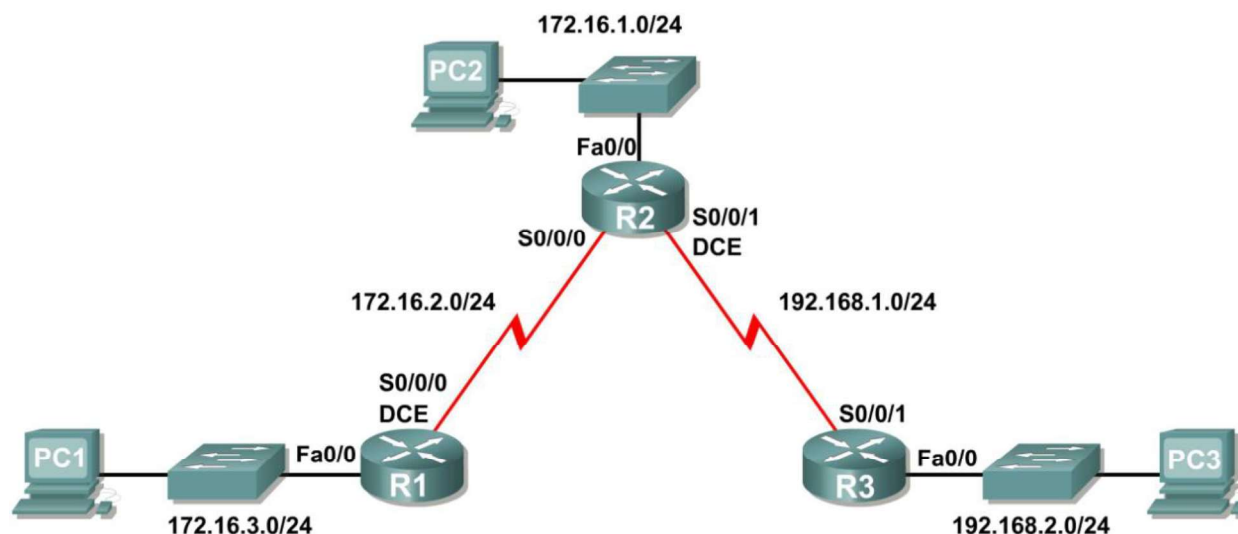# Lab 2.8.1: Basic Static Route Configuration

Topology Diagram

Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	172.16.3.1	255.255.255.0	N/A
R1	S0/0/0	172.16.2.1	255.255.255.0	N/A
R2	Fa0/0	172.16.1.1	255.255.255.0	N/A
R2	S0/0/0	172.16.2.2	255.255.255.0	N/A
R2	S0/0/1	192.168.1.2	255.255.255.0	N/A
R3	FA0/0	192.168.2.1	255.255.255.0	N/A
R3	S0/0/1	192.168.1.1	255.255.255.0	N/A
PC1	NIC	172.16.3.10	255.255.255.0	172.16.3.1
PC2	NIC	172.16.1.10	255.255.255.0	172.16.1.1
PC3	NIC	192.168.2.10	255.255.255.0	192.168.2.1

Learning Objectives

Upon completion of this lab, you will be able to:

- Cable a network according to the Topology Diagram.
- Erase the startup configuration and reload a router to the default state.
- Perform basic configuration tasks on a router.

- Interpret **debug ip routing** output.
- Configure and activate Serial and Ethernet interfaces.
- Test connectivity.
- Gather information to discover causes for lack of connectivity between devices.
- Configure a static route using an intermediate address.
- Configure a static route using an exit interface.
- Compare a static route with intermediate address to a static route with exit interface.
- Configure a default static route.
- Configure a summary static route.
- Document the network implementation.

Scenario

In this lab activity, you will create a network that is similar to the one shown in the Topology Diagram. Begin by cabling the network as shown in the Topology Diagram. You will then perform the initial router configurations required for connectivity. Use the IP addresses that are provided in the Addressing Table to apply an addressing scheme to the network devices. After completing the basic configuration, test connectivity between the devices on the network. First test the connections between directly connected devices, and then test connectivity between devices that are not directly connected. Static routes must be configured on the routers for end-to-end communication to take place between the network hosts. You will configure the static routes that are needed to allow communication between the hosts. View the routing table after each static route is added to observe how the routing table has changed.

Task 1: Cable, Erase, and Reload the Routers.

Step 1: Cable a network that is similar to the one in the Topology Diagram.

Step 2: Clear the configuration on each router.

Clear the configuration on each of the routers using the **erase startup-config** command and then **reload** the routers. Answer **no** if asked to save changes.

Task 2: Perform Basic Router Configuration.

Note: If you have difficulty with any of the commands in this task, see **Lab 1.5.1: Cabling a Network and Basic Router Configuration**.

Step 1: Use global configuration commands.

On the routers, enter global configuration mode and configure the basic global configuration commands including:

- **hostname**
- **no ip domain-lookup**
- **enable secret**

Step 2: Configure the console and virtual terminal line passwords on each of the routers.

- **password**
- **login**

Step 3: Add the `logging synchronous` command to the console and virtual terminal lines.

This command is very helpful in both lab and production environments and uses the following syntax:

```
Router(config-line)#logging synchronous
```

To synchronize unsolicited messages and debug output with solicited Cisco IOS software output and prompts for a specific console port line, auxiliary port line, or virtual terminal line, we can use the `logging synchronous` line configuration command. In other words, the `logging synchronous` command prevents IOS messages delivered to the console or Telnet lines from interrupting your keyboard input.

For example, you may have already experienced something similar to the following example:

Note: *Do not* configure R1 interfaces yet.

```
R1(config)#interface fastethernet 0/0
R1(config-if)#ip address 172.16.3.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#descri
*Mar  1 01:16:08.212: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed
state to up
*Mar  1 01:16:09.214: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/0, changed state to upption
R1(config-if)#
```

The IOS sends unsolicited messages to the console when you activate an interface with the `no shutdown` command. However, the next command you enter (in this case, `description`) is interrupted by these messages. The `logging synchronous` command solves this problem by copying the command entered up to that point down to the next router prompt.

```
R1(config)#interface fastethernet 0/0
R1(config-if)#ip address 172.16.3.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#description
*Mar  1 01:28:04.242: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed
state to up
*Mar  1 01:28:05.243: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/0, changed state to up
R1(config-if)#description  <-- Keyboard input copied after message
```

R1 is shown here as an example. Add `logging synchronous` to the console and virtual terminal lines on all routers.

```
R1(config)#line console 0
R1(config-line)#logging synchronous
R1(config-line)#line vty 0 4
R1(config-line)#logging synchronous
```

Step 4: Add the `exec-timeout` command to the console and virtual terminal lines.

To set the interval that the EXEC command interpreter waits until user input is detected, we can use the `exec-timeout` line configuration command. If no input is detected during the interval, the EXEC facility resumes the current connection. If no connections exist, the EXEC facility returns the terminal to the idle state and disconnects the incoming session. This command allows you to control the amount of time a console or virtual terminal line can be idle before the session is terminated. The syntax follows:

```
Router(config-line)#exec-timeout minutes [seconds]
```

Syntax description:

minutes—Integer that specifies the number of minutes.

seconds—(Optional) Additional time intervals in seconds.

In a lab environment, you can specify "no timeout" by entering the `exec-timeout 0 0` command. This command is very helpful because the default timeout for lines is 10 minutes. However, for security purposes, you would not normally set lines to "no timeout" in a production environment.

R1 is shown here as an example.

Add `exec-timeout 0 0` to console and virtual terminal lines on all routers.

```
R1(config)#line console 0
R1(config-line)#exec-timeout 0 0
R1(config-line)#line vty 0 4
R1(config-line)#exec-timeout 0 0
```

Task 3: Interpreting Debug Output.

Note: If you already configured IP addressing on R1, please remove all `interface` commands now before proceeding. R1, R2 and R3 should be configured through the end of Task 2 without any interface configurations.

Step 1: On R1 from privileged EXEC mode, enter the `debug ip routing` command.

```
R1#debug ip routing
IP routing debugging is on
```

The `debug ip routing` command shows when routes are added, modified, and deleted from the routing table. For example, every time you successfully configure and activate an interface, Cisco IOS adds a route to the routing table. We can verify this by observing output from the `debug ip routing` command.

Step 2: Enter interface configuration mode for R1's LAN interface.

```
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface fastethernet 0/0
```

Configure the IP address as specified in the Topology Diagram.

```
R1(config-if)#ip address 172.16.3.1 255.255.255.0
is_up: 0 state: 6 sub state: 1 line: 1 has_route: False
```

As soon as you press the **Enter** key, Cisco IOS debug output informs you that there is now a route, but its state is `False`. In other words, the route has not yet been added to the routing table. Why did this occur and what steps should be taken to ensure that the route is entered into the routing table?

_____

_____

Step 3: Enter the command necessary to install the route in the routing table.

If you are not sure what the correct command is, review the discussion in "Examining Router Interfaces" which is discussed in Section 2.2, "Router Configuration Review."

After you enter the correct command, you should see debug output. Your output may be slightly different from the example below.

```
is_up: 1 state: 4 sub state: 1 line: 1 has_route: False
RT: add 172.16.3.0/24 via 0.0.0.0, connected metric [0/0]
RT: NET-RED 172.16.3.0/24
RT: NET-RED queued, Queue size 1
RT: interface FastEthernet0/0 added to routing table
%LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
is_up: 1 state: 4 sub state: 1 line: 1 has_route: True
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, chan
ged state to up
is_up: 1 state: 4 sub state: 1 line: 1 has_route: True
is_up: 1 state: 4 sub state: 1 line: 1 has_route: True
```

The new network you configured on the LAN interface is now added to the routing table, as shown in the highlighted output.

If you do not see the route added to the routing table, the interface did not come up. Use the following systematic process to troubleshoot your connection:

1. Check your physical connections to the LAN interface.
    Is the correct interface attached? _____
    Your router may have more than one LAN interface. Did you connect the correct LAN interface?
    _____
    An interface will not come up unless it detects a carrier detect signal at the Physical layer from another device. Is the interface connected to another device such as a hub, switch, or PC?
    _____

2. Check link lights. Are all link lights blinking? _____

3. Check the cabling. Are the correct cables connected to the devices? _____

4. Has the interface been activated or enabled? _____

If you can answer **yes** to all the proceeding questions, the interface should come up.

Step 4: Enter the command to verify that the new route is now in the routing table.

Your output should look similar to the following output. There should now be one route in the table for R1.
What command did you use?

```
R1#_____
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.3.0 is directly connected, FastEthernet0/0
```

Step 5: Enter interface configuration mode for R1's WAN interface connected to R2.

```
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface Serial 0/0/0
```

Configure the IP address as specified in the Topology Diagram.

```
R1(config-if)#ip address 172.16.2.1 255.255.255.0
is_up: 0 state: 0 sub state: 1 line: 0 has_route: False
```

As soon as you press the **Enter** key, Cisco IOS debug output informs you that there is now a route, but its
state is `False`. Because R1 is the DCE side of our lab environment, we must specify how fast the bits will
be clocked between R1 and R2.

Step 6: Enter the `clock rate` command on R1.

You can specify any valid clocking speed. Use the **?** to find the valid rates. Here, we used 64000 bps.

```
R1(config-if)#clock rate 64000
is_up: 0 state: 0 sub state: 1 line: 0 has_route: False
```

Some IOS versions display the output shown above every 30 seconds. Why is the state of the route still
`False`? What step must you now take to make sure that the interface is fully configured?

_____

Step 7: Enter the command necessary to ensure that the interface is fully configured.

If you are not sure what the correct command is, review the discussion in "Examining Router Interfaces,"
which is discussed in Section 2.2, "Router Configuration Review."

```
R1(config-if)#_____
```

After you enter the correct command, you should see debug output similar to the following example:

```
is_up: 0 state: 0 sub state: 1 line: 0 has_route: False
%LINK-3-UPDOWN: Interface Serial0/0/0, changed state to down
```

Unlike configuring the LAN interface, fully configuring the WAN interface does not always guarantee that the route will be entered in the routing table, even if your cable connections are correct. The other side of the WAN link must also be configured.

Step 8: If possible, establish a separate terminal session by consoling into R2 from another workstation. Doing this allows you to observe the debug output on R1 when you make changes on R2. You can also turn on **debug ip routing** on R2.

```
R2#debug ip routing
IP routing debugging is on
```

Enter interface configuration mode for R2's WAN interface connected to R1.

```
R2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#interface serial 0/0/0
```

Configure the IP address as specified in the Topology Diagram.

```
R2(config-if)#ip address 172.16.2.2 255.255.255.0
is_up: 0 state: 6 sub state: 1 line: 0
```

Step 9: Enter the command necessary to ensure that the interface is fully configured.

If you are not sure what the correct command is, review the discussion in "Examining Router Interfaces," which is discussed in Section 2.2, "Router Configuration Review."

```
R2(config-if)#_____
```

After you enter the correct command, you should see debug output similar to the following example:

```
is_up: 0 state: 4 sub state: 1 line: 0
%LINK-3-UPDOWN: Interface Serial0/0/0, changed state to up
is_up: 1 state: 4 sub state: 1 line: 0
RT: add 172.16.2.0/24 via 0.0.0.0, connected metric [0/0]
RT: interface Serial0/0/0 added to routing table
is_up: 1 state: 4 sub state: 1 line: 0
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0/0, changed state to
up
is_up: 1 state: 4 sub state: 1 line: 0
```

The new network that you configured on the WAN interface is now added to the routing table, as shown in the highlighted output.

If you do not see the route added to the routing table, the interface did not come up. Use the following systematic process to troubleshoot your connection:

1. Check your physical connections between the two WAN interfaces for R1 and R2.
    Is the correct interface attached? _____
    Your router has more than one WAN interface. Did you connect the correct WAN interface?
    _____
    An interface will not come up unless it detects a link beat at the Physical layer from another device. Is the interface connected to the other router's interface? _____

2. Check link lights. Are all link lights blinking? _____

3. Check the cabling. R1 must have the DCE side of the cable attached and R2 must have the DTE side of the cable attached. Are the correct cables connected to the routers? _____

4. Has the interface been activated or enabled? _____

If you can answer **yes** to all the proceeding questions, the interface should come up.

Step 10: Enter the command to verify that the new route is now in the routing table for R1 and R2.

Your output should look similar to the following output. There should now be two routes in the routing table for R1 and one route in the table for R2. What command did you use?

```
R1#_____
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0

R2#_____
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.2.0 is directly connected, Serial0/0/0
```

Step 11: Turn off debugging on both routers using either `no debug ip routing` or simply, `undebug all`.

```
R1(config-if)#end
R1#no debug ip routing
IP routing debugging is off
```

Task 4: Finish Configuring Router Interfaces

Step 1: Configure Remaining R2 Interfaces

Finish configuring the remaining interfaces on R2 according to the Topology Diagram and Addressing Table.

Step 2: Configure R3 Interfaces

Console into R3 and configure the necessary interfaces according to the Topology Diagram and Addressing Table.

Task 5: Configure IP Addressing on the Host PCs.

Step 1: Configure the host PC1.

Configure the host PC1 with an IP address of 172.16.3.10/24 and a default gateway of 172.16.3.1.

Step 2: Configure the host PC2.

Configure the host PC2 with an IP address of 172.16.1.10/24 and a default gateway of 172.16.1.1.

Step 3: Configure the host PC3.

Configure the host PC3 with an IP address of 192.168.2.10/24 and a default gateway of 192.168.2.1.

Task 6: Test and Verify the Configurations.

Step 1: Test connectivity.

Test connectivity by pinging from each host to the default gateway that has been configured for that host.

From the host PC1, is it possible to ping the default gateway? _____

From the host PC2, is it possible to ping the default gateway? _____

From the host PC3, is it possible to ping the default gateway? _____

If the answer is **no** for any of these questions, troubleshoot the configurations to find the error using the following systematic process:

1. Check the cabling.
   Are the PCs physically connected to the correct router? _____
   (Connection could be through a switch or directly)
   Are link lights blinking on all relevant ports? _____

2. Check the PC configurations. Do they match the Topology Diagram? _____

3. Check the router interfaces using the `show ip interface brief` command.
   Are all relevant interfaces **up** and **up**? _____

If your answer to all three steps is **yes**, you should be able to successfully ping the default gateway.

Step 2: Use the `ping` command to test connectivity between directly connected routers.

From the router R2, is it possible to ping R1 at 172.16.2.1? _____

From the router R2, is it possible to ping R3 at 192.168.1.1? _____

If the answer is **no** for any of these questions, troubleshoot the configurations to find the error using the following systematic process:

1. Check the cabling.
   Are the routers physically connected? _____
   Are link lights blinking on all relevant ports? _____

2. Check the router configurations.
   Do they match the Topology Diagram? _____
   Did you configure the `clock rate` command on the DCE side of the link? _____

3. Has the interface been activated or enabled? _____

4. Check the router interfaces using the `show ip interface brief` command.
   Are the interfaces **up** and **up**? _____

If your answer to all three steps is **yes**, you should be able to successfully ping from R2 to R1 and from R2 to R3.

Step 3: Use `ping` to check connectivity between devices that are not directly connected.

From the host PC3, is it possible to ping the host PC1? _____

From the host PC3, is it possible to ping the host PC2? _____

From the host PC2, is it possible to ping the host PC1? _____

From the router R1, is it possible to ping router R3? _____

These pings should all fail. Why?

_____

_____

_____

Task 7: Gather Information.

Step 1: Check status of interfaces.

Check the status of the interfaces on each router with the command `show ip interface brief`. The following output is for R2.

```
R2#show ip interface brief
Interface            IP-Address      OK? Method Status                Protocol
FastEthernet0/0      172.16.1.1      YES manual up                    up
FastEthernet0/1      unassigned      YES unset  administratively down down
Serial0/0/0          172.16.2.2      YES manual up                    up
Serial0/0/1          192.168.1.2     YES manual up                    up
Vlan1                unassigned      YES manual administratively down down
```

Are all of the relevant interfaces on each router activated (that is, in the **up** and **up** state)? _____

How many interfaces are activated on R1 and R3? _____

Why are there three activated interfaces on R2? _____

_____

Step 2: View the routing table information for all three routers.

```
    R1#_____
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
        i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
        * - candidate default, U - per-user static route, o - ODR
        P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 2 subnets
C        172.16.2.0 is directly connected, Serial0/0/0
C        172.16.3.0 is directly connected, FastEthernet0/0
```

What networks are present in the Topology Diagram but not in the routing table for R1?

_____

```
    R2#_____
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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 2 subnets
C        172.16.1.0 is directly connected, FastEthernet0/0
C        172.16.2.0 is directly connected, Serial0/0/0
C     192.168.1.0/24 is directly connected, Serial0/0/1
```

What networks are present in the Topology Diagram but not in the routing table for R2?

_____

```
    R3#_____
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

Gateway of last resort is not set

C     192.168.1.0/24 is directly connected, Serial0/0/1
C     192.168.2.0/24 is directly connected, FastEthernet0/0
```

What networks are present in the Topology Diagram but not in the routing table for R3?

_____

Why are all the networks not in the routing tables for each of the routers?

_____

_____

What can be added to the network so that devices that are not directly connected can ping each other?

_____

Task 8: Configure a Static Route Using a Next-Hop Address.

Step 1: To configure static routes with a next-hop specified, use the following syntax:

```
Router(config)# ip route network-address subnet-mask ip-address
```

- *network-address*:—Destination network address of the remote network to be added to the routing table.
- *subnet-mask*—Subnet mask of the remote network to be added to the routing table. The subnet mask can be modified to summarize a group of networks.
- *ip-address*—Commonly referred to as the next-hop router's IP address.

On the R3 router, configure a static route to the 172.16.1.0 network using the Serial 0/0/1 interface of R2 as the next-hop address.

```
R3(config)#ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)#
```

Step 2: View the routing table to verify the new static route entry.

Notice that the route is coded with an **S**, which means that the route is a **static** route.

```
R3#_____

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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
S       172.16.1.0 [1/0] via 192.168.1.2
C    192.168.1.0/24 is directly connected, Serial0/0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
R3#
```

With this route entered in the routing table, any packet that matches the first 24 left-most bits of 172.16.1.0/24 will be forwarded to the next-hop router at 192.168.1.2.

What interface will R3 use to forward packets to the 172.16.1.0/24 network? _____

Assume that the following packets have arrived at R3 with the indicated destination addresses. Will R3 discard the packet or forward the packet? If R3 forwards the packet, with what interface will R3 send the packet?

Packet	Destination IP	Discard or Forward?	Interface
1	172.16.2.1	_____	_____
2	172.16.1.10	_____	_____
3	192.168.1.2	_____	_____
4	172.16.3.10	_____	_____
5	192.16.2.10	_____	_____

Although R3 will forward packets to destinations for which there is a route, this does not mean that a packet will arrive safely at the final destination.

Step 3: Use `ping` to check connectivity between the host PC3 and the host PC2.

From the host PC3, is it possible to ping the host PC2? _____

These pings should fail. The pings will arrive at PC2 if you have configured and verified all devices through Task 7, "Gather Information." PC2 will send a ping reply back to PC3. However, the ping reply will be discarded at R2 because the R2 does not have a return route to the 192.168.2.0 network in the routing table.

Step 4: On the R2 router, configure a static route to reach the 192.168.2.0 network.

What is the next-hop address to which R2 would send a packet destined for the 192.168.2.0/24 network?

```
R2(config)#ip route 192.168.2.0 255.255.255.0 _____
R2(config)#
```

Step 5: View the routing table to verify the new static route entry.

Notice that the route is coded with an **S**, which means the route is a **static** route.

```
R2#_____

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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.1.0 is directly connected, FastEthernet0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S    192.168.2.0/24 [1/0] via 192.168.1.1
R2#
```

Step 6: Use `ping` to check connectivity between the host PC3 and the host PC2.

From the host PC3, is it possible to ping the host PC2? _____

This ping should be successful.

Task 9: Configure a Static Route Using an Exit Interface.

To configure static routes with an exit interface specified, use the following syntax:

```
Router(config)# ip route network-address subnet-mask exit-interface
```

- *network-address*—Destination network address of the remote network to be added to the routing table.
- *subnet-mask*—Subnet mask of the remote network to be added to the routing table. The subnet mask can be modified to summarize a group of networks.
- *exit-interface*—Outgoing interface that would be used in forwarding packets to the destination network.

Step 1: On the R3 router, configure a static route.

On the R3 router, configure a static route to the 172.16.2.0 network using the Serial 0/0/1 interface of the R3 router as the exit interface.

```
R3(config)# ip route 172.16.2.0 255.255.255.0 Serial0/0/1
R3(config)#
```

Step 2: View the routing table to verify the new static route entry.

```
R3#_____
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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 2 subnets
S       172.16.1.0 [1/0] via 192.168.1.2
S       172.16.2.0 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
R3#
```

Use the **show running-config** command to verify the static routes that are currently configured on R3.

```
R3#show running-config
Building configuration...

<output omitted>
!
hostname R3
!
interface FastEthernet0/0
ip address 192.168.2.1 255.255.255.0
!
interface Serial0/0/0
 no ip address
 shutdown
```

```
 !
interface Serial0/0/1
 ip address 192.168.1.1 255.255.255.0
 !
ip route 172.16.1.0 255.255.255.0 192.168.1.2
ip route 172.16.2.0 255.255.255.0 Serial0/0/1
 !
end
```

How would you remove either of these routes from the configuration?

_____

Step 3: On the R2 router, configure a static route.

On the R2 router, configure a static route to the 172.16.3.0 network using the Serial 0/0/0 interface of the R2 router as the exit interface.

```
R2(config)# ip route 172.16.3.0 255.255.255.0 Serial0/0/0
R2(config)#
```

Step 4: View the routing table to verify the new static route entry.

```
R2#_____

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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
C       172.16.1.0 is directly connected, FastEthernet0/0
C       172.16.2.0 is directly connected, Serial0/0/0
S       172.16.3.0 is directly connected, Serial0/0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S    192.168.2.0/24 [1/0] via 192.168.1.1
R2#
```

At this point, R2 has a complete routing table with valid routes to all five networks shown in the Topology Diagram.

Does this mean that R2 can receive ping replies from all destinations shown in the Topology Diagram? _____

Why or why not?

_____

_____

Step 5: Use `ping` to check connectivity between the host PC2 and PC1.

This ping should fail because the R1 router does not have a return route to the 172.16.1.0 network in the routing table.

Task 10: Configure a Default Static Route.

In the previous steps, you configured the router for specific destination routes. But could you do this for every route on the Internet? No. The router and you would be overwhelmed. To minimize the size of the routing tables, add a default static route. A router uses the default static route when there is not a better, more specific route to a destination.

Instead of filling the routing table of R1 with static routes, we could assume that R1 is a *stub router*. This means that R2 is the default gateway for R1. If R1 has packets to route that do not belong to any of R1 directly connected networks, R1 should send the packet to R2. However, we must explicitly configure R1 with a default route before it will send packets with unknown destinations to R2. Otherwise, R1 discards packets with unknown destinations.

To configure a default static route, use the following syntax:

```
Router(config)#ip route 0.0.0.0 0.0.0.0 { ip-address | interface }
```

Step 1: Configure the R1 router with a default route.

Configure the R1 router with a default route using the interface option on Serial 0/0/0 of R1 as the next-hop interface.

```
R1(config)#ip route 0.0.0.0 0.0.0.0 172.16.2.2
R1(config)#
```

Step 2: View the routing table to verify the new static route entry.

```
R1#_____
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

Gateway of last resort is 172.16.2.2 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 [1/0] via 172.16.2.2
R1#
```

Note that the R1 router now has a default route, the *gateway of last resort*, and will send all unknown traffic out Serial 0/0/0, which is connected to R2.

Step 3: Use `ping` to check connectivity between the host PC2 and PC1.

From the host PC2, is it possible to ping PC1? _____

This ping should be successful this time because the R1 router can return the packet using the default route.

From the host PC3, is it possible to ping the host PC1? _____

Is there a route to the 172.16.3.0 network in the routing table on the R3 router? _____

Task 11: Configure a Summary Static Route.

We could configure another static route on R3 for the 172.16.3.0 network. However, we already have two static routes to 172.16.2.0/24 and 172.16.1.0/24. Because these networks are so close together, we can summarize them into one route. Again, doing this helps reduce the size of routing tables, which makes the route lookup process more efficient.

Looking at the three networks at the binary level, we can a common boundary at the 22nd bit from the left.

```
172.16.1.0    10101100.00010000.00000001.00000000
172.16.2.0    10101100.00010000.00000010.00000000
172.16.3.0    10101100.00010000.00000011.00000000
```

The prefix portion will include 172.16.0.0, because this would be the prefix if we turned off all the bits to the right of the 22nd bit.

```
Prefix    172.16.0.0
```

To mask the first 22 left-most bits, we use a mask with 22 bits turned on from left to right:

```
Bit Mask 11111111.11111111.11111100.00000000
```

This mask, in dotted-decimal format, is...

```
Mask     255.255.252.0
```

Step 1: Configure the summary static route on the R3 router.

The network to be used in the summary route is 172.16.0.0/22.

```
R3(config)#ip route 172.16.0.0 255.255.252.0 192.168.1.2
```

Step 2: Verify that the summary route is installed in the routing table.

```
R3#_____
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
S       172.16.0.0/22 [1/0] via 192.168.1.2
S       172.16.1.0/24 [1/0] via 192.168.1.2
S       172.16.2.0/24 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

Configuring a summary route on R3 did not remove the static routes configured earlier because these routes are more specific routes. They both use **/24** mask, whereas the new summary will be using a **/22** mask. To reduce the size of the routing table, we can now remove the more specific **/24** routes.

Step 3: Remove static routes on R3.

Remove the two static routes that are currently configured on R3 by using the **no** form of the command.

```
R3(config)#no ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)#no ip route 172.16.2.0 255.255.255.0 Serial0/0/1
```

Step 4: Verify that the routes are no longer in the routing table.

```
R3#_____
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/22 is subnetted, 1 subnets
S       172.16.0.0 [1/0] via 192.168.1.2
C     192.168.1.0/24 is directly connected, Serial0/0/1
C     192.168.2.0/24 is directly connected, FastEthernet0/0
```

R3 now only has one route to any host belonging to networks 172.16.0.0/24, 172.16.1.0/24, 172.16.2.0/24, and 172.16.3.0/24. Traffic destined for these networks will be sent to R2 at 192.168.1.2.

Step 5: Use `ping` to check connectivity between the host PC3 and PC1.

From the host PC3, is it possible to ping the host PC1? _____

This ping should be successful this time because there is a route to the 172.16.3.0 network on the R3 router, and the R1 router can return the packet using the default route.

Task 12: Summary, Reflection, and Documentation

With the completion of this lab, you have:

- Configured your first network with a combination of static and default routing to provide full connectivity to all networks
- Observed how a route is installed in the routing table when you correctly configure and activate the interface
- Learned how to statically configure routes to destinations that are not directly connected
- Learned how to configure a default route that is used to forward packets to unknown destinations
- Learned how to summarize a group of networks into one static route to reduce the size of a routing table

Along the way, you have also probably encountered some problems either in your physical lab setup or in your configurations. Hopefully, you have learned to systematically troubleshoot such problems. At this point, record any comments or notes that may help you in future labs.

_____

_____

_____

_____

Finally, you should document your network implementation. On each router, capture the following command output to a text (.txt) file and save for future reference.

- **`show running-config`**
- **`show ip route`**
- **`show ip interface brief`**

If you need to review the procedures for capturing command output, see Lab 1.5.1.

Task 13: Clean Up

Erase the configurations and reload the routers. Disconnect and store the cabling. For PC hosts that are normally connected to other networks (such as the school LAN or to the Internet), reconnect the appropriate cabling and restore the TCP/IP settings.

Task 14: Challenge

In the following exercise, fill in the blanks to document the process as the ping travels from source to destination. If you need help with this exercise see Section 1.4, "Path Determination and Switching Function."

1. The ICMP process on PC3 formulates a ping request to PC2 and sends the request to the IP process.

2. The IP process on PC3 encapsulates the ping packet with a source IP address of _____ and destination IP address of _____.

3. PC3 then frames the packet with the source MAC address of (indicate device name) ___ _____ and the destination MAC address of (indicate device name) _____ _____.

4. Next, PC3 sends the frame out on the media as an encoded bit stream.

5. R3 receives the bit stream on its _____ interface. Because the destination MAC address matches the receiving interface's MAC address, R3 strips off the Ethernet header.

6. R3 looks up the destination network address _____ in its routing table. This destination has a next-hop IP address of _____. The next-hop IP address is reachable out interface _____.

7. R3 encapsulates the packet in an HDLC frame and forwards the frame out the correct interface. (Because this is a point-to-point link, no address is needed. However, the address field in the HDLC packet contains the value 0x8F.)

8. R2 receives the frame on the _____ interface. Because the frame is HDLC, R2 strips off the header and looks up the network address _____ in its routing table. This destination address is directly connected to the _____ interface.

9. R2 encapsulates the ping request in a frame with the source MAC address of (indicated device name) ____ _____ and the destination MAC address of (indicate device name) _____.

10. R2 then sends the frame out on the media as an encoded bit stream.

11. PC2 receives the bit stream on its _____ interface. Because the destination MAC address matches the MAC address of PC2, PC2 strips off the Ethernet header.

12. The IP process on PC2 examines the _____ IP address to make sure that it matches its own IP address. Then PC2 passes the data to the ICMP process.

13. The ICMP process on PC2 formulates a ping reply to PC3 and sends the reply to the IP process.

14. The IP process on PC2 encapsulates the ping packet with a source IP address of _____ and destination IP address of _____.

15. PC2 then frames the packet with the source MAC address of (indicate device name) _____ and the destination MAC address of (indicate device name) _____.

16. PC2 then sends the frame out on the media as an encoded bit stream.

17. R2 receives the bit stream on its _____ interface. Because the destination MAC address matches the receiving interface's MAC address, R2 strips off the Ethernet header.

18. R2 looks up the destination network address _____ in its routing table. This destination has a next-hop IP address of _____. The next-hop IP address is reachable out interface _____.

19. R2 encapsulates the packet in an HDLC frame and forwards the frame out the correct interface. (Because this is a point-to-point link, no address is needed. However, the address field in the HDLC packet contains the value 0x8F.)

20. R3 receives the frame on the _____ interface. Because the frame is HDLC, R3 strips off the header and looks up the destination network address _____ in its routing table. This destination address is directly connected to the _____ interface.

21. R3 encapsulates the ping request in a frame with the source MAC address of (indicated device name) _____ and the destination MAC address of (indicate device name) _____.

22. R3 then sends the frame out on the media as an encoded bit stream.

23. PC3 receives the bit stream on its _____ interface. Because the destination MAC address matches the MAC address of PC3, PC3 strips off the Ethernet header.

24. The IP process on PC3 examines the _____ IP address to make sure that it matches its own IP address. Then PC3 passes the data to the ICMP process.

25. ICMP sends a "success" message to the requesting application.