Cisco Internetworking Operating System (IOS)

Learning Objectives:

- Understanding how to configure routers and verify configurations
- Understanding hosts configurations and verification.
- Understand how to configure and verify static routing.
- Understand how to configure and verify default routing.
- Understand how to configure and verify RIP routing.
- Understand the Address Resolution Protocol (ARP).

Note: Save Your File: Make sure you save the network layout file that you have been working with so that you can use the configurations in the next lab.

Activity 1: IP Routing

- Download *Standard Layout-Lab5-Student.pkt* from Moodle before going through the following lab.

Lab 1.1: Configuring the Routers

Configure routers 2621 Router0, 2811 Router3, and 2621 Router1 by setting the Hostname, Passwords, Interface descriptions, banner, IP addresses of each interface for each Router.

1. Click **2621 Router0** to bring up the three-tabbed device window and then click the **CLI** tab to set the following:

Hostname

Passwords

Interface descriptions

Banner

IP addresses of each interface

Router>enable

Router#config t

Router(config)#hostname 2621A

2621A(config)#enable secret todd

2621A(config)#line console 0

2621A(config-line)#password todd

2621A(config-line)#login

2621A(config-line)#line aux 0

2621A(config-line)#password todd

2621A(config-line)#login

2621A(config-line)#line vty 0 4

2621A(config-line)#password todd

2621A(config-line)#login

2621A(config-line)#int fa0/0

2621A(config-if)#ip address 172.16.40.1 255.255.255.0

2621A(config-if)#description connection to LAN 40

2621A(config-if)#no shutdown

2621A(config-if)#int s0/0

2621A(config-if)#ip address 172.16.20.2 255.255.255.0

2621A(config-if)#description connection to 2811A

2621A(config-if)#no shutdown

2621A(config-if)#clock rate 64000

2621A(config-if)#exit

2621A(config)#banner motd #

This is the router 2621A

#

2621A(config)#exit

2621A#copy run start

Destination filename [startup-config]? (press Enter)
Building configuration...
[OK]
2621A#

2. Click 2811 Router2 and click the **CLI** tab to set the following:

Hostname

Passwords

Interface descriptions

Banners

IP addresses of each interface

Router>enable

Router#config t

Router(config)#hostname 2811A

2811A(config)#enable secret todd

2811A(config)#line console 0

2811A(config-line)#password todd

2811A(config-line)#login

2811A(config-line)#line aux 0

2811A(config-line)#password todd

2811A(config-line)#login

2811A(config-line)#line vty 0 15

2811A(config-line)#password todd

2811A(config-line)#login

2811A(config-line)#int fa0/0

2811A(config-if)#ip address 172.16.10.1 255.255.255.0

2811A(config-if)#description connection to LAN 10

2811A(config-if)#no shutdown

2811A(config-if)#int s0/1/1

2811A(config-if)#ip address 172.16.20.1 255.255.255.0

2811A(config-if)#description connection to 2621A

2811A(config-if)#no shutdown

2811A(config-if)#int s0/0/1

2811A(config-if)#ip address 172.16.30.1 255.255.255.0

2811A(config-if)#description connection to 2621B

2811A(config-if)#no shutdown

2811A(config-if)#exit

2811A(config)#banner motd #

This is the router 2811A

#

2811A(config)#exit

2811A#copy run start

Destination filename [startup-config]? (press Enter)
Building configuration...
[OK]
2811A#

Clock Rate - it is important to understand clocking on the interface. On a real connection, clocking issues will typically cause data loss and or packet errors. You will also see framing slips on a carrier circuit when there is a clocking issue.

You do not have to set a clock rate if the DCE side of your connection is a 2811 router. The clock rate for the serial interface is set by default to 2000000. However, on the 2621 router you still need to explicitly set the clock rate. In our lab the DCE side of the connection is interface serial 0/1/1 and serial 0/0/1.

Finding DCE - DCE (data communications equipment) is the side of the connection that provides the clocking. Unless it is a 2811 router, you would enter the clock rate on the DCE side of a connection between routers. If you cannot remember what side of your connection is DCE, you can use the **show controllers** command. Here is an example:

```
2811#show controllers s0/1/1
Interface Serial0/1/1
Hardware is GT96K
DCE V.35, clock rate 2000000
idb at 0x454E69C8, driver data structure at 0x454EE0EC
wic_info 0x454EE6E8
Physical Port 0, SCC Num 0
[output cut]
```

3. Click 2621 Router1. Click on CLI tab and set the following:

Hostname

Passwords

Interface descriptions

Banners

IP addresses of each interface

Router>enable

Router#config t

Router(config)#hostname 2621B

2621B(config)#enable secret todd

2621B(config)#line console 0

2621B(config-line)#password todd

2621B(config-line)#login

2621B(config-line)#line aux 0

2621B(config-line)#password todd

2621B(config-line)#login

2621B(config-line)#line vty 0 15

2621B(config-line)#password todd

2621B(config-line)#login

2621B(config-line)#int fa0/1

2621B(config-if)#ip address 172.16.50.1 255.255.255.0

2621B(config-if)#description connection to LAN 50

2621B(config-if)#no shutdown

2621Bconfig-if)#int s0/0

2621B(config-if)#ip address 172.16.30.2 255.255.255.0

2621B(config-if)#description connection to 2811A

2621B(config-if)#no shutdown

2621B(config-if)#clock rate 64000

2621B(config-if)#exit

2621B(config)#banner motd #

This is the router 2621B

#

2621B(config)#exit

2621B#copy run start

Destination filename [startup-config]? (press Enter)
Building configuration...
[OK]
2621B#

Rename and Save Your File: Make sure you save the actual network layout file that you have been working with. We highly recommend that you name the network to another file name rather than *Standard Layout.pkt*. This allows you to start over with a non-configured network if you wish. You will be using the Standard Layout network in the next few labs and it is important to be able to start over with a non-configured network.

In the next few labs you will be instructed to load *Standard Layout.pkt* but we are really referring to the name of the network that you save at the end of this lab.

You can click ***File*** on the menu and choose ***Save*** from the dropdown menu.

Lab 1.2: Verifying Router Configurations

verify your routers' configurations by using the commands: ***show run*** and ***show ip route.***

Notice that the command ***show run,*** the running-config shows the complete configuration your router is running. Whereas, ***show ip route*** is used to see the routing table on your router. It is important to notice that only the directly connected networks are showing in the routing tables being displayed. This means the routers can only route to directly connected networks. In order to send packets to another network not in the current routing table, we must configure the router with **static** or **dynamic** routing so that the router knows how to get to the remote network.

Lab Steps

1. Starting with 2621 Router0 and finishing with 2621 Router1, run the following two commands:

2621A#**show run**

Building configuration...
Current configuration : 625 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname 2621A
!
enable secret 5 1u76B$IOFVJ7VxfVXYVpGDrFTcI0
!
ip subnet-zero

```
!
!
!
!
!
interface FastEthernet0/0
 description connection to LAN 40

[output cut]


2621A#show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR, P - periodic downloaded static route
       T - traffic engineered route

Gateway of last resort is not set

    172.16.0.0/24 is subnetted, 2 subnets
C       172.16.40.0 is directly connected, FastEthernet0/0
C       172.16.20.0 is directly connected, Serial0/0

2621A#
```

show ip route - is used to see the routing table on your router. It is important to notice that only the directly connected networks are showing in the routing tables being displayed. This means the routers can only route to directly connected networks. In order to send packets to another network not in the current routing table, we must configure the router with static or dynamic routing so that the router knows how to get to the remote network.

Notice that the running-config shows the complete configuration your router is running.

Task1: Repeat step 1 on routers 2621B and 2811A and understand the output.

Lab 3.3: Configuring and Verifying the Hosts

We will now configure all the hosts in the network and then verify the configurations.

Configure the connected hosts by setting IP Address, Subnet Mask and Default Gateway.

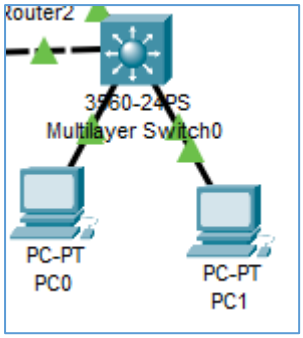
IP Address - unique identification number for a device that is located on a network.

Subnet Mask - when you split up an IP network it is used to determine what section or subnet the IP address of a networked device belongs to. An IP address has two parts, the network address and the host address.

Default Gateway - IP address configured on a networked device that allows that device to communicate outside of its own subnet. A default gateway is usually a layer 3 device like a router. When a network device wants to get to the Internet, it uses a default gateway.

Lab Steps

1. Click on PC0.



2. Click on the *Config* tab.

3. Click on FastEthernet0 and configure as shown in the figure below.

IP Address: 172.16.10.5

Subnet Mask: 255.255.255.0

4. click on Setting to configure the Default Gateway: 172.16.10.1.

IP Address - unique identification number for a device that is located on a network. An IP address is equivalent to the address of your home. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 172.16.10.6 could be an IP address.

Subnet Mask - when you split up an IP network it is used to determine what section or subnet the IP address of a networked device belongs to. An IP address has two parts, the network address and the host address.

Let's examine IP address 172.16.10.6. Assuming this is part of a Class B network, the first two numbers (172.16) represent the Class B network address, and the second two numbers (10.6) identify a particular host on this network.

Default Gateway - IP address configured on a networked device that allows that device to communicate outside of its own subnet. A default gateway is usually a layer 3 device like a router. When a network device wants to get to the Internet, it uses a default gateway. A default gateway IP address is equivalent to the on ramp of a highway.

5. On Host PC1 configure

IP Address: **172.16.10.6**

Subnet Mask: **255.255.255.0**

Default Gateway: **172.16.10.1**

6. On Host PC2 configure

IP Address: **172.16.10.7**

Subnet Mask: **255.255.255.0**

Default Gateway: **172.16.10.1**

7. On Host PC3 configure

IP Address: **172.16.10.8**

Subnet Mask: **255.255.255.0**

Default Gateway: **172.16.10.1**

8. On Host PC4 configure

IP Address: **172.16.40.3**

Subnet Mask: **255.255.255.0**

Default Gateway: **172.16.40.1**

9. On Host PC5 configure

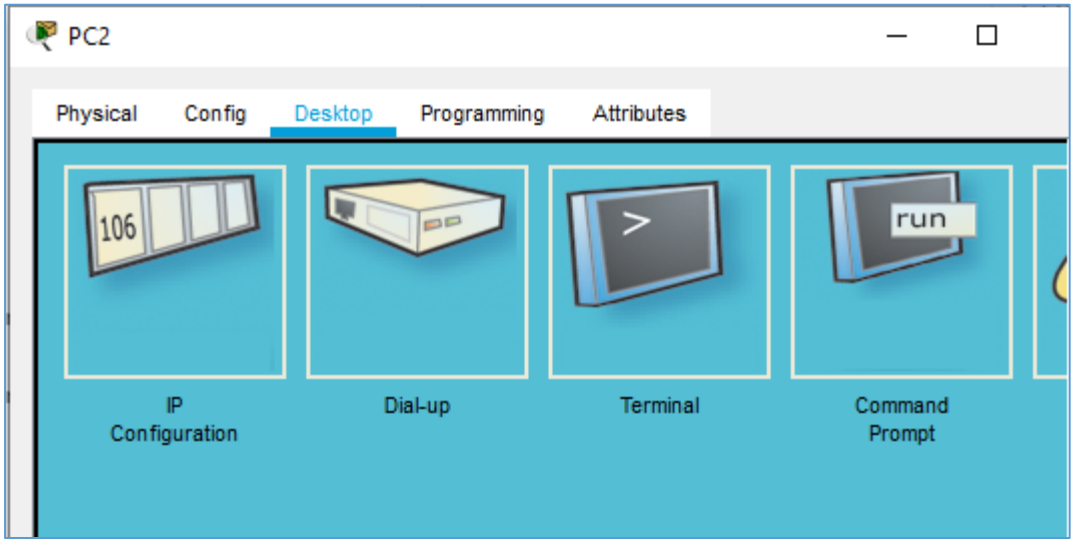
IP Address: **172.16.50.3**

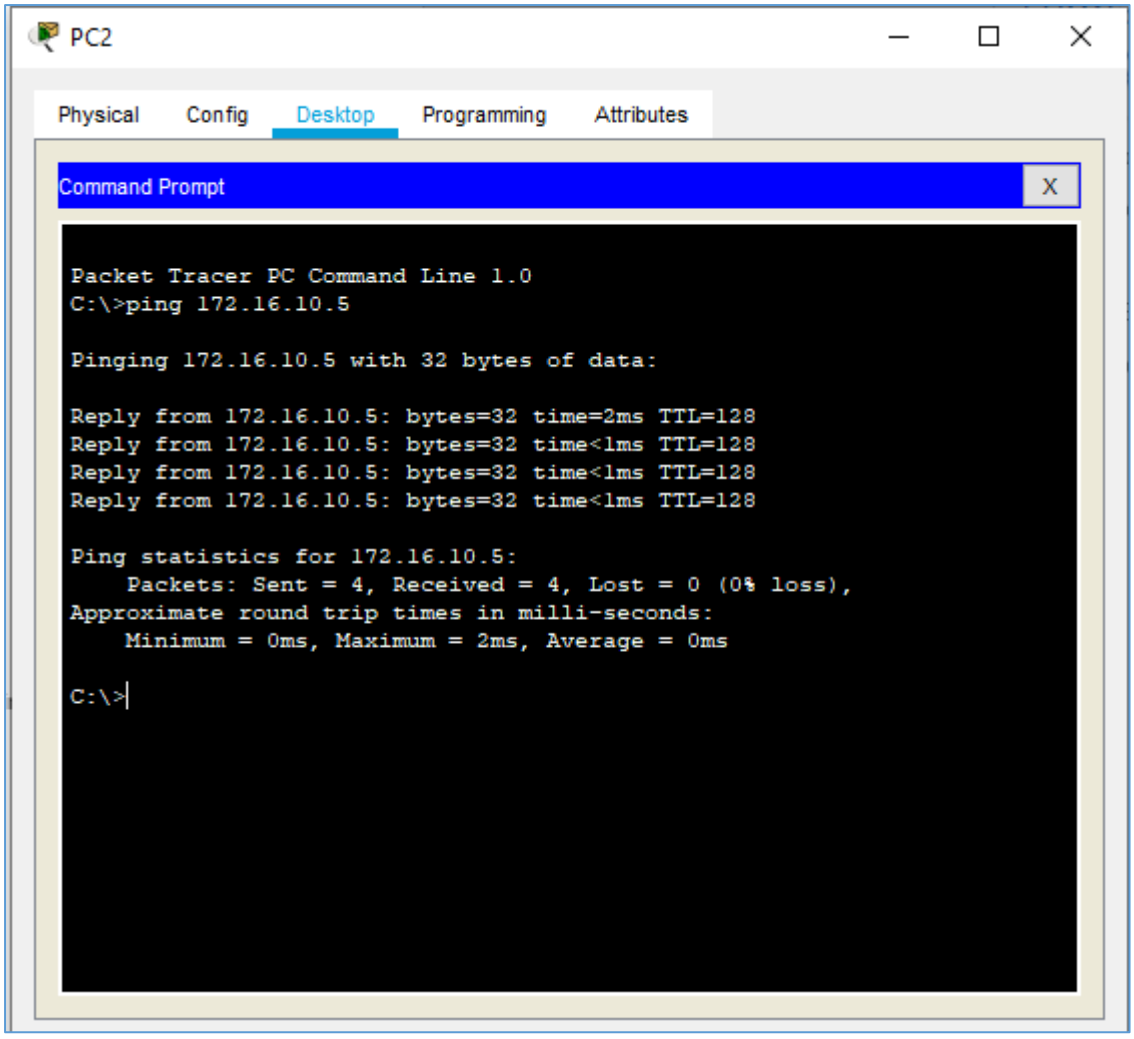
Subnet Mask: **255.255.255.0**

Default Gateway: **172.16.50.1**

10. From each host, ping all other hosts. Here is an example where we ping all other hosts from host PC2 for instance.

Click on PC2, click on **Desktop** tab then click **Command Prompt** as shown in the figure below.





C:\>**ping 172.16.10.5**

C:\>**ping 172.16.10.6**

C:\>**ping 172.16.10.7**

C:\>**ping 172.16.40.3**

C:\>**ping 172.16.50.3**

Which pings are successful? Which ones are not? Why? Think about routing protocols. Some pings may work in a later lab.

Save Your File: Make sure you save the network layout file that you have been working with.

Lab 1.3: Configuring Static Routing

This lab will have you build the routing tables by hand, which means you will create static routing tables on each router. This will allow you to route throughout the entire network. At this point you can only route to directly connected networks of each router. Remember that the routing will not work until all static routes are configured in all routers. In this lab, you will create a static route in all three routers so that the routers see all networks. Verify with the Ping program when complete.

Create static routing tables on each router manually using the **ip route** command.

Static Route - is a manually hard-coded routing statement that creates a route in the routing table of a router. The static route specifies how the router will get to a certain network by using a certain path. Static routing refers to the manual method used to set up routing. This method has the advantage of being simple to create and predictable in its functionality. It is easy to manage in small networks but in larger ones it is difficult to set up and manage all possible static routes. Static routes are not dynamically responsive to topology changes in a network.

Lab Steps

1. On 2621 Router0, use the **ip route** command to configure static routing. 2621 Router0 is connected to networks 172.16.20.0 and 172.16.40.0 and a static route must be configured for EVERY network that is not directly connected. The next hop gateway is always 172.16.20.1 (2811 Router2). Use the following commands to add the static routes.

2621A#**config t**

2621A(config)#**ip route 172.16.10.0 255.255.255.0 172.16.20.1**

2621A(config)#**ip route 172.16.30.0 255.255.255.0 172.16.20.1**

2621A(config)#**ip route 172.16.50.0 255.255.255.0 172.16.20.1**

2621A(config)#**exit**

2621A#**copy run start**

Anatomy of a Command:ip route 172.16.10.0 255.255.255.0 172.16.20.1

ip route - tells the system we are entering a static route.

172.16.10.0 - the destination IP network address, where we want to send packets.

255.255.255.0 - the mask of the destination IP network.

172.16.20.1 - the IP address of the next hop used to reach the destination address.

2. On 2621 Router1, use the **ip route** command to configure static routing. 2621 Router1 is connected to networks 172.16.30.0 and 172.16.50.0 and a static route must be configured for EVERY network that is not directly connected. The next hop gateway is always 172.16.30.1 (router 2811 A).

2621B#**config t**

2621B(config)#**ip route 172.16.10.0 255.255.255.0 172.16.30.1**

2621B(config)#**ip route 172.16.20.0 255.255.255.0 172.16.30.1**

2621B(config)#**ip route 172.16.40.0 255.255.255.0 172.16.30.1**

2621B(config)#**exit**

2621B#**copy run start**

3. On 2811 Router2, use the **ip route** command to configure static routing. 2811 Router A is connected to networks 172.16.10.0, 172.16.20.0, and 172.16.30.0, and a static route must be configured for EVERY network that is not directly connected. The next hop gateway will be either to 2621 Router A or the 2621 Router B.

2811A#**config t**

2811A(config)#**ip route 172.16.40.0 255.255.255.0 172.16.20.2**

2811A(config)#**ip route 172.16.50.0 255.255.255.0 172.16.30.2**

2811A(config)#**exit**

2811A#**copy run start**

Directly Connected Routes - In the preceding set of ip route commands for 2811 Router2, routes are not established for networks 20 and 30. 2811 Router2 knows about these networks (routes) because they are directly connected to the router. Therefore, you do not have to enter ip route commands for these two networks; only for networks that are not directly connected to 2811 Router2, such as networks 40 and 50.

Save Your File: Make sure you save the network layout file that you have been working with so that you can use the configurations in the next lab.

Lab 1.4: Verifying Static Routing

It is important to be able to verify your configurations. The best command to use is **show ip route**. However, if a route is not in your routing table, make sure it is correctly configured in the running-config. If you see a routing entry in the running-config but it is not in the routing table, check the entry for a typo. If it is correct, then make sure the link to that network is up.

verify your static routing table configurations using the ***show ip route*** command. Once you verify the routing tables in all routers, use the ***ping*** command to verify IP connectivity between routers

Lab Steps

1. On 2621 Router2, use the **show ip route** command to verify your routing table.

2621A#show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
U - per-user static route, o - ODR, P - periodic downloaded static route
T - traffic engineered route

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 5 subnets
S 172.16.30.0 [1/0] via 172.16.20.1
C 172.16.40.0 is directly connected, FastEthernet0/0

S 172.16.50.0 [1/0] via 172.16.20.1
C 172.16.20.0 is directly connected, Serial0/0
S 172.16.10.0 [1/0] via 172.16.20.1
2621A#

Anatomy of a Routing Table

Output	Description	Metric
172.16.0.0/24 is subnetted, 5 subnets	Class B network 172.16.0.0 is subnetted into 5 class C networks.	**/24** means a class C network. The 5 subnetted Class C networks are 172.16.50.0 172.16.40.0 172.16.30.0 172.16.20.0 172.16.10.0
S 172.16.30.0 [1/0] via 172.16.20.1	Any packets destined for network 172.16.30.0 are forwarded to the next hop router with the IP address of 172.16.20.1.	**S** means the route is a static route and was manually added using the **ip route** command. **[1/0]** is the administrative distance (1) and routing metric (0).
C 172.16.40.0 is directly connected, FastEthernet0/0	Any packets destined for network 172.16.40.0 are forwarded to the IP address assigned to the FastEthernet0/0 interface.	**C** means the route is directly connected to the local router's fastethernet0/0 interface The route is automatically added to the local routing table when F0/0 is assigned an IP address, has a physical cable connection, and is turned up for service.
S 172.16.50.0 [1/0] via 172.16.20.1	Any packets destined for network 172.16.50.0 are forwarded to the next hop router with the IP address of 172.16.20.1.	**S** means the route is a static route and was manually added using the **ip route** command. **[1/0]** is the administrative distance (1) and routing metric (0).
C 172.16.20.0 is directly connected, Serial0/0	Any packets destined for network 172.16.20.0 are forwarded to IP address assigned to the Serial0/0 interface.	**C** means the route is directly connected to the local router's serial0/0 interface The route is automatically added to the local routing table when S0/0 is assigned an IP address, has a physical cable connection, and is turned up for service.
S 172.16.10.0 [1/0] via 172.16.20.1	Any packets destined for network 172.16.10.0 are forwarded to the next hop router with the IP address of 172.16.20.1.	**S** means the route is a static route and was manually added using the **ip route** command. **[1/0]** is the administrative distance (1) and routing metric (0).

2. On 2621 Router1, use the **show ip route** command to verify your routing table.

2621B#show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
U - per-user static route, o - ODR, P - periodic downloaded static route
T - traffic engineered route

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 5 subnets
C 172.16.30.0 is directly connected, Serial0/0
S 172.16.40.0 [1/0] via 172.16.30.1
C 172.16.50.0 is directly connected, FastEthernet0/0
S 172.16.20.0 [1/0] via 172.16.30.1
S 172.16.10.0 [1/0] via 172.16.30.1
2621B#

3. On 2811 Router2, use the **show ip route** command to verify your routing table. We will purposely go into the *global configuration* mode in order to use the **do** command.

2811A#config t

2811A(config#)do show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
U - per-user static route, o - ODR, P - periodic downloaded static route
T - traffic engineered route

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 5 subnets
C 172.16.30.0 is directly connected, Serial0/0/1
S 172.16.40.0 [1/0] via 172.16.20.2
S 172.16.50.0 [1/0] via 172.16.30.2
C 172.16.20.0 is directly connected, Serial0/1/1
C 172.16.10.0 is directly connected, FastEthernet0/0
2811A#

4. Once you verify the routing tables in all routers, use the **ping** command to verify IP connectivity between routers.

2621A#ping 172.16.50.1

2621A#ping 172.16.30.2

2621B#ping 172.16.40.1

2621B#ping 172.16.20.2

Lab 1.5: Configuring Default Routing

Static routing is great in small networks and is even better when you are trying to learn IP routing since you really have to understand how the network works to make static routing perform correctly. Configuring default routing on a router is not like setting the default gateway on a host. Remember that a router is the default gateway and you cannot set a default gateway on a router. However, you can set what is called a Gateway of Last Resort.

Gateway of Last Resort - if a packet is destined for a network that is not listed in the routing table, the router will forward the packet to the default route.

You can only configure default routing on a router that is connected to a stub network, which means that there is not another router on the connected networks. In other words, there is only one way in and out. 2621 Router0 and 2621 Rouber1 are stub routers to the LANs because they are the only way in and out of the LAN. 2811 Router2 cannot use default routing because it is connected to multiple routes.

If a packet is destined for a network that is not listed in the routing table, the router will forward the packet to the default route, this is called a **Gateway of Last Resort**.

You can only configure *default routing* on a router that is connected to a *stub network*, which means that there is not another router on the connected networks. In other words, there is only one way in and out.

To configure default routing, use the ***ip route*** command, but instead of using the network and subnet mask, you use all zeros (0's), which mean all networks all masks. You must also use the ***ip classless*** command when using default routing. This tells the router to not drop packets, but instead to forward them to the default route address.

Instead of typing all the commands by hand, you can use your up-arrow key to get the command you want to remove. Then press **Ctrl+A** to move your cursor to the beginning of the line, then type **no** and press **Enter**. This is just an easier way to remove the static routes.

Lab Steps

1. Before configuring 2621 Router0 and 2621 Router1 with default routing, you must remove the static routes we created in the lab *Configuring Static Routing*. Use the **no ip route** command.

2621A#config t

2621A(config)#no ip route 172.16.10.0 255.255.255.0 172.16.20.1

2621A(config)#no ip route 172.16.30.0 255.255.255.0 172.16.20.1

2621A(config)#no ip route 172.16.50.0 255.255.255.0 172.16.20.1

2621A(config)#exit

Anatomy of a Command: no ip route 172.16.10.0 255.255.255.0 172.16.20.1

no ip route - tells the system we are removing a static route

172.16.10.0 - the destination IP network address, where we want to send packets

255.255.255.0 - the mask of the destination IP network

172.16.20.1 - the IP address of the next hop used to reach the destination address

2. Remove the static routes from 2621 Router1.

2621B#config t

2621B(config)#no ip route 172.16.10.0 255.255.255.0 172.16.30.1

2621B(config)#no ip route 172.16.20.0 255.255.255.0 172.16.30.1

2621B(config)#no ip route 172.16.40.0 255.255.255.0 172.16.30.1

2621B(config)#exit

3. Verify 2621 Router0 and 2621 Router1 only have directly connected networks in the routing table.

2621A#show ip route

[output cut]

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 2 subnets
C 172.16.40.0 is directly connected, FastEthernet0/0
C 172.16.20.0 is directly connected, Serial0/0

2621B#show ip route

[output cut]

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 2 subnets
C 172.16.30.0 is directly connected, Serial0/0
C 172.16.50.0 is directly connected, FastEthernet0/0

4. On 2621 Router0, add the default route to 2811 Router2. The **default route** command will tell the router to send all packets destined for any network not in the routing table to 2811 Router2, which will then route the packet.

2621A(config)#**ip route 0.0.0.0 0.0.0.0 172.16.20.1**

2621A(config)#**exit**

2621A#**copy run start**

Anatomy of a Command: [default] ip route 0.0.0.0 0.0.0.0 172.16.20.1

ip route - tells the system we are removing a static route

0.0.0.0 - the destination IP network address prefix that is not in the local routing table

0.0.0.0 - the destination IP network mask prefix that is not in the local routing table

172.16.20.1 - the IP address of the next hop router where packets destined for networks that have no local routing table entry will be forwarded

5. On 2621 Router1, add the default route to 2811 Router2. The **default route** command will tell the router to send all packets destined for any network not in the routing table to 2811 Router2, which will then route the packet.

2621B#config t

2621B(config)#ip route 0.0.0.0 0.0.0.0 172.16.30.1

2621B(config)#exit

2621B#copy run start

Save Your File: Make sure you save the network layout file that you have been working on.

Lab 1.6: Verifying Default Routing

To verify the configurations of the default route, use the ***show ip route*** and ***ping*** commands. You can remove default routing using the ***no ip route*** command.

1. Verify that the network is working by using the **show ip route** command on 2621 Router0 to verify the routing tables.

2621A#**show ip route**

[output cut]

Gateway of last resort is 172.16.20.1 to network 0.0.0.0

172.16.0.0/24 is subnetted, 2 subnets
C 172.16.40.0 is directly connected, FastEthernet0/0
C 172.16.20.0 is directly connected, Serial0/0
S* 0.0.0.0 [1/0] via 172.16.20.1

2621B#**show ip route**

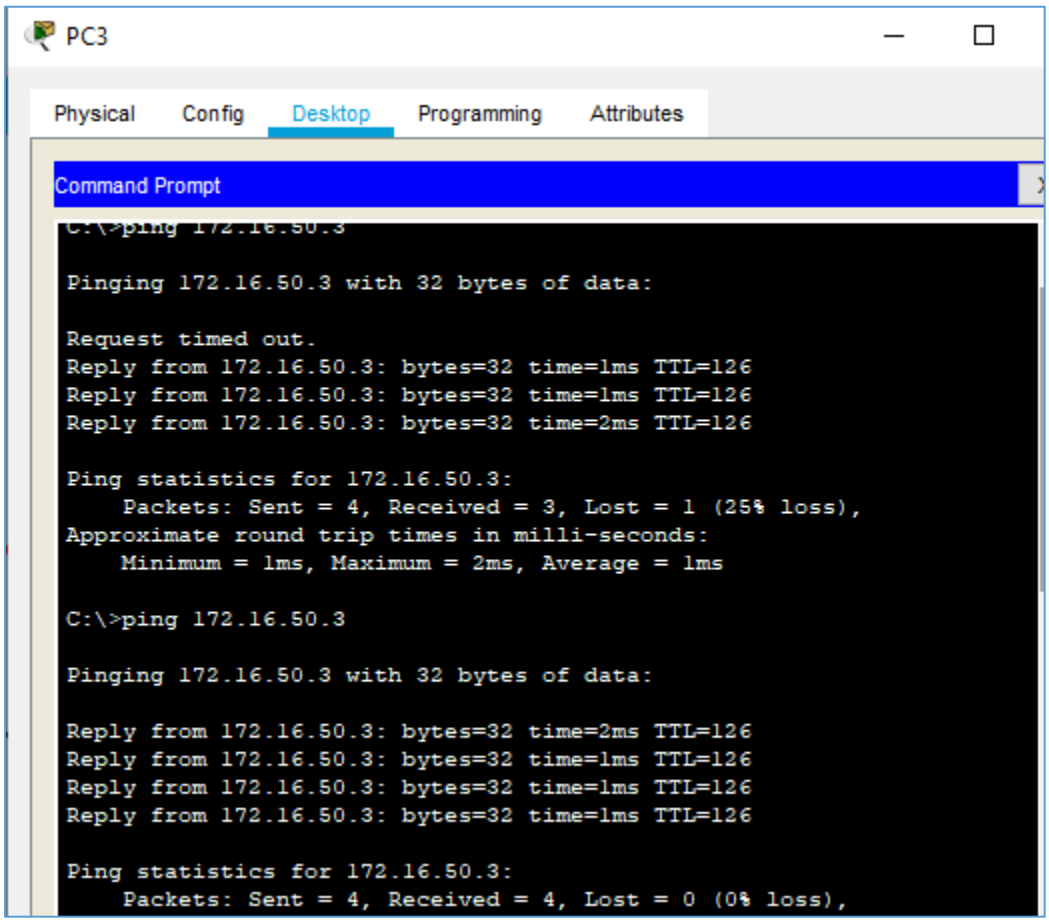
[output cut]

Gateway of last resort is 172.16.30.1 to network 0.0.0.0

172.16.0.0/24 is subnetted, 2 subnets
C 172.16.30.0 is directly connected, Serial0/0
C 172.16.50.0 is directly connected, FastEthernet0/0
S* 0.0.0.0 [1/0] via 172.16.30.1

Please Note: The Gateway of Last Resort has now been set because a default route was configured for each router. In 2621 Router1, for example, it is denoted by the routing table entry S* 0.0.0.0 [1/0] via 172.16.30.1.

2. Verify your network is working. Ping each host from Host PC3. Click Host PC3 on the network, click Desktop tab, click Command Prompt



C:\>**ping 172.16.10.5**

C:\>**ping 172.16.10.6**

C:\>**ping 172.16.10.7**

C:\>**ping 172.16.40.3**

C:\>**ping 172.16.50.3**

Removing Default Routing

3. Based on the cofigurations entered in the earlier lab, enter the following command to remove default routing:

2621A(config)#**no ip route 0.0.0.0 0.0.0.0 172.16.20.1**

2621B(config)#**no ip route 0.0.0.0 0.0.0.0 172.16.30.1**

Lab 1.7: Configuring RIP Routing

It is not very often that you would use just static and default routing in a network these days. This lab will configure Routing Information Protocol (RIP), one of the first dynamic routing protocols created. It is easy and works pretty well in small to medium size networks.

Configuring the routers with static and default routing is interesting to say the least. However, it is not very often that you would use just static and default routing in a network these days. This lab will configure Routing Information Protocol (RIP), one of the first dynamic routing protocols created. It is easy and works pretty well in small to medium size networks.

Dynamic Routing - the process that routers in an intranet or Internet advertising go through to route infomation automatically. There is typically a common dynamic routing protocol configured on each router. RIP Version 1 and 2, OSPF, EIGRP, and BGP are some examples of dynamic routing protocols. When all routers have received routing updates and have updated routing tables, the network is said to have converged. Convergence means that all routers in the internetwork have the same routing information. At this point, a routed protocol, IP for example, can send user data throughout the internetwork.

Lab Steps

To configure RIP routing, you first have to remove the static and default routes configured on the routers. This is assuming that you completed the lab *Configuring Default Routes*. Skip to step 4 if you did not work with the labs *Configuring Static Routes* and *Configuring Default Routes*.

If you do not remove static and default routes, you will have connectivity throughout the network and will not know if you have correctly set up RIP. Removing static and default routes will help you clearly determine when and if you have set up RIP throughout the network. Then use the **router rip** command to configure RIP. Then tell the routers which networks are advertised with RIP.

1. On 2621 Router0, delete the default route and then verify the routing table with the **show ip route** command. Only the directly connected networks should be in the routing table.

2621A#**config t**

2621A(config)#**no ip route 0.0.0.0 0.0.0.0 172.16.20.1**

2621A(config)#**exit**

2621A#**show ip route**

[output cut]

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 2 subnets
C 172.16.40.0 is directly connected, FastEthernet0/0
C 172.16.20.0 is directly connected, Serial0/0

2. On 2621 Router1, delete the default route and then verify the routing table with the **show ip route** command. Only the directly connected networks should be in the routing table.

2621B#**config t**

2621B(config)#**no ip route 0.0.0.0 0.0.0.0 172.16.30.1**

2621B(config)#**exit**

2621B#**show ip route**

[output cut]

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 2 subnets
C 172.16.30.0 is directly connected, Serial0/0
C 172.16.50.0 is directly connected, FastEthernet0/0

3. On 2811 Router2, delete the static routes and then verify the routing table with the **show ip route** command. Only the directly connected networks should be in the routing table.

2811A#**config t**

2811A(config)#**no ip route 172.16.40.0 255.255.255.0 172.16.20.2**

2811A(config)#**no ip route 172.16.50.0 255.255.255.0 172.16.30.2**

2811A(config)#**do show ip route**

[output cut]

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 3 subnets
C 172.16.30.0 is directly connected, Serial0/0/1
C 172.16.20.0 is directly connected, Serial0/1/1
C 172.16.10.0 is directly connected, FastEthernet0/0

Deleting the static and default routes was the hardest part of configuring RIP routing! Now, configure each router with RIP.

4. On 2621 Router0, configure RIP routing and tell RIP the network you want to advertise.

RIP

- Stands for Routing Information Protocol.
- Sends routing-update messages at regular intervals (usually every 30 seconds) and when the network topology changes.
- Uses a single metric called a hop, which measures the distance between the source and destination.
- Is limited to a hop count of 15. It has a maximum hop count. This means a network cannot be more than 15 hops from the source to the destination. Otherwise the destination is deemed as unreachable.
- Has a routing update timer that is used so that on a period basis (usually every 30 seconds), it creates an update for each known route. If the timer times out this usually means that path is no longer available. Therefore that route is removed from routing tables.
- Does not support VLSM.

router rip command - turns on RIP routing.

network command - should be entered for each of the networks that the router is connected to and is a part of the RIP network. In our network we have only one network, network 172.16.0.0.

2621A#**config t**

2621A(config)#**router rip**

2621A(config-router)#**network 172.16.0.0**

2621A(config-router)#**ctrl+z**

That's all there is to it! Dynamic routing is easy on small networks. The important thing to notice here is that the network address is a classful address, which means you use the classful boundary.

Classful Routing - routing protocols (i.e., RIPv1 and IGRP) where subnet masks (routing masks) are not sent in the periodic routing updates. For example, we use the 172.16.0.0 class B network address and subnet that network with 24 bits of subnetting. This means the third octet is used for subnets and the fourth octet is the host addresses for each subnet. RIP is a classful routing protocol, which means that you do not type in any subnet addresses, only the class B address. When using a classful network protocol like RIP, make sure that all networked devices have the same subnet mask.

5. On 2621 Router1, configure RIP routing and tell RIP the network you want to advertise.

2621B#**config t**

2621B(config)#**router rip**

2621B(config-router)#**network 172.16.0.0**

2621B(config-router)#**ctrl+z**

6. On 2811 Router2, configure RIP routing and tell RIP the network you want to advertise.

2811A#**config t**

2811A(config)#**router rip**

2811A(config-router)#**network 172.16.0.0**

2811A(config-router)#**ctrl+z**

Save Your File: Make sure you save the network layout file that you have been working on so that you can use it in the next lab, *Verifying RIP Routing*.

Lab 1.8: Verifying RIP Routing

There are some commands to verify RIP. The ***show ip route*** command to verify the routing table. The Ping command ; from each host, ping all other hosts to verify the host to host connectivity. The ***debug ip rip*** command to see RIP updates being sent and received on the router. To turn off debugging, use the ***no debug ip rip*** command, or the ***undebug all*** command. To see detailed information about currently configured protocols on a router, use the ***show ip protocols*** command. Notice that the *administrative distance* for RIP is 120 by default. Administrative Distance - is a measure of the trustworthiness of the source of the routing information. It is as a number between 0 and 255. The smaller the number, the more reliable the protocol.

The ***show protocols*** command, shows you the routed protocol configuration of each interface.

Lab Steps

1. On 2621 Router0, use the **show ip route** command to verify the routing table.

2621A#**show ip route**

172.16.0.0/24 is subnetted, 5 subnets

R 172.16.30.0 [120/1] via 172.16.20.1, 00:00:13, Serial0/0
C 172.16.40.0 is directly connected, FastEthernet0/0
C 172.16.20.0 is directly connected, Serial0/0
R 172.16.10.0 [120/1] via 172.16.20.1, 00:00:13, Serial0/0
R 172.16.50.0 [120/1] via 172.16.20.1, 00:00:13, Serial0/0

Notice the *R*, which means it is a RIP found route. The *C* is a directly connected network. You should see two directly connected routes and three RIP routes.

2. On 2621 Router1, use the **show ip route** command to verify the routing table.

2621B#**show ip route**

172.16.0.0/24 is subnetted, 5 subnets
C 172.16.30.0 is directly connected, Serial0/0
R 172.16.40.0 [120/2] via 172.16.30.1, 00:00:21, Serial0/0
C 172.16.50.0 is directly connected, FastEthernet0/0
R 172.16.20.0 [120/1] via 172.16.30.1, 00:00:21, Serial0/0
R 172.16.10.0 [120/1] via 172.16.30.1, 00:00:21, Serial0/0

3. On 2811 Router2, use the **show ip route** command to verify the routing table.

2811A#**show ip route**

172.16.0.0/24 is subnetted, 5 subnets
C 172.16.30.0 is directly connected, Serial0/0/1
R 172.16.40.0 [120/1] via 172.16.20.2, 00:00:27, Serial0/1/1
R 172.16.50.0 [120/1] via 172.16.30.2, 00:00:27, Serial0/0/1
C 172.16.20.0 is directly connected, Serial0/1/1
C 172.16.10.0 is directly connected, FastEthernet0/0

4. From each host, ping all other hosts. Here is an example where we ping all other hosts from Host PC3.

Click Host PC3 on the network.

C:\>**ping 172.16.10.5**

C:\>**ping 172.16.10.6**

C:\>**ping 172.16.10.7**

C:\>**ping 172.16.40.3**

C:\>**ping 172.16.50.3**

Notice that we can now ping Hosts PC4 and F from Host PC5. Why?

5 On 2621 Router1, use the **debug ip rip** command to see RIP updates being sent and received on the router.

2621B#**debug ip rip**

RIP protocol debugging is on
2621B#

then after a few seconds ....

*Oct 13 17:19:25.906: RIP: received v1 update from 172.16.30.1 on Serial0/0
*Oct 13 17:19:25.906: 172.16.40.0 in 2 hops
*Oct 13 17:19:25.906: 172.16.20.0 in 2 hops
*Oct 13 17:19:25.906: RIP: received v1 update from 172.16.30.1 on Serial0/0
*Oct 13 17:19:25.906: 172.16.40.0 in 3 hops
*Oct 13 17:19:25.906: 172.16.20.0 in 3 hops
*Oct 13 17:19:25.906: RIP: received v1 update from 172.16.30.1 on Serial0/0
*Oct 13 17:19:25.906: 172.16.40.0 in 4 hops
*Oct 13 17:19:25.906: 172.16.20.0 in 4 hops
*Oct 13 17:19:25.906: RIP: received v1 update from 172.16.30.1 on Serial0/0
*Oct 13 17:19:25.906: 172.16.40.0 in 5 hops

[output cut]

6. To turn off debugging, use the **no debug ip rip** command, or the **undebug all** command.

2621B#**undebug all**

7. To see detailed information about currently configured protocols on a router, use the **show ip protocols** command.

2621B#**show ip protocols**

Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 27 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive any version

```
  Interface          Send  Recv  Triggered RIP  Key-chain
  Serial0/0          1     1 2
  FastEthernet0/0    1     1 2
 Automatic network summarization is in effect
 Maximum path: 4
 Routing for networks:
  172.16.0.0
 Routing information sources:
  Gateway         Distance      Last Update
  172.16.30.1         120       00:00:03
 Distance: <default is 120>

2621B#
```

Notice the timers. RIP is sent out every 30 seconds by default. The administrative distance for RIP is 120 by default.

Administrative Distance - is a measure of the trustworthiness of the source of the routing information. It is reported as a number between 0 and 255. The smaller the number, the more reliable the protocol. If you have, for example, two protocols, IGRP and RIP, configured on a router, the IGRP routes will be preferred over the RIP routes. This is because you have an administrative distance of 120 for RIP and 100 for IGRP.

Source	Default Distance Value
Connected interface	0
Static route	1
Enhanced Interior Gateway Routing Protocol (EIGRP) summary route	5
External Border Gateway Protocol (BGP)	20
Internal EIGRP	90
IGRP	100
OSPF	110
Intermediate System-to-Intermediate System (IS-IS)	115
Routing Information Protocol (RIP)	120
Exterior Gateway Protocol (EGP)	140
On Demand Routing (ODR)	160

External EIGRP	170
Internal BGP	200
Unknown	255

8. Another really good command is the **show protocols** command, which shows you the routed protocol configuration of each interface.

2621B#**show protocols**

Global values:
Internet protocol routing is enabled
Serial0/1 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
Internet address is 172.16.30.2/24
FastEthernet0/1 is administratively down, line protocol is down
FastEthernet0/0 is up, line protocol is up
Internet address is 172.16.50.1/24

9. On 2811 Router2, use the **show protocols** command.

2811A#**show protocols**

Global values:
Internet protocol routing is enabled
Serial0/0/0 is administratively down, line protocol is down
Serial0/0/1 is up, line protocol is up
Internet address is 172.16.30.1/24
Serial0/1/0 is administratively down, line protocol is down
Serial0/1/1 is up, line protocol is up
Internet address is 172.16.20.1/24
FastEthernet0/0 is up, line protocol is up
Internet address is 172.16.10.1/24

Lab 1.9: Using Traceroute

With the **traceroute** command, you can display a list of routers on a path from a source to a destination in your network

Lab Steps

We will first configure all the devices with IP addresses.

1. Click 2621 Router0. Click CLI and configure interface s0/0.

Router>**enable**

Router#**config t**

Router(config)#**hostname 2621A**

2621A(config-if)#**int s0/0**

2621A(config-if)#**ip address 172.16.20.2 255.255.255.0**

2621A(config-if)#**no shutdown**

2621A(config-if)#**ctrl+z**

2621A#**copy run start**

Destination filename [startup-config]? (press **Enter**)
Building configuration...
[OK]
2621A#

2. Bring up the console for 2811 Router2. After the console screen appears, configure the interfaces.

Router>**enable**

Router#**config t**

Router(config)#**hostname 2811A**

2811A(config-if)#**int s0/1/1**

2811A(config-if)#**ip address 172.16.20.1 255.255.255.0**

2811A(config-if)#**no shutdown**

2811A(config-if)#**int s0/0/1**

2811A(config-if)#**ip address 172.16.30.1 255.255.255.0**

2811A(config-if)#**no shutdown**

2811A(config-if)#**ctrl+z**

2811A#**copy run start**

Destination filename [startup-config]? (press **Enter**)
Building configuration...
[OK]
2811A#

Please Note: You do not have to set the DCE connection associated with interface s0/1/1, which has a clock rate of 2000000. It is there by default. The DCE connection is associated with interface s0/1/1 and a clock rate of 2000000.

3. Double-click 2621 Router1. After the console screen comes up configure interface s0/0.

Router>**enable**

Router#**config t**

Router(config)#**hostname 2621B**

2621Bconfig-if)#**int s0/0**

2621B(config-if)#**ip address 172.16.30.2 255.255.255.0**

2621B(config-if)#**no shutdown**

2621B(config-if)#**ctr+z**

2621B#**copy run start**

Destination filename [startup-config]? (press **Enter**)
Building configuration...
[OK]
2621B#

4. On each the 2621 routers, enter the command **show ip route.** You should only see directly connected networks in the routing table.

2621B#**show ip route**

172.16.0.0/24 is subnetted, 1 subnets
C 172.16.30.0 is directly connected, Serial0/0

2621A#**show ip route**

172.16.0.0/24 is subnetted, 1 subnets
C 172.16.20.0 is directly connected, Serial0/0

5. On 2621 Router0, trace the route to interface s0/0 of 2621 Router1.

2621A#**traceroute 172.16.30.2**

Type escape sequence to abort.
Tracing the route to 172.16.30.2

1 172.16.20.1 12 msec 14 msec 12 msec
2 172.16.30.2 32 msec * 28 msec

Lab 1.10: Configuring and Verifying a Loopback Interface

A loopback interface is not a real, hardware-based interface like serial 0/0/0/ or fa0/1. It is a logical or virtual interface that is always up unlike a hardware interface that may be up or down. It is the best interface to ping in order to see if the router is up.

Lab Steps

1. Create a loopback interface on 2811 Router2..

2811A>en

2811A(config)#config t

2811A(config)#int loopback 0

2. Enter an IP address for the loopback interface.

2811A(config-if)#ip address 172.16.40.1 255.255.255.0

3. Verify the loopback interface on 2811 Router2..

2811A(config-if)#ctrl+z

2811A#show ip interface brief

Interface IP-Address OK? Method Status Protocol

FastEthernet0/0 172.16.10.1 YES manual up up

FastEthernet0/1 unassigned YES unset administratively down down

Serial0/0/0 unassigned YES unset administratively down down

Serial0/0/1 172.16.30.1 YES manual up up

Serial0/1/0 unassigned YES unset administratively down down

Serial0/1/1 172.16.20.1 YES manual up up

Loopback0 172.16.40.1 YES manual up up

4. From 2811 Router2, ping the loopback interface.

2811A#ping 172.16.40.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.40.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms

5. You can see the loopback entry in the running configs of 2811 Router2

2811A#show run

interface Loopback0

ip address 172.16.40.1 255.255.255.0

!

interface FastEthernet0/0

description connection to LAN 10

ip address 172.16.10.1 255.255.255.0

no ip directed-broadcast

duplex auto

!

[output cut]

6. You should be able to successfully ping the loopback interface from another device. Go to 2621 Router0 and ping the loopback interface on 2811 Router2. Interface s0/0 is administratively up.

2621A#ping 172.16.40.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.40.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms

7. Unlike the physical interfaces on a router, a loopback interface is virtual and can be removed.

2811A#config t

2811A(config)#no interface loopback 0

2811A(config)#ctl+z

2811A#

8. You can confirm the removal of loopback interface 0.

2811A#show run

interface FastEthernet0/0

description connection to LAN 10

ip address 172.16.10.1 255.255.255.0

no ip directed-broadcast

duplex auto

!

[output cut]

9. You can also use the show ip interface brief command to verify the removal of the loopback interface.

2811A#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	172.16.10.1	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0/0	unassigned	YES	unset	administratively down	down
Serial0/0/1	172.16.30.1	YES	manual	up	up
Serial0/1/0	unassigned	YES	unset	administratively down	down
Serial0/1/1	172.16.20.1	YES	manual	up	up

Lab 1.11: Using ARP (Address Resolution Protocol)

ARP finds the unique hardware address of network devices based on IP addresses of the interface. If IP cannot find the destination of the hardware address, the system uses ARP to retrieve this information. In sending data (packets) the source must also have a destination MAC address. If the

source does not know the MAC address of the destination, it has to get that address before data can be sent.

To obtain the unknown layer 2 address when the layer 3 address is known, the source transmits an ARP Request. All devices on the path will see it but the only device that will answer it is the one with the matching layer 3 address. That device will send an ARP Reply, unicast back to the source. The sender will then have a MAC address to go with the IP address and can then transmit.

Lab Steps

1. Bring up the console for 2811 Router2. After the console screen appears, create a hostname.

Router>**enable**

Router#**config t**

Router(config)#**hostname 2811A**

2811A(config)#**exit**

2811A#

2. Before any devices are configured the ARP table should have no entries. Use the command **show arp** to confirm this.

2811A#**show arp**

Protocol Address Age (min) Hardware Addr Type Interface

3. Configure 2811 Router A.

2811A(config-if)#**config t**

2811A(config-if)#**int fa0/1**

2811A(config-if)#**ip address 172.16.20.1 255.255.255.0**

2811A(config-if)#**no shutdown**

2811A(config-if)#**int fa0/0**

2811A(config-if)#**ip address 172.16.30.1 255.255.255.0**

2811A(config-if)#**no shutdown**

2811A(config-if)#**ctrl+z**
2811A#

4. Use the **show arp** command on 2811 Router2 to view the ARP table again. Notice the unique MAC addresses associated with the two IP addresses.

2811A#**show arp**

Protocol Address Age (min) Hardware Addr Type Interface

Internet 172.16.30.1 - 00b0.b250.5f37 ARPA FastEthernet0/0

Internet 172.16.20.1 - 00b0.8911.1e7e ARPA FastEthernet0/1

5. Click 2621 Router0. Click on CLI tag and configure the interface.

```
Router>enable

Router#config t

Router(config)#hostname 2621A

2621A(config-if)#int fa0/0

2621A(config-if)#ip address 172.16.20.2 255.255.255.0

2621A(config-if)#no shutdown

2621A(config-if)#ctrl+z
2621A#
```

6. Double-click 2621 Router1. After the console screen comes up configure the interface.

```
Router>enable

Router#config t

Router(config)#hostname 2621B

2621Bconfig-if)#int fa0/0

2621B(config-if)#ip address 172.16.30.2 255.255.255.0

2621B(config-if)#no shutdown

2621B(config-if)#ctr+z
2621B#
```

7. Go back to 2811 Router2 and issue the **show arp** command. Notice that every IP address has an accompanying, unique MAC address or hardware address..

```
2811A#show arp

Protocol  Address          Age (min)  Hardware Addr   Type   Interface

Internet       172.16.30.1                   -          00b0.b250.5f37     ARPA   FastEthernet0/0
Internet       172.16.20.2                  30          00b0.76f0.f7c5     ARPA   FastEthernet0/1
Internet       172.16.20.1                   -          00b0.8911.1e7e     ARPA   FastEthernet0/1
Internet  172.16.30.2          28   00b0.1dc0.652f  ARPA   FastEthernet0/0
```