as shown in the topology.
- b. Configure the management interface IP addresses as shown in the Topology and Addressing Table.
- c. Disable DNS lookup.
- d. Configure a privileged EXEC mode password of **class**.
- e. Configure a default gateway address.

Step 6: Configure EIGRP routing on R1, ISP, and R3.

- a. Configure autonomous system (AS) number 10 and advertise all networks on R1, ISP, and R3. Disable automatic summarization.
- b. After configuring EIGRP on R1, ISP, and R3, verify that all routers have complete routing tables listing all networks. Troubleshoot if this is not the case.

Step 7: Verify connectivity between devices.

Note: It is very important to verify connectivity **before** you configure and apply ACLs! Ensure that your network is properly functioning before you start to filter out traffic.

- a. From PC-A, ping PC-C and the loopback and serial interfaces on R3.

Were your pings successful? _____ Yes

- b. From R1, ping PC-C and the loopback and serial interface on R3.

Were your pings successful? _____ Yes

- c. From PC-C, ping PC-A and the loopback and serial interface on R1.

Were your pings successful? _____ Yes

- d. From R3, ping PC-A and the loopback and serial interface on R1.

Were your pings successful? _____ Yes

- e. From PC-A, ping the loopback interfaces on the ISP router.

Were your pings successful? _____ Yes

- f. From PC-C, ping the loopback interfaces on the ISP router.

Were your pings successful? _____ Yes

- g. Open a web browser on PC-A and go to <http://209.165.200.225> on ISP. You will be prompted for a username and password. Use **admin** for the username and **class** for the password. If you are prompted to accept a signature, accept it. The router will load the Cisco Configuration Professional (CCP) Express in a separate window. You may be prompted for a username and password. Use **admin** for the username and **class** for the password.

- h. Open a web browser on PC-C and go to <http://10.1.1.1> on R1. You will be prompted for a username and password. Use **admin** for username and **class** for the password. If you are prompted to accept a signature, accept it. The router will load CCP Express in a separate window. You may be prompted for a username and password. Use **admin** for the username and **class** for the password.

Part 3: Configure and Verify Extended Numbered and Named ACLs

Extended ACLs can filter traffic in many different ways. Extended ACLs can filter on source IP addresses, source ports, destination IP addresses, destination ports, as well as various protocols and services.

Security policies are as follows:

1. Allow web traffic originating from the 192.168.10.0/24 network to go to any network.
2. Allow an SSH connection to the R3 serial interface from PC-A.
3. Allow users on 192.168.10.0.24 network access to 192.168.20.0/24 network.
4. Allow web traffic originating from the 192.168.30.0/24 network to access R1 via the web interface and the 209.165.200.224/27 network on ISP. The 192.168.30.0/24 network should NOT be allowed to access any other network via the web.

In looking at the security policies listed above, you will need at least two ACLs to fulfill the security policies. A best practice is to place extended ACLs as close to the source as possible. We will follow this practice for these policies.

Step 1: Configure a numbered extended ACL on R1 for security policy numbers 1 and 2.

You will use a numbered extended ACL on R1. What are the ranges for extended ACLs?

Lab – Configuring and Verifying Extended ACLs

100 – 199 and 2000 to 2699

- a. Configure the ACL on R1. Use 100 for the ACL number.

```
R1(config)# access-list 100 remark Allow Web & SSH Access
R1(config)# access-list 100 permit tcp host 192.168.10.3 host 10.2.2.1 eq 22
R1(config)# access-list 100 permit tcp any any eq 80
```

What does the 80 signify in the command output listed above?

80 is the destination port. TCP port 80 is a well-known port used for the HTTP protocol.

To what interface should ACL 100 be applied?

There are two possible answers here: G0/1 and S0/0/0. Placing it on G0/1 could block the users on network 192.168.10.0/24 from getting to any other LANs attached to R1 such as the 192.168.20.0/24 network. For this reason you will place it on S0/0/0.

In what direction should ACL 100 be applied?

If G0/1 interface was used for the previous answer, ACL 100 should be applied going **in**. If student answered with S0/0/0, ACL 100 would be applied going **out**.

- b. Apply ACL 100 to the S0/0/0 interface.

```
R1(config)# int s0/0/0
R1(config-if)# ip access-group 100 out
```

- c. Verify ACL 100.

- 1) Open up a web browser on PC-A, and access <http://209.165.200.225> (the ISP router). It should be successful; troubleshoot, if not.
- 2) Establish an SSH connection from PC-A to R3 using 10.2.2.1 for the IP address. Log in with **admin** and **class** for your credentials. It should be successful; troubleshoot, if not.
- 3) From privileged EXEC mode prompt on R1, issue the **show access-lists** command.

```
R1# show access-lists
Extended IP access list 100
  10 permit tcp host 192.168.10.3 host 10.2.2.1 eq 22 (22 matches)
  20 permit tcp any any eq www (111 matches)
```

- 4) From the PC-A command prompt, issue a ping to 10.2.2.1. Explain your results?
-
-

The pings failed. Message was “Reply from 192.168.10.1: Destination net unreachable.” This is because of the implicit **deny any** at the end of every ACL. ACL 100 only allows out Web and SSH traffic.

Step 2: Configure a named extended ACL on R3 for security policy number 3.

- Configure the policy on R3. Name the ACL WEB-POLICY.

```
R3(config)# ip access-list extended WEB-POLICY
R3(config-ext-nacl)# permit tcp 192.168.30.0 0.0.0.255 host 10.1.1.1 eq 80
R3(config-ext-nacl)# permit tcp 192.168.30.0 0.0.0.255 209.165.200.224
0.0.0.31 eq 80
```

- Apply ACL WEB-POLICY to the S0/0/1 interface.

```
R3(config-ext-nacl)# int s0/0/1
R3(config-if)# ip access-group WEB-POLICY out
```

- Verify the ACL WEB-POLICY.

- From R3 privileged EXEC mode command prompt, issue the **show ip interface s0/0/1** command.

What, if any, is the name of the ACL? _____ **WEB-POLICY**

In what direction is the ACL applied? _____ **Out**

- Open up a web browser on PC-C and access <http://209.165.200.225> (the ISP router). It should be successful; troubleshoot, if not.
- From PC-C, open a web session to <http://10.1.1.1> (R1). It should be successful; troubleshoot, if not.
- From PC-C, open a web session to <http://209.165.201.1> (ISP router). It should fail; troubleshoot, if not.
- From a PC-C command prompt, ping PC-A. What was your result and why?

The pings failed. Only web traffic is allowed to exit from the 192.168.30.0/24 network.

Part 4: Modify and Verify Extended ACLs

Because of the ACLs applied on R1 and R3, no pings or any other kind of traffic is allowed between the LAN networks on R1 and R3. Management has decided that all traffic between the 192.168.10.0/24 and 192.168.30.0/24 networks should be allowed. You must modify both ACLs on R1 and R3.

Step 1: Modify ACL 100 on R1.

- From R1 privileged EXEC mode, issue the **show access-lists** command.

How many lines are there in this access list? _____ **2 lines, numbered 10 and line 20**

- Enter global configuration mode and modify the ACL on R1.

```
R1(config)# ip access-list extended 100
R1(config-ext-nacl)# 30 permit ip 192.168.10.0 0.0.0.255 192.168.30.0
0.0.0.255
R1(config-ext-nacl)# end
```

- Issue the **show access-lists** command.

Where did the new line that you just added appear in ACL 100?

Line 30. The last line in the ACL.

Step 2: Modify ACL WEB-POLICY on R3.

- a. From R3 privileged EXEC mode, issue the **show access-lists** command.

How many lines are there in this access list? _____ 2 lines, numbered 10 and 20

- b. Enter global configuration mode and modify the ACL on R3.

```
R3(config)# ip access-list extended WEB-POLICY  
R3(config-ext-nacl)# 30 permit ip 192.168.30.0 0.0.0.255 192.168.10.0  
0.0.0.255  
R3(config-ext-nacl)# end
```

- c. Issue the **show access-lists** command to verify that the new line was added at the end of the ACL.

Step 3: Verify modified ACLs.

- a. From PC-A, ping the IP address of PC-C. Were the pings successful? _____ Yes
- b. From PC-C, ping the IP address of PC-A. Were the pings successful? _____ Yes

Why did the ACLs work immediately for the pings after you changed them?

The ACLs on both R1 and R3 were still applied to their respective interfaces with the **ip access-group command**.

Reflection

1. Why is careful planning and testing of ACLs required?

ACLs can unintentionally block legitimate traffic from entering or leaving a network.

2. Which type of ACL is better: standard or extended?

They both have their purpose and place in a network. A standard ACL is easy to write and configure if you need to permit or deny all traffic. The downside of a standard ACL is that it can only check source addresses and has no granularity. Extended ACLs can be written to filter virtually any kind of traffic generated. However, they can be complex to configure and understand.

3. Why are EIGRP hello packets and routing updates not blocked by the implicit **deny any** access control entry (ACE) or ACL statement of the ACLs applied to R1 and R3?

EIGRP updates originate from the serial interfaces on R1 and R3 and not from within the LAN. ACLs filter traffic passing through the router and not traffic sourced by the router. If an ACL had been placed on the ISP

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router, it may have blocked EIGRP updates between R1 and R3, as well as other router-to-router communication. This could have resulted in loss of connectivity between the PC-A and PC-B LANs.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1

```
R1# show run
Current configuration : 1811 bytes
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUg.2
!
no ip domain lookup
!
username admin privilege 15 secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUg.2
interface Loopback0
 ip address 192.168.20.1 255.255.255.0
!
interface GigabitEthernet0/1
 ip address 192.168.10.1 255.255.255.0
```

Lab – Configuring and Verifying Extended ACLs

```
duplex auto
speed auto
!
interface Serial0/0/0
ip address 10.1.1.1 255.255.255.252
ip access-group 100 out
clock rate 128000
!
router eigrp 10
network 10.1.1.0 0.0.0.3
network 192.168.10.0
network 192.168.20.0
!
ip http server
ip http authentication local
no ip http secure-server
!
access-list 100 remark Allow Web & SSH Access
access-list 100 permit tcp host 192.168.10.3 host 10.2.2.1 eq 22
access-list 100 permit tcp any any eq www
access-list 100 permit ip 192.168.10.0 0.0.0.255 192.168.30.0 0.0.0.255
!
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
logging synchronous
login
transport input all
!
end
```

Router ISP

```
ISP# sh run
Building configuration...
Current configuration : 1657 bytes
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no ip domain lookup
!
```

Lab – Configuring and Verifying Extended ACLs

```
username admin privilege 15 secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.224
!
interface Loopback1
 ip address 209.165.201.1 255.255.255.224
!
interface Serial0/0/0
 ip address 10.1.1.2 255.255.255.252
!
interface Serial0/0/1
 ip address 10.2.2.2 255.255.255.252
 clock rate 128000
!
router eigrp 10
 network 10.1.1.0 0.0.0.3
 network 10.2.2.0 0.0.0.3
 network 209.165.200.224 0.0.0.31
 network 209.165.201.0 0.0.0.31
!
ip http server
ip http authentication local
no ip http secure-server
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 logging synchronous
 login
 transport input all
!
end
```

Router R3

```
R3# show run
Building configuration...
Current configuration : 1802 bytes
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R3
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
```

Lab – Configuring and Verifying Extended ACLs

```
!
no ip domain lookup
ip domain name cisco.com
!
username admin privilege 15 secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
ip ssh version 1
!
interface Loopback0
 ip address 192.168.40.1 255.255.255.0
!
interface GigabitEthernet0/1
 ip address 192.168.30.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0/1
 ip address 10.2.2.1 255.255.255.252
 ip access-group WEB-POLICY out
!
router eigrp 10
 network 10.2.2.0 0.0.0.3
 network 192.168.30.0
 network 192.168.40.0
!
ip http server
ip http authentication local
no ip http secure-server
!
ip access-list extended WEB-POLICY
 permit tcp 192.168.30.0 0.0.0.255 host 10.1.1.1 eq www
 permit tcp 192.168.30.0 0.0.0.255 209.165.200.224 0.0.0.31 eq www
 permit ip 192.168.30.0 0.0.0.255 192.168.10.0 0.0.0.255
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 login local
 transport input ssh
!
end
```

Switch S1

```
S1# sh run
Building configuration...
Current configuration : 1416 bytes
version 15.0
```

Lab – Configuring and Verifying Extended ACLs

```
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
interface FastEthernet0/1
!
interface FastEthernet0/2
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
```

Lab – Configuring and Verifying Extended ACLs

```
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.10.11 255.255.255.0
!
ip default-gateway 192.168.10.1
ip http server
ip http secure-server
line con 0
line vty 5 15
!
end
```

Switch S3

```
S3# show run
Building configuration...
Current configuration : 1416 bytes
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S3
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
```

Lab – Configuring and Verifying Extended ACLs

```
interface FastEthernet0/1
!
interface FastEthernet0/2
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
```

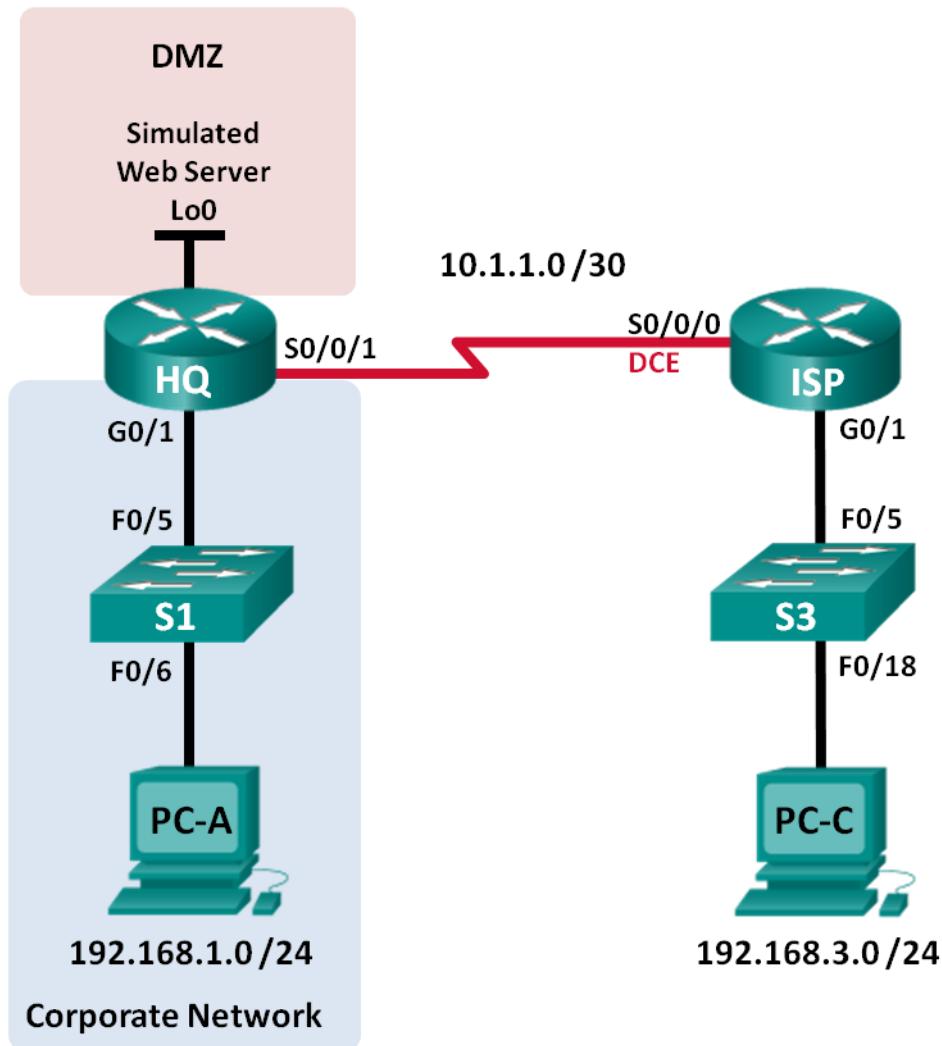
Lab – Configuring and Verifying Extended ACLs

```
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
interface Vlan1
    ip address 192.168.30.11 255.255.255.0
!
ip default-gateway 192.168.30.1
ip http server
ip http secure-server
!
line con 0
line vty 5 15
!
end
```

Lab - Troubleshooting ACL Configuration and Placement (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
HQ	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/1	10.1.1.2	255.255.255.252	N/A
	Lo0	192.168.4.1	255.255.255.0	N/A
ISP	G0/1	192.168.3.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S3	VLAN 1	192.168.3.11	255.255.255.0	192.168.3.1
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-C	NIC	192.168.3.3	255.255.255.0	192.168.3.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot Internal Access

Part 3: Troubleshoot Remote Access

Background / Scenario

An access control list (ACL) is a series of IOS commands that can provide basic traffic filtering on a Cisco router. ACLs are used to select the types of traffic to be processed. A single ACL statement is called and access control entry (ACE). The ACEs in the ACL are evaluated from top to bottom with an implicit deny all ACE at the end of the list. ACLs can also control the types of traffic into or out of a network by the source and destination hosts or network. To process the desired traffic correctly, the placement of the ACLs is critical.

In this lab, a small company has just added a web server to the network to allow customers to access confidential information. The company network is divided into two zones: Corporate network zone and Demilitarized Zone (DMZ). The corporate network zone houses private servers and internal clients. The DMZ houses the externally accessible web server (simulated by Lo0 on HQ). Because the company can only administer its own HQ router, all ACLs must be applied to the HQ router.

- ACL 101 is implemented to limit the traffic out of the corporate network zone. This zone houses the private servers and internal clients (192.168.1.0/24). No other network should be able to access it.
- ACL 102 is used to limit the traffic into the corporate network. Only responses to requests that originated from within the corporate network are allowed back into that network. This includes TCP-based requests from internal hosts such as Web and FTP. ICMP is allowed into the network for troubleshooting purposes so that incoming ICMP messages generated in response to pings can be received by internal hosts.
- ACL 121 controls outside traffic to the DMZ and corporate network. Only HTTP traffic is allowed to the DMZ web server (simulated by Lo0 on R1). Other network related traffic, such as EIGRP, is allowed from outside networks. Furthermore, valid internal private addresses, such as 192.168.1.0, loopback address such as 127.0.0.0 and multicast addresses are denied entrance to the corporate network to prevent malicious network attacks from outside users.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco

IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you set up the network topology and configure the routers and switches with some basic settings, such as passwords and IP addresses. Preset configurations are also provided for you for the initial router configurations. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the routers and switches as necessary.

Step 4: (Optional) Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure host names as shown in the Topology.
- c. Configure IP address and default gateway in Addressing Table.
- d. Assign **cisco** as the console and vty passwords.
- e. Assign **class** as the privileged EXEC password.
- f. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 5: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure host names as shown in the topology.
- c. Assign **cisco** as the console and vty passwords.
- d. Assign **class** as the privileged EXEC password.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 6: Configure HTTP access and user credentials on HQ router.

Local user credentials are configured to access the simulated web server (192.168.4.1).

```
HQ(config)# ip http server
HQ(config)# username admin privilege 15 secret adminpass
HQ(config)# ip http authentication local
```

Step 7: Load router configurations.

The configurations for the routers ISP and HQ are provided for you. There are errors within these configurations, and it is your job to determine the incorrect configurations and correct them.

Router ISP

```
hostname ISP
interface GigabitEthernet0/1
  ip address 192.168.3.1 255.255.255.0
  no shutdown
interface Serial0/0/0
  ip address 10.1.1.1 255.255.255.252
  clock rate 128000
  no shutdown
router eigrp 1
  network 10.1.1.0 0.0.0.3
  network 192.168.3.0
  no auto-summary
end
```

Router HQ

```
hostname HQ
interface Loopback0
  ip address 192.168.4.1 255.255.255.0
interface GigabitEthernet0/1
  ip address 192.168.1.1 255.255.255.0
  ip access-group 101 out
  !ip access-group 101 in
  ip access-group 102 in
  !ip access-group 102 out
  no shutdown
interface Serial0/0/1
  ip address 10.1.1.2 255.255.255.252
  ip access-group 121 in
  no shutdown
router eigrp 1
  network 10.1.1.0 0.0.0.3
  network 192.168.1.0
  network 192.168.4.0
  no auto-summary
access-list 101 permit ip 192.168.11.0 0.0.0.255 any
!access-list 101 permit ip 192.168.1.0 0.0.0.255 any
access-list 101 deny ip any any
access-list 102 permit tcp any any established
access-list 102 permit icmp any any echo-reply
access-list 102 permit icmp any any unreachable
```

```
access-list 102 deny ip any any
access-list 121 permit tcp any host 192.168.4.1 eq 89
!access-list 121 permit tcp any host 192.168.4.1 eq www
access-list 121 deny icmp any host 192.168.4.11
!access-list 121 deny icmp any host 192.168.4.1
access-list 121 deny ip 192.168.1.0 0.0.0.255 any
access-list 121 deny ip 127.0.0.0 0.255.255.255 any
access-list 121 deny ip 224.0.0.0 31.255.255.255 any
access-list 121 permit ip any any
access-list 121 deny ip any any
end
```

Part 2: Troubleshoot Internal Access

In Part 2, the ACLs on router HQ are examined to determine if they are configured correctly.

Step 1: Troubleshoot ACL 101

ACL 101 is implemented to limit the traffic out of the corporate network zone. This zone houses only internal clients and private servers. Only 192.168.1.0/24 network can exit this corporate network zone.

- Can PC-A ping its default gateway? _____ **no**
- After verifying that the PC-A was configured correctly, examine the HQ router to find possible configuration errors by viewing the summary of ACL 101. Enter the command **show access-lists 101**.

```
HQ# show access-lists 101
Extended IP access list 101
    10 permit ip 192.168.11.0 0.0.0.255 any
    20 deny ip any any
```

- Are there any problems with ACL 101?

Yes. ACL 101 is permitting network 192.168.11.0 /24 instead of 192.168.1.0 /24.

- Examine the default gateway interface for the 192.168.1.0 /24 network. Verify that the ACL 101 is applied in the correct direction on the G0/1 interface. Enter the **show ip interface g0/1** command.

```
HQ# show ip interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 192.168.1.1/24
  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: 224.0.0.10
  Outgoing access list is 101
  Inbound access list is 102
```

Is the direction for interface G0/1 configured correctly for ACL 101?

No. The direction for ACL 101 should be into the router.

Lab - Troubleshooting ACL Configuration and Placement

- e. Correct the errors found regarding ACL 101 and verify the traffic from network 192.168.1.0 /24 can exit the corporate network. Record the commands used to correct the errors.

```
HQ(config)# no access-list 101
HQ(config)# access-list 101 permit ip 192.168.1.0 0.0.0.255 any
HQ(config)# access-list 101 deny ip any any
HQ(config)# interface g0/1
HQ(config-if)# ip access-group 101 in
```

- f. Verify PC-A can ping its default gateway interface.

Step 2: Troubleshoot ACL 102

ACL 102 is implemented to limit traffic into the corporate network. Traffic originating from the outside network is not allowed onto the corporate network. Remote traffic is allowed into the corporate network if the established traffic originated from the internal network. ICMP reply messages are allowed for troubleshooting purposes.

- a. Can PC-A ping PC-C? _____ no
- b. Examine the HQ router to find possible configuration errors by viewing the summary of ACL 102. Enter the command **show access-lists 102**.

```
HQ# show access-lists 102
Extended IP access list 102
    10 permit tcp any any established
    20 permit icmp any any echo-reply
    30 permit icmp any any unreachable
    40 deny ip any any (57 matches)
```

- c. Are there any problems with ACL 102?

No.

- d. Verify that the ACL 102 is applied in the correct direction on G0/1 interface. Enter the **show ip interface g0/1** command.

```
HQ# show ip interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 192.168.1.1/24
  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: 224.0.0.10
  Outgoing access list is 101
  Inbound access list is 101
```

Lab - Troubleshooting ACL Configuration and Placement

- e. Are there any problems with the application of ACL 102 to interface G0/1?

Yes. ACL 101 is configured as the outgoing ACL and it should be 102.

- f. Correct any errors found regarding ACL 102. Record the commands used to correct the errors.

```
HQ(config)# interface g0/1  
HQ(config-if)# ip access-group 102 out
```

- g. Can PC-A ping PC-C now? _____ yes

Part 3: Troubleshoot Remote Access

In Part 3, ACL 121 is configured to prevent spoofing attacks from the outside networks and allow only remote HTTP access to the web server (192.168.4.1) in DMZ.

- a. Verify ACL 121 has been configured correctly. Enter the **show ip access-list 121** command.

```
HQ# show ip access-lists 121  
Extended IP access list 121  
 10 permit tcp any host 192.168.4.1 eq 89  
 20 deny icmp any host 192.168.4.11  
 30 deny ip 192.168.1.0 0.0.0.255 any  
 40 deny ip 127.0.0.0 0.255.255.255 any  
 50 deny ip 224.0.0.0 31.255.255.255 any  
 60 permit ip any any (354 matches)  
 70 deny ip any any
```

Are there any problems with this ACL?

Yes. The port number on line 10 should be 80. The host address on line 20 should 192.168.4.1 for the web server.

- b. Verify that the ACL 121 is applied in the correct direction on the R1 S0/0/1 interface. Enter the **show ip interface s0/0/1** command.

```
HQ# show ip interface s0/0/1  
Serial0/0/1 is up, line protocol is up  
  Internet address is 10.1.1.2/30  
  Broadcast address is 255.255.255.255  
<output omitted>  
  Multicast reserved groups joined: 224.0.0.10  
  Outgoing access list is not set  
  Inbound  access list is 121
```

Are there any problems with the application of this ACL?

No. It is applied to S0/0/1 incoming.

- c. If any errors were found, make and record the necessary configuration changes to ACL 121.
-

```
HQ(config)# no access-list 121
HQ(config)# access-list 121 permit tcp any host 192.168.4.1 eq 80
HQ(config)# access-list 121 deny icmp any host 192.168.4.1
HQ(config)# access-list 121 deny ip 192.168.1.0 0.0.0.255 any
HQ(config)# access-list 121 deny ip 127.0.0.0 0.255.255.255 any
HQ(config)# access-list 121 deny ip 224.0.0.0 31.255.255.255 any
HQ(config)# access-list 121 permit ip any any
HQ(config)# access-list 121 deny ip any any
```

- d. Verify that PC-C can only access the simulated web server on HQ by using the web browser. Provide the username **admin** and password **adminpass** to access the web server (192.168.4.1).

Reflection

1. How should the ACL statement be ordered? From general to specific or vice versa?

The order should be from specific to general because the ACL is executed from top to bottom in sequential order. When a condition is true, the processing in the list is stopped and no further comparisons are made.

2. If you delete an ACL by using the **no access-list** command and the ACL is still applied to the interface, what happens?

A default deny any would be applied. So care should be taken when deleting an ACL that is applied to an active interface.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router ISP

```
ISP#show run
Building configuration...

Current configuration : 1423 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 10
!
!
```

Lab - Troubleshooting ACL Configuration and Placement

```
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  ip address 192.168.3.1 255.255.255.0
  duplex auto
  speed auto
!
interface Serial0/0/0
  ip address 10.1.1.1 255.255.255.252
  clock rate 2000000
!
interface Serial0/0/1
  no ip address
  shutdown
!
!
router eigrp 1
  network 10.1.1.0 0.0.0.3
  network 192.168.3.0
!
ip forward-protocol nd
!
no ip http server

no ip http secure-server
!
!
control-plane
!
!
```

```
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router HQ (Corrected)

```
HQ# show run
Building configuration...

Current configuration : 2292 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname HQ
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
!
no ip domain lookup
ip cef
```

Lab - Troubleshooting ACL Configuration and Placement

```
no ipv6 cef
multilink bundle-name authenticated
!
!
username admin privilege 15 secret 4 QHjxdsVkjtoP7VxK1cPsLdTiMIVyLkyjT1HbmYxZigc
!
!
interface Loopback0
 ip address 192.168.4.1 255.255.255.0
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
 ip access-group 101 in
 ip access-group 102 out
 duplex auto
 speed auto
!
interface Serial0/0/0
 no ip address
!shutdown
!
interface Serial0/0/1
 ip address 10.1.1.2 255.255.255.252
 ip access-group 121 in
!
interface Serial0/0/1
 no ip address
!shutdown
!
router eigrp 1
 network 10.1.1.0 0.0.0.3
 network 192.168.1.0
 network 192.168.4.0
!
ip forward-protocol nd
!
ip http server
ip http authentication local
no ip http secure-server
```

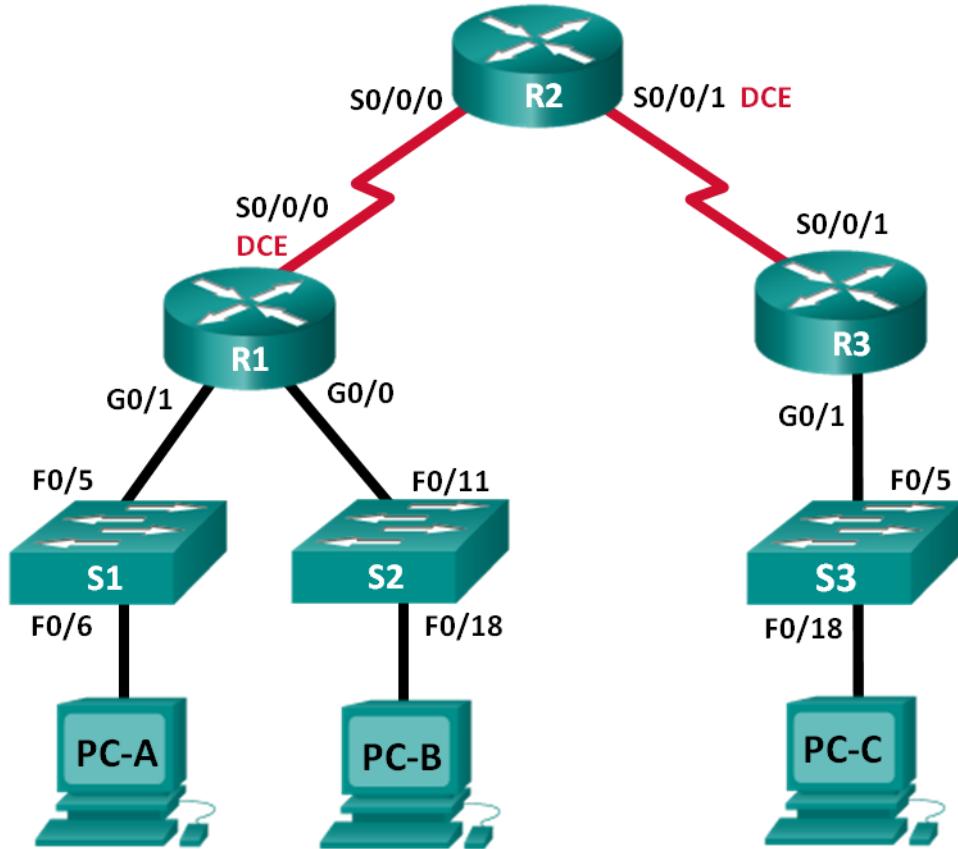
Lab - Troubleshooting ACL Configuration and Placement

```
!
!
access-list 101 permit ip 192.168.1.0 0.0.0.255 any
access-list 101 deny ip any any
access-list 102 permit tcp any any established
access-list 102 permit icmp any any echo-reply
access-list 102 permit icmp any any unreachable
access-list 102 deny ip any any
access-list 121 permit tcp any host 192.168.4.1 eq www
access-list 121 deny icmp any host 192.168.4.1
access-list 121 deny ip 192.168.1.0 0.0.0.255
access-list 121 deny ip 127.0.0.0 0.255.255.255
access-list 121 deny ip 224.0.0.0 31.255.255.255
access-list 121 permit ip any any
access-list 121 deny ip any any
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring and Verifying IPv6 ACLs (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Default Gateway
R1	G0/0	2001:DB8:ACAD:B::1/64	N/A
	G0/1	2001:DB8:ACAD:A::1/64	N/A
	S0/0/0 (DCE)	2001:DB8:AAAA:1::1/64	N/A
R2	S0/0/0	2001:DB8:AAAA:1::2/64	N/A
	S0/0/1 (DCE)	2001:DB8:AAAA:2::2/64	N/A
R3	G0/1	2001:DB8:CAFE:C::1/64	N/A
	S0/0/1	2001:DB8:AAAA:2::1/64	N/A
S1	VLAN1	2001:DB8:ACAD:A::A/64	N/A
S2	VLAN1	2001:DB8:ACAD:B::A/64	N/A
S3	VLAN1	2001:DB8:CAFE:C::A/64	N/A
PC-A	NIC	2001:DB8:ACAD:A::3/64	FE80::1
PC-B	NIC	2001:DB8:ACAD:B::3/64	FE80::1
PC-C	NIC	2001:DB8:CAFE:C::3/64	FE80::1

Objectives

Part 1: Set Up the Topology and Initialize Devices

Part 2: Configure Devices and Verify Connectivity

Part 3: Configure and Verify IPv6 ACLs

Part 4: Edit IPv6 ACLs

Background / Scenario

You can filter IPv6 traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similarly to the way that you create IPv4 named ACLs. IPv6 ACL types are extended and named. Standard and numbered ACLs are no longer used with IPv6. To apply an IPv6 ACL to a vty interface, you use the new **ipv6 traffic-filter** command. The **ipv6 access-class** command is still used to apply an IPv6 ACL to interfaces.

In this lab, you will apply IPv6 filtering rules and then verify that they are restricting access as expected. You will also edit an IPv6 ACL and clear the match counters.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Instructor Note: The **default bias** template used by the Switch Database Manager (SDM) does not provide IPv6 address capabilities. Verify that SDM is using either the **dual-ipv4-and-ipv6** template or the **lanbase-routing** template. The new template will be used after reboot even if the configuration is not saved.

```
S1# show sdm prefer
```

Use the following commands to assign the **dual-ipv4-and-ipv6** template as the default SDM template.

```
S1# configure terminal
S1(config)# sdm prefer dual-ipv4-and-ipv6 default
S1(config)# end
S1# reload
```

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Set Up the Topology and Initialize Devices

In Part 1, you set up the network topology and clear any configurations if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Part 2: Configure Devices and Verify Connectivity

In Part 2, you configure basic settings on the routers, switches and PCs. Refer to the Topology and Addressing Table at the beginning of this lab for device names and address information.

Step 1: Configure IPv6 addresses on all PCs.

Configure IPv6 global unicast addresses according to the Addressing Table. Use the link-local address of **FE80::1** for the default-gateway on all PCs.

Step 2: Configure the switches.

- a. Disable DNS lookup.
- b. Assign the hostname.
- c. Assign a domain-name of **ccna-lab.com**.
- d. Encrypt plain text passwords.
- e. Create a MOTD banner warning users that unauthorized access is prohibited.
- f. Create a local user database with a username of **admin** and password as **classadm**.
- g. Assign **class** as the privileged EXEC encrypted password.
- h. Assign **cisco** as the console password and enable login.
- i. Enable login on the VTY lines using the local database.

Lab – Configuring and Verifying IPv6 ACLs

- j. Generate a crypto rsa key for ssh using a modulus size of 1024 bits.
- k. Change the transport input VTY lines to all for SSH and Telnet only.
- l. Assign an IPv6 address to VLAN 1 according to the Addressing Table.
- m. Administratively disable all inactive interfaces.

Step 3: Configure basic settings on all routers.

- a. Disable DNS lookup.
- b. Assign the hostname.
- c. Assign a domain-name of **ccna-lab.com**.
- d. Encrypt plain text passwords.
- e. Create a MOTD banner warning users that unauthorized access is prohibited.
- f. Create a local user database with a username of **admin** and password as **classadm**.
- g. Assign **class** as the privileged EXEC encrypted password.
- h. Assign **cisco** as the console password and enable login.
- i. Enable login on the VTY lines using the local database.
- j. Generate a crypto rsa key for ssh using a modulus size of 1024 bits.
- k. Change the transport input VTY lines to all for SSH and Telnet only.

Step 4: Configure IPv6 settings on R1.

- a. Configure the IPv6 unicast address on interface G0/0, G0/1, and S0/0/0.
- b. Configure the IPv6 link-local address on interface G0/0, G0/1, and S0/0/0. Use **FE80::1** for the link-local address on all three interfaces.
- c. Set the clock rate on S0/0/0 to 128000.
- d. Enable the interfaces.
- e. Enable IPv6 unicast routing.
- f. Configure an IPv6 default route to use interface S0/0/0.

```
R1(config)# ipv6 route ::/0 s0/0/0
```

Step 5: Configure IPv6 settings on R2.

- a. Configure the IPv6 unicast address on interface S0/0/0 and S0/0/1.
- b. Configure the IPv6 link-local address on interface S0/0/0 and S0/0/1. Use **FE80::2** for the link-local address on both interfaces.
- c. Set the clock rate on S0/0/1 to 128000.
- d. Enable the interfaces.
- e. Enable IPv6 unicast routing.
- f. Configure static IPv6 routes for traffic handling of R1 and R3 LAN subnets.

```
R2(config)# ipv6 route 2001:db8:acad::/48 s0/0/0  
R2(config)# ipv6 route 2001:db8:cafe:c::/64 s0/0/1
```

Step 6: Configure IPv6 settings on R3.

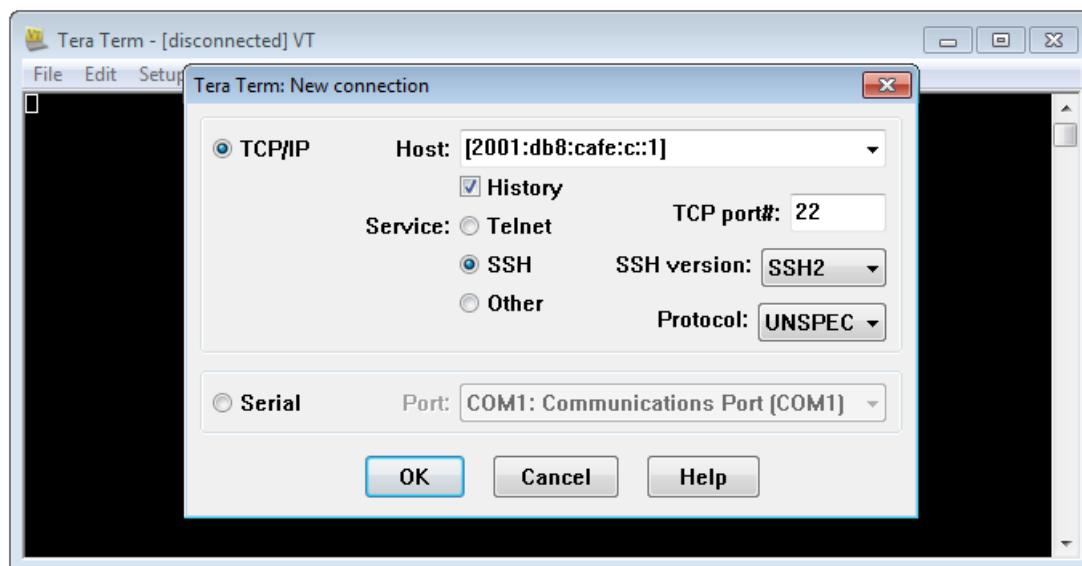
- a. Configure the IPv6 unicast address on interface G0/1 and S0/0/1.
- b. Configure the IPv6 link-local address on interface G0/1 and S0/0/1. Use **FE80::1** for the link-local address on both interfaces.
- c. Enable the interfaces.
- d. Enable IPv6 unicast routing.
- e. Configure an IPv6 default route to use interface S0/0/1.

```
R3(config)# ipv6 route ::/0 s0/0/1
```

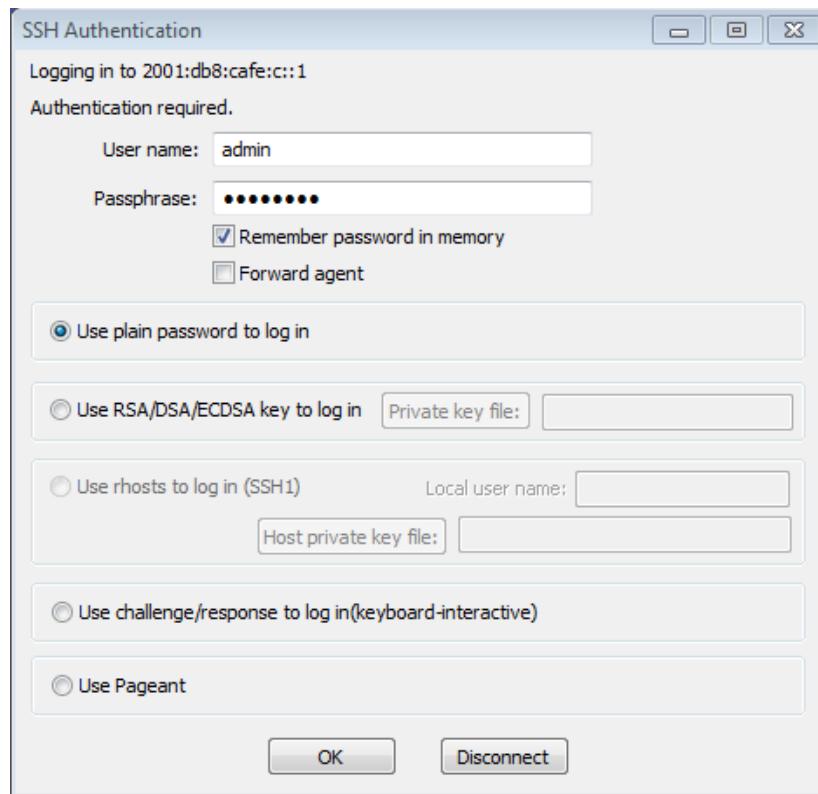
Step 7: Verify connectivity.

- a. Each PC should be able to ping the other PCs in the topology.
- b. Telnet to R1 from all PCs in the Topology.
- c. SSH to R1 from all PCs in the Topology.
- d. Telnet to S1 from all PCs in the Topology.
- e. SSH to S1 from all PCs in the Topology.
- f. Troubleshoot connectivity issues now because the ACLs that you create in Part 3 of this lab will restrict access to some areas of the network.

Note: Tera Term requires the target IPv6 address to be enclosed in brackets. Enter the IPv6 address as shown, click **OK** and then click **Continue** to accept the security warning and connect to the router.



Input the user credentials configured (username **admin** and password **classadm**) and select the **Use plain password to log in** in the SSH Authentication dialogue box. Click **OK** to continue.



Part 3: Configure and Verify IPv6 ACLs

Step 1: Configure and verify VTY restrictions on R1.

- a. Create an ACL to only allow hosts from the 2001:db8:acad:a::/64 network to telnet to R1. All hosts should only be able to ssh to R1.

```
R1(config)# ipv6 access-list RESTRICT-VTY
R1(config-ipv6-acl)# permit tcp 2001:db8:acad:a::/64 any
R1(config-ipv6-acl)# permit tcp any any eq 22
```

- b. Apply the RESTRICT-VTY ACL to R1's VTY lines.

```
R1(config-ipv6-acl)# line vty 0 4
R1(config-line)# ipv6 access-class RESTRICT-VTY in
R1(config-line)# end
R1#
```

- c. Show the new ACL.

```
R1# show access-lists
IPv6 access list RESTRICT-VTY
    permit tcp 2001:DB8:ACAD:A::/64 any sequence 10
    permit tcp any any eq 22 sequence 20
```

- d. Verify that the RESTRICT-VTY ACL is only allowing Telnet traffic from the 2001:db8:acad:a::/64 network.

How does the RESTRICT-VTY ACL only allow hosts from the 2001:db8:acad:a::/64 network to telnet to R1?

The first statement allows all tcp traffic from the 2001:db8:acad:a::/64 network, which would include Telnet traffic. If traffic does not match any of the explicit statements in an ACL, it will be denied by the implicit **deny any any** statement at the end of all ACLs. This implicit deny is what is preventing Telnet traffic from hosts on the other networks from accessing R1.

What does the second permit statement in the RESTRICT-VTY ACL do?

It permits any host access to R1 using ssh, port 22.

Step 2: Restrict Telnet access to the 2001:db8:acad:a::/64 network.

- Create an ACL called RESTRICTED-LAN that will block Telnet access to the 2001:db8:acad:a::/64 network.

```
R1(config)# ipv6 access-list RESTRICTED-LAN
R1(config-ipv6-acl)# remark Block Telnet from outside
R1(config-ipv6-acl)# deny tcp any 2001:db8:acad:a::/64 eq telnet
R1(config-ipv6-acl)# permit ipv6 any any
```

- Apply the RESTRICTED-LAN ACL to interface G0/1 for all outbound traffic.

```
R1(config-ipv6-acl)# int g0/1
R1(config-if)# ipv6 traffic-filter RESTRICTED-LAN out
R1(config-if)# end
```

- Telnet to S1 from PC-B and PC-C to verify that Telnet has been restricted. SSH to S1 from PC-B to verify that it can still be reached using SSH. Troubleshoot if necessary.
- Use the **show ipv6 access-list** command to view the RESTRICTED-LAN ACL.

```
R1# show ipv6 access-lists RESTRICTED-LAN
IPv6 access list RESTRICTED-LAN
    deny tcp any 2001:DB8:ACAD:A::/64 eq telnet (6 matches) sequence 20
    permit ipv6 any any (45 matches) sequence 30
```

Notice that each statement identifies the number of hits or matches that have occurred since the ACL was applied to the interface.

- Use the **clear ipv6 access-list** to reset the match counters for the RESTRICTED-LAN ACL.
- Redisplay the ACL with the **show access-lists** command to confirm that the counters were cleared.

```
R1# clear ipv6 access-list RESTRICTED-LAN
R1# show access-lists RESTRICTED-LAN
IPv6 access list RESTRICTED-LAN
    deny tcp any 2001:DB8:ACAD:A::/64 eq telnet sequence 20
    permit ipv6 any any sequence 30
```

Part 4: Edit IPv6 ACLs

In Part 4, you will edit the RESTRICTED-LAN ACL that you created in Part 3. It is always a good idea to remove the ACL from the interface to which it is applied before editing it. After you complete your edits, then reapply the ACL to the interface.

Lab – Configuring and Verifying IPv6 ACLs

Note: Many network administrators will make a copy of the ACL and edit the copy. When editing is complete, the administrator will remove the old ACL and apply the newly edited ACL to the interface. This method keeps the ACL in place until you are ready to apply the edited copy of the ACL.

Step 1: Remove the ACL from the interface.

```
R1(config)# int g0/1
R1(config-if)# no ipv6 traffic-filter RESTRICTED-LAN out
R1(config-if)# end
```

Step 2: Use the show access-lists command to view the ACL.

```
R1# show access-lists
IPv6 access list RESTRICT-VTY
    permit tcp 2001:DB8:ACAD:A::/64 any (4 matches) sequence 10
    permit tcp any any eq 22 (6 matches) sequence 20
IPv6 access list RESTRICTED-LAN
    deny tcp any 2001:DB8:ACAD:A::/64 eq telnet sequence 20
    permit ipv6 any any (36 matches) sequence 30
```

Step 3: Insert a new ACL statement using sequence numbering.

```
R1(config)# ipv6 access-list RESTRICTED-LAN
R1(config-ipv6-acl)# permit tcp 2001:db8:acad:b::/64 host 2001:db8:acad:a::a
eq 23 sequence 15
```

What does this new permit statement do?

It allows hosts on the 2001:db8:acad:b::/64 network to Telnet to S1.

Step 4: Insert a new ACL statement at the end of the ACL.

```
R1(config-ipv6-acl)# permit tcp any host 2001:db8:acad:a::3 eq www
```

Note: This permit statement is only used to show how to add a statement to the end of an ACL. This ACL line would never be matched because the previous permit statement is matching on everything.

Step 5: Use the do show access-lists command to view the ACL change.

```
R1(config-ipv6-acl)# do show access-list
IPv6 access list RESTRICT-VTY
    permit tcp 2001:DB8:ACAD:A::/64 any (2 matches) sequence 10
    permit tcp any any eq 22 (6 matches) sequence 20
IPv6 access list RESTRICTED-LAN
    permit tcp 2001:DB8:ACAD:B::/64 host 2001:DB8:ACAD:A::A eq telnet sequence 15
    deny tcp any 2001:DB8:ACAD:A::/64 eq telnet sequence 20
    permit ipv6 any any (124 matches) sequence 30
    permit tcp any host 2001:DB8:ACAD:A::3 eq www sequence 40
```

Note: The **do** command can be used to execute any privileged EXEC command while in global configuration mode or a submode.

Step 6: Delete an ACL statement.

Use the **no** command to delete the permit statement that you just added.

Lab – Configuring and Verifying IPv6 ACLs

```
R1(config-ipv6-acl)# no permit tcp any host 2001:DB8:ACAD:A::3 eq www
```

Step 7: Use the do show access-list RESTRICTED-LAN command to view the ACL.

```
R1(config-ipv6-acl)# do show access-list RESTRICTED-LAN
IPv6 access list RESTRICTED-LAN
  permit tcp 2001:DB8:ACAD:B::/64 host 2001:DB8:ACAD:A::A eq telnet sequence 15
  deny tcp any 2001:DB8:ACAD:A::/64 eq telnet sequence 20
  permit ipv6 any any (214 matches) sequence 30
```

Step 8: Re-apply the RESTRICTED-LAN ACL to the interface G0/1.

```
R1(config-ipv6-acl)# int g0/1
R1(config-if)# ipv6 traffic-filter RESTRICTED-LAN out
R1(config-if)# end
```

Step 9: Test ACL changes.

Telnet to S1 from PC-B. Troubleshoot if necessary.

Reflection

1. What is causing the match count on the RESTRICTED-LAN **permit ipv6 any any** statement to continue to increase?

IPv6 does not use ARP to resolve Layer 3 addresses to Layer 2 MAC addresses. It uses ICMP Neighbor Discovery (ND) messages to accomplish this. All IPv6 ACLs have implicit **permit icmp any any nd-na** (Neighbor Advertisement) and **permit icmp any any nd-ns** (Neighbor Solicitation) before the implicit **deny ipv6 any any** statement. The explicit **permit ipv6 any any** is matching on the IPv6 ICMP ND traffic, which is causing the match counter to continually increase.

2. What command would you use to reset the counters for the ACL on the VTY lines?

```
R1# clear ipv6 access-list RESTRICT-VTY
```

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs - Part 1 and 2 combined for R1 and R3**Router R1 (After parts 1 and 2 of this lab)**

```
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
ip domain name ccna-lab.com
ip cef
ipv6 unicast-routing
no ipv6 cef
multilink bundle-name authenticated
!
username admin privilege 15 secret 4 ZmhI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:B::1/64
!
interface GigabitEthernet0/1
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
!
interface Serial0/0/0
no ip address
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:AAAA:1::1/64
clock rate 2000000
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 route ::/0 Serial0/0/0
!
control-plane
!
banner motd ^C
```

```
Unauthorized Access is Prohibited!
```

```
^C
!
line con 0
password 7 02050D480809
login
line aux 0
!
line vty 0 4
login local
transport input telnet ssh
!
scheduler allocate 20000 1000
```

```
!  
end
```

Router R2 (After parts 1 and 2 of this lab)

```
service password-encryption  
!  
hostname R2  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
memory-size iomem 15  
!  
no ip domain lookup  
ip domain name ccna-lab.com  
ip cef  
ipv6 unicast-routing  
no ipv6 cef  
multilink bundle-name authenticated  
!  
username admin privilege 15 secret 4 ZmHI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo  
!  
interface Serial0/0/0  
no ip address  
ipv6 address FE80::2 link-local  
ipv6 address 2001:DB8:AAAA:1::2/64  
!  
interface Serial0/0/1  
no ip address  
ipv6 address FE80::2 link-local  
ipv6 address 2001:DB8:AAAA:2::2/64  
clock rate 2000000  
!  
ip forward-protocol nd  
!  
no ip http server  
no ip http secure-server  
!  
ipv6 route 2001:DB8:ACAD::/48 Serial0/0/0  
ipv6 route 2001:DB8:CAFE:C::/64 Serial0/0/1  
!  
control-plane  
!  
banner motd ^C
```

```
Unauthorized Access is Prohibited!
```

```
^C
!
line con 0
 password 7 02050D480809
login
line aux 0
line vty 0 4
 login local
 transport input telnet ssh
!
scheduler allocate 20000 1000
!
end
```

Router R3 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
no ip domain lookup
ip domain name ccna-lab.com
ip cef
ipv6 unicast-routing
ipv6 cef
multilink bundle-name authenticated
!
username admin privilege 15 secret 4 ZmhI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:CAFE:C::1/64
!
interface Serial0/0/1
 no ip address
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:AAAA:2::1/64
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 route ::/0 Serial0/0/1
!
control-plane
!
banner motd ^C
```

```
Unauthorized Access is Prohibited!
```

```
^C
!
line con 0
password 7 02050D480809
login
line aux 0
line vty 0 4
login local
transport input telnet ssh
!
scheduler allocate 20000 1000
!
end
```

Switch S1 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
username admin privilege 15 secret 4 ZmhI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
ip domain-name ccna-lan.com
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
interface FastEthernet0/1
    shutdown
!
interface FastEthernet0/2
    shutdown
!
interface FastEthernet0/3
    shutdown
!
interface FastEthernet0/4
    shutdown
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
    shutdown
!
interface FastEthernet0/8
    shutdown
!
interface FastEthernet0/9
    shutdown
!
interface FastEthernet0/10
    shutdown
!
interface FastEthernet0/11
    shutdown
!
interface FastEthernet0/12
    shutdown
!
interface FastEthernet0/13
    shutdown
!
interface FastEthernet0/14
    shutdown
!
interface FastEthernet0/15
    shutdown
!
interface FastEthernet0/16
    shutdown
!
interface FastEthernet0/17
    shutdown
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
interface FastEthernet0/18
    shutdown
!
interface FastEthernet0/19
    shutdown
!
interface FastEthernet0/20
    shutdown
!
interface FastEthernet0/21
    shutdown
!
interface FastEthernet0/22
    shutdown
!
interface FastEthernet0/23
    shutdown
!
interface FastEthernet0/24
    shutdown
!
interface GigabitEthernet0/1
    shutdown
!
interface GigabitEthernet0/2
    shutdown
!
interface Vlan1
    no ip address
    ipv6 address 2001:DB8:ACAD:A::A/64
!
ip http server
ip http secure-server
!
!
banner motd ^C
```

```
Unauthorized Access is Prohibited!
```

```
^C
!
line con 0
    password 7 070C285F4D06
    login
line vty 0 4
    password 7 070C285F4D06
    login local
    transport input telnet ssh
line vty 5 15
```

Lab – Configuring and Verifying IPv6 ACLs

```
password 7 070C285F4D06
login local
transport input telnet ssh
!
end
```

Switch S2 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
username admin privilege 15 secret 4 ZmhI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
ip domain-name ccna-lan.com
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
interface FastEthernet0/8
    shutdown
!
interface FastEthernet0/9
    shutdown
!
interface FastEthernet0/10
    shutdown
!
interface FastEthernet0/11
!
interface FastEthernet0/12
    shutdown
!
interface FastEthernet0/13
    shutdown
!
interface FastEthernet0/14
    shutdown
!
interface FastEthernet0/15
    shutdown
!
interface FastEthernet0/16
    shutdown
!
interface FastEthernet0/17
    shutdown
!
interface FastEthernet0/18
!
interface FastEthernet0/19
    shutdown
!
interface FastEthernet0/20
    shutdown
!
interface FastEthernet0/21
    shutdown
!
interface FastEthernet0/22
    shutdown
!
interface FastEthernet0/23
    shutdown
!
interface FastEthernet0/24
    shutdown
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
interface GigabitEthernet0/1
    shutdown
!
interface GigabitEthernet0/2
    shutdown
!
interface Vlan1
    no ip address
    ipv6 address 2001:DB8:ACAD:B::A/64
!
ip http server
ip http secure-server
!
!
banner motd ^C
```

```
Unauthorized Access is Prohibited!
```

```
^C
!
line con 0
password 7 070C285F4D06
login
line vty 0 4
password 7 070C285F4D06
login local
transport input telnet ssh
line vty 5 15
password 7 070C285F4D06
login local
transport input telnet ssh
!
end
```

Switch S3 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname S3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
username admin privilege 15 secret 4 ZmhI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
```

Lab – Configuring and Verifying IPv6 ACLs

```
ip domain-name ccna-lan.com
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
```

Lab – Configuring and Verifying IPv6 ACLs

```
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
ipv6 address 2001:DB8:CAFE:C::A/64
!
ip http server
ip http secure-server
!
!
banner motd ^C
```

```
Unauthorized Access is Prohibited!
```

```
^C
!
line con 0
```

Lab – Configuring and Verifying IPv6 ACLs

```
password 7 070C285F4D06
login
line vty 0 4
password 7 070C285F4D06
login local
transport input telnet ssh
line vty 5 15
password 7 070C285F4D06
login local
transport input telnet ssh
!
end
```

Router R1 (Final)

```
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
ip domain name ccna-lab.com
ip cef
ipv6 unicast-routing
no ipv6 cef
multilink bundle-name authenticated
!
username admin privilege 15 secret 4 ZmhI/vTsQqF92f2bJfMu8RX1Xe6PaPPHjIushdB4qQo
!
interface GigabitEthernet0/0
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:B::1/64
!
interface GigabitEthernet0/1
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
ipv6 traffic-filter RESTRICTED-LAN out
!
```

Lab – Configuring and Verifying IPv6 ACLs

```
interface Serial0/0/0
no ip address
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:AAAA:1::1/64
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ipv6 route ::/0 Serial0/0/0
!
ipv6 access-list RESTRICT-VTY
permit tcp 2001:DB8:ACAD:A::/64 any
permit tcp any any eq 22
!
ipv6 access-list RESTRICTED-LAN
remark Block Telnet from users not on LAN.
deny tcp any 2001:DB8:ACAD:A::/64 eq telnet
sequence 25 permit tcp 2001:DB8:ACAD:B::/64 host 2001:DB8:ACAD:A::A eq telnet
sequence 30 permit ipv6 any any
!
control-plane
!
banner motd ^C
```

Unauthorized Access is Prohibited!

```
^C
!
line con 0
password 7 02050D480809
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
ipv6 access-class RESTRICT-VTY in
login local
```

Lab – Configuring and Verifying IPv6 ACLs

```
transport input telnet ssh
!
scheduler allocate 20000 1000
!
end
```



FTP Denied (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Implement packet filtering using extended IPv4 ACLs according to networking requirements (to include named and numbered ACLs).

Students will use Packet Tracer to write and apply an ACL to deny a particular host from accessing the FTP process on their small- to medium-size business network.

Scenario

It was recently reported that viruses are on the rise within your small- to medium-sized business network. Your network administrator has been tracking network performance and has determined that one particular host is constantly downloading files from a remote FTP server. This host just may be the virus source perpetuating throughout the network!

Use Packet Tracer to complete this activity. Write a named ACL to deny the host access to the FTP server. Apply the ACL to the most effective interface on the router.

To complete the physical topology, you must use:

- One PC host station
- Two switches
- One Cisco 1941 series Integrated Services Router
- One server

Using the Packet Tracer text tool, record the ACL you prepared. Validate that the ACL works to deny access to the FTP server by trying to access the FTP server's address. Observe what happens while in simulation mode. Save your file and be prepared to share it with another student, or with the entire class. (**Instructor choice**)

Reflection

1. What was the most difficult part of completing this modeling activity?

Answers will vary – writing the ACL, naming it, applying it, changing it, etc.

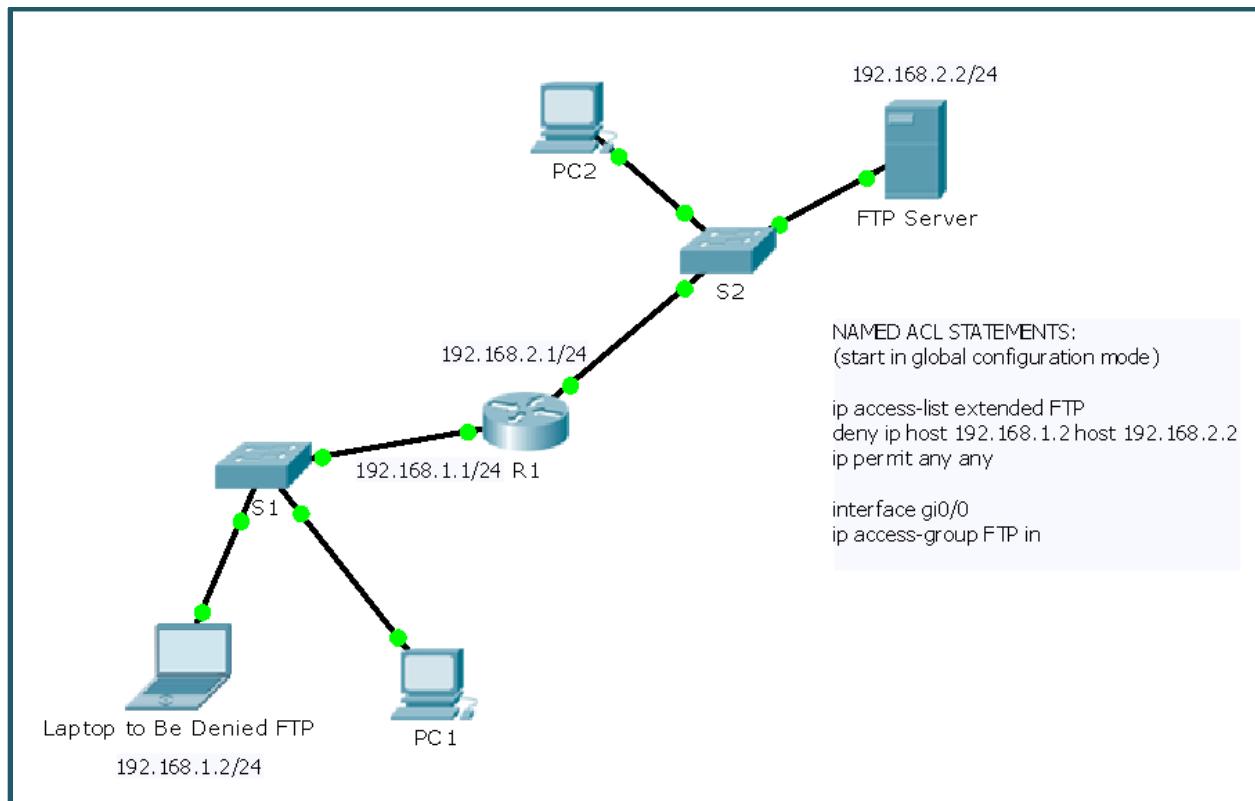
2. How often do you think network administrators need to change their ACLs on their networks?

ACLs are implemented to address security issues, regulate network traffic, and provide stability to the operation of a network. Therefore, any time network performance, security and stability degrade, ACLs should be considered as one way to mitigate those network challenges.

3. Why would you consider using a named extended ACL instead of a regular extended ACL?

Named ACLs are easy to correct or change – you can edit the ACL statements by line and use the “no...” command. This saves time in having to rewrite and reapply an entire ACL to a network.

Packet Tracer Example (topology, ACL names and IP addresses will vary)



Instructor Note: Identify elements of the model that map to IT-related content:

- ACLs are processes that determine whether to permit or deny network traffic.
- Criteria must be established in advance of permitting or denying network traffic.
- The order of importance must be established when developing criteria for permitting or denying network participation.
- A named ACL saves time vs. using a regular extended or standard ACL if when corrections must be made to the configuration of the ACL or to its placement.
- ACLs must be tested for the validity of their operation, as an ACL may need to be rewritten and/or reapplied correctly if it does not work correctly.



Own or Lease? (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure DHCP for IPv4 on a LAN switch.

In preparation of learning DHCP in this chapter, students will visit a Linksys tutorial web site, <http://ui.linksys.com/WRT54GL/4.30.0/Setup.htm>. They will use the simulation on this site to practice how to configure IPv4 on a simple ISR LAN switch.

Scenario

This chapter presents the concept of using the DHCP process in a small- to medium-sized business network. This modeling activity describes how very basic wireless ISR devices work using the DHCP process.

Visit <http://ui.linksys.com/WRT54GL/4.30.0/Setup.htm>, which is a web-based simulator that helps you learn to configure DHCP using a Linksys wireless 54GL router. To the right of the simulator (in the blue description column), you can click **More** to read information about configuring DHCP settings on this particular integrated services router (ISR) simulator.

Practice configuring the ISR's:

- Hostname
- Local IP address with subnet mask
- DHCP (enable and disable)
- Starting IP address
- Maximum number of users to receive an IP DHCP address
- Lease time
- Time zone (use yours or a favorite as an alternative)

When you have completed configuring the settings as listed for this assignment, take a screen shot of your settings by using the **PrtScr** key command. Copy and place your screen shot into a word processing document. Save it and be prepared to discuss your configuration choices with the class.

Required Resources

Internet connectivity

Reflection

1. Why would any network administrator need to save a bank of IP addresses for DHCP **not** to use?

Some IP addresses need to be reserved for important equipment, such as network printers, ports on network routers, and servers.

2. You are designing your small- to medium-sized network and you have a choice as to whether to buy a small, generic ISR for DHCP purposes, or use a DHCP full server. Before you read this chapter, how would you make your decision?

Students will probably mention cost, mobility, ease of use. They may also want to mention security and configuration options as other answers.

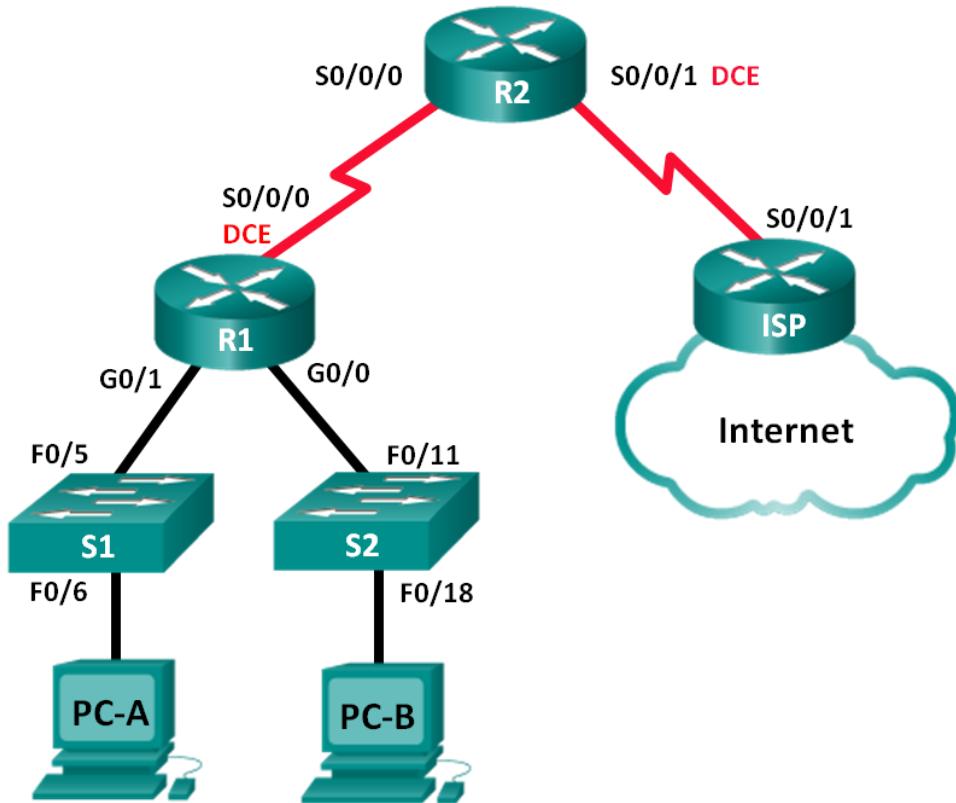
Identify elements of the model that map to IT-related content:

- Wireless routers may be used as DHCP servers.
- Wireless routers can be changed to respect different lease times for IP assignments.
- Some wireless routers function as both routers and switches (ISRs).
- It is good practice to keep a bank of IP addresses within a network for important static end device IP addressing and for specific users.

Lab - Configuring Basic DHCPv4 on a Router (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.0	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.2.253	255.255.255.252	N/A
R2	S0/0/0	192.168.2.254	255.255.255.252	N/A
	S0/0/1 (DCE)	209.165.200.226	255.255.255.224	N/A
ISP	S0/0/1	209.165.200.225	255.255.255.224	N/A
PC-A	NIC	DHCP	DHCP	DHCP
PC-B	NIC	DHCP	DHCP	DHCP

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure a DHCPv4 Server and a DHCP Relay Agent

Background / Scenario

The Dynamic Host Configuration Protocol (DHCP) is a network protocol that lets network administrators manage and automate the assignment of IP addresses. Without DHCP, the administrator must manually assign and configure IP addresses, preferred DNS servers, and default gateways. As the network grows in size, this becomes an administrative problem when devices are moved from one internal network to another.

In this scenario, the company has grown in size, and the network administrators can no longer assign IP addresses to devices manually. Your job is to configure the R2 router to assign IPv4 addresses on two different subnets connected to router R1.

Note: This lab provides minimal assistance with the actual commands necessary to configure DHCP. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the routers and switches with basic settings, such as passwords and IP addresses. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup
- b. Configure the device name as shown in the topology.
- c. Assign **class** as the encrypted privileged EXEC mode password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Lab - Configuring Basic DHCPv4 on a Router

- f. Configure the IP addresses for all the router interfaces according to the Addressing Table.
- g. Configure the serial DCE interface on R1 and R2 with a clock rate of 128000.
- h. Configure EIGRP for R1.

```
R1(config)# router eigrp 1
R1(config-router)# network 192.168.0.0 0.0.0.255
R1(config-router)# network 192.168.1.0 0.0.0.255
R1(config-router)# network 192.168.2.252 0.0.0.3
R1(config-router)# no auto-summary
```

- i. Configure EIGRP and a default route to the ISP on R2.

```
R2(config)# router eigrp 1
R2(config-router)# network 192.168.2.252 0.0.0.3
R2(config-router)# redistribute static
R2(config-router)# exit
R2(config)# ip route 0.0.0.0 0.0.0.0 209.165.200.225
```

- j. Configure a summary static route on ISP to reach the networks on the R1 and R2 routers.

```
ISP(config)# ip route 192.168.0.0 255.255.252.0 209.165.200.226
```

- k. Copy the running configuration to the startup configuration.

Step 4: Verify network connectivity between the routers.

If any pings between routers fail, correct the errors before proceeding to the next step. Use **show ip route** and **show ip interface brief** to locate possible issues.

Step 5: Verify the host PCs are configured for DHCP.

Part 2: Configure a DHCPv4 Server and a DHCP Relay Agent

To automatically assign address information on the network, you will configure R2 as a DHCPv4 server and R1 as a DHCP relay agent.

Step 1: Configure DHCPv4 server settings on router R2.

On R2, you will configure a DHCP address pool for each of the R1 LANs. Use the pool name **R1G0** for the G0/0 LAN and **R1G1** for the G0/1 LAN. You will also configure the addresses to be excluded from the address pools. Best practice dictates that excluded addresses be configured first, to guarantee that they are not accidentally leased to other devices.

Exclude the first 9 addresses in each R1 LAN starting with .1. All other addresses should be available in the DHCP address pool. Make sure that each DHCP address pool includes a default gateway, the domain **ccna-lab.com**, a DNS server (209.165.200.225), and a lease time of 2 days.

On the lines below, write the commands necessary for configuring DHCP services on router R2, including the DHCP-excluded addresses and the DHCP address pools.

Note: The required commands for Part 2 are provided in Appendix A. Test your knowledge by trying to configure DHCP on R1 and R2 without referring to the appendix.

Lab - Configuring Basic DHCPv4 on a Router

```
R2(config) # ip dhcp excluded-address 192.168.0.1 192.168.0.9
R2(config) # ip dhcp excluded-address 192.168.1.1 192.168.1.9
R2(config) # ip dhcp pool R1G1
R2(dhcp-config) # network 192.168.1.0 255.255.255.0
R2(dhcp-config) # default-router 192.168.1.1
R2(dhcp-config) # dns-server 209.165.200.225
R2(dhcp-config) # domain-name ccna-lab.com
R2(dhcp-config) # lease 2
R2(dhcp-config) # exit
R2(config) # ip dhcp pool R1G0
R2(dhcp-config) # network 192.168.0.0 255.255.255.0
R2(dhcp-config) # default-router 192.168.0.1
R2(dhcp-config) # dns-server 209.165.200.225
R2(dhcp-config) # domain-name ccna-lab.com
R2(dhcp-config) # lease 2
```

On PC-A or PC-B, open a command prompt and enter the **ipconfig /all** command. Did either of the host PCs receive an IP address from the DHCP server? Why?

The host computers will not have received IP addresses from the DHCP server at R2 until R1 is configured as a DHCP relay agent.

Step 2: Configure R1 as a DHCP relay agent.

Configure IP helper addresses on R1 to forward all DHCP requests to the R2 DHCP server.

On the lines below, write the commands necessary to configure R1 as a DHCP relay agent for the R1 LANs.

Lab - Configuring Basic DHCPv4 on a Router

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.2.254
R1(config-if)# exit
R1(config)# interface g0/1
R1(config-if)# ip helper-address 192.168.2.254
```

Step 3: Record IP settings for PC-A and PC-B.

On PC-A and PC-B, issue the **ipconfig /all** command to verify that the PCs have received IP address information from the DHCP server on R2. Record the IP and MAC address for each PC.

Answers may vary.

Based on the DHCP pool that was configured on R2, what are the first available IP addresses that PC-A and PC-B can lease?

PC-B: 192.168.0.10, and PC-A: 192.168.1.10

Step 4: Verify DHCP services and address leases on R2.

- On R2, enter the **show ip dhcp binding** command to view DHCP address leases.

```
R2# show ip dhcp binding
Bindings from all pools not associated with VRF:
  IP address          Client-ID/           Lease expiration      Type
                           Hardware address/
                           User name
  192.168.0.10        011c.clde.91c3.5d    Mar 13 2013 02:07 AM  Automatic
  192.168.1.10        0100.2170.0c05.0c    Mar 13 2013 02:09 AM  Automatic
```

Along with the IP addresses that were leased, what other piece of useful client identification information is in the output?

The client hardware addresses identify the specific computers that have joined the network.

- On R2, enter the **show ip dhcp server statistics** command to view the DHCP pool statistics and message activity.

```
R2# show ip dhcp server statistics
Memory usage            42175
Address pools           2
Database agents         0
Automatic bindings      2
Manual bindings         0
Expired bindings        0
Malformed messages     0
Secure arp entries      0

Message                Received
BOOTREQUEST             0
DHCPDISCOVER            2
DHCPREQUEST             2
```

Lab - Configuring Basic DHCPv4 on a Router

```
DHCPDECLINE      0
DHCPRELEASE      0
DHCPINFORM       2

Message          Sent
BOOTREPLY        0
DHCPoffer        2
DHCPACK          4
DHCPNAK          0
```

How many types of DHCP messages are listed in the output?

Ten different types of DHCP messages are listed.

- c. On R2, enter the **show ip dhcp pool** command to view the DHCP pool settings.

```
R2# show ip dhcp pool
```

```
Pool R1G1 :
  Utilization mark (high/low)      : 100 / 0
  Subnet size (first/next)         : 0 / 0
  Total addresses                 : 254
  Leased addresses                : 1
  Pending event                   : none
  1 subnet is currently in the pool :
    Current index      IP address range           Leased addresses
    192.168.1.11       192.168.1.1      - 192.168.1.254     1

Pool R1G0 :
  Utilization mark (high/low)      : 100 / 0
  Subnet size (first/next)         : 0 / 0
  Total addresses                 : 254
  Leased addresses                : 1
  Pending event                   : none
  1 subnet is currently in the pool :
    Current index      IP address range           Leased addresses
    192.168.0.11       192.168.0.1      - 192.168.0.254     1
```

In the output of the **show ip dhcp pool** command, what does the Current index refer to?

The next available address for leasing

- d. On R2, enter the **show run | section dhcp** command to view the DHCP configuration in the running configuration.

```
R2# show run | section dhcp
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp excluded-address 192.168.1.1 192.168.1.9
ip dhcp pool R1G1
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.1
  domain-name ccna-lab.com
```

Lab - Configuring Basic DHCPv4 on a Router

```
dns-server 209.165.200.225
lease 2
ip dhcp pool R1G0
network 192.168.0.0 255.255.255.0
default-router 192.168.0.1
domain-name ccna-lab.com
dns-server 209.165.200.225
lease 2
```

- e. On R2, enter the **show run interface** command for interfaces G0/0 and G0/1 to view the DHCP relay configuration in the running configuration.

```
R2# show run interface g0/0
Building configuration...

Current configuration : 132 bytes
!
interface GigabitEthernet0/0
 ip address 192.168.0.1 255.255.255.0
 ip helper-address 192.168.2.254
 duplex auto
 speed auto
end
```

```
R2# show run interface g0/1
Building configuration...

Current configuration : 132 bytes
!
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
 ip helper-address 192.168.2.254
 duplex auto
 speed auto
end
```

Reflection

What do you think is the benefit of using DHCP relay agents instead of multiple routers acting as DHCP servers?

Having a separate router DHCP server for each subnet would add more complexity and decrease centralized management for the network. It would also require that each router work harder to manage its own DHCP addressing, in addition to the primary function of routing traffic. One DHCP server (router or computer) that is dedicated to the job is easier to manage and more centralized.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A – DHCP Configuration Commands

Router R1

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.2.254
R1(config-if)# exit
R1(config-if)# interface g0/1
R1(config-if)# ip helper-address 192.168.2.254
```

Router R2

```
R2(config)# ip dhcp excluded-address 192.168.0.1 192.168.0.9
R2(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.9
R2(config)# ip dhcp pool R1G1
R2(dhcp-config)# network 192.168.1.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.1.1
R2(dhcp-config)# dns-server 209.165.200.225
R2(dhcp-config)# domain-name ccna-lab.com
R2(dhcp-config)# lease 2
R2(dhcp-config)# exit
R2(config)# ip dhcp pool R1G0
R2(dhcp-config)# network 192.168.0.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.0.1
R2(dhcp-config)# dns-server 209.165.200.225
R2(dhcp-config)# domain-name ccna-lab.com
```

```
R2 (dhcp-config) # lease 2
```

Device Configs

Router R1

```
R1# show run
Building configuration...

Current configuration : 1478 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
```

Lab - Configuring Basic DHCPv4 on a Router

```
!
interface GigabitEthernet0/0
 ip address 192.168.0.1 255.255.255.0
 ip helper-address 192.168.2.254
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
 ip helper-address 192.168.2.254
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 192.168.2.253 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 no ip address
 shutdown!
!
router eigrp 1
 network 192.168.0.0
 network 192.168.1.0
 network 192.168.2.252 0.0.0.3
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
```

Lab - Configuring Basic DHCPv4 on a Router

```
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2# show run
Building configuration...

Current configuration : 1795 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
!
!
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp excluded-address 192.168.1.1 192.168.1.9
!
ip dhcp pool R1G1
network 192.168.1.0 255.255.255.0
default-router 192.168.1.1
domain-name ccna-lab.com
dns-server 209.165.200.225
lease 2
!
ip dhcp pool R1G0
network 192.168.0.0 255.255.255.0
default-router 192.168.0.1
domain-name ccna-lab.com
```

Lab - Configuring Basic DHCPv4 on a Router

```
dns-server 209.165.200.225
lease 2
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.2.254 255.255.255.252
!
interface Serial0/0/1
ip address 209.165.200.226 255.255.255.224
clock rate 128000
!
!
router eigrp 1
network 192.168.2.252 0.0.0.3
redistribute static
!
ip forward-protocol nd
```

Lab - Configuring Basic DHCPv4 on a Router

```
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 209.165.200.225
!
!
!
!
control-plane
!
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router ISP

```
ISP#show run
Building configuration...

Current configuration : 1247 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
```

Lab - Configuring Basic DHCPv4 on a Router

```
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 10
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
```

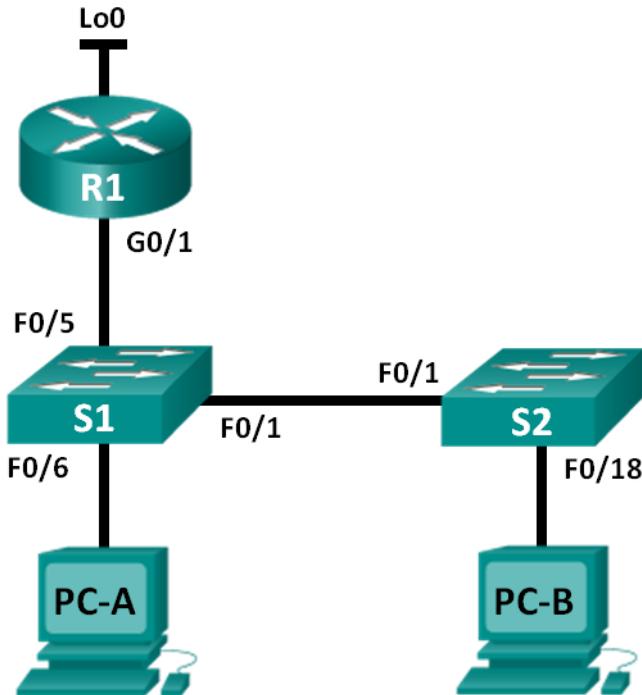
Lab - Configuring Basic DHCPv4 on a Router

```
ip address 209.165.200.225 255.255.255.224
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.0.0 255.255.252.0 209.165.200.226
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring Basic DHCPv4 on a Switch (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
R1	G0/1	192.168.1.10	255.255.255.0
	Lo0	209.165.200.225	255.255.255.224
S1	VLAN 1	192.168.1.1	255.255.255.0
	VLAN 2	192.168.2.1	255.255.255.0

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Change the SDM Preference

- Set the SDM preference to lanbase-routing on S1.

Part 3: Configure DHCPv4

- Configure DHCPv4 for VLAN 1.
- Verify DHCPv4 and connectivity.

Part 4: Configure DHCP for Multiple VLANs

- Assign ports to VLAN 2.
- Configure DHCPv4 for VLAN 2.
- Verify DHCPv4 and connectivity.

Part 5: Enable IP Routing

- Enable IP routing on the switch.
- Create static routes.

Background / Scenario

A Cisco 2960 switch can function as a DHCPv4 server. The Cisco DHCPv4 server assigns and manages IPv4 addresses from identified address pools that are associated with specific VLANs and switch virtual interfaces (SVIs). The Cisco 2960 switch can also function as a Layer 3 device and route between VLANs and a limited number of static routes. In this lab, you will configure DHCPv4 for both single and multiple VLANs on a Cisco 2960 switch, enable routing on the switch to allow for communication between VLANs, and add static routes to allow for communication between all hosts.

Note: This lab provides minimal assistance with the actual commands necessary to configure DHCP. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switches.

Step 3: Configure basic setting on devices.

- a. Assign device names as shown in the topology.
- b. Disable DNS lookup.
- c. Assign **class** as the enable password and assign **cisco** as the console and vty passwords.

- d. Configure the IP addresses on R1 G0/1 and Lo0 interfaces, according to the Addressing Table.
- e. Configure the IP addresses on S1 VLAN 1 and VLAN 2 interfaces, according to the Addressing Table.
- f. Save the running configuration to the startup configuration file.

Part 2: Change the SDM Preference

The Cisco Switch Database Manager (SDM) provides multiple templates for the Cisco 2960 switch. The templates can be enabled to support specific roles depending on how the switch is used in the network. In this lab, the sdm lanbase-routing template is enabled to allow the switch to route between VLANs and to support static routing.

Step 1: Display the SDM preference on S1.

On S1, issue the **show sdm prefer** command in privileged EXEC mode. If the template has not been changed from the factory default, it should still be the **default** template. The **default** template does not support static routing. If IPv6 addressing has been enabled, the template will be **dual-ipv4-and-ipv6 default**.

```
S1# show sdm prefer
```

```
The current template is "default" template.  
The selected template optimizes the resources in  
the switch to support this level of features for  
0 routed interfaces and 255 VLANs.
```

number of unicast mac addresses:	8K
number of IPv4 IGMP groups:	0.25K
number of IPv4/MAC qos aces:	0.125k
number of IPv4/MAC security aces:	0.375k

```
S1# show sdm prefer
```

```
The current template is "dual-ipv4-and-ipv6 default" template.  
The selected template optimizes the resources in  
the switch to support this level of features for  
0 routed interfaces and 255 VLANs.
```

number of unicast mac addresses:	4K
number of IPv4 IGMP groups + multicast routes:	0.25K
number of IPv4 unicast routes:	0
number of IPv6 multicast groups:	0.375k
number of directly-connected IPv6 addresses:	0
number of indirect IPv6 unicast routes:	0
number of IPv4 policy based routing aces:	0
number of IPv4/MAC qos aces:	0.125k
number of IPv4/MAC security aces:	0.375k
number of IPv6 policy based routing aces:	0
number of IPv6 qos aces:	0.625k
number of IPv6 security aces:	125

```
S1# show sdm prefer
```

```
The current template is "lanbase-routing" template.  
The selected template optimizes the resources in
```

Lab – Configuring Basic DHCPv4 on a Switch

the switch to support this level of features for 0 routed interfaces and 255 VLANs.

number of unicast mac addresses:	4K
number of IPv4 IGMP groups + multicast routes:	0.25K
number of IPv4 unicast routes:	0.75K
number of directly-connected IPv4 hosts:	0.75K
number of indirect IPv4 routes:	16
number of IPv6 multicast groups:	0.375k
number of directly-connected IPv6 addresses:	0.75K
number of indirect IPv6 unicast routes:	16
number of IPv4 policy based routing aces:	0
number of IPv4/MAC qos aces:	0.125k
number of IPv4/MAC security aces:	0.375k
number of IPv6 policy based routing aces:	0
number of IPv6 qos aces:	0.375k
number of IPv6 security aces:	127

What is the current template?

Answers will vary. "default" or "dual-ipv4-and-ipv6 default" or "lanbase-routing".

Step 2: Change the SDM Preference on S1.

- Set the SDM preference to **lanbase-routing**. (If lanbase-routing is the current template, please proceed to Part 3.) From global configuration mode, issue the **sdm prefer lanbase-routing** command.

```
S1(config)# sdm prefer lanbase-routing
```

Changes to the running SDM preferences have been stored, but cannot take effect until the next reload.

Use 'show sdm prefer' to see what SDM preference is currently active.

```
S1# show sdm prefer
```

The current template is "default" template.

The selected template optimizes the resources in the switch to support this level of features for 0 routed interfaces and 255 VLANs.

number of unicast mac addresses:	8K
number of IPv4 IGMP groups:	0.25K
number of IPv4/MAC qos aces:	0.125k
number of IPv4/MAC security aces:	0.375k

On next reload, template will be "lanbase-routing" template.

Which template will be available after reload? _____

lanbase-routing

- The switch must be reloaded for the template to be enabled.

```
S1# reload
```

System configuration has been modified. Save? [yes/no]: no

Proceed with reload? [confirm]

Lab – Configuring Basic DHCPv4 on a Switch

Note: The new template will be used after reboot even if the running configuration has not been saved. To save the running configuration, answer **yes** to save the modified system configuration.

Step 3: Verify that lanbase-routing template is loaded.

Issue the **show sdm prefer** command to verify that the lanbase-routing template has been loaded on S1.

```
S1# show sdm prefer
The current template is "lanbase-routing" template.
The selected template optimizes the resources in
the switch to support this level of features for
0 routed interfaces and 255 VLANs.

number of unicast mac addresses: 4K
number of IPv4 IGMP groups + multicast routes: 0.25K
number of IPv4 unicast routes: 0.75K
    number of directly-connected IPv4 hosts: 0.75K
    number of indirect IPv4 routes: 16
number of IPv6 multicast groups: 0.375k
number of directly-connected IPv6 addresses: 0.75K
    number of indirect IPv6 unicast routes: 16
number of IPv4 policy based routing aces: 0
number of IPv4/MAC qos aces: 0.125k
number of IPv4/MAC security aces: 0.375k
number of IPv6 policy based routing aces: 0
number of IPv6 qos aces: 0.375k
number of IPv6 security aces: 127
```

Part 3: Configure DHCPv4

In Part 3, you will configure DHCPv4 for VLAN 1, check IP settings on host computers to validate DHCP functionality, and verify connectivity for all devices in VLAN 1.

Step 1: Configure DHCP for VLAN 1.

- Exclude the first 10 valid host addresses from network 192.168.1.0/24. Write the command you used in the space provided.

```
S1(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.10
```

- Create a DHCP pool named **DHCP1**. Write the command you used in the space provided.

```
S1(config)# ip dhcp pool DHCP1
```

- Assign the network 192.168.1.0/24 for available addresses. Write the command you used in the space provided.

```
S1(dhcp-config)# network 192.168.1.0 255.255.255.0
```

- Assign the default gateway as 192.168.1.1. Write the command you used in the space provided.

Lab – Configuring Basic DHCPv4 on a Switch

```
S1(dhcp-config) # default-router 192.168.1.1
```

- e. Assign the DNS server as 192.168.1.9. Write the command you used in the space provided.
-

```
S1(dhcp-config) # dns-server 192.168.1.9
```

- f. Assign a lease time of 3 days. Write the command you used in the space provided.
-

```
S1(dhcp-config) # lease 3
```

- g. Save the running configuration to the startup configuration file.

Step 2: Verify DHCP and connectivity.

- a. On PC-A and PC-B, open the command prompt and issue the **ipconfig** command. If IP information is not present, or if it is incomplete, issue the **ipconfig /release** command, followed by the **ipconfig /renew** command.

For PC-A, list the following:

IP Address: _____ 192.168.1.11

Subnet Mask: _____ 255.255.255.0

Default Gateway: _____ 192.168.1.1

For PC-B, list the following:

IP Address: _____ 192.168.1.12

Subnet Mask: _____ 255.255.255.0

Default Gateway: _____ 192.168.1.1

- b. Test connectivity by pinging from PC-A to the default gateway, PC-B, and R1.

From PC-A, is it possible to ping the VLAN 1 default gateway? _____ Yes

From PC-A, is it possible to ping PC-B? _____ Yes

From PC-A, is it possible to ping R1 G0/1? _____ Yes

If the answer is no to any of these questions, troubleshoot the configurations and correct the error.

Part 4: Configure DHCPv4 for Multiple VLANs

In Part 4, you will assign PC-A to a port accessing VLAN 2, configure DHCPv4 for VLAN 2, renew the IP configuration of PC-A to validate DHCPv4, and verify connectivity within the VLAN.

Step 1: Assign a port to VLAN 2.

Place port F0/6 into VLAN 2. Write the command you used in the space provided.

```
S1(config) # interface f0/6
S1(config-if) # switchport access vlan 2
```

Step 2: Configure DHCPv4 for VLAN 2

- a. Exclude the first 10 valid host addresses from network 192.168.2.0. Write the command you used in the space provided.

```
S1(config)# ip dhcp excluded-address 192.168.2.1 192.168.2.10
```

- b. Create a DHCP pool named **DHCP2**. Write the command you used in the space provided.

```
S1(config)# ip dhcp pool DHCP2
```

- c. Assign the network 192.168.2.0/24 for available addresses. Write the command you used in the space provided.

```
S1(dhcp-config)# network 192.168.2.0 255.255.255.0
```

- d. Assign the default gateway as 192.168.2.1. Write the command you used in the space provided.

```
S1(dhcp-config)# default-router 192.168.2.1
```

- e. Assign the DNS server as 192.168.2.9. Write the command you used in the space provided.

```
S1(dhcp-config)# dns-server 192.168.2.9
```

- f. Assign a lease time of 3 days. Write the command you used in the space provided.

```
S1(dhcp-config)# lease 3
```

- g. Save the running configuration to the startup configuration file.

Step 3: Verify DHCPv4 and connectivity.

- a. On PC-A, open the command prompt and issue the **ipconfig /release** command, followed by **ipconfig /renew** command.

For PC-A, list the following:

IP Address: _____ 192.168.2.11

Subnet Mask: _____ 255.255.255.0

Default Gateway: _____ 192.168.2.1

- b. Test connectivity by pinging from PC-A to the VLAN 2 default gateway and PC-B.

From PC-A, is it possible to ping the default gateway? _____ Yes

From PC-A, is it possible to ping PC-B? _____ No

Were these pings successful? Why?

Because the default gateway is in the same network as PC-A, PC-A can ping the default gateway. PC-B is in a different network; therefore, the ping from PC-A is not successful.

- c. Issue the **show ip route** command on S1.

```
S1# show ip route
Default gateway is not set

Host           Gateway           Last Use   Total Uses  Interface
ICMP redirect cache is empty
```

What was the result of this command?

No default gateway has been set and no routing table is present on the switch.

Part 5: Enable IP Routing

In Part 5, you will enable IP routing on the switch, which will allow for inter-VLAN communication. For all networks to communicate, static routes on S1 and R1 must be implemented.

Step 1: Enable IP routing on S1.

- From global configuration mode, use the **ip routing** command to enable routing on S1.

```
S1(config)# ip routing
```

- Verify inter-VLAN connectivity.

From PC-A, is it possible to ping PC-B? _____ **Yes**

What function is the switch performing?

The switch is routing between VLANs.

- View the routing table information for S1.

```
S1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
    192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, Vlan1
L        192.168.1.1/32 is directly connected, Vlan1
    192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, Vlan2
L        192.168.2.1/32 is directly connected, Vlan2
```

What route information is contained in the output of this command?

Lab – Configuring Basic DHCPv4 on a Switch

The switch exhibits a routing table showing VLANs as directly connected networks 192.168.1.0/24 and 192.168.2.0/24.

- d. View the routing table information for R1.

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.10/32 is directly connected, GigabitEthernet0/1
      209.165.200.0/27 is variably subnetted, 2 subnets, 2 masks
C        209.165.200.0/27 is directly connected, Loopback0
L        209.165.200.225/32 is directly connected, Loopback0
```

What route information is contained in the output of this command?

The router output shows directly connected networks of 192.168.1.0 and to 209.165.200.224 but has no entry for the 192.168.2.0 network.

- e. From PC-A, is it possible to ping R1? _____ No

From PC-A, is it possible to ping Lo0? _____ No

Consider the routing table of the two devices, what must be added to communicate between all networks?

In order for communication to occur between all networks, routes must be added to the routing tables.

Step 2: Assign static routes.

Enabling IP routing allows the switch to route between VLANs assigned on the switch. For all VLANs to communicate with the router, static routes must be added to the routing table of both the switch and the router.

- a. On S1, create a default static route to R1. Write the command you used in the space provided.
-

```
S1(config)# ip route 0.0.0.0 0.0.0.0 192.168.1.10
```

- b. On R1, create a static route to VLAN 2. Write the command you used in the space provided.
-

Lab – Configuring Basic DHCPv4 on a Switch

```
R1(config)# ip route 192.168.2.0 255.255.255.0 g0/1
```

- c. View the routing table information for S1.

```
S1# show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP  
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area  
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2  
E1 - OSPF external type 1, E2 - OSPF external type 2  
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2  
ia - IS-IS inter area, * - candidate default, U - per-user static route  
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP  
+ - replicated route, % - next hop override
```

```
Gateway of last resort is 192.168.1.10 to network 0.0.0.0
```

```
S*    0.0.0.0/0 [1/0] via 192.168.1.10  
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.1.0/24 is directly connected, Vlan1  
L      192.168.1.1/32 is directly connected, Vlan1  
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.2.0/24 is directly connected, Vlan2  
L      192.168.2.1/32 is directly connected, Vlan2
```

How is the default static route represented?

```
Gateway of last resort is 192.168.1.10 to network 0.0.0.0
```

- d. View the routing table information for R1.

```
R1# show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP  
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area  
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2  
E1 - OSPF external type 1, E2 - OSPF external type 2  
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2  
ia - IS-IS inter area, * - candidate default, U - per-user static route  
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP  
+ - replicated route, % - next hop override
```

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

```
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks  
C      192.168.1.0/24 is directly connected, GigabitEthernet0/1  
L      192.168.1.10/32 is directly connected, GigabitEthernet0/1  
S      192.168.2.0/24 is directly connected, GigabitEthernet0/1  
      209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks  
C      209.165.200.0/27 is directly connected, Loopback0  
L      209.165.200.225/32 is directly connected, Loopback0
```

How is the static route represented?

Lab – Configuring Basic DHCPv4 on a Switch

S 192.168.2.0/24 is directly connected, GigabitEthernet0/1

- e. From PC-A, is it possible to ping R1? _____ Yes
From PC-A, is it possible to ping Lo0? _____ Yes

Reflection

1. In configuring DHCPv4, why would you exclude the static addresses prior to setting up the DHCPv4 pool?

If the static addresses were excluded after the DHCPv4 pool was created, a window of time exists where the excluded addresses could be given out dynamically to hosts.

2. If multiple DHCPv4 pools are present, how does the switch assign the IP information to hosts?

The switch will assign IP configurations based on the VLAN assignment of the port to which the host is connected.

3. Besides switching, what functions can the Cisco 2960 switch perform?

The switch can function as a DHCP server and can perform static and inter-VLAN routing.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Configuration Commands

Configure DHCPv4

```
S1(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.10
S1(config)# ip dhcp pool DHCP1
S1(dhcp-config)# network 192.168.1.0 255.255.255.0
S1(dhcp-config)# default-router 192.168.1.1
S1(dhcp-config)# dns-server 192.168.1.9
S1(dhcp-config)# lease 3
```

Configure DHCPv4 for Multiple VLANs

```
S1(config)# interface f0/6
S1(config-if)# switchport access vlan 2
S1(config)# ip dhcp excluded-address 192.168.2.1 192.168.2.10
S1(config)# ip dhcp pool DHCP2
S1(dhcp-config)# network 192.168.2.0 255.255.255.0
S1(dhcp-config)# default-router 192.168.2.1
S1(dhcp-config)# dns-server 192.168.2.9
S1(dhcp-config)# lease 3
```

Enable IP Routing

```
S1(config)# ip routing
S1(config)# ip route 0.0.0.0 0.0.0.0 192.168.1.10
R1(config)# ip route 192.168.2.0 255.255.255.0 g0/1
```

Device Configs

Router R1

```
R1#show run
Building configuration...

Current configuration : 1489 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.0
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
```

Lab – Configuring Basic DHCPv4 on a Switch

```
interface GigabitEthernet0/1
 ip address 192.168.1.10 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.2.0 255.255.255.0 GigabitEthernet0/1
!
!
!
!
control-plane
!
!
!
line con 0
 password cisco
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1#show run
Building configuration...

Current configuration : 3636 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
ip routing
ip dhcp excluded-address 192.168.1.1 192.168.1.10
ip dhcp excluded-address 192.168.2.1 192.168.2.10
!
ip dhcp pool DHCP1
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.1
  dns-server 192.168.1.9
  lease 3
!
ip dhcp pool DHCP2
  network 192.168.2.0 255.255.255.0
  default-router 192.168.2.1
  dns-server 192.168.2.9
  lease 3
!
!
no ip domain-lookup
!
!
crypto pki trustpoint TP-self-signed-2531409152
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-2531409152
  revocation-check none
  rsakeypair TP-self-signed-2531409152
!
!
crypto pki certificate chain TP-self-signed-2531409152
```

Lab – Configuring Basic DHCPv4 on a Switch

```
certificate self-signed 01
3082022B 30820194 A0030201 02020101 300D0609 2A864886 F70D0101 05050030
31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
69666963 6174652D 32353331 34303931 3532301E 170D3933 30333031 30303030
35365A17 0D323030 31303130 30303030 305A3031 312F302D 06035504 03132649
4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 35333134
30393135 3230819F 300D0609 2A864886 F70D0101 01050003 818D0030 81890281
8100CA1B 27DE634E CF9FE284 C86127EF 41E7A52F 0A82FA2B 7C5448B7 184EA1AB
C22510E1 38A742BC D9F416FD 93A52DC6 BA77A928 B317DA75 1B3E2C66 C2D9061B
806132D9 E3189012 467C7A2C DCAC3EF4 4C419338 790AA98B C7A81D73 8621536C
4A90659E 267BA2E3 36F801A4 F06BEC65 386A40DA 255D9790 F9412706 9E73A660
45230203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF 301F0603
551D2304 18301680 14A7356A D364AE65 E1E9D42F 9B059B27 B69BB9C6 FD301D06
03551D0E 04160414 A7356AD3 64AE65E1 E9D42F9B 059B27B6 9BB9C6FD 300D0609
2A864886 F70D0101 05050003 8181002A D78919E7 0D75567C EF60036C 6C4B051A
2ABC5B9C DA1C1E48 AF33C405 5C64E074 B954C5B5 D825BE61 7340C695 03049797
D869E516 3936D0EC C871F140 66A1DEB2 BA57AB0D D2AB2706 17674B3A 7423C276
B96CFB88 DE98A86E 7B539B68 7DEE53BB ED16BFA0 A89A5CA4 79F15F49 59DDF6E5
E716514A 5CFC7522 8E76778E 029E8F
quit
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
!
interface FastEthernet0/1
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
switchport access vlan 2
!
interface FastEthernet0/7
```

Lab – Configuring Basic DHCPv4 on a Switch

```
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.1 255.255.255.0
!
interface Vlan2
 ip address 192.168.2.1 255.255.255.0
!
ip http server
ip http secure-server
ip route 0.0.0.0 0.0.0.0 192.168.1.10
!
```

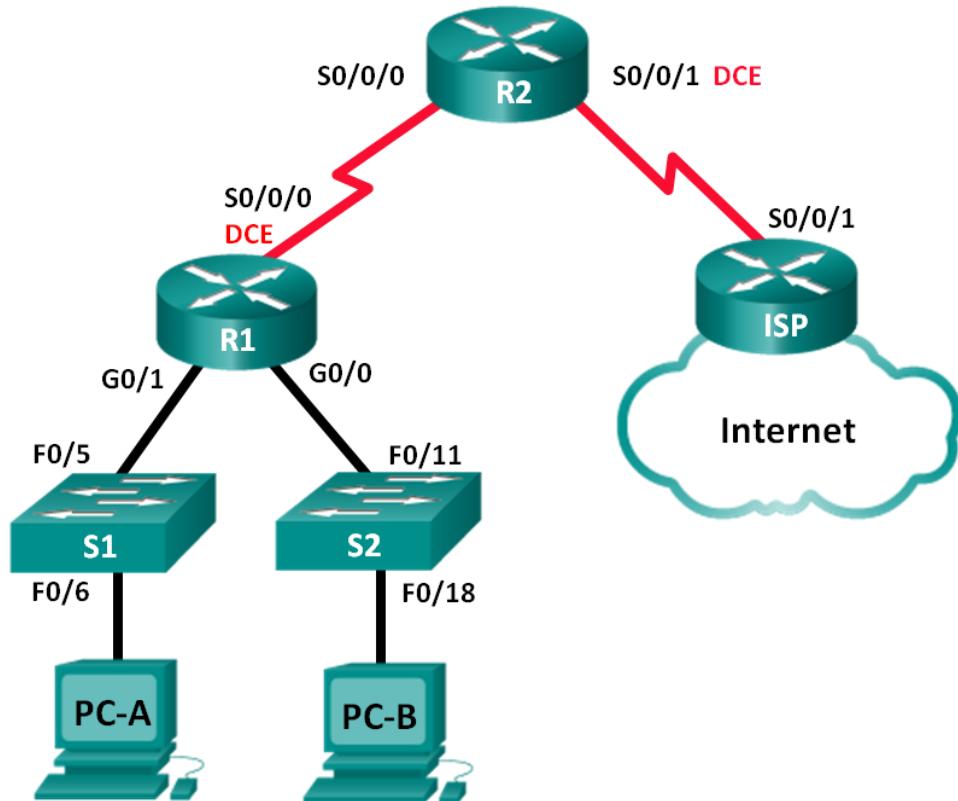
Lab – Configuring Basic DHCPv4 on a Switch

```
!
!
line con 0
password cisco
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Lab - Troubleshooting DHCPv4 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.128	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.0.253	255.255.255.252	N/A
R2	S0/0/0	192.168.0.254	255.255.255.252	N/A
	S0/0/1 (DCE)	209.165.200.226	255.255.255.252	N/A
ISP	S0/0/1	209.165.200.225	255.255.255.252	N/A
S1	VLAN 1	192.168.1.2	255.255.255.0	192.168.1.1
S2	VLAN 1	192.168.0.2	255.255.255.128	192.168.0.1
PC-A	NIC	DHCP	DHCP	DHCP
PC-B	NIC	DHCP	DHCP	DHCP

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot DHCPv4 Issues

Background / Scenario

The Dynamic Host Configuration Protocol (DHCP) is a network protocol that lets the network administrators manage and automate the assignment of IP addresses. Without DHCP, the administrator must manually assign and configure IP addresses, preferred DNS servers, and the default gateway. As the network grows in size, this becomes an administrative problem when devices are moved from one internal network to another.

In this scenario, the company has grown in size, and the network administrators can no longer assign IP addresses to devices manually. The R2 router has been configured as a DHCP server to assign IP addresses to the host devices on router R1 LANs. Several errors in the configuration have resulted in connectivity issues. You are asked to troubleshoot and correct the configuration errors and document your work.

Ensure that the network supports the following:

- 1) The router R2 should function as the DHCP server for the 192.168.0.0/25 and 192.168.1.0/24 networks connected to R1.
- 2) All PCs connected to S1 and S2 should receive an IP address in the correct network via DHCP.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Instructions for erasing the switches and routers are provided in the Lab Manual.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 2: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the routers and switches with basic settings, such as passwords and IP addresses. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.
- f. Configure the IP addresses for all the router interfaces.
- g. Set clock rate to **128000** for all DCE router interfaces.
- h. Configure EIGRP for R1.

```
R1(config)# router eigrp 1
R1(config-router)# network 192.168.0.0 0.0.0.127
R1(config-router)# network 192.168.0.252 0.0.0.3
R1(config-router)# network 192.168.1.0
R1(config-router)# no auto-summary
```

- i. Configure EIGRP and a static default route on R2.

```
R2(config)# router eigrp 1
R2(config-router)# network 192.168.0.252 0.0.0.3
R2(config-router)# redistribute static
R2(config-router)# exit
R2(config)# ip route 0.0.0.0 0.0.0.0 209.165.200.225
```

- j. Configure a summary static route on ISP to the networks on R1 and R2 routers.

```
ISP(config)# ip route 192.168.0.0 255.255.254.0 209.165.200.226
```

Step 4: Verify network connectivity between the routers.

If any pings between the routers fail, correct the errors before proceeding to the next step. Use **show ip route** and **show ip interface brief** to locate possible issues.

Step 5: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Configure the IP address for the VLAN 1 interface and the default gateway for each switch.
- d. Assign **class** as the privileged EXEC mode password.
- e. Assign **cisco** as the console and vty passwords.
- f. Configure **logging synchronous** for the console line.

Step 6: Verify the hosts are configured for DHCP.

Step 7: Load the initial DHCP configuration for R1 and R2.

Router R1

```
!interface GigabitEthernet0/0
! ip helper-address 192.168.0.254
interface GigabitEthernet0/1
    ip helper-address 192.168.0.253
! ip helper-address 192.168.0.254
```

Router R2

```
ip dhcp excluded-address 192.168.11.1 192.168.11.9
!ip dhcp excluded-address 192.168.1.1 192.168.1.9
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp pool R1G1
    network 192.168.1.0 255.255.255.0
    default-router 192.168.1.1
ip dhcp pool R1G0
    network 192.168.0.0 255.255.255.128
    default-router 192.168.11.1
!default-router 192.168.0.1
```

Part 3: Troubleshoot DHCPv4 Issues

After configuring routers R1 and R2 with DHCPv4 settings, several errors in the DHCP configurations were introduced and resulted in connectivity issues. R2 is configured as a DHCP server. For both pools of DHCP addresses, the first nine addresses are reserved for the routers and switches. R1 relays the DHCP information to all the R1 LANs. Currently, PC-A and PC-B have no access to the network. Use the **show** and **debug** commands to determine and correct the network connectivity issues.

Step 1: Record IP settings for PC-A and PC-B.

- a. For PC-A and PC-B, at the command prompt, enter **ipconfig /all** to display the IP and MAC addresses.
- b. Record the IP and MAC addresses in the table below. The MAC address can be used to determine which PC is involved in the debug message.

	IP Address/Subnet Mask	MAC Address
PC-A	No IP address is assigned by DHCP. (Students may record an APIPA address starting with 169.254.x.x. This is a private local address that Microsoft OS assigns when the host cannot reach a DHCP server to obtain an IP address.)	0050:56BE:768C
PC-B	No IP address is assigned by DHCP. (Students may record an APIPA address starting with 169.254.x.x. This is a private local address that Microsoft OS assigns when the host cannot reach a DHCP server to obtain an IP address.)	0050:56BE:F6DB

Step 2: Troubleshoot DHCP issues for the 192.168.1.0/24 network on router R1.

Router R1 is a DHCP relay agent for all the R1 LANs. In this step, only the DHCP process for the 192.168.1.0/24 network will be examined. The first nine addresses are reserved for other network devices, such as routers, switches, and servers.

- Use a DHCP **debug** command to observe the DHCP process on R2 router.

```
R2# debug ip dhcp server events
```

- On R1, display the running configuration for the G0/1 interface.

```
R1# show run interface g0/1
interface GigabitEthernet0/1
  ip address 192.168.1.1 255.255.255.0
  ip helper-address 192.168.0.253
  duplex auto
  speed auto
```

If there are any DHCP relay issues, record any commands that are necessary to correct the configurations errors.

DHCP relay was incorrectly configured for G0/1 interface. The command **ip helper-address 192.168.0.254** needs to be added to the R1 router. The incorrect helper address should be removed from the configuration. The issue can be resolved using the following commands:

```
R1(config)# interface g0/1
R1(config-if)## no ip helper-address 192.168.0.253
R1(config-if)# ip helper-address 192.168.0.254
```

- In a command prompt on PC-A, type **ipconfig /renew** to receive an address from the DHCP server. Record the configured IP address, subnet mask, and default gateway for PC-A.

IP address: 192.168.1.3, subnet mask: 255.255.255.0, default gateway: 192.168.1.1

Lab - Troubleshooting DHCPv4

- d. Observe the debug messages on R2 router for the DHCP renewal process for PC-A. The DHCP server attempted to assign 192.168.1.1/24 to PC-A. This address is already in use for G0/1 interface on R1. The same issue occurs with IP address 192.168.1.2/24 because this address has been assigned to S1 in the initial configuration. Therefore, an IP address of 192.168.1.3/24 has been assigned to PC-A. The DHCP assignment conflict indicates there may be an issue with the excluded-address statement on the DHCP server configuration on R2.

```
*Mar  5 06:32:16.939: DHCPD: Sending notification of DISCOVER:  
*Mar  5 06:32:16.939:   DHCPD: htype 1 chaddr 0050.56be.768c  
*Mar  5 06:32:16.939:   DHCPD: circuit id 00000000  
*Mar  5 06:32:16.939: DHCPD: Seeing if there is an internally specified pool class:  
*Mar  5 06:32:16.939:   DHCPD: htype 1 chaddr 0050.56be.768c  
*Mar  5 06:32:16.939:   DHCPD: circuit id 00000000  
*Mar  5 06:32:16.943: DHCPD: Allocated binding 2944C764  
*Mar  5 06:32:16.943: DHCPD: Adding binding to radix tree (192.168.1.1)  
*Mar  5 06:32:16.943: DHCPD: Adding binding to hash tree  
*Mar  5 06:32:16.943: DHCPD: assigned IP address 192.168.1.1 to client  
0100.5056.be76.8c.  
*Mar  5 06:32:16.951: %DHCPD-4-PING_CONFLICT: DHCP address conflict: server pinged  
192.168.1.1.  
*Mar  5 06:32:16.951: DHCPD: returned 192.168.1.1 to address pool R1G1.  
*Mar  5 06:32:16.951: DHCPD: Sending notification of DISCOVER:  
*Mar  5 06:32:16.951:   DHCPD: htype 1 chaddr 0050.56be.768c  
*Mar  5 06:32:16.951:   DHCPD: circuit id 00000000  
*Mar  5 06:32:1  
R2#6.951: DHCPD: Seeing if there is an internally specified pool class:  
*Mar  5 06:32:16.951:   DHCPD: htype 1 chaddr 0050.56be.768c  
*Mar  5 06:32:16.951:   DHCPD: circuit id 00000000  
*Mar  5 06:32:16.951:   DHCPD: Allocated binding 31DC93C8  
*Mar  5 06:32:16.951:   DHCPD: Adding binding to radix tree (192.168.1.2)  
*Mar  5 06:32:16.951:   DHCPD: Adding binding to hash tree  
*Mar  5 06:32:16.951:   DHCPD: assigned IP address 192.168.1.2 to client  
0100.5056.be76.8c.  
*Mar  5 06:32:18.383: %DHCPD-4-PING_CONFLICT: DHCP address conflict: server pinged  
192.168.1.2.  
*Mar  5 06:32:18.383: DHCPD: returned 192.168.1.2 to address pool R1G1.  
*Mar  5 06:32:18.383: DHCPD: Sending notification of DISCOVER:  
*Mar  5 06:32:18.383:   DHCPD: htype 1 chaddr 0050.56be.6c89  
*Mar  5 06:32:18.383:   DHCPD: circuit id 00000000  
*Mar  5 06:32:18.383:   DHCPD: Seeing if there is an internally specified pool class:  
*Mar  5 06:32:18.383:   DHCPD: htype 1 chaddr 0050.56be.6c89  
*Mar  5 06:32:18.383:   DHCPD: circuit id 00000000  
*Mar  5 06:32:18.383:   DHCPD: Allocated binding 2A40E074  
*Mar  5 06:32:18.383:   DHCPD: Adding binding to radix tree (192.168.1.3)  
*Mar  5 06:32:18.383:   DHCPD: Adding binding to hash tree  
*Mar  5 06:32:18.383:   DHCPD: assigned IP address 192.168.1.3 to client  
0100.5056.be76.8c.  
<output omitted>
```

- e. Display the DHCP server configuration on R2. The first nine addresses for 192.168.1.0/24 network are not excluded from the DHCP pool.

```
R2# show run | section dhcp
```

Lab - Troubleshooting DHCPv4

```
ip dhcp excluded-address 192.168.11.1 192.168.11.9
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp pool R1G1
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.1
ip dhcp pool R1G0
  network 192.168.0.0 255.255.255.128
  default-router 192.168.1.1
```

Record the commands to resolve the issue on R2.

```
R2(config)# no ip dhcp excluded-address 192.168.11.1 192.168.11.9
R2(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.9
```

- f. At the command prompt on PC-A, type **ipconfig /release** to return the 192.168.1.3 address back to the DHCP pool. The process can be observed in the debug message on R2.

```
*Mar  5 06:49:59.563: DHCPD: Sending notification of TERMINATION:
*Mar  5 06:49:59.563:   DHCPD: address 192.168.1.3 mask 255.255.255.0
*Mar  5 06:49:59.563:   DHCPD: reason flags: RELEASE
*Mar  5 06:49:59.563:     DHCPD: htype 1 chaddr 0050.56be.768c
*Mar  5 06:49:59.563:     DHCPD: lease time remaining (secs) = 85340
*Mar  5 06:49:59.563:   DHCPD: returned 192.168.1.3 to address pool R1G1.
```

- g. At the command prompt on PC-A, type **ipconfig /renew** to be assigned a new IP address from the DHCP server. Record the assigned IP address and default gateway information.
-

IP address/subnet mask: 192.168.1.10/24 Default gateway: 192.168.1.1

The process can be observed in the debug message on R2.

```
*Mar  5 06:50:11.863: DHCPD: Sending notification of DISCOVER:
*Mar  5 06:50:11.863:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar  5 06:50:11.863:   DHCPD: circuit id 00000000
*Mar  5 06:50:11.863: DHCPD: Seeing if there is an internally specified pool class:
*Mar  5 06:50:11.863:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar  5 06:50:11.863:   DHCPD: circuit id 00000000
*Mar  5 06:50:11.863: DHCPD: requested address 192.168.1.3 has already been assigned.
*Mar  5 06:50:11.863: DHCPD: Allocated binding 3003018C
*Mar  5 06:50:11.863: DHCPD: Adding binding to radix tree (192.168.1.10)
*Mar  5 06:50:11.863: DHCPD: Adding binding to hash tree
*Mar  5 06:50:11.863: DHCPD: assigned IP address 192.168.1.10 to client 0100.5056.be76.8c.
<output omitted>
```

- h. Verify network connectivity.

Can PC-A ping the assigned default gateway? _____ Yes

Can PC-A ping the R2 router? _____ Yes

Can PC-A ping the ISP router? _____ Yes

Step 3: Troubleshoot DHCP issues for 192.168.0.0/25 network on R1.

Router R1 is a DHCP relay agent for all the R1 LANs. In this step, only the DHCP process for the 192.168.0.0/25 network is examined. The first nine addresses are reserved for other network devices.

- a. Use a DHCP **debug** command to observe the DHCP process on R2.

```
R2# debug ip dhcp server events
```

- b. Display the running configuration for the G0/0 interface on R1 to identify possible DHCP issues.

```
R1# show run interface g0/0
interface GigabitEthernet0/0
  ip address 192.168.0.1 255.255.255.128
  duplex auto
  speed auto
```

Record the issues and any commands that are necessary to correct the configurations errors.

DHCP relay was not configured on the R1 G0/0 interface. The issue can be resolved using the following commands:

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.0.254
```

- c. From the command prompt on PC-B, type **ipconfig /renew** to receive an address from the DHCP server. Record the configured IP address, subnet mask, and default gateway for PC-B.

IP address: 192.168.0.10, subnet mask: 255.255.255.128, default gateway: 192.168.11.1

- d. Observe the debug messages on R2 router for the renewal process for PC-A. The DHCP server assigned 192.168.0.10/25 to PC-B.

```
*Mar  5 07:15:09.663: DHCPD: Sending notification of DISCOVER:
*Mar  5 07:15:09.663:   DHCPD: htype 1 chaddr 0050.56be.f6db
*Mar  5 07:15:09.663:   DHCPD: circuit id 00000000
*Mar  5 07:15:09.663: DHCPD: Seeing if there is an internally specified pool class:
*Mar  5 07:15:09.663:   DHCPD: htype 1 chaddr 0050.56be.f6db
*Mar  5 07:15:09.663:   DHCPD: circuit id 00000000
*Mar  5 07:15:09.707: DHCPD: Sending notification of ASSIGNMENT:
*Mar  5 07:15:09.707: DHCPD: address 192.168.0.10 mask 255.255.255.128
*Mar  5 07:15:09.707:   DHCPD: htype 1 chaddr 0050.56be.f6db
*Mar  5 07:15:09.707:   DHCPD: lease time remaining (secs) = 86400
```

- e. Verify network connectivity.

Can PC-B ping the DHCP assigned default gateway? _____ No

Can PC-B ping its default gateway (192.168.0.1)? _____ Yes

Can PC-B ping the R2 router? _____ Yes

Can PC-B ping the ISP router? _____ Yes

- f. If any issues failed in Step e, record the problems and any commands to resolve the issues.

PC-B is unable to ping the DHCP assigned default gateway. The issue can be resolved using the following commands.

```
R2(config)# ip dhcp pool R1G0  
R2(dhcp-config) # default-router 192.168.0.1
```

- g. Release and renew the IP configurations on PC-B. Repeat Step e to verify network connectivity.
- h. Discontinue the debug process by using the **undebbug all** command.

```
R2# undebbug all  
All possible debugging has been turned off
```

Reflection

What are the benefits of using DHCP?

Answers will vary. DHCP can prevent address conflicts caused by a previous assigned IP address still in use, supply additional configuration values, such as a DNS server, and can be used with mobile or portable computers.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (Corrected)

```
R1# show run
Building configuration...

Current configuration : 1419 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 15
!
```

Lab - Troubleshooting DHCPv4

```
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
ip address 192.168.0.1 255.255.255.128
ip helper-address 192.168.0.254
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
ip helper-address 192.168.0.254
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.0.253 255.255.255.252
clock rate 128000
!
interface Serial0/0/1
no ip address
shutdown
!
!
router eigrp 1
network 192.168.0.0 0.0.0.127
network 192.168.0.252 0.0.0.3
network 192.168.1.0
```

Lab - Troubleshooting DHCPv4

```
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2 (Corrected)

```
R2# show run
Building configuration...

Current configuration : 1552 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
```

Lab - Troubleshooting DHCPv4

```
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp excluded-address 192.168.1.1 192.168.1.9
!
ip dhcp pool R1G1
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.1
!
ip dhcp pool R1G0
  network 192.168.0.0 255.255.255.128
  default-router 192.168.0.1
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
license udi pid CISCO1941/K9 sn FTX163283R9
license accept end user agreement
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
```

Lab - Troubleshooting DHCPv4

```
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.0.254 255.255.255.252
!
interface Serial0/0/1
ip address 209.165.200.226 255.255.255.252
clock rate 128000
!
!
router eigrp 1
network 192.168.0.252 0.0.0.3
redistribute static
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 209.165.200.225
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
```

```
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router ISP

```
ISP#show run
Building configuration...

Current configuration : 1247 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
```

Lab - Troubleshooting DHCPv4

```
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
ip address 209.165.200.225 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.0.0 255.255.254.0 209.165.200.226
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
```

Lab - Troubleshooting DHCPv4

```
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring Stateless and Stateful DHCPv6 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IPv6 Address	Prefix Length	Default Gateway
R1	G0/1	2001:DB8:ACAD:A::1	64	N/A
S1	VLAN 1	Assigned by SLAAC	64	Assigned by SLAAC
PC-A	NIC	Assigned by SLAAC and DHCPv6	64	Assigned by R1

Objectives

- Part 1: Build the Network and Configure Basic Device Settings**
- Part 2: Configure the Network for SLAAC**
- Part 3: Configure the Network for Stateless DHCPv6**
- Part 4: Configure the Network for Stateful DHCPv6**

Background / Scenario

The dynamic assignment of IPv6 global unicast addresses can be configured in three ways:

- Stateless Address Autoconfiguration (SLAAC) only
- Stateless Dynamic Host Configuration Protocol for IPv6 (DHCPv6)
- Stateful DHCPv6

With SLAAC (pronounced slack), a DHCPv6 server is not needed for hosts to acquire IPv6 addresses. It can be used to receive additional information that the host needs, such as the domain name and the domain name server (DNS) address. When SLAAC is used to assign the IPv6 host addresses and DHCPv6 is used to assign other network parameters, it is called Stateless DHCPv6.

With Stateful DHCPv6, the DHCP server assigns all information, including the host IPv6 address.

Determination of how hosts obtain their dynamic IPv6 addressing information is dependent on flag settings contained within the router advertisement (RA) messages.

In this lab, you will initially configure the network to use SLAAC. After connectivity has been verified, you will configure DHCPv6 settings and change the network to use Stateless DHCPv6. After verification that Stateless DHCPv6 is functioning correctly, you will change the configuration on R1 to use Stateful DHCPv6. Wireshark will be used on PC-A to verify all three dynamic network configurations.

Lab – Configuring Stateless and Stateful DHCPv6

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Note: The **default bias** template (used by the Switch Database Manager (SDM)) does not provide IPv6 address capabilities. Verify that SDM is using either the **dual-ipv4-and-ipv6** template or the **lanbase-routing** template. The new template will be used after reboot even if the config is not saved.

```
S1# show sdm prefer
```

Follow these steps to assign the **dual-ipv4-and-ipv6** template as the default SDM template:

```
S1# config t
S1(config)# sdm prefer dual-ipv4-and-ipv6 default
S1(config)# end
S1# reload
```

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7 or Vista with Wireshark and terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Instructor Note: Wireshark needs to be preinstalled on PC-A.

Note: DHCPv6 client services are disabled on Windows XP. It is recommended to use a Windows 7 host for this lab.

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings, such as device names, passwords and interface IP addresses.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switch as necessary.

Step 3: Configure R1.

- a. Disable DNS lookup.
- b. Configure the device name.
- c. Encrypt plain text passwords.
- d. Create a MOTD banner warning users that unauthorized access is prohibited.
- e. Assign **class** as the encrypted privileged EXEC mode password.

Lab – Configuring Stateless and Stateful DHCPv6

- f. Assign **cisco** as the console and vty password and enable login.
- g. Set console logging to synchronous mode.
- h. Save the running configuration to the startup configuration.

Step 4: Configure S1.

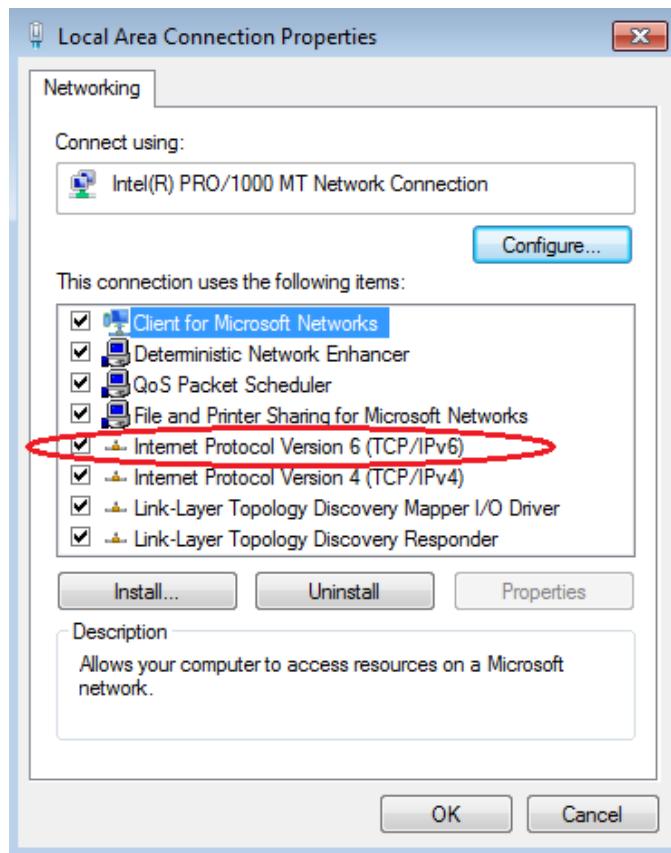
- a. Disable DNS lookup.
- b. Configure the device name.
- c. Encrypt plain text passwords.
- d. Create a MOTD banner warning users that unauthorized access is prohibited.
- e. Assign **class** as the encrypted privileged EXEC mode password.
- f. Assign **cisco** as the console and vty password and enable login.
- g. Set console logging to synchronous mode.
- h. Administratively disable all inactive interfaces.
- i. Save running configuration to the startup configuration.

Part 2: Configure the Network for SLAAC

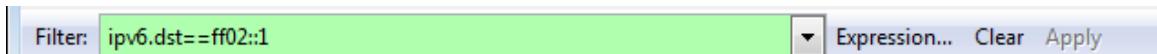
Step 1: Prepare PC-A.

- a. Verify that the IPv6 protocol has been enabled on the Local Area Connection Properties window. If the Internet Protocol Version 6 (TCP/IPv6) check box is not checked, click to enable it.

Lab – Configuring Stateless and Stateful DHCPv6



- b. Start a Wireshark capture of traffic on the NIC.
- c. Filter the data capture to see only RA messages. This can be done by filtering on IPv6 packets with a destination address of FF02::1, which is the all-unicast client group address. The filter entry used with Wireshark is **ipv6.dst==ff02::1**, as shown here.



Step 2: Configure R1.

- a. Enable IPv6 unicast routing.
- b. Assign the IPv6 unicast address to interface G0/1 according to the Addressing Table.
- c. Assign FE80::1 as the IPv6 link-local address for interface G0/1.
- d. Activate interface G0/1.

Step 3: Verify that R1 is part of the all-router multicast group.

Use the **show ipv6 interface g0/1** command to verify that G0/1 is part of the All-router multicast group (FF02::2). RA messages are not sent out G0/1 without that group assignment.

```
R1# show ipv6 interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es) :
  Global unicast address(es) :
```

Lab – Configuring Stateless and Stateful DHCPv6

```
2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
Joined group address(es):
  FF02::1
  FF02::2
  FF02::1:FF00:1
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ICMP unreachables are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
ND advertised default router preference is Medium
Hosts use stateless autoconfig for addresses.
```

Step 4: Configure S1.

Use the **ipv6 address autoconfig** command on VLAN 1 to obtain an IPv6 address through SLAAC.

```
S1(config)# interface vlan 1
S1(config-if)# ipv6 address autoconfig
S1(config-if)# end
```

Step 5: Verify that SLAAC provided a unicast address to S1.

Use the **show ipv6 interface** command to verify that SLAAC provided a unicast address to VLAN1 on S1.

```
S1# show ipv6 interface
Vlan1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::ED9:96FF:FE8:8A40
  No Virtual link-local address(es):
  Stateless address autoconfig enabled
  Global unicast address(es):
    2001:DB8:ACAD:A:ED9:96FF:FE8:8A40, subnet is 2001:DB8:ACAD:A::/64 [EUI/CAL/PRE]
      valid lifetime 2591988 preferred lifetime 604788
  Joined group address(es):
    FF02::1
    FF02::1:FFE8:8A40
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  Output features: Check hwidb
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND NS retransmit interval is 1000 milliseconds
  Default router is FE80::1 on Vlan1
```

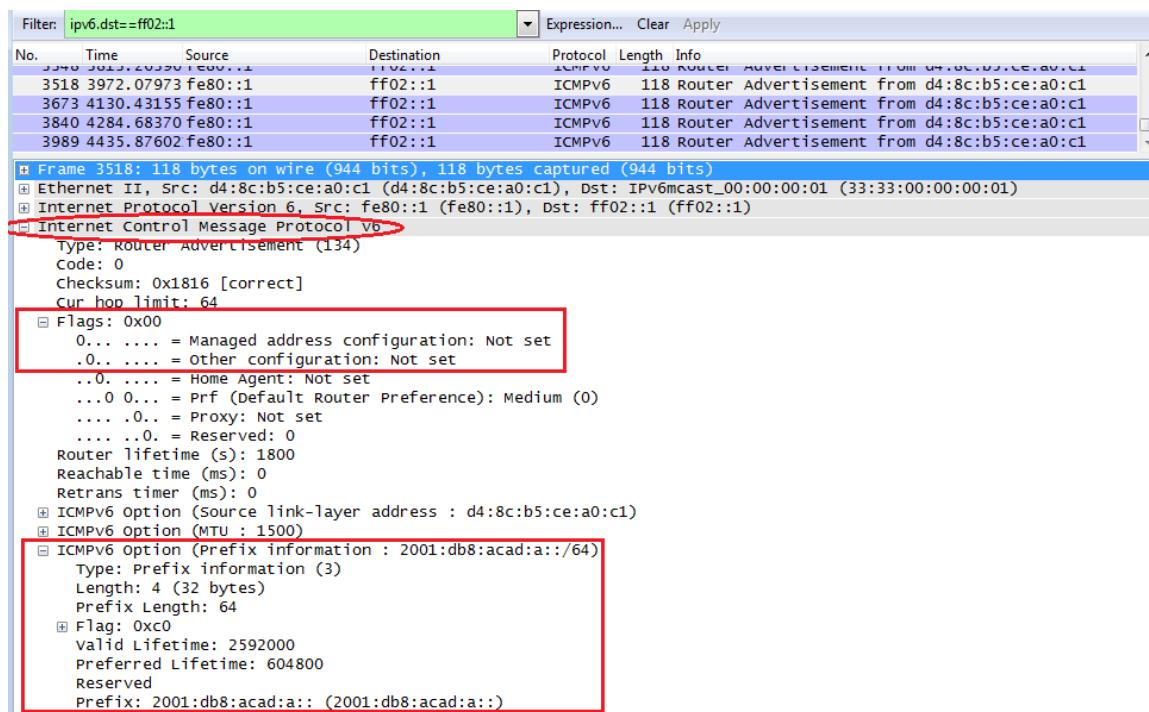
Lab – Configuring Stateless and Stateful DHCPv6

Step 6: Verify that SLAAC provided IPv6 address information on PC-A.

- From a command prompt on PC-A, issue the **ipconfig /all** command. Verify that PC-A is showing an IPv6 address with the 2001:db8:acad:a::/64 prefix. The Default Gateway should have the FE80::1 address.

```
Ethernet adapter Local Area Connection:
  Connection-specific DNS Suffix . . . . . : Intel(R) PRO/1000 MT Network Connection
  Description . . . . . : Intel(R) PRO/1000 MT Network Connection
  Physical Address . . . . . : 00-50-56-BE-76-8C
  DHCP Enabled . . . . . : Yes
  Autoconfiguration Enabled . . . . . : Yes
  IPv6 Address . . . . . : 2001:db8:acad:a:24ba:a0a0:9f0:ff88 (Preferred)
    Temporary IPv6 Address . . . . . : 2001:db8:acad:a:c05b:d3f7:31be:100e (Preferred)
    Link-local IPv6 Address . . . . . : fe80::24ba:a0a0:9f0:ff88%11 (Preferred)
    Autoconfiguration IPv4 Address . . . . . : 169.254.255.136 (Preferred)
    Subnet Mask . . . . . : 255.255.0.0
    Default Gateway . . . . . : fe80::1:11
    DNS Servers . . . . . : fec0:0:0:ffff::1%1
                            fec0:0:0:ffff::2%1
                            fec0:0:0:ffff::3%1
  NetBIOS over Tcpip. . . . . : Enabled
```

- From Wireshark, look at one of the RA messages that were captured. Expand the Internet Control Message Protocol v6 layer to view the Flags and Prefix information. The first two flags control DHCPv6 usage and are not set if DHCPv6 is not configured. The prefix information is also contained within this RA message.



Part 3: Configure the Network for Stateless DHCPv6

Step 1: Configure an IPv6 DHCP server on R1.

- Create an IPv6 DHCP pool.

```
R1(config)# ipv6 dhcp pool IPV6POOL-A
```

Lab – Configuring Stateless and Stateful DHCPv6

- b. Assign a domain name to the pool.

```
R1 (config-dhcpv6) # domain-name ccna-statelessDHCPv6.com
```

- c. Assign a DNS server address.

```
R1 (config-dhcpv6) # dns-server 2001:db8:acad:a::abcd
```

```
R1 (config-dhcpv6) # exit
```

- d. Assign the DHCPv6 pool to the interface.

```
R1 (config) # interface g0/1
```

```
R1 (config-if) # ipv6 dhcp server IPV6POOL-A
```

- e. Set the DHCPv6 network discovery (ND) **other-config-flag**.

```
R1 (config-if) # ipv6 nd other-config-flag
```

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

Step 2: Verify DHCPv6 settings on interface G0/1 on R1.

Use the **show ipv6 interface g0/1** command to verify that the interface is now part of the IPv6 multicast all-DHCPv6-servers group (FF02::1:2). The last line of the output from this **show** command verifies that the other-config-flag has been set.

```
R1# show ipv6 interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:2
    FF02::1:FF00:1
    FF05::1:3
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
  Hosts use DHCP to obtain other configuration.
```

Step 3: View network changes to PC-A.

Use the **ipconfig /all** command to review the network changes. Notice that additional information, including the domain name and DNS server information, has been retrieved from the DHCPv6 server. However, the IPv6 global unicast and link-local addresses were obtained previously from SLAAC.

Lab – Configuring Stateless and Stateful DHCPv6

```
Ethernet adapter Local Area Connection:  
  Connection-specific DNS Suffix . : ccna-statelessDHCPv6.com  
  Description . . . . . Intel(R) PRO/1000 MT Network Connection  
  Physical Address . . . . . 00-50-56-BE-76-8C  
  DHCP Enabled. . . . . Yes  
  Autoconfiguration Enabled . . . . . Yes  
  IPv6 Address. . . . . 2001:db8:acad:a:24ba:a0a0:9f0:ff88<Preferred>  
  Temporary IPv6 Address. . . . . 2001:db8:acad:a:103a:4344:4b5e:ab1d<Preferred>  
  Link-local IPv6 Address . . . . . fe80::24ba:a0a0:9f0:ff88%11<Preferred>  
  Autoconfiguration IPv4 Address . . . . . 169.254.255.136<Preferred>  
  Subnet Mask . . . . . 255.255.0.0  
  Default Gateway . . . . . fe80::1%11  
  DHCPv6 IAID . . . . . 234884137  
  DHCPv6 Client DUID. . . . . 00-01-00-01-17-F6-72-3D-00-0C-29-8D-54-44  
  DNS Servers . . . . . 2001:db8:acad:a::abcd  
  NetBIOS over Tcpip . . . . . Enabled  
  Connection-specific DNS Suffix Search List :  
                                             ccna-statelessDHCPv6.com  
  
Tunnel adapter isatap.{E2FC1866-B195-460A-BF40-F04F42A38FFE}:  
  Media State . . . . . Media disconnected  
  Connection-specific DNS Suffix . . . . . ccna-statelessDHCPv6.com  
  Description . . . . . Microsoft ISATAP Adapter  
  Physical Address . . . . . 00-00-00-00-00-00-E0  
  DHCP Enabled. . . . . No  
  Autoconfiguration Enabled . . . . . Yes
```

Step 4: View the RA messages in Wireshark.

Scroll down to the last RA message that is displayed in Wireshark and expand it to view the ICMPv6 flag settings. Notice that the other configuration flag is set to 1.

No.	Time	Source	Destination	Protocol	Length	Info
191	190.005980	fe80::1	ff02::1	ICMPV6	118	Router Advertisement from d4:8c:b5:ce:a0:c1
422	383.803033	fe80::1	ff02::1	ICMPV6	118	Router Advertisement from d4:8c:b5:ce:a0:c1
696	581.355847	fe80::1	ff02::1	ICMPV6	118	Router Advertisement from d4:8c:b5:ce:a0:c1
877	776.644829	fe80::1	ff02::1	ICMPV6	118	Router Advertisement from d4:8c:b5:ce:a0:c1

Frame 877: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)
Ethernet II, Src: d4:8c:b5:ce:a0:c1 (d4:8c:b5:ce:a0:c1), Dst: IPv6mcast_00:00:00:00:01 (33:33:00:00:00:01)
Internet Protocol Version 6, Src: fe80::1 (fe80::1), Dst: ff02::1 (ff02::1)
Internet Control Message Protocol v6
 Type: Router Advertisement (134)
 Code: 0
 Checksum: 0x17d6 [correct]
 Cur hop limit: 64
 Flags: 0x40
 0... = Managed address configuration: Not set
 .1... = Other configuration: Set
 ..0.... = Home Agent: Not set
 ...0 0... = Prf (Default Router Preference): Medium (0)
 0.. = Proxy: Not set
 0.0 = Reserved: 0
 Router lifetime (s): 1800
 Reachable time (ms): 0
 Retrans timer (ms): 0
 ICMPV6 option (Source link-layer address : d4:8c:b5:ce:a0:c1)
 ICMPV6 option (MTU : 1500)
 ICMPV6 option (Prefix information : 2001:db8:acad:a::/64)

Step 5: Verify that PC-A did not obtain its IPv6 address from a DHCPv6 server.

Use the **show ipv6 dhcp binding** and **show ipv6 dhcp pool** commands to verify that PC-A did not obtain an IPv6 address from the DHCPv6 pool.

```
R1# show ipv6 dhcp binding  
R1# show ipv6 dhcp pool  
DHCPv6 pool: IPV6POOL-A
```

Lab – Configuring Stateless and Stateful DHCPv6

```
DNS server: 2001:DB8:ACAD:A::ABCD  
Domain name: ccna-statelessDHCPv6.com  
Active clients: 0
```

Step 6: Reset PC-A IPv6 network settings.

- Shut down interface F0/6 on S1.

Note: Shutting down the interface F0/6 prevents PC-A from receiving a new IPv6 address before you reconfigure R1 for Stateful DHCPv6 in Part 4.

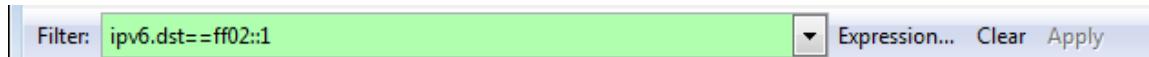
```
S1(config)# interface f0/6  
S1(config-if)# shutdown
```

- Stop Wireshark capture of traffic on the PC-A NIC.
- Reset the IPv6 settings on PC-A to remove the Stateless DHCPv6 settings.
 - Open the Local Area Connection Properties window, deselect the **Internet Protocol Version 6 (TCP/IPv6)** check box, and click **OK** to accept the change.
 - Open the Local Area Connection Properties window again, click to enable the **Internet Protocol Version 6 (TCP/IPv6)** check box, and then click **OK** to accept the change.

Part 4: Configure the Network for Stateful DHCPv6

Step 1: Prepare PC-A.

- Start a Wireshark capture of traffic on the NIC.
- Filter the data capture to see only RA messages. This can be done by filtering on IPv6 packets with a destination address of FF02::1, which is the all-unicast client group address.



Step 2: Change the DHCPv6 pool on R1.

- Add the network prefix to the pool.

```
R1(config)# ipv6 dhcp pool IPV6POOL-A  
R1(config-dhcpv6)# address prefix 2001:db8:acad:a::/64
```
- Change the domain name to **ccna-statefulDHCPv6.com**.

Note: You must remove the old domain name. It is not replaced by the **domain-name** command.

```
R1(config-dhcpv6)# no domain-name ccna-statelessDHCPv6.com  
R1(config-dhcpv6)# domain-name ccna-StatefulDHCPv6.com  
R1(config-dhcpv6)# end
```

- Verify DHCPv6 pool settings.

```
R1# show ipv6 dhcp pool  
DHCPv6 pool: IPV6POOL-A  
Address allocation prefix: 2001:DB8:ACAD:A::/64 valid 172800 preferred 86400 (0 in use, 0 conflicts)  
DNS server: 2001:DB8:ACAD:A::ABCD  
Domain name: ccna-StatefulDHCPv6.com  
Active clients: 0
```

- d. Enter debug mode to verify the Stateful DHCPv6 address assignment.

```
R1# debug ipv6 dhcp detail  
IPv6 DHCP debugging is on (detailed)
```

Step 3: Set the flag on G0/1 for Stateful DHCPv6.

Note: Shutting down the G0/1 interface before making changes ensures that an RA message is sent when the interface is activated.

```
R1(config)# interface g0/1  
R1(config-if)# shutdown  
R1(config-if)# ipv6 nd managed-config-flag  
R1(config-if)# no shutdown  
R1(config-if)# end
```

Step 4: Enable interface F0/6 on S1.

Now that R1 has been configured for Stateful DHCPv6, you can reconnect PC-A to the network by activating interface F0/6 on S1.

```
S1(config)# interface f0/6  
S1(config-if)# no shutdown  
S1(config-if)# end
```

Step 5: Verify Stateful DHCPv6 settings on R1.

- a. Issue the **show ipv6 interface g0/1** command to verify that the interface is in Stateful DHCPv6 mode.

```
R1# show ipv6 interface g0/1  
GigabitEthernet0/1 is up, line protocol is up  
  IPv6 is enabled, link-local address is FE80::1  
  No Virtual link-local address(es):  
  Global unicast address(es):  
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64  
  Joined group address(es):  
    FF02::1  
    FF02::2  
    FF02::1:2  
    FF02::1:FF00:1  
    FF05::1:3  
  MTU is 1500 bytes  
  ICMP error messages limited to one every 100 milliseconds  
  ICMP redirects are enabled  
  ICMP unreachable messages are sent  
  ND DAD is enabled, number of DAD attempts: 1  
  ND reachable time is 30000 milliseconds (using 30000)  
  ND advertised reachable time is 0 (unspecified)  
  ND advertised retransmit interval is 0 (unspecified)  
  ND router advertisements are sent every 200 seconds  
  ND router advertisements live for 1800 seconds  
  ND advertised default router preference is Medium  
  Hosts use DHCP to obtain routable addresses.
```

Lab – Configuring Stateless and Stateful DHCPv6

Hosts use DHCP to obtain other configuration.

- b. In a command prompt on PC-A, type **ipconfig /release6** to release the currently assigned IPv6 address. Then type **ipconfig /renew6** to request an IPv6 address from the DHCPv6 server.
- c. Issue the **show ipv6 dhcp pool** command to verify the number of active clients.

```
R1# show ipv6 dhcp pool
DHCPv6 pool: IPV6POOL-A
  Address allocation prefix: 2001:DB8:ACAD:A::/64 valid 172800 preferred 86400 (1 in
  use, 0 conflicts)
    DNS server: 2001:DB8:ACAD:A::ABCD
    Domain name: ccna-StatefulDHCPv6.com
    Active clients: 1
```

- d. Issue the **show ipv6 dhcp binding** command to verify that PC-A received its IPv6 unicast address from the DHCP pool. Compare the client address to the link-local IPv6 address on PC-A using the **ipconfig /all** command. Compare the address provided by the **show** command to the IPv6 address listed with the **ipconfig /all** command on PC-A.

```
R1# show ipv6 dhcp binding
Client: FE80::D428:7DE2:997C:B05A
  DUID: 0001000117F6723D000C298D5444
  Username : unassigned
  IA NA: IA ID 0x0E000C29, T1 43200, T2 69120
  Address: 2001:DB8:ACAD:A:B55C:8519:8915:57CE
    preferred lifetime 86400, valid lifetime 172800
    expires at Mar 07 2013 04:09 PM (171595 seconds)
```

```
Ethernet adapter Local Area Connection:
  Connection-specific DNS Suffix . : ccna-StatefulDHCPv6.com
  Description . . . . . : Intel(R) PRO/1000 MT Network Connection
  Physical Address . . . . . : 00-50-56-BE-6C-89
  DHCP Enabled. . . . . : Yes
  Autoconfiguration Enabled . . . . . : Yes
  IPv6 Address. . . . . : 2001:db8:acad:a:b55c:8519:8915:57ce [Preferred]
  Lease Obtained. . . . . : Tuesday, March 05, 2013 11:53:11 AM
  Lease Expires . . . . . : Thursday, March 07, 2013 11:53:11 AM
  IPv6 Address. . . . . : 2001:db8:acad:a:d428:7de2:997c:b05a<Preferred>
  Temporary IPv6 Address. . . . . : 2001:db8:acad:a:dd37:1e42:948c:225b<Preferred>
  Link-local IPv6 Address . . . . . : fe80::d428:7de2:997c:b05a:11<Preferred>
  Autoconfiguration IPv4 Address . . . . . : 162.251.176.93<Preferred>
  Subnet Mask . . . . . : 255.255.0.0
  Default Gateway . . . . . : fe80::1%11
  DHCPv6 IAID . . . . . : 234884137
  DHCPv6 Client DUID. . . . . : 00-01-00-01-17-F6-72-3D-00-0C-29-8D-54-44
  DNS Servers . . . . . : 2001:db8:acad:a::abcd
  NetBIOS over Tcpip. . . . . : Enabled
  Connection-specific DNS Suffix Search List :
                                ccna-StatefulDHCPv6.com
```

- e. Issue the **undebug all** command on R1 to stop debugging DHCPv6.

Note: Typing **u all** is the shortest form of this command and is useful to know if you are trying to stop debug messages from continually scrolling down your terminal session screen. If multiple debugs are in process, the **undebug all** command stops all of them.

```
R1# u all
All possible debugging has been turned off
```

Lab – Configuring Stateless and Stateful DHCPv6

f. Review the debug messages that appeared on your R1 terminal screen.

1) Examine the solicit message from PC-A requesting network information.

```
*Mar 5 16:42:39.775: IPv6 DHCP: Received SOLICIT from FE80::D428:7DE2:997C:B05A on  
GigabitEthernet0/1  
*Mar 5 16:42:39.775: IPv6 DHCP: detailed packet contents  
*Mar 5 16:42:39.775: src FE80::D428:7DE2:997C:B05A (GigabitEthernet0/1)  
*Mar 5 16:42:39.775: dst FF02::1:2  
*Mar 5 16:42:39.775: type SOLICIT(1), xid 1039238  
*Mar 5 16:42:39.775: option ELAPSED-TIME(8), len 2  
*Mar 5 16:42:39.775: elapsed-time 6300  
*Mar 5 16:42:39.775: option CLIENTID(1), len 14
```

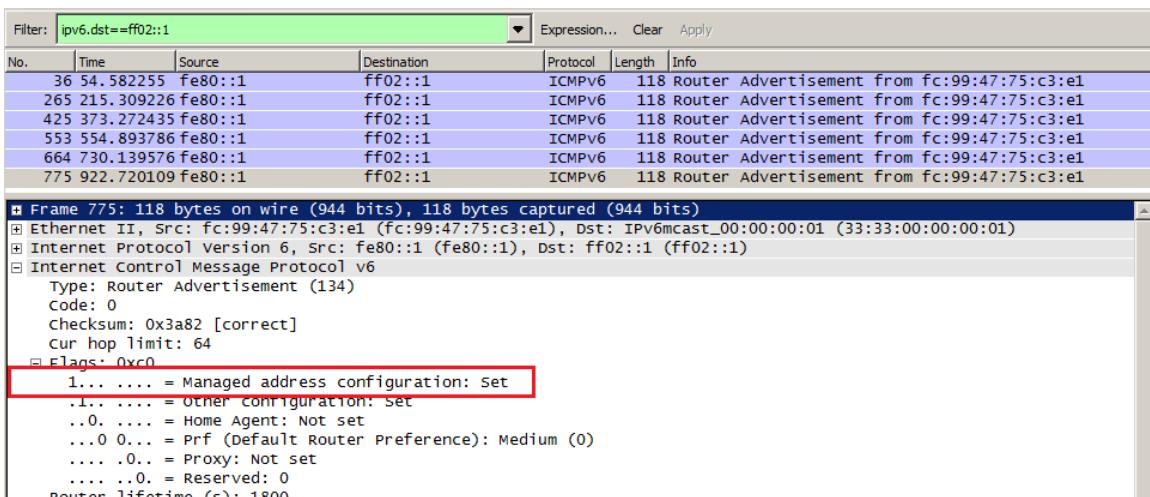
2) Examine the reply message sent back to PC-A with the DHCP network information.

```
*Mar 5 16:42:39.779: IPv6 DHCP: Sending REPLY to FE80::D428:7DE2:997C:B05A on  
GigabitEthernet0/1  
*Mar 5 16:42:39.779: IPv6 DHCP: detailed packet contents  
*Mar 5 16:42:39.779: src FE80::1  
*Mar 5 16:42:39.779: dst FE80::D428:7DE2:997C:B05A (GigabitEthernet0/1)  
*Mar 5 16:42:39.779: type REPLY(7), xid 1039238  
*Mar 5 16:42:39.779: option SERVERID(2), len 10  
*Mar 5 16:42:39.779: 00030001FC994775C3E0  
*Mar 5 16:42:39.779: option CLIENTID(1), len 14  
*Mar 5 16:42:39.779: 00010001  
R1#17F6723D000C298D5444  
*Mar 5 16:42:39.779: option IA-NA(3), len 40  
*Mar 5 16:42:39.779: IAID 0x0E000C29, T1 43200, T2 69120  
*Mar 5 16:42:39.779: option IAADDR(5), len 24  
*Mar 5 16:42:39.779: IPv6 address 2001:DB8:ACAD:A:B55C:8519:8915:57CE  
*Mar 5 16:42:39.779: preferred 86400, valid 172800  
*Mar 5 16:42:39.779: option DNS-SERVERS(23), len 16  
*Mar 5 16:42:39.779: 2001:DB8:ACAD:A::ABCD  
*Mar 5 16:42:39.779: option DOMAIN-LIST(24), len 26  
*Mar 5 16:42:39.779: ccna-StatefulDHCPv6.com
```

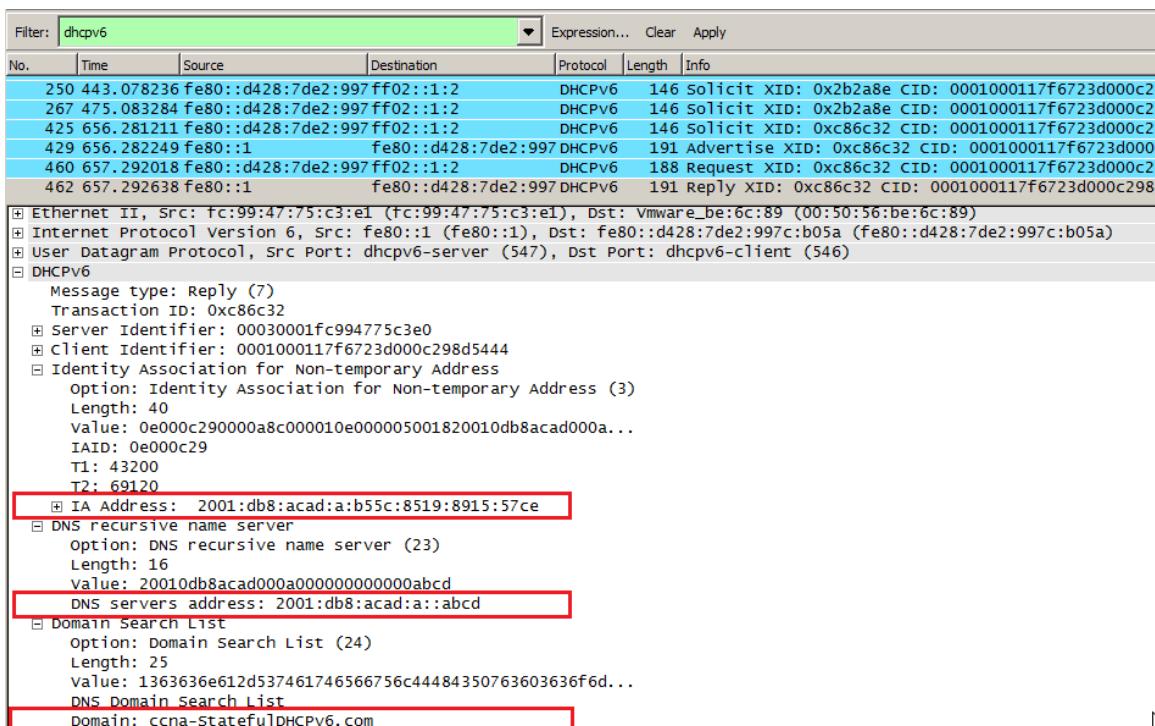
Step 6: Verify Stateful DHCPv6 on PC-A

- a. Stop the Wireshark capture on PC-A.
- b. Expand the most recent RA message listed in Wireshark. Verify that the **Managed address configuration** flag has been set.

Lab – Configuring Stateless and Stateful DHCPv6



- c. Change the filter in Wireshark to view **DHCPv6** packets only by typing **dhcpv6**, and then **Apply** the filter. Highlight the last DHCPv6 reply listed and expand the DHCPv6 information. Examine the DHCPv6 network information that is contained in this packet.



Reflection

1. What IPv6 addressing method uses more memory resources on the router configured as a DHCPv6 server, Stateless DHCPv6 or Stateful DHCPv6? Why?

Lab – Configuring Stateless and Stateful DHCPv6

Stateful DHCPv6 uses more memory resources. Answers will vary, but Stateful DHCPv6 requires the router to store dynamic state information about the DHCPv6 clients. Stateless DHCPv6 clients do not use the DHCP server to obtain address information, so this information does not need to be stored.

2. Which type of dynamic IPv6 address assignment is recommended by Cisco, Stateless DHCPv6 or Stateful DHCPv6?
-
-

Cisco recommends Stateless DHCPv6 when implementing and deploying IPv6 networks without a Cisco Network Registrar (CNR).

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs - Part 1 and 2 combined for R1 and S1

Router R1 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
```

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```
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C
Unauthorized Access is Prohibited!
^C
!
line con 0
password 7 070C285F4D06
logging synchronous
login
line aux 0
!
line vty 0 4
```

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```
password 7 13061E010803
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
```

Lab – Configuring Stateless and Stateful DHCPv6

```
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
```

Lab – Configuring Stateless and Stateful DHCPv6

```
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 no ip address
 shutdown
!
ip http server
ip http secure-server
!
banner motd ^C
 Unauthorized Access is Prohibited!
^C
!
line con 0
 password 7 05080F1C2243
 logging synchronous
 login
line vty 0 4
 password 7 02050D480809
 login
line vty 5 15
 password 7 02050D480809
 login
!
end
```

Router R1 (Final)

```
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
ip cef
ipv6 unicast-routing
ipv6 dhcp pool IPV6POOL-A
```

Lab – Configuring Stateless and Stateful DHCPv6

```
address prefix 2001:DB8:ACAD:A::/64
dns-server 2001:DB8:ACAD:A::ABCD
domain-name ccna-StatefulDHCPv6.com
!
ipv6 cef
multilink bundle-name authenticated
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
ipv6 nd managed-config-flag
ipv6 nd other-config-flag
ipv6 dhcp server IPV6POOL-A
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
!
banner motd ^C
Unauthorized Access is Prohibited!
^C
!
line con 0
password 7 070C285F4D06
logging synchronous
login
line aux 0
```

Lab – Configuring Stateless and Stateful DHCPv6

```
!
line vty 0 4
password 7 13061E010803
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab - Troubleshooting DHCPv6 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IPv6 Address	Prefix Length	Default Gateway
R1	G0/1	2001:DB8:ACAD:A::1	64	N/A
S1	VLAN 1	Assigned by SLAAC	64	Assigned by SLAAC
PC-A	NIC	Assigned by SLAAC and DHCPv6	64	Assigned by SLAAC

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot IPv6 Connectivity

Part 3: Troubleshoot Stateless DHCPv6

Background / Scenario

The ability to troubleshoot network issues is a very useful skill for network administrators. It is important to understand IPv6 address groups and how they are used when troubleshooting a network. Knowing what commands to use to extract IPv6 network information is necessary to effectively troubleshoot.

In this lab, you will load configurations on R1 and S1. These configurations will contain issues that prevent Stateless DHCPv6 from functioning on the network. You will troubleshoot R1 and S1 to resolve these issues.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Note: The default bias template used by the Switch Database Manager (SDM) does not provide IPv6 address capabilities. Verify that SDM is using either the **dual-ipv4-and-ipv6** template or the **lanbase-routing** template. The new template will be used after reboot even if the configuration is not saved.

```
S1# show sdm prefer
```

Follow this configuration to assign the **dual-ipv4-and-ipv6** template as the default SDM template:

```
S1# config t
```

```
S1(config)# sdm prefer dual-ipv4-and-ipv6 default
S1(config)# end
S1# reload
```

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and clear any configurations if necessary. You will configure basic settings on the router and switch. Then you will load the provided IPv6 configurations before you start troubleshooting.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and the switch.

Step 3: Configure basic settings on the router and switch.

- a. Disable DNS lookup.
- b. Configure device names as shown in the topology.
- c. Encrypt plain text passwords.
- d. Create a MOTD banner warning users that unauthorized access is prohibited.
- e. Assign **class** as the encrypted privileged EXEC mode password.
- f. Assign **cisco** as the console and vty passwords and enable login.
- g. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 4: Load the IPv6 configuration to R1.

```
ip domain name ccna-lab.com
! ipv6 unicast-routing
ipv6 dhcp pool IPV6POOL-A
  dns-server 2001:DB8:ACAD:CAFE::A
  domain-name ccna-lab.com
interface g0/0
  no ip address
  shutdown
  duplex auto
  speed auto
interface g0/1
  no ip address
  duplex auto
```

Lab – Troubleshooting DHCPv6

```
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::11/64
! no ipv6 address 2001:db8:acad:a::11/64
! ipv6 address 2001:db8:acad:a::1/64
! ipv6 nd other-config-flag
! ipv6 dhcp server IPV6POOL-A
! no shutdown
end
```

Step 5: Load the IPv6 configuration to S1.

```
interface range f0/1-24
shutdown
!interface range f0/5-6
! no shutdown
interface range g0/1-2
shutdown
interface Vlan1
shutdown
! ipv6 address autoconfig
! no shutdown
end
```

Step 6: Save the running configurations on R1 and S1.

Step 7: Verify that IPv6 is enabled on PC-A.

Verify that IPv6 has been enabled in the Local Area Connection Properties window on PC-A.

Part 2: Troubleshoot IPv6 Connectivity

In Part 2, you will test and verify Layer 3 IPv6 connectivity on the network. Continue troubleshooting the network until Layer 3 connectivity has been established on all devices. Do not continue to Part 3 until you have successfully completed Part 2.

Step 1: Troubleshoot IPv6 interfaces on R1.

- According to the topology, which interface must be active on R1 for network connectivity to be established? Record any commands used to identify which interfaces are active.

G0/1

```
R1# show ip interface brief
```

- If necessary, take the steps required to bring up the interface. Record the commands used to correct the configuration errors and verify that the interface is active.
-
-

```
R1(config)# interface g0/1
```

Lab – Troubleshooting DHCPv6

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

- c. Identify the IPv6 addresses configured on R1. Record the addresses found and the commands used to view the IPv6 addresses.
-
-

2001:DB8:ACAD:A::11/64

show ipv6 interface or **show ipv6 interface g0/1**. **Show run interface g0/1** can also be used.

- d. Determine if a configuration error has been made. If any errors are identified, record all the commands used to correct the configuration.
-
-

```
R1(config) # interface g0/1
```

```
R1(config-if) # no ipv6 address 2001:db8:acad:a::11/64
```

```
R1(config-if) # ipv6 address 2001:db8:acad:a::1/64
```

- e. On R1, what multicast group is needed for SLAAC to function?
-

All-routers multicast group (FF02::2)

- f. What command is used to verify that R1 is a member of that group?
-

show ipv6 interface or **show ipv6 interface g0/1**

```
R1# show ipv6 interface
```

```
GigabitEthernet0/1 is down, line protocol is down
```

```
    IPv6 is tentative, link-local address is FE80::1 [TEN]
```

```
No Virtual link-local address(es) :
```

```
Global unicast address(es) :
```

```
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64 [TEN]
```

```
Joined group address(es) :
```

```
    FF02::1
```

```
MTU is 1500 bytes
```

```
ICMP error messages limited to one every 100 milliseconds
```

```
ICMP redirects are enabled
```

```
ICMP unreachable messages are sent
```

```
ND DAD is enabled, number of DAD attempts: 1
```

```
ND reachable time is 30000 milliseconds (using 30000)
```

```
ND advertised reachable time is 0 (unspecified)
```

```
ND advertised retransmit interval is 0 (unspecified)
```

```
ND router advertisements are sent every 200 seconds
```

```
ND router advertisements live for 1800 seconds
```

```
ND advertised default router preference is Medium
```

```
Hosts use stateless autoconfig for addresses.
```

Lab – Troubleshooting DHCPv6

- g. If R1 is not a member of the multicast group that is needed for SLAAC to function correctly, make the necessary changes to the configuration so that it joins the group. Record any commands necessary to correct the configurations errors.

```
R1(config)# ipv6 unicast-routing
```

- h. Re-issue the command to verify that interface G0/1 has joined the all-routers multicast group (FF02::2).

Note: If you are unable to join the all-routers multicast group, you may need to save your current configuration and reload the router.

Step 2: Troubleshoot S1.

- a. Are the interfaces needed for network connectivity active on S1? _____ No

Record any commands that are used to activate necessary interfaces on S1.

```
S1(config)# interface range f0/5-6
```

```
S1(config-if)# no shutdown
```

```
S1(config-if)# interface vlan 1
```

```
S1(config-if)# no shutdown
```

- b. What command could you use to determine if an IPv6 unicast address has been assigned to S1?

Issue the **show ipv6 interface** or **show ipv6 interface vlan1** command.

- c. Does S1 have an IPv6 unicast address configured? If so, what is it?

No IPv6 address has been assigned.

- d. If S1 is not receiving a SLAAC address, make the necessary configuration changes to allow it to receive one. Record the commands used.

```
S1(config)# interface vlan 1
S1(config-if)# ipv6 address autoconfig
```

- e. Re-issue the command that verifies that the interface now receives a SLAAC address.

- f. Can S1 ping the IPv6 unicast address assigned to the G0/1 interface assigned to R1?

Yes, S1 should be able to ping the 2001:db8:acad:a::1 IPv6 address.

Step 3: Troubleshoot PC-A.

- a. Issue the command used on PC-A to verify the IPv6 address assigned. Record the command.

Lab – Troubleshooting DHCPv6

ipconfig /all

- b. What is the IPv6 unicast address SLAAC is providing to PC-A?

If all the changes were made to R1 and S1, PC-A should receive an IPv6 address with the 2001:db8:acad:a::/64 prefix.

- c. Can PC-A ping the default gateway address that was assigned by SLAAC?

Yes, PC-A should be able to ping the FE80::1 address.

- d. Can PC-A ping the management interface on S1?

Yes, PC-A should be able to ping the IPv6 address assigned to VLAN 1. This address can be found by issuing the **show ipv6 interface vlan1** command on S1 and then looking for the IPv6 address with a prefix of 2001:db8:acad:a::/64.

Note: Continue troubleshooting until you can ping R1 and S1 from PC-A.

Part 3: Troubleshoot Stateless DHCPv6

In Part 3, you will test and verify that Stateless DHCPv6 is working correctly on the network. You will need to use the correct IPv6 CLI commands on the router to determine if Stateless DHCPv6 is working. You may want to use debug to help determine if the DHCP server is being solicited.

Step 1: Determine if Stateless DHCPv6 is functioning correctly.

- a. What is the name of the IPv6 DHCP pool? How did you determine this?

IPV6POOL-A. Issue the **show ipv6 dhcp pool** command to determine the name of the DHCPv6 Server pool. You can also issue the **show run | section ipv6 dhcp** command to see this information.

```
R1# show ipv6 dhcp pool
DHCPv6 pool: IPV6POOL-A
  DNS server: 2001:DB8:ACAD:CAFE::A
  Domain name: ccna-lab.com
  Active clients: 0
```

- b. What network information is listed in the DHCPv6 pool?

A DNS server is listed with a 2001:DB8:ACAD:CAFE::A, and a domain name is listed as ccna-lab.com.

- c. Was the DHCPv6 information assigned to PC-A? How did you determine this?

No, this can be determined by issuing an **ipconfig /all** command at the command prompt on PC-A.

Lab – Troubleshooting DHCPv6

Step 2: Troubleshoot R1.

- a. What commands can be used to determine if R1 is configured for Stateless DHCPv6?

The **show ipv6 interface** command can be used to determine if an interface has the Stateless DHCPv6 flag set. The **show run** command can also be used to view the configuration on the interface.

```
R1# show ipv6 interface
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachable messages are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
```

- b. Is the G0/1 interface on R1 in Stateless DHCPv6 mode?

No. The interface is not part of the all-DHCPv6 Servers group because the FF02::1:2 group address is not listed. It also does not mention the state of the DHCP server at the bottom of the output.

- c. What command can be used to have R1 join the all-DHCPv6 server group?

Issue the command **ipv6 dhcp server IPV6POOL-A** on interface G0/1.

```
R1(config)# interface g0/1
R1(config-if)# ipv6 dhcp server IPV6POOL-A
```

- d. Verify that the all-DHCPv6 server group is configured for interface G0/1.

```
R1# show ipv6 interface
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
```

Lab – Troubleshooting DHCPv6

```
No Virtual link-local address(es) :  
Global unicast address(es) :  
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64  
Joined group address(es) :  
    FF02::1  
    FF02::2  
    FF02::1:2  
    FF02::1:FF00:1  
    FF05::1:3  
MTU is 1500 bytes  
ICMP error messages limited to one every 100 milliseconds  
ICMP redirects are enabled  
ICMP unreachables are sent  
ND DAD is enabled, number of DAD attempts: 1  
ND reachable time is 30000 milliseconds (using 30000)  
ND advertised reachable time is 0 (unspecified)  
ND advertised retransmit interval is 0 (unspecified)  
ND router advertisements are sent every 200 seconds  
ND router advertisements live for 1800 seconds  
ND advertised default router preference is Medium  
Hosts use stateless autoconfig for addresses.
```

- e. Will PC-A receive the DHCP information now? Explain?
-

No, the **show ipv6 interface** command is still not showing that hosts are going to use DHCP to obtain other configuration information. This can be verified by issuing an **ipconfig /all** on PC-A.

- f. What is missing from the configuration of G0/1 that causes hosts to use the DHCP server to retrieve other network information?
-

The **ipv6 nd other-config-flag** command is needed to tell hosts to use the DHCP server to retrieve other network information.

```
R1(config)# interface g0/1  
R1(config-if)# ipv6 nd other-config-flag  
R1# show ipv6 interface  
GigabitEthernet0/1 is up, line protocol is up  
    IPv6 is enabled, link-local address is FE80::1  
    No Virtual link-local address(es) :  
    Global unicast address(es) :  
        2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64  
    Joined group address(es) :  
        FF02::1  
        FF02::2  
        FF02::1:2  
        FF02::1:FF00:1  
        FF05::1:3  
    MTU is 1500 bytes
```

Lab – Troubleshooting DHCPv6

```
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ICMP unreachables are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
ND advertised default router preference is Medium
Hosts use stateless autoconfig for addresses.
Hosts use DHCP to obtain other configuration.
```

- g. Reset the IPv6 settings on PC-A.
 - 1) Open the Local Area Connection Properties window, deselect the Internet Protocol Version 6 (TCP/IPv6) check box, and then click **OK** to accept the change.
 - 2) Open the Local Area Connection Properties window again, click the Internet Protocol Version 6 (TCP/IPv6) check box, and then click **OK** to accept the change.
- h. Issue the command to verify changes have been made on PC-A.

Note: Continue troubleshooting until PC-A receives the additional DHCP information from R1.

Reflection

1. What command is needed in the DHCPv6 pool for Stateful DHCPv6 that is not needed for Stateless DHCPv6? Why?

The **address prefix <ipv6 prefix address>** command is needed for Stateful DHCPv6. Hosts receive their IPv6 unicast addresses from the DHCP server so this command is needed to provide the IPv6 prefix to use for the network.

2. What command is needed on the interface to change the network to use Stateful DHCPv6 instead of Stateless DHCPv6?

The **ipv6 nd managed-config-flag** command is used to set the Stateful DHCPv6 flag. This is transmitted to all hosts on the network through the router advertisement messages sent by R1.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs**Router R1 (Final)**

```
R1#sh run
Building configuration...

Current configuration : 1829 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
memory-size iomem 10
!
ipv6 unicast-routing
```

Lab – Troubleshooting DHCPv6

```
ipv6 dhcp pool IPV6POOL-A
 dns-server 2001:DB8:ACAD:CAFE::A
 domain-name ccna-lab.com
!
ipv6 cef
!
no ip domain lookup
ip domain name ccna-lab.com
ip cef
!
multilink bundle-name authenticated
!
crypto pki token default removal timeout 0
!
redundancy
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:ACAD:A::1/64
 ipv6 nd other-config-flag
 ipv6 dhcp server IPV6POOL-A
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
```

Lab – Troubleshooting DHCPv6

```
control-plane
!
banner motd ^CC
    Unauthorized Access is Prohibited!
^C
!
line con 0
exec-timeout 0 0
password 7 0205085A1815
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 104D05181604
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1 (Final)

```
S1#sh run
Building configuration...

Current configuration : 3365 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
```

Lab – Troubleshooting DHCPv6

```
ip subnet-zero
!
!
no ip domain-lookup
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
```

Lab – Troubleshooting DHCPv6

```
interface FastEthernet0/14
    shutdown
!
interface FastEthernet0/15
    shutdown
!
interface FastEthernet0/16
    shutdown
!
interface FastEthernet0/17
    shutdown
!
interface FastEthernet0/18
    shutdown
!
interface FastEthernet0/19
    shutdown
!
interface FastEthernet0/20
    shutdown
!
interface FastEthernet0/21
    shutdown
!
interface FastEthernet0/22
    shutdown
!
interface FastEthernet0/23
    shutdown
!
interface FastEthernet0/24
    shutdown
!
interface GigabitEthernet0/1
    shutdown
!
interface GigabitEthernet0/2
    shutdown
!
interface Vlan1
    no ip address
    ipv6 address autoconfig
!
ip http server
ip http secure-server
!
control-plane
!
banner motd ^C
```

Lab – Troubleshooting DHCPv6

```
Unauthorized Access is Prohibited!
^C
!
line con 0
password 7 104D000A0618
logging synchronous
login
line vty 0 4
password 7 104D000A0618
login
line vty 5 15
password 7 104D000A0618
login
!
end
```



IoE and DHCP (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure DHCP for IPv4 or IPv6 on a Cisco 1941 router.

At the end of this chapter, students should be able to configure a Cisco 1941 router for IPv4 and IPv6 DHCP end-device addressing. In this activity, students will use Packet Tracer to configure DHCP addressing for end devices in a home environment.

Scenario

This chapter presents the concept of using the DHCP process in a small- to medium-sized business network; however, DHCP also has other uses!

With the advent of the Internet of Everything (IoE), any device in your home capable of wired or wireless connectivity to a network will be able to be accessed from just about anywhere.

Using Packet Tracer for this modeling activity, perform the following tasks:

- Configure a Cisco 1941 router (or DHCP-server-capable ISR device) for IPv4 or IPv6 DHCP addressing.
- Think of five devices in your home you would like to receive IP addresses from the router's DHCP service. Set the end devices to claim DHCP addresses from the DHCP server.
- Show output validating that each end device secures an IP address from the server. Save your output information via a screen capture program or use the **PrtScrn** key command.
- Present your findings to a fellow classmate or to the class.

Required Resources

Packet Tracer software

Reflection

1. Why would a user want to use a Cisco 1941 router to configure DHCP on his home network? Wouldn't a smaller ISR be good enough to use as a DHCP server?

Answers will vary. The 1941 routers are more expensive than smaller ISRs, but they offer more options to implement security plans and are more robust in processing/bandwidth power.

2. How do you think small- medium-sized businesses are able to use DHCP IP address allocation in the IoE and IPv6 network world? Brainstorm and record five possible answers.

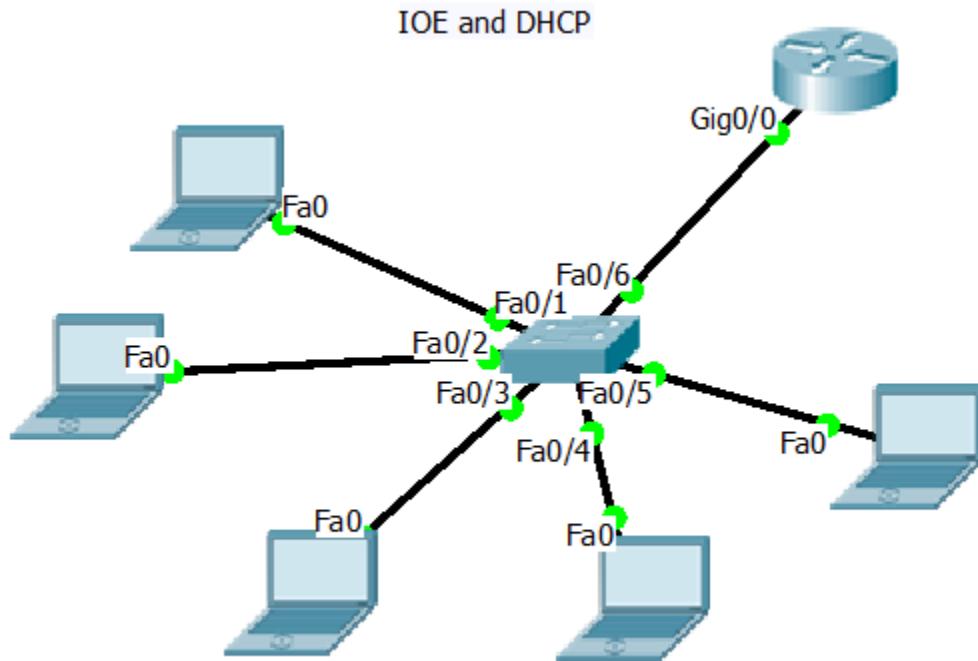
Small landscaping firms may be able to turn on sprinkler systems for customers when they go on vacation, based on the landscaping firm's DHCP server IP address allocations.

Small electric companies may be able to check error codes on any device with an IP address to evaluate the end-device for repair by using their own DHCP servers' IP address allocations.

Small automotive businesses may be able to provide estimates for repair based on DHCP IP addressing of automobiles with auto addresses linked to the business' DHCP server.

A homeowner may be able to start the washer or dryer from any location, based upon a DNS server location and their own DHCP server address.

Televisions may be controlled to turn off, turn on, select stations to record, record programs, and more using a DNS server and personal DHCP server.

Instructor Activity Representative Topology and Output

```
Router# show run
(output omitted)

hostname Router

ip dhcp excluded-address 192.168.1.1 192.168.1.10
!
ip dhcp pool HOME-ADDRESSES
network 192.168.1.0 255.255.255.0
default-router 192.168.1.1
!
(output omitted)

spanning-tree mode pvst
!
interface GigabitEthernet0/0
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
```

Router# show ip dhcp binding			
IP address	Client-ID/ Hardware address	Lease expiration	Type
192.168.1.11	0090.0CC1.A57B	--	Automatic
192.168.1.14	0060.3E80.2074	--	Automatic
192.168.1.13	0001.C9B3.382D	--	Automatic
192.168.1.12	000A.F345.487C	--	Automatic
192.168.1.15	00E0.F995.0C3B	--	Automatic

Identify elements of the model that map to IT-related content:

- DHCP servers can allocate IP addresses to any network-capable device.
- DHCP servers can provide small- to medium-sized businesses with functionality that is not provided with static addressing.
- Network administrators, who configure network DHCP servers, such as routers, switches or dedicated servers, can save time in implementing an IP addressing scheme.



Conceptual NAT (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Describe NAT characteristics.

This activity introduces students to the concept of network address translation.

Scenario

You work for a large university or school system. Because you are the network administrator, many professors, administrative workers, and other network administrators need your assistance with their networks on a daily basis. They call you at all working hours of the day and, because of the number of telephone calls, you cannot complete your regular network administration tasks.

You need to find a way to limit when you take calls and from whom. You also need to mask your telephone number so that when you call someone, another number is displayed to the recipient.

This scenario describes a very common problem for most small- to medium-sized businesses. Visit, “How Network Address Translation Works” located at <http://computer.howstuffworks.com/nat.htm/printable> to view more information about how the digital world handles these types of workday interruptions.

Use the PDF provided accompanying this activity to reflect further on how a process, known as NAT, could be the answer to this scenario’s challenge.

Resources

Internet connection

Directions

Step 1: Read Information on the Internet Site.

- a. Go to “How Network Address Translation Works” located at <http://computer.howstuffworks.com/nat.htm/printable>
- b. Read the information provided to introduce the basic concepts of NAT.
- c. Record five facts you find to be interesting about the NAT process.

Step 2: View the NAT graphics.

- a. On the same Internet page, look at the types of NAT that are available for configuration on most networks.
- b. Define the four NAT types:
 - 1) Static NAT
 - 2) Dynamic NAT
 - 3) NAT Overload
 - 4) NAT Overlap

Step 3: Meet together in a full-class setting.

- a. Report your five NAT facts to the class.
- b. As other students state their interesting facts to the class, check off the stated fact if you already recorded it.

Conceptual NAT

- c. If a student reports a fact to the class that you did not record, add it to your list.

Instructor Resource Information

- It is suggested that you display the Web page used as a basis for this activity while comparing facts students report after reading the article.
- Make sure you correct any misunderstandings found in the reading of the web article before moving to the curriculum content.
- At the end of the class or group meeting, reiterate that NAT is a process used to conserve network address allocations and provide a measure of security for users.

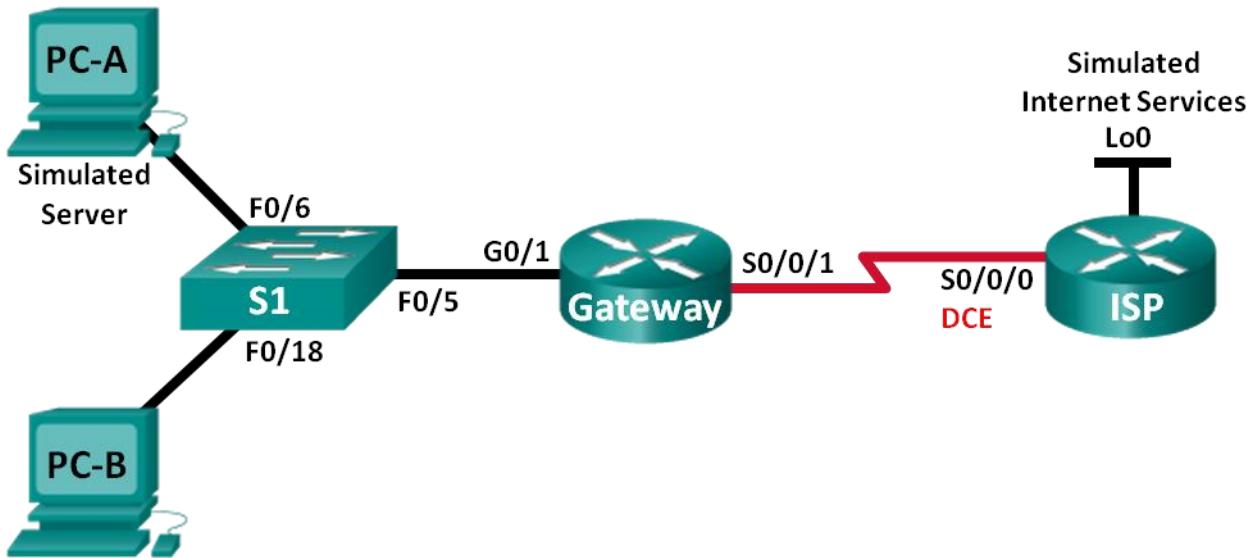
Identify elements of the model that map to IT-related content:

- NAT
- Static NAT
- Dynamic NAT
- NAT Overload
- NAT Overlap

Lab – Configuring Dynamic and Static NAT (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
Gateway	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/1	209.165.201.18	255.255.255.252	N/A
ISP	S0/0/0 (DCE)	209.165.201.17	255.255.255.252	N/A
	Lo0	192.31.7.1	255.255.255.255	N/A
PC-A (Simulated Server)	NIC	192.168.1.20	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.1.21	255.255.255.0	192.168.1.1

Objectives

Part 1: Build the Network and Verify Connectivity

Part 2: Configure and Verify Static NAT

Part 3: Configure and Verify Dynamic NAT

Background / Scenario

Network Address Translation (NAT) is the process where a network device, such as a Cisco router, assigns a public address to host devices inside a private network. The main reason to use NAT is to reduce the number of public IP addresses that an organization uses because the number of available IPv4 public addresses is limited.

Lab – Configuring Dynamic and Static NAT

In this lab, an ISP has allocated the public IP address space of 209.165.200.224/27 to a company. This provides the company with 30 public IP addresses. The addresses, 209.165.200.225 to 209.165.200.241, are for static allocation and 209.165.200.242 to 209.165.200.254 are for dynamic allocation. A static route is used from the ISP to the gateway router, and a default route is used from the gateway to the ISP router. The ISP connection to the Internet is simulated by a loopback address on the ISP router.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Verify Connectivity

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, static routing, device access, and passwords.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the routers and switches as necessary.

Step 4: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure IP addresses for the routers as listed in the Addressing Table.
- c. Set the clock rate to **1280000** for the DCE serial interfaces.
- d. Configure device name as shown in the topology.
- e. Assign **cisco** as the console and vty passwords.
- f. Assign **class** as the encrypted privileged EXEC mode password.
- g. Configure **logging synchronous** to prevent console messages from interrupting the command entry.

Step 5: Create a simulated web server on ISP.

- a. Create a local user named **webuser** with an encrypted password of **webpass**.

Lab – Configuring Dynamic and Static NAT

```
ISP(config)# username webuser privilege 15 secret webpass
```

- b. Enable the HTTP server service on ISP.

```
ISP(config)# ip http server
```

- c. Configure the HTTP service to use the local user database.

```
ISP(config)# ip http authentication local
```

Step 6: Configure static routing.

- a. Create a static route from the ISP router to the Gateway router using the assigned public network address range 209.165.200.224/27.

```
ISP(config)# ip route 209.165.200.224 255.255.255.224 209.165.201.18
```

- b. Create a default route from the Gateway router to the ISP router.

```
Gateway(config)# ip route 0.0.0.0 0.0.0.0 209.165.201.17
```

Step 7: Save the running configuration to the startup configuration.

Step 8: Verify network connectivity.

- a. From the PC hosts, ping the G0/1 interface on the Gateway router. Troubleshoot if the pings are unsuccessful.
- b. Display the routing tables on both routers to verify that the static routes are in the routing table and configured correctly on both routers.

Part 2: Configure and Verify Static NAT

Static NAT uses a one-to-one mapping of local and global addresses, and these mappings remain constant. Static NAT is particularly useful for web servers or devices that must have static addresses that are accessible from the Internet.

Step 1: Configure a static mapping.

A static map is configured to tell the router to translate between the private inside server address 192.168.1.20 and the public address 209.165.200.225. This allows a user from the Internet to access PC-A. PC-A is simulating a server or device with a constant address that can be accessed from the Internet.

```
Gateway(config)# ip nat inside source static 192.168.1.20 209.165.200.225
```

Step 2: Specify the interfaces.

Issue the **ip nat inside** and **ip nat outside** commands to the interfaces.

```
Gateway(config)# interface g0/1
```

```
Gateway(config-if)# ip nat inside
```

```
Gateway(config-if)# interface s0/0/1
```

```
Gateway(config-if)# ip nat outside
```

Step 3: Test the configuration.

- a. Display the static NAT table by issuing the **show ip nat translations** command.

```
Gateway# show ip nat translations
```

Pro	Inside global	Inside local	Outside local	Outside global
---	209.165.200.225	192.168.1.20	---	---

Lab – Configuring Dynamic and Static NAT

What is the translation of the Inside local host address?

192.168.1.20 = _____ 209.165.200.225

The Inside global address is assigned by?

The router from the NAT pool.

The Inside local address is assigned by?

The administrator for the workstation.

- b. From PC-A, ping the Lo0 interface (192.31.7.1) on ISP. If the ping was unsuccessful, troubleshoot and correct the issues. On the Gateway router, display the NAT table.

Gateway# **show ip nat translations**

Protocol	Inside global	Inside local	Outside local	Outside global
icmp	209.165.200.225:1	192.168.1.20:1	192.31.7.1:1	192.31.7.1:1
	---	209.165.200.225	192.168.1.20	---

A NAT entry was added to the table with ICMP listed as the protocol when PC-A sent an ICMP request (ping) to 192.31.7.1 on ISP.

What port number was used in this ICMP exchange? _____ 1, answers will vary.

Note: It may be necessary to disable the PC-A firewall for the ping to be successful.

- c. From PC-A, telnet to the ISP Lo0 interface and display the NAT table.

Protocol	Inside global	Inside local	Outside local	Outside global
icmp	209.165.200.225:1	192.168.1.20:1	192.31.7.1:1	192.31.7.1:1
tcp	209.165.200.225:1034	192.168.1.20:1034	192.31.7.1:23	192.31.7.1:23
	---	209.165.200.225	192.168.1.20	---

Note: The NAT for the ICMP request may have timed out and been removed from the NAT table.

What was the protocol used in this translation? _____ tcp

What are the port numbers used?

Inside global / local: _____ 1034, answers will vary.

Outside global / local: _____ 23

- d. Because static NAT was configured for PC-A, verify that pinging from ISP to PC-A at the static NAT public address (209.165.200.225) is successful.
- e. On the Gateway router, display the NAT table to verify the translation.

Gateway# **show ip nat translations**

Protocol	Inside global	Inside local	Outside local	Outside global
icmp	209.165.200.225:12	192.168.1.20:12	209.165.201.17:12	209.165.201.17:12
	---	209.165.200.225	192.168.1.20	---

Notice that the Outside local and Outside global addresses are the same. This address is the ISP remote network source address. For the ping from the ISP to succeed, the Inside global static NAT address 209.165.200.225 was translated to the Inside local address of PC-A (192.168.1.20).

- f. Verify NAT statistics by using the **show ip nat statistics** command on the Gateway router.

Gateway# **show ip nat statistics**

Total active translations: 2 (1 static, 1 dynamic; 1 extended)

Lab – Configuring Dynamic and Static NAT

```
Peak translations: 2, occurred 00:02:12 ago
Outside interfaces:
  Serial0/0/1
Inside interfaces:
  GigabitEthernet0/1
Hits: 39 Misses: 0
CEF Translated packets: 39, CEF Punted packets: 0
Expired translations: 3
Dynamic mappings:

Total doors: 0
Appl doors: 0
Normal doors: 0
Queued Packets: 0
```

Note: This is only a sample output. Your output may not match exactly.

Part 3: Configure and Verify Dynamic NAT

Dynamic NAT uses a pool of public addresses and assigns them on a first-come, first-served basis. When an inside device requests access to an outside network, dynamic NAT assigns an available public IPv4 address from the pool. Dynamic NAT results in a many-to-many address mapping between local and global addresses.

Step 1: Clear NATs.

Before proceeding to add dynamic NATs, clear the NATs and statistics from Part 2.

```
Gateway# clear ip nat translation *
Gateway# clear ip nat statistics
```

Step 2: Define an access control list (ACL) that matches the LAN private IP address range.

ACL 1 is used to allow 192.168.1.0/24 network to be translated.

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

Step 3: Verify that the NAT interface configurations are still valid.

Issue the **show ip nat statistics** command on the Gateway router to verify the NAT configurations.

```
Gateway# show ip nat statistics
Total active translations: 1 (1 static, 0 dynamic; 0 extended)
Peak translations: 0
Outside interfaces:
  Serial0/0/1
Inside interfaces:
  FastEthernet0/1
Hits: 0 Misses: 0
CEF Translated packets: 0, CEF Punted packets: 0
Expired translations: 0
Dynamic mappings:

Total doors: 0
```

```
Appl doors: 0  
Normal doors: 0  
Queued Packets: 0
```

Step 4: Define the pool of usable public IP addresses.

```
Gateway(config)# ip nat pool public_access 209.165.200.242 209.165.200.254  
netmask 255.255.255.224
```

Step 5: Define the NAT from the inside source list to the outside pool.

Note: Remember that NAT pool names are case-sensitive and the pool name entered here must match that used in the previous step.

```
Gateway(config)# ip nat inside source list 1 pool public_access
```

Step 6: Test the configuration.

- From PC-B, ping the Lo0 interface (192.31.7.1) on ISP. If the ping was unsuccessful, troubleshoot and correct the issues. On the Gateway router, display the NAT table.

```
Gateway# show ip nat translations  
Pro Inside global      Inside local      Outside local      Outside global  
--- 209.165.200.225    192.168.1.20     ---             ---  
icmp 209.165.200.242:1 192.168.1.21:1   192.31.7.1:1   192.31.7.1:1  
--- 209.165.200.242    192.168.1.21     ---             ---
```

What is the translation of the Inside local host address for PC-B?

192.168.1.21 = _____ 209.165.200.242

A dynamic NAT entry was added to the table with ICMP as the protocol when PC-B sent an ICMP message to 192.31.7.1 on ISP.

What port number was used in this ICMP exchange? _____ 1, answers will vary.

- From PC-B, open a browser and enter the IP address of the ISP-simulated web server (Lo0 interface). When prompted, log in as **webuser** with a password of **webpass**.
- Display the NAT table.

```
Pro Inside global      Inside local      Outside local      Outside global  
--- 209.165.200.225    192.168.1.20     ---             ---  
tcp 209.165.200.242:1038 192.168.1.21:1038 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1039 192.168.1.21:1039 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1040 192.168.1.21:1040 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1041 192.168.1.21:1041 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1042 192.168.1.21:1042 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1043 192.168.1.21:1043 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1044 192.168.1.21:1044 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1045 192.168.1.21:1045 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1046 192.168.1.21:1046 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1047 192.168.1.21:1047 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1048 192.168.1.21:1048 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1049 192.168.1.21:1049 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1050 192.168.1.21:1050 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1051 192.168.1.21:1051 192.31.7.1:80 192.31.7.1:80  
tcp 209.165.200.242:1052 192.168.1.21:1052 192.31.7.1:80 192.31.7.1:80
```

Lab – Configuring Dynamic and Static NAT

--- 209.165.200.242 192.168.1.22 --- ---

What protocol was used in this translation? _____ **tcp**

What port numbers were used?

Inside: _____ 1038 to 1052. Answers will vary

outside: _____ 80

What well-known port number and service was used? _____ **port 80, www or http**

- d. Verify NAT statistics by using the **show ip nat statistics** command on the Gateway router.

```
Gateway# show ip nat statistics
```

```
Total active translations: 3 (1 static, 2 dynamic; 1 extended)
```

```
Peak translations: 17, occurred 00:06:40 ago
```

```
Outside interfaces:
```

```
Serial0/0/1
```

```
Inside interfaces:
```

```
GigabitEthernet0/1
```

```
Hits: 345 Misses: 0
```

```
CEF Translated packets: 345, CEF Punted packets: 0
```

```
Expired translations: 20
```

```
Dynamic mappings:
```

```
-- Inside Source
```

```
[Id: 1] access-list 1 pool public_access refcount 2
```

```
pool public_access: netmask 255.255.255.224
```

```
start 209.165.200.242 end 209.165.200.254
```

```
type generic, total addresses 13, allocated 1 (7%), misses 0
```

```
Total doors: 0
```

```
Appl doors: 0
```

```
Normal doors: 0
```

```
Queued Packets: 0
```

Note: This is only a sample output. Your output may not match exactly.

Step 7: Remove the static NAT entry.

In Step 7, the static NAT entry is removed and you can observe the NAT entry.

- a. Remove the static NAT from Part 2. Enter **yes** when prompted to delete child entries.

```
Gateway(config)# no ip nat inside source static 192.168.1.20 209.165.200.225
```

```
Static entry in use, do you want to delete child entries? [no]: yes
```

- b. Clear the NATs and statistics.

- c. Ping the ISP (192.31.7.1) from both hosts.

- d. Display the NAT table and statistics.

```
Gateway# show ip nat statistics
```

```
Total active translations: 4 (0 static, 4 dynamic; 2 extended)
```

```
Peak translations: 15, occurred 00:00:43 ago
```

```
Outside interfaces:
```

```
Serial0/0/1
```

Lab – Configuring Dynamic and Static NAT

```
Inside interfaces:  
  GigabitEthernet0/1  
    Hits: 16  Misses: 0  
    CEF Translated packets: 285, CEF Punted packets: 0  
    Expired translations: 11  
Dynamic mappings:  
  -- Inside Source  
    [Id: 1] access-list 1 pool public_access refcount 4  
      pool public_access: netmask 255.255.255.224  
        start 209.165.200.242 end 209.165.200.254  
        type generic, total addresses 13, allocated 2 (15%), misses 0
```

```
Total doors: 0  
Appl doors: 0  
Normal doors: 0  
Queued Packets: 0
```

```
Gateway# show ip nat translation
```

Pro	Inside global	Inside local	Outside local	Outside global
icmp	209.165.200.243:512	192.168.1.20:512	192.31.7.1:512	192.31.7.1:512
---	209.165.200.243	192.168.1.20	---	---
icmp	209.165.200.242:512	192.168.1.21:512	192.31.7.1:512	192.31.7.1:512
---	209.165.200.242	192.168.1.21	---	---

Note: This is only a sample output. Your output may not match exactly.

Reflection

1. Why would NAT be used in a network?

Answers will vary, but should include: whenever there are not enough public IP addresses and to avoid the cost of purchasing public addresses from an ISP. NAT can also provide a measure of security by hiding internal addresses from outside networks.

2. What are the limitations of NAT?

NAT needs IP information or port number information in the IP header and TCP header of packets for translation. Here is a partial list of protocols that cannot be used with NAT: SNMP, LDAP, Kerberos version 5.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs**Gateway (After Part 2)**

```
Gateway# show run
Building configuration...

Current configuration : 1666 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Gateway
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 15
!
```

Lab – Configuring Dynamic and Static NAT

```
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
ip nat inside
ip virtual-reassembly in
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
ip address 209.165.201.18 255.255.255.252
ip nat outside
ip virtual-reassembly in
!
ip forward-protocol nd
!
```

Lab – Configuring Dynamic and Static NAT

```
no ip http server
no ip http secure-server
!
ip nat inside source static 192.168.1.20 209.165.200.225
ip route 0.0.0.0 0.0.0.0 209.165.201.17
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Gateway (Final)

```
Gateway# show run
Building configuration...

Current configuration : 1701 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Gateway
!
boot-start-marker
boot-end-marker
```

Lab – Configuring Dynamic and Static NAT

```
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh01QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
ip nat inside
ip virtual-reassembly in
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
```

Lab – Configuring Dynamic and Static NAT

```
ip address 209.165.201.18 255.255.255.252
ip nat outside
ip virtual-reassembly in
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip nat pool public_access 209.165.200.242 209.165.200.254 netmask 255.255.255.224
ip nat inside source list 1 pool public_access
ip route 0.0.0.0 0.0.0.0 209.165.201.17
!
access-list 1 permit 192.168.1.0 0.0.0.255
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

ISP (Final)

```
ISP# show run
Building configuration...

Current configuration : 1557 bytes
!
! Last configuration change at 09:16:34 UTC Sun Mar 24 2013
```

Lab – Configuring Dynamic and Static NAT

```
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUG.2
!
no aaa new-model
memory-size iomem 10
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
username webuser privilege 15 secret 4 ZMYyKvmzVsyor8jHyP9ox.cMoz9loLfZN75illtozY2
!
!
!
!
!
!
interface Loopback0
 ip address 192.31.7.1 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
```

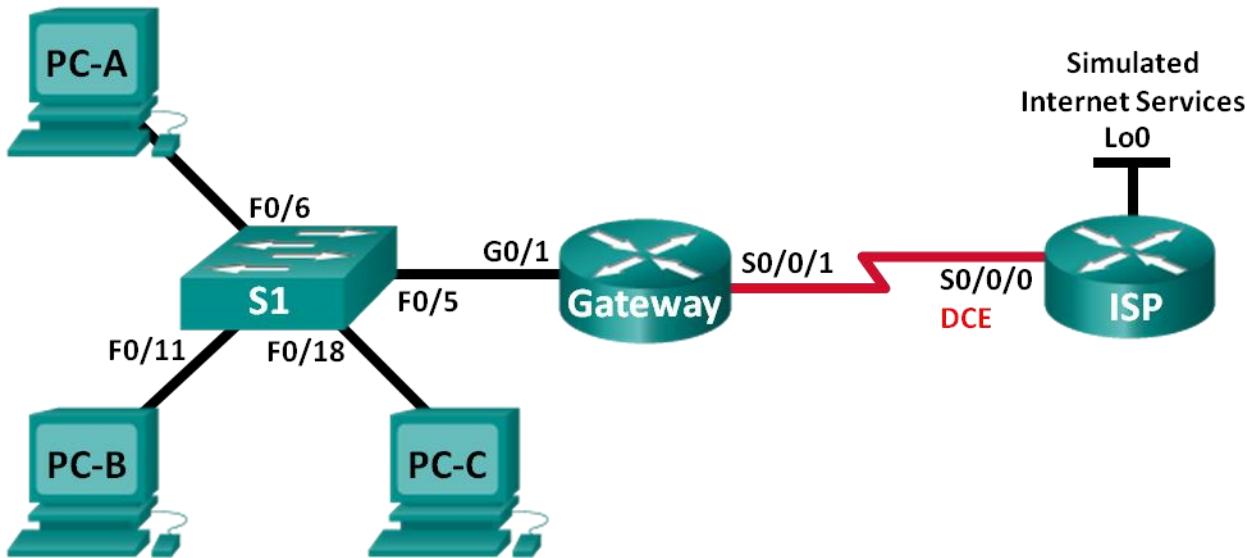
Lab – Configuring Dynamic and Static NAT

```
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 209.165.201.17 255.255.255.252
clock rate 128000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
ip http server
ip http authentication local
no ip http secure-server
!
ip route 209.165.200.224 255.255.255.224 209.165.201.18
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring NAT Pool Overload and PAT (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
Gateway	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/1	209.165.201.18	255.255.255.252	N/A
ISP	S0/0/0 (DCE)	209.165.201.17	255.255.255.252	N/A
	Lo0	192.31.7.1	255.255.255.255	N/A
PC-A	NIC	192.168.1.20	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.1.21	255.255.255.0	192.168.1.1
PC-C	NIC	192.168.1.22	255.255.255.0	192.168.1.1

Objectives

Part 1: Build the Network and Verify Connectivity

Part 2: Configure and Verify NAT Pool Overload

Part 3: Configure and Verify PAT

Background / Scenario

In the first part of the lab, your company is allocated the public IP address range of 209.165.200.224/29 by the ISP. This provides the company with six public IP addresses. Dynamic NAT pool overload uses a pool of IP addresses in a many-to-many relationship. The router uses the first IP address in the pool and assigns connections using the IP address plus a unique port number. After the maximum number of translations for a

Lab – Configuring NAT Pool Overload and PAT

single IP address have been reached on the router (platform and hardware specific), it uses the next IP address in the pool.

In Part 2, the ISP has allocated a single IP address, 209.165.201.18, to your company for use on the Internet connection from the company Gateway router to the ISP. You will use the Port Address Translation (PAT) to convert multiple internal addresses into the one usable public address. You will test, view, and verify that the translations are taking place, and you will interpret the NAT/PAT statistics to monitor the process.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Verify Connectivity

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, static routing, device access, and passwords.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the routers and switches.

Step 4: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure IP addresses for the routers as listed in the Addressing Table.
- c. Set the clock rate to **128000** for DCE serial interface.
- d. Configure device name as shown in the topology.
- e. Assign **cisco** as the console and vty passwords.
- f. Assign **class** as the encrypted privileged EXEC mode password.
- g. Configure **logging synchronous** to prevent console messages from interrupting the command entry.

Step 5: Configure static routing.

- a. Create a static route from the ISP router to the Gateway router.

Lab – Configuring NAT Pool Overload and PAT

```
ISP(config)# ip route 209.165.200.224 255.255.255.248 209.165.201.18
```

- b. Create a default route from the Gateway router to the ISP router.

```
Gateway(config)# ip route 0.0.0.0 0.0.0.0 209.165.201.17
```

Step 6: Verify network connectivity.

- a. From the PC hosts, ping the G0/1 interface on the Gateway router. Troubleshoot if the pings are unsuccessful.
- b. Verify that the static routes are configured correctly on both routers.

Part 2: Configure and Verify NAT Pool Overload

In Part 2, you will configure the Gateway router to translate the IP addresses from the 192.168.1.0/24 network to one of the six usable addresses in the 209.165.200.224/29 range.

Step 1: Define an access control list that matches the LAN private IP addresses.

ACL 1 is used to allow the 192.168.1.0/24 network to be translated.

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

Step 2: Define the pool of usable public IP addresses.

```
Gateway(config)# ip nat pool public_access 209.165.200.225 209.165.200.230  
netmask 255.255.255.248
```

Step 3: Define the NAT from the inside source list to the outside pool.

```
Gateway(config)# ip nat inside source list 1 pool public_access overload
```

Step 4: Specify the interfaces.

Issue the **ip nat inside** and **ip nat outside** commands to the interfaces.

```
Gateway(config)# interface g0/1  
Gateway(config-if)# ip nat inside  
Gateway(config-if)# interface s0/0/1  
Gateway(config-if)# ip nat outside
```

Step 5: Verify the NAT pool overload configuration.

- a. From each PC host, ping the 192.31.7.1 address on the ISP router.
- b. Display NAT statistics on the Gateway router.

```
Gateway# show ip nat statistics  
Total active translations: 3 (0 static, 3 dynamic; 3 extended)  
Peak translations: 3, occurred 00:00:25 ago  
Outside interfaces:  
    Serial0/0/1  
Inside interfaces:  
    GigabitEthernet0/1  
Hits: 24 Misses: 0  
CEF Translated packets: 24, CEF Punted packets: 0  
Expired translations: 0
```

Lab – Configuring NAT Pool Overload and PAT

```
Dynamic mappings:  
-- Inside Source  
[Id: 1] access-list 1 pool public_access refcount 3  
pool public_access: netmask 255.255.255.248  
    start 209.165.200.225 end 209.165.200.230  
    type generic, total addresses 6, allocated 1 (16%), misses 0
```

Total doors: 0

Appl doors: 0

Normal doors: 0

Queued Packets: 0

- c. Display NATs on the Gateway router.

```
Gateway# show ip nat translations  
Pro Inside global      Inside local      Outside local      Outside global  
icmp 209.165.200.225:0 192.168.1.20:1  192.31.7.1:1  192.31.7.1:0  
icmp 209.165.200.225:1 192.168.1.21:1  192.31.7.1:1  192.31.7.1:1  
icmp 209.165.200.225:2 192.168.1.22:1  192.31.7.1:1  192.31.7.1:2
```

Note: Depending on how much time has elapsed since you performed the pings from each PC, you may not see all three translations. ICMP translations have a short timeout value.

How many Inside local IP addresses are listed in the sample output above? _____ 3

How many Inside global IP addresses are listed? _____ 1

How many port numbers are used paired with the Inside global addresses _____ 3

What would be the result of pinging the Inside local address of PC-A from the ISP router? Why?

The ping would fail because the router knows the location of the Inside global address in its routing table but the Inside local address is not advertised.

Part 3: Configure and Verify PAT

In Part 3, you will configure PAT by using an interface instead of a pool of addresses to define the outside address. Not all of the commands in Part 2 will be reused in Part 3.

Step 1: Clear NATs and statistics on the Gateway router.

Step 2: Verify the configuration for NAT.

- a. Verify that statistics have been cleared.
- b. Verify that the outside and inside interfaces are configured for NATs.
- c. Verify that the ACL is still configured for NATs.

What command did you use to confirm the results from steps a to c?

```
Gateway# show ip nat statistics
```

Step 3: Remove the pool of useable public IP addresses.

```
Gateway(config)# no ip nat pool public_access 209.165.200.225 209.165.200.230  
netmask 255.255.255.248
```

Step 4: Remove the NAT translation from inside source list to outside pool.

```
Gateway(config)# no ip nat inside source list 1 pool public_access overload
```

Step 5: Associate the source list with the outside interface.

```
Gateway(config)# ip nat inside source list 1 interface serial 0/0/1 overload
```

Step 6: Test the PAT configuration.

- From each PC, ping the 192.31.7.1 address on the ISP router.
- Display NAT statistics on the Gateway router.

```
Gateway# show ip nat statistics  
Total active translations: 3 (0 static, 3 dynamic; 3 extended)  
Peak translations: 3, occurred 00:00:19 ago  
Outside interfaces:  
    Serial0/0/1  
Inside interfaces:  
    GigabitEthernet0/1  
Hits: 24 Misses: 0  
CEF Translated packets: 24, CEF Punted packets: 0  
Expired translations: 0  
Dynamic mappings:  
-- Inside Source  
[Id: 2] access-list 1 interface Serial0/0/1 refcount 3
```

```
Total doors: 0  
Appl doors: 0  
Normal doors: 0  
Queued Packets: 0
```

- Display NAT translations on Gateway.

```
Gateway# show ip nat translations  
Pro Inside global      Inside local        Outside local      Outside global  
icmp 209.165.201.18:3  192.168.1.20:1    192.31.7.1:1    192.31.7.1:3  
icmp 209.165.201.18:1  192.168.1.21:1    192.31.7.1:1    192.31.7.1:1  
icmp 209.165.201.18:4  192.168.1.22:1    192.31.7.1:1    192.31.7.1:4
```

Reflection

What advantages does PAT provide?

Answers will vary, but should include that PAT minimizes the number of public addresses needed to provide Internet access, and that PAT, like NAT, serves to “hide” private addresses from outside networks.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router Gateway (After Part 2)

```
Gateway# show run
Building configuration...

Current configuration : 1790 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Gateway
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGh0lQM5EnRtoyr8cHAug.2
!
no aaa new-model
memory-size iomem 15
!
```

Lab – Configuring NAT Pool Overload and PAT

```
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
ip nat inside
ip virtual-reassembly in
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
!
interface Serial0/0/1
ip address 209.165.201.18 255.255.255.252
ip nat outside
ip virtual-reassembly in
!
ip forward-protocol nd
!
no ip http server
```

Lab – Configuring NAT Pool Overload and PAT

```
no ip http secure-server
!
ip nat pool public_access 209.165.200.225 209.165.200.230 netmask 255.255.255.248
ip nat inside source list 1 pool public_access overload
ip route 0.0.0.0 0.0.0.0 209.165.201.17
!
access-list 1 permit 192.168.1.0 0.0.0.255
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router Gateway (After Part 3)

```
Gateway# show run
Building configuration...

Current configuration : 1711 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Gateway
!
boot-start-marker
```

Lab – Configuring NAT Pool Overload and PAT

```
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  ip address 192.168.1.1 255.255.255.0
  ip nat inside
  ip virtual-reassembly in
  duplex auto
  speed auto
!
interface Serial0/0/0
  no ip address
  shutdown
!
```

Lab – Configuring NAT Pool Overload and PAT

```
interface Serial0/0/1
 ip address 209.165.201.18 255.255.255.252
 ip nat outside
 ip virtual-reassembly in
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip nat inside source list 1 interface Serial0/0/1 overload
ip route 0.0.0.0 0.0.0.0 209.165.201.17
!
access-list 1 permit 192.168.1.0 0.0.0.255
!
!
!
Control-plane
!
!
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router ISP

```
ISP# show run
Building configuration...

Current configuration : 1487 bytes
!
version 15.2
```

Lab – Configuring NAT Pool Overload and PAT

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
interface Loopback0
 ip address 192.31.7.1 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
```

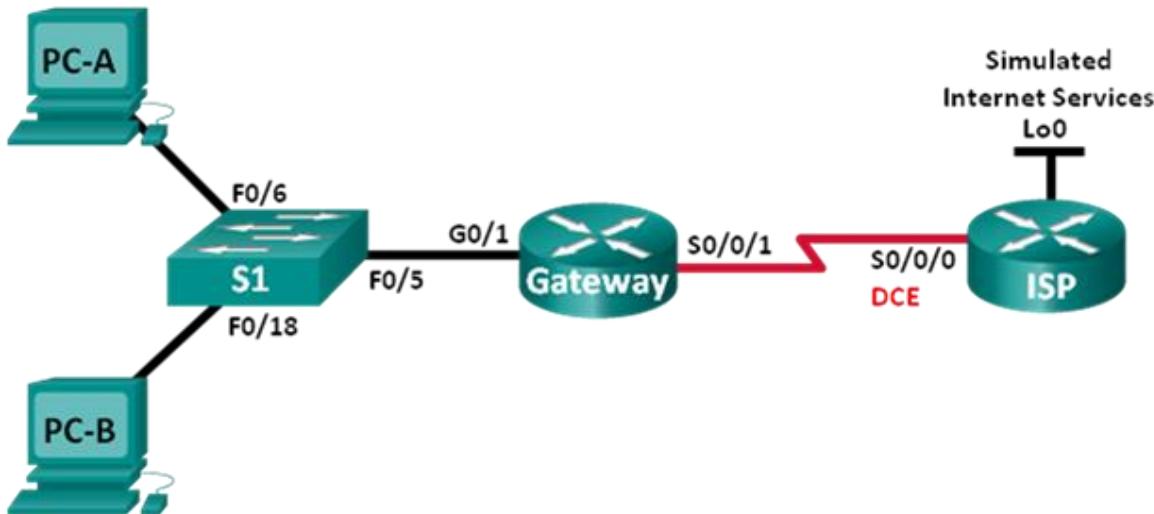
Lab – Configuring NAT Pool Overload and PAT

```
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
 ip address 209.165.201.17 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 209.165.200.224 255.255.255.224 209.165.201.18
!
!
!
!
control-plane
!
!
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab - Troubleshooting NAT Configurations (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
Gateway	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/1	209.165.200.225	255.255.255.252	N/A
ISP	S0/0/0 (DCE)	209.165.200.226	255.255.255.252	N/A
	Lo0	198.133.219.1	255.255.255.255	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-B	NIC	192.168.1.4	255.255.255.0	192.168.1.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot Static NAT

Part 3: Troubleshoot Dynamic NAT

Background / Scenario

In this lab, the Gateway router was configured by an inexperienced network administrator at your company. Several errors in the configuration have resulted in NAT issues. Your boss has asked you to troubleshoot and correct the NAT errors and document your work. Ensure that the network supports the following:

- PC-A acts as a web server with a static NAT and will be reachable from the outside using the 209.165.200.254 address.

Lab - Troubleshooting NAT Configurations

- PC-B acts as a host computer and dynamically receives an IP address from the created pool of addresses called NAT_POOL, which uses the 209.165.200.240/29 range.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the routers with basic settings. Additional NAT-related configurations are provided. The NAT configurations for the Gateway router contains errors that you will identify and correct as you proceed through the lab.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the switch and routers.

Step 4: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Configure IP addresses as listed in the Address Table.
- d. Set the clock rate to **128000** for DCE serial interfaces.
- e. Assign **cisco** as the console and vty password.
- f. Assign **class** as the encrypted privileged EXEC mode password.
- g. Configure **logging synchronous** to prevent console messages from interrupting the command entry.

Step 5: Configure static routing.

- a. Create a static route from the ISP router to the Gateway router-assigned public network address range 209.165.200.224/27.

```
ISP(config)# ip route 209.165.200.224 255.255.255.224 s0/0/0
```

- b. Create a default route from the Gateway router to the ISP router.

```
Gateway(config)# ip route 0.0.0.0 0.0.0.0 s0/0/1
```

Step 6: Load router configurations.

The configurations for the routers are provided for you. There are errors with the configuration for the Gateway router. Identify and correct the configurations errors.

Gateway Router Configuration

```
interface g0/1
  ip nat outside
  ! ip nat inside
  no shutdown
interface s0/0/0
  ip nat outside
  ! no ip nat outside
interface s0/0/1
  ! ip nat outside
  no shutdown
ip nat inside source static 192.168.2.3 209.165.200.254
! ip nat inside source static 192.168.1.3 209.165.200.254
ip nat pool NAT_POOL 209.165.200.241 209.165.200.246 netmask 255.255.255.248
ip nat inside source list NAT_ACL pool NATPOOL
! ip nat inside source list NAT_ACL pool NAT_POOL
ip access-list standard NAT_ACL
  permit 192.168.10.0 0.0.0.255
! permit 192.168.1.0 0.0.0.255
banner motd $AUTHORIZED ACCESS ONLY$
end
```

Step 7: Save the running configuration to the startup configuration.

Part 2: Troubleshoot Static NAT

In Part 2, you will examine the static NAT for PC-A to determine if it is configured correctly. You will troubleshoot the scenario until the correct static NAT is verified.

- a. To troubleshoot issues with NAT, use the **debug ip nat** command. Turn on NAT debugging to see translations in real-time across the Gateway router.

```
Gateway# debug ip nat
```

- b. From PC-A, ping Lo0 on the ISP router. Do any NAT debug translations appear on the Gateway router?

No.

- c. On the Gateway router, enter the command that allows you to see all current NAT translations on the Gateway router. Write the command in the space below.

show ip nat translations

```
Gateway# show ip nat translations
Pro Inside global      Inside local      Outside local      Outside global
```

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```
--- 209.165.200.254      192.168.2.3      ---      ---
```

Why are you seeing a NAT translation in the table, but none occurred when PC-A pinged the ISP loopback interface? What is needed to correct the issue?

The static translation is for an incorrect inside local address.

- d. Record any commands that are necessary to correct the static NAT configuration error.
-
-

```
Gateway(config)# no ip nat inside source static 192.168.2.3 209.165.200.254
Gateway(config)# ip nat inside source static 192.168.1.3 209.165.200.254
```

- e. From PC-A, ping Lo0 on the ISP router. Do any NAT debug translations appear on the Gateway router?
-

No

- f. On the Gateway router, enter the command that allows you to observe the total number of current NATs. Write the command in the space below.
-

show ip nat statistics

```
Gateway# show ip nat statistics
Total active translations: 1 (1 static, 0 dynamic; 0 extended)
Peak translations: 1, occurred 00:08:12 ago
Outside interfaces:
  GigabitEthernet0/1, Serial0/0/0
Inside interfaces:
  Hits: 0  Misses: 0
  CEF Translated packets: 0, CEF Punted packets: 0
  Expired translations: 0
  Dynamic mappings:
    -- Inside Source
    [Id: 1] access-list NAT_ACL pool NATPOOL refcount 0

  Total doors: 0
  Appl doors: 0
  Normal doors: 0
  Queued Packets: 0
```

Is the static NAT occurring successfully? Why?

No NAT translation is occurring because both of G0/1 and S0/0/0 interfaces are configured with the **ip nat outside** command. No active interfaces area assigned as inside.

- g. On the Gateway router, enter the command that allows you to view the current configuration of the router. Write the command in the space below.
-

show running-config

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```
Gateway# show running-config
Building configuration...

Current configuration : 1806 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Gateway
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
!
multilink bundle-name authenticated
!
redundancy
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  ip address 192.168.1.1 255.255.255.0
  ip nat outside
  ip virtual-reassembly in
  duplex auto
  speed auto
!
interface Serial0/0/0
  no ip address
  ip nat outside
  ip virtual-reassembly in
  shutdown
  clock rate 2000000
!
interface Serial0/0/1
```

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```
ip address 209.165.200.225 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip nat pool NAT_POOL 209.165.200.241 209.165.200.246 netmask 255.255.255.248
ip nat inside source list NAT_ACL pool NATPOOL
ip nat inside source static 192.168.1.3 209.165.200.254
ip route 0.0.0.0 0.0.0.0 Serial0/0/1
!
ip access-list standard NAT_ACL
 permit 192.168.10.0 0.0.0.255
!
!
!
control-plane
!
!
banner motd ^CAUTHORIZED ACCESS ONLY^C
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

- h. Are there any problems with the current configuration that prevent the static NAT from occurring?

Yes. The inside and outside NAT interfaces are incorrectly configured.

- i. Record any commands that are necessary to correct the static NAT configuration errors.

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```
Gateway(config)# interface g0/1
Gateway(config-if)# no ip nat outside
Gateway(config-if)# ip nat inside
Gateway(config-if)# exit
Gateway(config)# interface s0/0/0
Gateway(config-if)# no ip nat outside
Gateway(config-if)# exit
Gateway(config)# interface s0/0/1
Gateway(config-if)# ip nat outside
Gateway(config-if)# exit
```

- j. From PC-A, ping Lo0 on the ISP router. Do any NAT debug translations appear on the Gateway router?
-

Yes

```
*Mar 18 23:53:50.707: NAT*: s=192.168.1.3->209.165.200.254, d=198.133.219.1 [187]
*Mar 18 23:53:50.715: NAT*: s=198.133.219.1, d=209.165.200.254->192.168.1.3 [187]
Gateway#
*Mar 18 23:53:51.711: NAT*: s=192.168.1.3->209.165.200.254, d=198.133.219.1 [188]
*Mar 18 23:53:51.719: NAT*: s=198.133.219.1, d=209.165.200.254->192.168.1.3 [188]
*Mar 18 23:53:52.707: NAT*: s=192.168.1.3->209.165.200.254, d=198.133.219.1 [189]
Gateway#
*Mar 18 23:53:52.715: NAT*: s=198.133.219.1, d=209.165.200.254->192.168.1.3 [189]
*Mar 18 23:53:53.707: NAT*: s=192.168.1.3->209.165.200.254, d=198.133.219.1 [190]
Gateway#
*Mar 18 23:53:53.715: NAT*: s=198.133.219.1, d=209.165.200.254->192.168.1.3 [190]
```

- k. Use the **show ip nat translations verbose** command to verify static NAT functionality.

Note: The timeout value for ICMP is very short. If you do not see all the translations in the output, redo the ping.

```
Gateway# show ip nat translations verbose
Pro Inside global      Inside local      Outside local      Outside global
icmp 209.165.200.254:1 192.168.1.3:1    198.133.219.1:1  198.133.219.1:1
      create 00:00:04, use 00:00:01 timeout:60000, left 00:00:58,
      flags:
      extended, use_count: 0, entry-id: 12, lc_entries: 0
      --- 209.165.200.254      192.168.1.3      ---      ---
      create 00:30:09, use 00:00:04 timeout:0,
      flags:
      static, use_count: 1, entry-id: 2, lc_entries: 0
```

Is the static NAT translation occurring successfully? _____ Yes

If static NAT is not occurring, repeat the steps above to troubleshoot the configuration.

Part 3: Troubleshoot Dynamic NAT

- a. From PC-B, ping Lo0 on the ISP router. Do any NAT debug translations appear on the Gateway router?

_____ No

- b. On the Gateway router, enter the command that allows you to view the current configuration of the router. Are there any problems with the current configuration that prevent dynamic NAT from occurring?

Yes. The NAT pool is incorrectly identified in the source statement. The NAT access list has an incorrect network statement.

- c. Record any commands that are necessary to correct the dynamic NAT configuration errors.

```
Gateway(config) # no ip nat inside source list NAT_ACL pool NATPOOL
Gateway(config) # ip nat inside source list NAT_ACL pool NAT_POOL
Gateway(config) # ip access-list standard NAT_ACL
Gateway(config-std-nacl) # no permit 192.168.10.0 0.0.0.255
Gateway(config-std-nacl) # permit 192.168.1.0 0.0.0.255
```

- d. From PC-B, ping Lo0 on the ISP router. Do any NAT debug translations appear on the Gateway router?

_____ Yes

```
*Mar 19 00:01:17.303: NAT*: s=192.168.1.4->209.165.200.241, d=198.133.219.1 [198]
*Mar 19 00:01:17.315: NAT*: s=198.133.219.1, d=209.165.200.241->192.168.1.4 [198]
Gateway#
*Mar 19 00:01:18.307: NAT*: s=192.168.1.4->209.165.200.241, d=198.133.219.1 [199]
*Mar 19 00:01:18.315: NAT*: s=198.133.219.1, d=209.165.200.241->192.168.1.4 [199]
*Mar 19 00:01:19.303: NAT*: s=192.168.1.4->209.165.200.241, d=198.133.219.1 [200]
Gateway#
*Mar 19 00:01:19.315: NAT*: s=198.133.219.1, d=209.165.200.241->192.168.1.4 [200]
*Mar 19 00:01:20.303: NAT*: s=192.168.1.4->209.165.200.241, d=198.133.219.1 [201]
*Mar 19 00:01:20.311: NAT*: s=198.133.219.1, d=209.165.200.241->192.168.1.4 [201]
```

- e. Use the **show ip nat statistics** to view NAT usage.

```
Gateway# show ip nat statistics
Total active translations: 2 (1 static, 1 dynamic; 0 extended)
Peak translations: 3, occurred 00:02:58 ago
Outside interfaces:
  Serial0/0/1
Inside interfaces:
  GigabitEthernet0/1
Hits: 24  Misses: 0
CEF Translated packets: 24, CEF Punted packets: 0
Expired translations: 3
Dynamic mappings:
-- Inside Source
```

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```
[Id: 2] access-list NAT_ACL pool NAT_POOL refcount 1
pool NAT_POOL: netmask 255.255.255.248
    start 209.165.200.241 end 209.165.200.246
    type generic, total addresses 6, allocated 1 (16%), misses 0

Total doors: 0
Appl doors: 0
Normal doors: 0
Queued Packets: 0
```

Is the NAT occurring successfully? _____ Yes

What percentage of dynamic addresses has been allocated? _____ 16%

- f. Turn off all debugging using the **undebug all** command.

Reflection

1. What is the benefit of a static NAT?

A static NAT translation allows users from outside the LAN access to the computer or server on the internal network.

2. What issues would arise if 10 host computers in this network were attempting simultaneous Internet communication?

Not enough public addresses exist in the NAT pool to satisfy 10 simultaneous user sessions, but as hosts drop off different hosts will be able to claim the pool addresses to access the Internet.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Config**Router Gateway**

```
Gateway#show run
Building configuration...

Current configuration : 1805 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Gateway
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
no aaa new-model
!
!
no ip domain lookup
```

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```
ip cef
no ipv6 cef
!
multilink bundle-name authenticated
!
!
!
redundancy
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.1.1 255.255.255.0
ip nat inside
ip virtual-reassembly in
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
!
interface Serial0/0/1
ip address 209.165.200.225 255.255.255.252
ip nat outside
ip virtual-reassembly in
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip nat pool NAT_POOL 209.165.200.241 209.165.200.246 netmask 255.255.255.248
ip nat inside source list NAT_ACL pool NAT_POOL
ip nat inside source static 192.168.1.3 209.165.200.254
ip route 0.0.0.0 0.0.0.0 Serial0/0/1
!
ip access-list standard NAT_ACL
permit 192.168.1.0 0.0.0.255
```

```
!
!
!
!
control-plane
!
!
banner motd ^CAUTHORIZED ACCESS ONLY^C
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router ISP

```
ISP#show run
Building configuration...

Current configuration : 1482 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISP
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAug.2
!
```

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```
no aaa new-model
memory-size iomem 15
!
no ip domain lookup
ip cef
!
!
!
!
!
!
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
interface Loopback0
 ip address 198.133.219.1 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 209.165.200.226 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
```

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```
!
no ip http server
no ip http secure-server
!
ip route 209.165.200.224 255.255.255.224 Serial0/0/0
!
!
!
!
control-plane
!
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
line vty 5 15
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```



NAT Check (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure, verify and analyze static NAT, dynamic NAT and NAT with overloading.

Instructor Note: This activity can be completed individually or in small or large groups.

Scenario

Network address translation is not currently included in your company's network design. It has been decided to configure some devices to use NAT services for connecting to the mail server.

Before deploying NAT live on the network, you prototype it using a network simulation program.

Resources

- Packet Tracer software
- Word processing or presentation software

Directions

Step 1: Create a very small network topology using Packet Tracer, including, at minimum:

- a. Two 1941 routers, interconnected
- b. Two LAN switches, one per router
- c. One mail server, connected to the LAN on one router
- d. One PC or laptop, connected the LAN on the other router

Step 2: Address the topology.

- a. Use private addressing for all networks, hosts, and device.
- b. DHCP addressing of the PC or laptop is optional.
- c. Static addressing of the mail server is mandatory.

Step 3: Configure a routing protocol for the network.

Step 4: Validate full network connectivity without NAT services.

- a. Ping from one end of the topology and back to ensure the network is functioning fully.
- b. Troubleshoot and correct any problems preventing full network functionality.

Step 5: Configure NAT services on either router from the host PC or laptop to the mail server

Step 6: Produce output validating NAT operations on the simulated network.

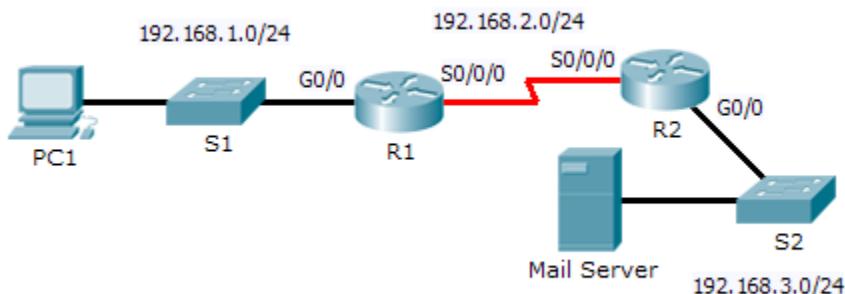
- a. Use the **show ip nat statistics**, **show access-lists**, and **show ip nat translations** commands to gather information about NAT's operation on the router
- b. Copy and paste or save screenshots of the topology and output information to a word processing or presentation document.

NAT Check

Step 7: Explain the NAT design and output to another group or to the class.

Suggested Activity Example (student designs will vary):

NAT Topology Diagram



```
R2# show ip nat translations  
  
Pro Inside global     Inside local      Outside local     Outside global  
icmp 192.168.1.1:2    192.168.1.2:2    192.168.3.2:2    192.168.3.2:2
```

```
R2# show ip nat statistics  
Total translations: 1 (0 static, 1 dynamic, 1 extended)  
Outside Interfaces: GigabitEthernet0/0  
Inside Interfaces: Serial0/0/0  
Hits: 2 Misses: 5  
Expired translations: 2  
Dynamic mappings:  
-- Inside Source  
access-list 1 pool R1 refCount 1  
pool R1: netmask 255.255.255.0  
    start 192.168.1.1 end 192.168.1.254  
    type generic, total addresses 254 , allocated 1 (0%), misses 0
```

```
R2# show access-lists  
Standard IP access list 1  
 permit 192.168.1.0 0.0.0.255 (6 match(es))
```

Identify elements of the model that map to IT-related content:

NAT

1. Configuration

- 2. Operation
- 3. Troubleshooting