

# Chapter 6: Static Routing

## Objectives

- Explain the advantages and disadvantages of static routing.
- Explain the purpose of different types of static routes.
- Configure IPV4 and IPV6 static routes using the next-hop address.
- Configure an IPv4 and IPv6 default routes.
- Configure and IPv4 and IPv6 summary network address to reduce the number of routing table updates
- Configure a floating static route to provide a backup connection.
- Understand how a router process packets when static route is configured.
- Troubleshooting and testing static and default routes.

## 1. Introduction

Static routing is a type of network routing technique. Static routing is not a routing protocol; instead, it is the manual configuration and selection of a network route, usually managed by the network administrator. It is employed in scenarios where the network parameters and environment are expected to remain constant.

Static routing is only optimal in a few situations. Network degradation, latency and congestion are inevitable consequences of the non-flexible nature of static routing because there is no adjustment when the primary route is unavailable.

Routing is one of the most essential procedures in data communication. It ensures that data travels from one network to another with optimal speed and minimal delay, and that its integrity is maintained in the process.

Broadly, routing is performed in two different ways:

- Dynamic routing continuously updates its routing table with paths and their cost/metric, while making optimal routing decisions based on changing network operating environments.
- Static routing performs routing decisions with preconfigured routes in the routing table, which can be changed manually only by administrators. Static routes are normally implemented in those situations where the choices in route selection are limited, or there is only a single default route available. Also, static routing can be used if you have only few devices for route configuration and there is no need for route change in the future.

Static routing is considered the simplest form of routing.

## Why Static Routing?

Static routing provides some advantages over dynamic routing, including:

- Static routes are not advertised over the network, resulting in better security.
- Static routes use less bandwidth than dynamic routing protocols, as routers do not exchange routes.
- No CPU cycles are used to calculate and communicate routes.
- The path a static route uses to send data is known.

Static routing has the following disadvantages:

- Initial configuration and maintenance is time-consuming.
- Configuration can be error-prone, especially in large networks.
- Administrator intervention is required to maintain changing route information.
- Does not scale well with growing networks; maintenance becomes cumbersome.
- Requires complete knowledge of the whole network for proper implementation.

## 2. Advantages and Disadvantages of Static Routing

In Table 6-1, dynamic and static routing features are compared. Notice that the advantages of one method are the disadvantages of the other.

**Table 6-1 Dynamic Routing Versus Static Routing**

	<b>Dynamic Routing</b>	<b>Static Routing</b>
<b>Configuration Complexity</b>	Generally independent of the network size	Increases with the network size
<b>Topology Changes</b>	Automatically adapts to topology changes	Administrator intervention required
<b>Scaling</b>	Suitable for simple and complex topologies	Suitable for simple topologies
<b>Security</b>	Less secure	More secure
<b>Resource Usage</b>	Uses CPU, memory, link bandwidth	No extra resources needed
<b>Predictability</b>	Route depends on the current topology	Route to destination is always the same

Static routes are useful for smaller networks with only one path to an outside network. They also provide security in a larger network for certain types of traffic or links to other networks that need more control. It is important to understand that static and dynamic routing are not mutually exclusive. Rather, most networks use a combination of dynamic routing protocols and static routes. This may result in the router having multiple paths

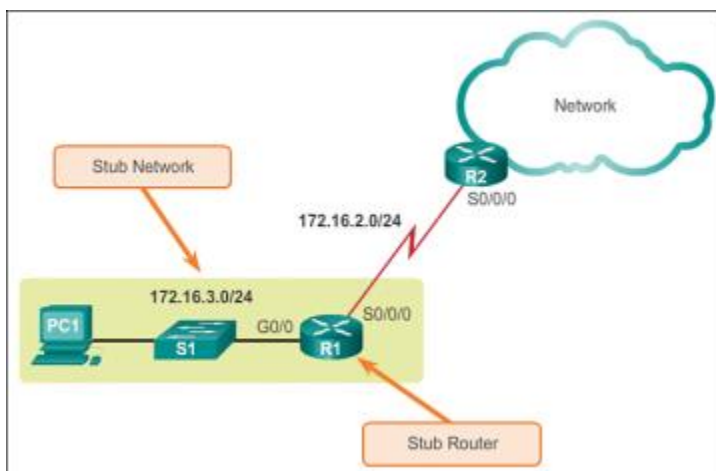
to a destination network via static routes and dynamically learned routes. However, the administrative distance (AD) of a static route is 1. Therefore, a static route will take precedence over all dynamically learned routes.

## When to Use Static Routes

Static routing has three primary uses:

- Providing ease of routing table maintenance in smaller networks that are not expected to grow significantly.
- Routing to and from stub networks. A **stub network** is a network accessed by a single route, and the router has only one neighbor.
- Using a single default route to represent a path to any network that does not have a more specific match with another route in the routing table. Default routes are used to send traffic to any destination beyond the next upstream router.

[Figure 6-1](#) shows an example of a stub network connection and a default route connection. Notice in the figure that any network attached to R1 would only have one way to reach other destinations, whether to networks attached to R2, or to destinations beyond R2. This means that network 172.16.3.0 is a stub network and R1 is a stub router. Running a routing protocol between R2 and R1 is a waste of resources.



[Figure 6-1](#) Stub Networks and Stub Routers

In this example, a static route can be configured on R2 to reach the R1 LAN. Additionally, because R1 has only one way to send out non-local traffic, a default static route can be

### 3. Static Route Applications

Static routes are most often used to connect to a specific network or to provide a Gateway of Last Resort for a stub network. They can also be used to:

- Reduce the number of routes advertised by summarizing several contiguous networks as one static route
- Create a backup route in case a primary route link fails

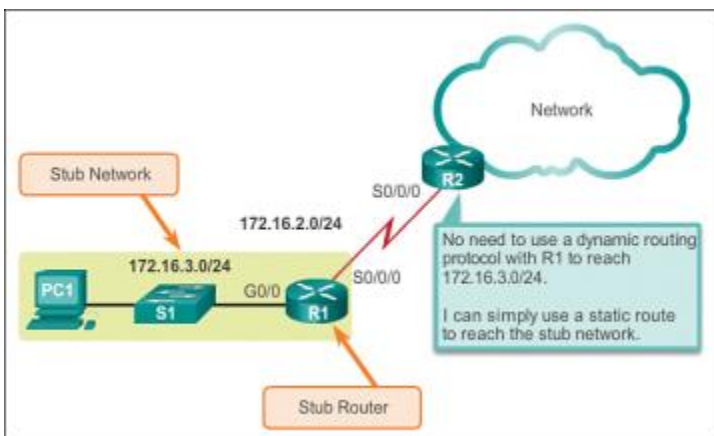
The following types of IPv4 and IPv6 static routes will be discussed:

- Standard static route
- Default static route
- Summary static route
- Floating static route

#### Standard Static Route

Both IPv4 and IPv6 support the configuration of static routes. Static routes are useful when connecting to a specific remote network.

[Figure 6-2](#) shows that R2 can be configured with a static route to reach the stub network 172.16.3.0/24.



[Figure 6-2](#) Connecting to a Stub Network



The example is highlighting a stub network, but in fact, a static route can be used to connect to any network.

## 4. Ip Route Command

When using the **ip route** command, you can identify where packets should be routed to in two ways:

- The next-hop address
- The exit interface

	172.16.3.0 = destination network
	255.255.255.0 = subnet mask
Router(config)# <b>ip route 172.16.3.0</b> <b>255.255.255.0 172.16.2.2</b>	172.16.2.2 = next-hop address
	Read this to say: To get to the destination network of 172.16.3.0, with a subnet mask of 255.255.255.0, send all packets to 172.16.2.2
	172.16.3.0 = destination network
	255.255.255.0 = subnet mask
Router(config)# <b>ip route 172.16.3.0</b> <b>255.255.255.0 s0/0/0</b>	s0/0 = exit interface
	Read this to say: To get to the destination network of 172.16.20.0, with a subnet mask of 255.255.255.0, send all packets out interface Serial 0/0

## 5. Default Static Route

A default static route is a route that matches all packets. A default route identifies the gateway IP address to which the router sends all IP packets that it does not have a learned or static route for. A default static route is simply a static route with 0.0.0.0/0 as the destination IPv4 address. Configuring a default static route creates a Gateway of Last Resort.

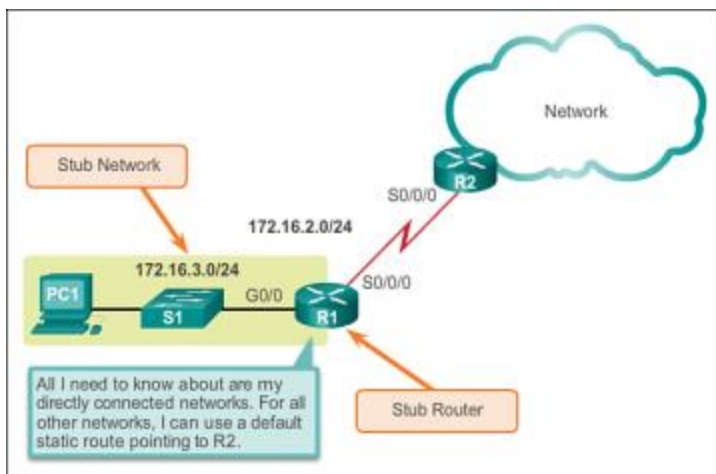


All routes that identify a specific destination with a larger subnet mask take precedence over the default route.

### Default static routes are used:

- When no other routes in the routing table match the packet destination IP address. In other words, when a more specific match does not exist. A common use is when connecting a company's edge router to the ISP network.
- When a router has only one other router to which it is connected. This condition is known as a stub router.

Refer to [Figure 6-2](#) for a sample scenario of implementing default static routing.



[Figure 6-2](#) Connecting to a Stub Router

## Default Static Route command

Router(config)#**ip route 0.0.0.0 0.0.0.0**  
**172.16.2.2**

Send all packets destined for networks not in my routing table to  
 172.16.2.2

Send all packets destined for networks not in my routing table out  
 my Serial 0/0 interface

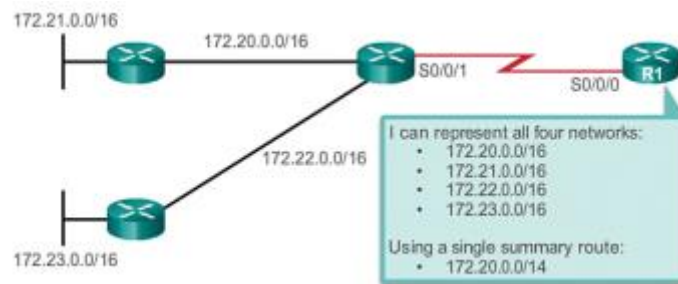
Router(config)#**ip route 0.0.0.0 0.0.0.0**  
**s0/0/0**

## 6. Route Summarization

To reduce the number of routing table entries, multiple static routes can be summarized into a single *summary static route* if:

- The destination networks are contiguous and can be summarized into a single network address.
- The multiple static routes all use the same exit interface or next-hop IP address.

In [Figure 6-3](#), R1 would require four separate static routes to reach the 172.20.0.0/16 to 172.23.0.0/16 networks. Instead, one *summary static route* can be configured and still provide connectivity to those networks.



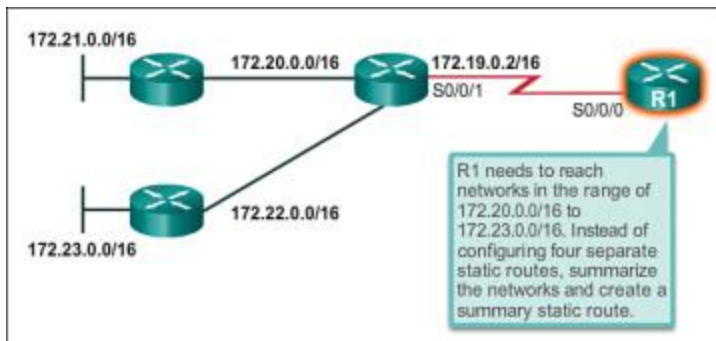
[Figure 6-3](#) Using One Summary Static Route

A single IPv4 static *summary route* can be used to replace multiple static routes when those routes can be summarized with a common prefix length. The configuration of a summary static route is similar to the configuration of other IPv4 static routes.

**Route summarization**, also known as route aggregation, is the process of advertising a contiguous set of addresses as a single address with a less-specific, shorter subnet mask. CIDR is a form of route summarization and is synonymous with the term supernetting.

CIDR ignores the limitation of classful boundaries, and allows summarization with masks that are smaller than that of the default classful mask. This type of summarization helps reduce the number of entries in routing updates and lowers the number of entries in local routing tables. It also helps reduce bandwidth utilization for routing updates and results in faster routing table lookups.

In [Figure 6-4](#), R1 requires a summary static route to reach networks in the range of 172.20.0.0/16 to 172.23.0.0/16.



[Figure 6-4](#) Basic Topology

### Calculate a Summary Route

Summarizing networks into a single address and mask can be done in three steps, as shown in [Figure 6-5](#):



- **Step 1.** List the networks in binary format. [Figure 6-5](#) lists networks 172.20.0.0/16 to 172.23.0.0/16 in binary format.
- **Step 2.** Count the number of far left matching bits to determine the mask for the summary route. [Figure 6-5](#) highlights the 14 far left matching bits. This is the prefix, or subnet mask, for the summarized route: /14 or 255.252.0.0.
- **Step 3.** Copy the matching bits and then add zero bits to determine the summarized network address. [Figure 6-5](#) shows that the matching bits with zeros at the end results in the network address 172.20.0.0. The four networks—172.20.0.0/16, 172.21.0.0/16, 172.22.0.0/16, and 172.23.0.0/16—can be summarized into the single network address and prefix 172.20.0.0/14.



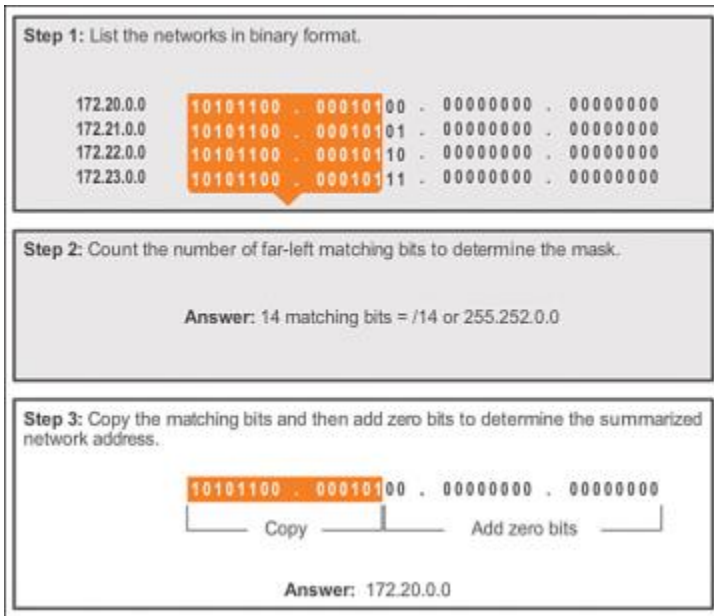


Figure 6-5 Calculating a Route Summary

Figure 6-6 displays R1 configured with a summary static route to reach networks 172.20.0.0/16 to 172.23.0.0/16.

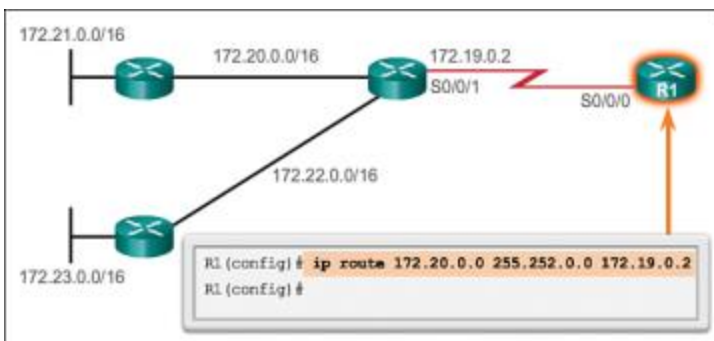


Figure 6-6 One Summary Static Route

### Summary Static Route Example

Multiple static routes can be summarized into a single static route if:

- The destination networks are contiguous and can be summarized into a single network address.
- The multiple static routes all use the same exit interface or next-hop IP address.

Consider the example in Figure 6-7. All routers have connectivity using static routes.

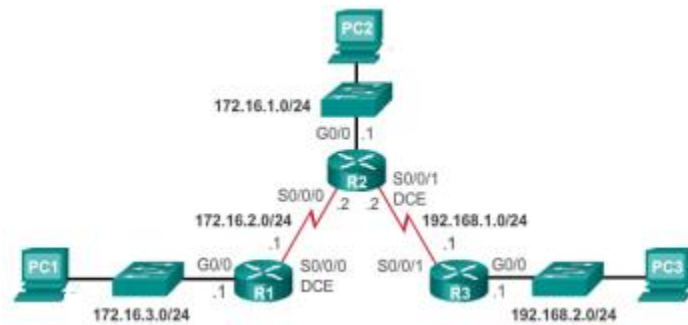


Figure 6-7 Basic Topology

The following output displays the static routing table entries for R3. Notice that it has three static routes that can be summarized because they share the same two first octets.

```
R3# show ip route static | begin Gateway
Gateway of last resort is not set
  172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 is directly connected, Serial0/0/1
S       172.16.2.0 is directly connected, Serial0/0/1
S       172.16.3.0 is directly connected, Serial0/0/1
R3#
```

Figure 6-8 displays the steps to summarize those three networks:



- **Step 1.** Write out the networks to summarize in binary.
- **Step 2.** To find the subnet mask for summarization, start with the far left bit, work to the right, finding all the bits that match consecutively until a column of bits that do not match is found, identifying the summary boundary.
- **Step 3.** Count the number of far left matching bits; in our example, it is 22. This number identifies the subnet mask for the summarized route as /22 or 255.255.252.0.
- **Step 4.** To find the network address for summarization, copy the matching 22 bits and add all 0 bits to the end to make 32 bits.

After the summary route is identified, replace the existing routes with the one summary route.

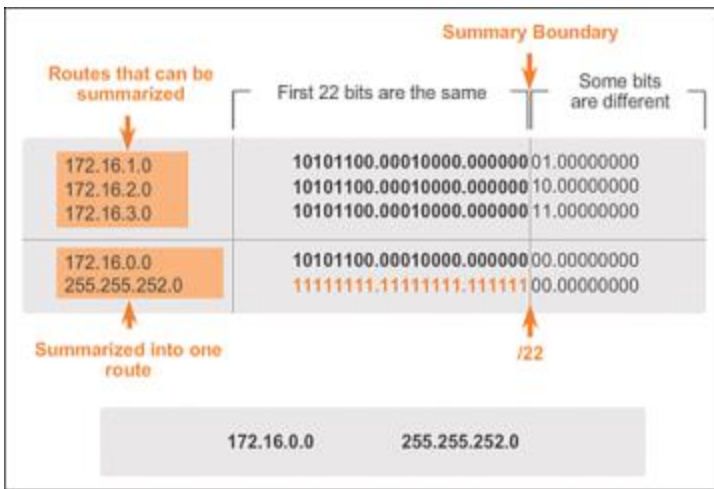


Figure 6-8 Summarize the Networks

The following output shows how the three existing routes are removed and then the new summary static route is configured:

```
R3(config)# no ip route 172.16.1.0 255.255.255.0 s0/0/1
R3(config)# no ip route 172.16.2.0 255.255.255.0 s0/0/1
R3(config)# no ip route 172.16.3.0 255.255.255.0 s0/0/1
R3(config)# ip route 172.16.0.0 255.255.252.0 s0/0/1
R3(config)#
```

The following output confirms that the summary static route is in the routing table of R3:

```
R3# show ip route static | begin Gateway
Gateway of last resort is not set
  172.16.0.0/22 is subnetted, 1 subnets
S       172.16.0.0 is directly connected, Serial0/0/1
R3#
```

## Configure IPv6 Summary Routes

Similar to IPv4, a single IPv6 static summary route can be used to replace multiple IPv6 static routes with a common prefix length. The calculation and configuration of an IPv6 summary static route is similar to the configuration of an IPv4 static summary route.

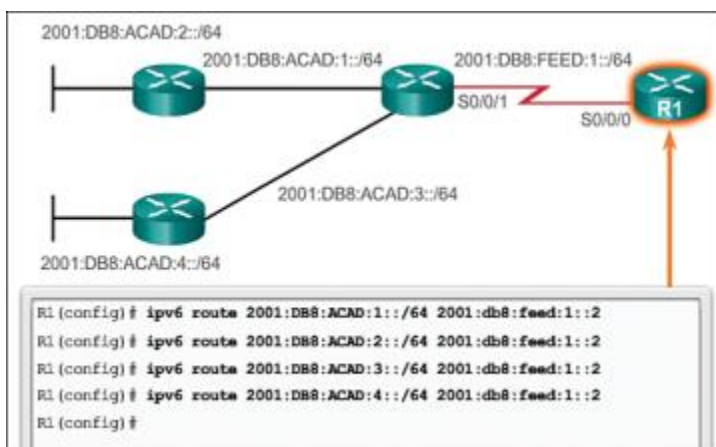
## Summarize IPv6 Network Addresses

Aside from the fact that IPv6 addresses are 128 bits long and written in hexadecimal, summarizing IPv6 addresses is actually similar to the summarization of IPv4 addresses. It just requires a few extra steps due to the abbreviated IPv6 addresses and hex conversion.

Multiple static IPv6 routes can be summarized into a single static IPv6 route if:

- The destination networks are contiguous and can be summarized into a single network address.
- The multiple static routes all use the same exit interface or next-hop IPv6 address.

Refer to the network in [Figure 6-9](#). R1 currently has four static IPv6 routes to reach networks 2001:DB8:ACAD:1::/64 to 2001:DB8:ACAD:4::/64.



[Figure 6-9](#) Basic Topology

The following output displays the IPv6 static routes installed in the IPv6 routing table:

```

R1# show ipv6 route static
IPv6 Routing Table - default - 7 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S    2001:DB8:ACAD:1::/64 [1/0]
    via 2001:DB8:FEED:1::2
S    2001:DB8:ACAD:2::/64 [1/0]
    via 2001:DB8:FEED:1::2
S    2001:DB8:ACAD:3::/64 [1/0]
    via 2001:DB8:FEED:1::2
S    2001:DB8:ACAD:4::/64 [1/0]
    via 2001:DB8:FEED:1::2
R1#
  
```

## Calculate IPv6 Network Addresses

Summarizing IPv6 networks into a single IPv6 prefix and prefix length can be done in seven steps as shown in [Figures 6-10](#) to [2-64](#):



- **Step 1.** List the network addresses (prefixes) and identify the part where the addresses differ.
- **Step 2.** Expand the IPv6 if it is abbreviated.
- **Step 3.** Convert the differing section from hex to binary.
- **Step 4.** Count the number of far left matching bits to determine the prefix length for the summary route.
- **Step 5.** Copy the matching bits and then add zero bits to determine the summarized network address (prefix).
- **Step 6.** Convert the binary section back to hex.
- **Step 7.** Append the prefix of the summary route (result of Step 4).

2001:0DB8:ACAD:1::/64
2001:0DB8:ACAD:2::/64
2001:0DB8:ACAD:3::/64
2001:0DB8:ACAD:4::/64

[Figure 6-10](#) Identify the Part Where the Addresses Differ

2001:0DB8:ACAD:0001::/64
2001:0DB8:ACAD:0002::/64
2001:0DB8:ACAD:0003::/64
2001:0DB8:ACAD:0004::/64

[Figure 6-11](#) Identify the Part Where the Addresses Differ – Expanded View

2001:0DB8:ACAD:0000000000000001::/64
2001:0DB8:ACAD:0000000000000010::/64
2001:0DB8:ACAD:0000000000000011::/64
2001:0DB8:ACAD:0000000000000100::/64

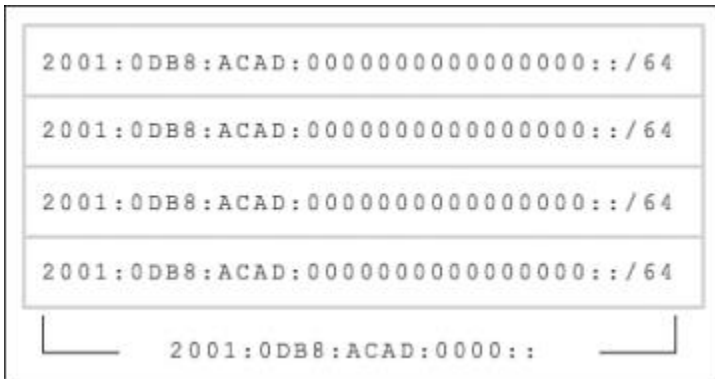
[Figure 6-12](#) Convert the Section from Hex to Binary

2001:0DB8:ACAD:0000000000000001::/64
2001:0DB8:ACAD:0000000000000010::/64
2001:0DB8:ACAD:0000000000000011::/64
2001:0DB8:ACAD:0000000000000100::/64
<div>16 bits</div> <div>16 bits</div> <div>16 bits</div> <div>13 bits</div>
<div>16 + 16 + 16 + 13 = /61</div>

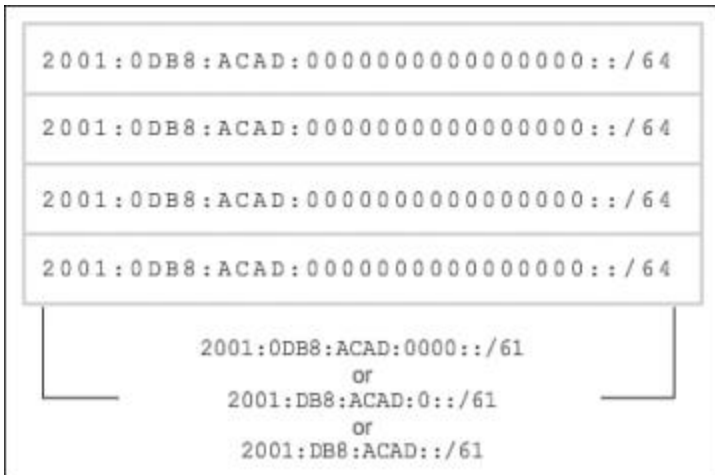
[Figure 6-13](#) Count the Number of Far Left Matching Bits

2001:0DB8:ACAD:0000000000000000::/64
2001:0DB8:ACAD:0000000000000000::/64
2001:0DB8:ACAD:0000000000000000::/64
2001:0DB8:ACAD:0000000000000000::/64

[Figure 6-14](#) Add Zero Bits to Determine the Summarized Network Address



[Figure 6-15](#) Convert the Binary Section Back to Hex

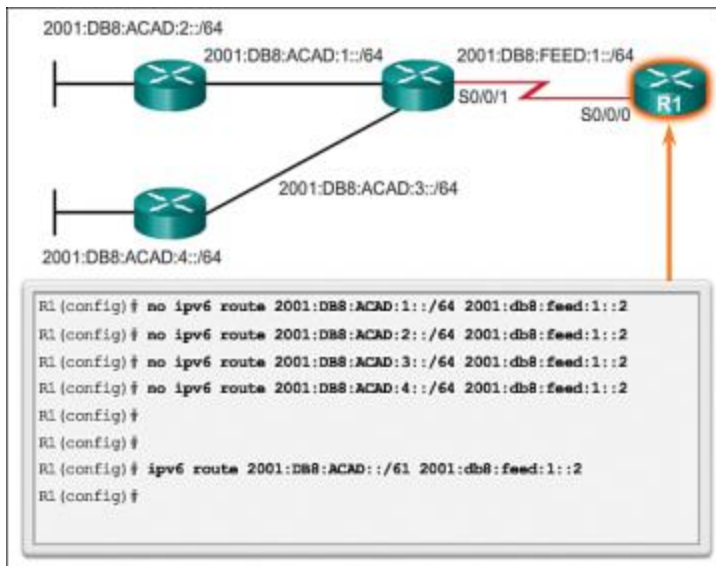


[Figure 6-16](#) Count the Number of Far Left Matching Bits

### Configure an IPv6 Summary Address

After the summary route is identified, replace the existing routes with the single summary route.

[Figure 6-17](#) displays how the four existing routes are removed and then the new summary static IPv6 route is configured.



[Figure 6-18](#) Remove Static Routes and Configure Summary IPv6 Route

The following output confirms that the summary static route is in the routing table of R1:

```

R1# show ipv6 route static
IPv6 Routing Table - default - 4 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S    2001:DB8:ACA8::/45 [1/0]
    via 2001:DB8:FEED:1::2
R1#
  
```

## 7. Floating Static Route

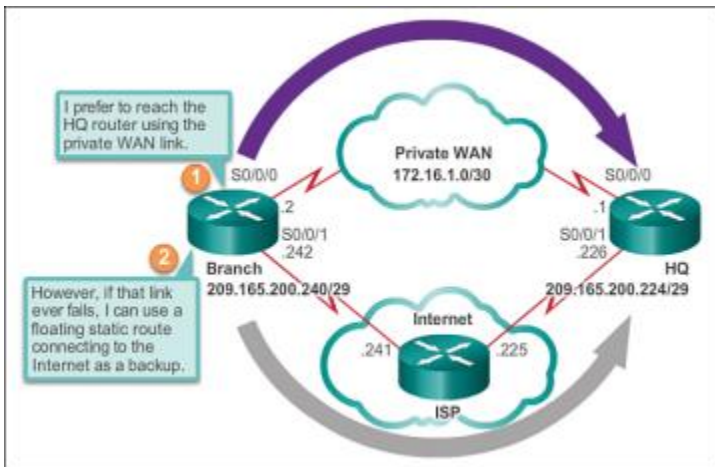
Another type of static route is a *floating static route*. Floating static routes are static routes that are used to provide a backup path to a primary static or dynamic route, in the event of a link failure. The floating static route is only used when the primary route is not available.

To accomplish this, the floating static route is configured with a higher administrative distance than the primary route. Recall that the administrative distance represents the trustworthiness of a route. If multiple paths to the destination exist, the router will choose the path with the lowest administrative distance.



For example, assume that an administrator wants to create a floating static route as a backup to an EIGRP-learned route. The floating static route must be configured with a higher administrative distance than EIGRP. EIGRP has an administrative distance of 90. If the floating static route is configured with an administrative distance of 95, the dynamic route learned through EIGRP is preferred to the floating static route. If the EIGRP-learned route is lost, the floating static route is used in its place.

In [Figure 6-19](#), the Branch router typically forwards all traffic to the HQ router over the private WAN link. In this example, the routers exchange route information using EIGRP. A floating static route, with an administrative distance of 91 or higher, could be configured to serve as a backup route. If the private WAN link fails and the EIGRP route disappears from the routing table, the router selects the floating static route as the best path to reach the HQ LAN.



[Figure 6-19](#) Configuring a Backup Route

By default, static routes have an administrative distance of 1, making them preferable to routes learned from dynamic routing protocols. For example, the administrative distances of some common dynamic routing protocols are:

- EIGRP = 90
- IGRP = 100
- OSPF = 110
- IS-IS = 115
- RIP = 120

The administrative distance of a static route can be increased to make the route less desirable than that of another static route or a route learned through a dynamic routing protocol. In this way, the static route “floats” and is not used when the route with the better administrative distance is active. However, if the preferred route is lost, the floating static route can take over, and traffic can be sent through this alternate route.

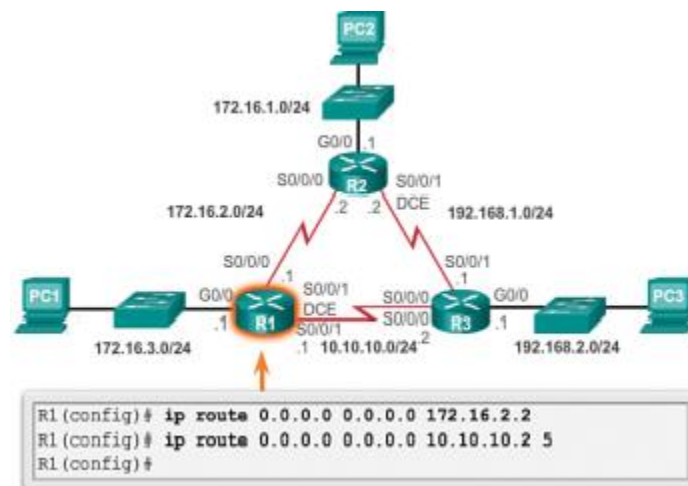
A floating static route can be used to provide a backup route to multiple interfaces or networks on a router. It is also encapsulation independent, meaning it can be used to forward packets out any interface, regardless of encapsulation type.

An important consideration of a floating static route is that it is affected by convergence time. A route that is continuously dropping and re-establishing a connection can cause the backup interface to be activated unnecessarily.

### Configure a Floating Static Route

IPv4 static routes are configured using the **ip route** global configuration command and specifying an administrative distance. If no administrative distance is configured, the default value (1) is used.

Refer to the topology in [Figure 6-20](#). In this scenario, the preferred route from R1 is to R2. The connection to R3 should be used for backup only.



[Figure 6-20](#) Configure a Floating Static Route to R3

R1 is configured with a default static route pointing to R2. Because no administrative distance is configured, the default value (1) is used for this static route. R1 is also configured with a floating static default pointing to R3 with an administrative distance of 5. This value is greater than the default value of 1 and, therefore, this route floats and is not present in the routing table, unless the preferred route fails.

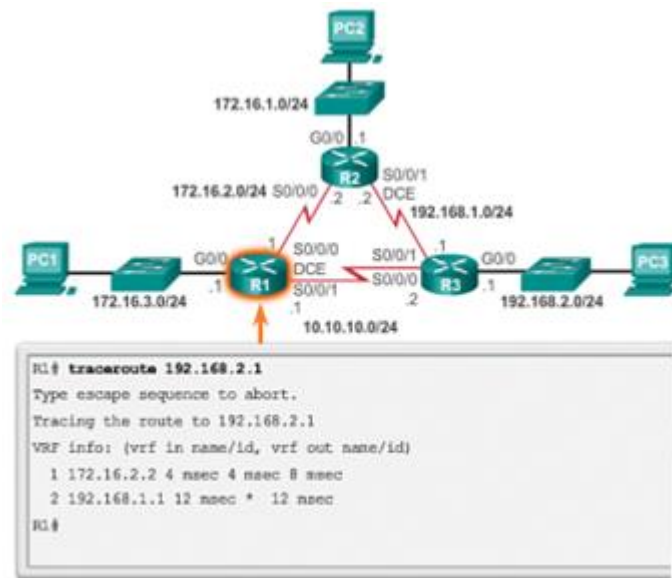
The following output verifies that the default route to R2 is installed in the routing table. Note that the backup route to R3 is not present in the routing table.

```

R1# show ip route static | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
S*    0.0.0.0/0 [1/0] via 172.16.2.2
R1#
  
```

## Test the Floating Static Route

Because the default static route on R1 to R2 has an administrative distance of 1, traffic from R1 to R3 should go through R2. The output in [Figure 6-21](#) confirms that traffic between R1 and R3 flows through R2.



[Figure 6-21](#) Verify the Path to the R3 LAN

What would happen if R2 failed? To simulate this failure, both serial interfaces of R2 are shut down, as shown in the following output:

```
R2(config)# int s0/0/0
R2(config-if)# shut
*Feb 21 16:33:35.939: %LINK-5-CHANGED: Interface Serial0/0/0, changed state to admin-
  istratively down
*Feb 21 16:33:36.939: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0/0,
  changed state to down
R2(config-if)# int s0/0/1
R2(config-if)# shut
R2(config-if)#
*Feb 21 16:33:42.543: %LINK-5-CHANGED: Interface Serial0/0/1, changed state to admini-
  stratively down
*Feb 21 16:33:43.543: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0/1,
  changed state to down
```

Notice in the following output that R1 automatically generates messages indicating that the serial interface to R2 is down. A look at the routing table verifies that the default route is now pointing to R3 using the floating static default route configured for next-hop 10.10.10.2.

```
*Feb 21 16:35:58.435: %LINK-3-UPDOWN: Interface Serial0/0/0, changed state to down
*Feb 21 16:35:59.435: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0/0,
```

```
changed state to down
R1#
R1# show ip route static | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
S*    0.0.0.0/0 [5/0] via 10.10.10.2
R1#
```

The output confirms that traffic now flows directly between R1 and R3:

```
R1# traceroute 192.168.2.1
Type escape sequence to abort.
Tracing the route to 192.168.2.1
VRF info: (vrf in name/id, vrf out name/id)
 1 10.10.10.2 4 msec 4 msec *
R1#
```

## 8. Troubleshooting Static and Default Routes

Troubleshooting is a skill that develops as you gain experience. It is always best to look for the most obvious and simplest issues first, such as an interface still in shutdown mode or an interface with the wrong IP address. After these items have been verified, begin looking for more complicated possibilities like an error in the static route configuration.

### Static Routes and Packet Forwarding

The following example describes the packet forwarding process with static routes.

Examine [Figure 6-22](#), where PC1 is sending a packet to PC3:

1. The packet arrives on the FastEthernet 0/0 interface of R1.
2. R1 does not have a specific route to the destination network, 192.168.2.0/24; therefore, R1 uses the default static route.
3. R1 encapsulates the packet in a new frame. Because the link to R2 is a point-to-point link, R1 adds an “all 1s” address for the Layer 2 destination address.
4. The frame is forwarded out of the Serial 0/0/0 interface. The packet arrives on the Serial 0/0/0 interface on R2.
5. R2 de-encapsulates the frame and looks for a route to the destination. R2 has a static route to 192.168.2.0/24 out of the Serial 0/0/1 interface.
6. R2 encapsulates the packet in a new frame. Because the link to R3 is a point-to-point link, R2 adds an “all 1s” address for the Layer 2 destination address.
7. The frame is forwarded out of the Serial 0/0/1 interface. The packet arrives on the Serial 0/0/1 interface on R3.
8. R3 de-encapsulates the frame and looks for a route to the destination. R3 has a connected route to 192.168.2.0/24 out of the FastEthernet 0/0 interface.

9. R3 looks up the ARP table entry for 192.168.2.10 to find the Layer 2 Media Access Control (MAC) address for PC3. If no entry exists, R3 sends an Address Resolution Protocol (ARP) request out of the FastEthernet 0/0 interface, and PC3 responds with an ARP reply, which includes the PC3 MAC address.
10. R3 encapsulates the packet in a new frame with the MAC address of the FastEthernet 0/0 interface as the source Layer 2 address and the MAC address of PC3 as the destination MAC address.
11. The frame is forwarded out of the FastEthernet 0/0 interface. The packet arrives on the network interface card (NIC) interface of PC3.

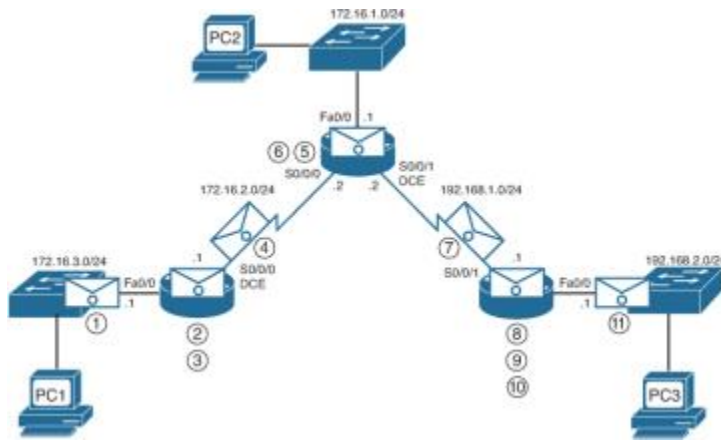


Figure 6-22 Static Routes and Packet Forwarding

### Troubleshooting a Missing Route

When end-to-end connectivity is a problem, begin by making sure that you can ping your own interface and other devices on your own directly connected networks. When this has been verified, begin testing connectivity to remote networks from other devices.

Networks are subject to forces that can cause their status to change quite often:

- An interface fails.
- A service provider drops a connection.
- Links become oversaturated.
- An administrator enters a wrong configuration.

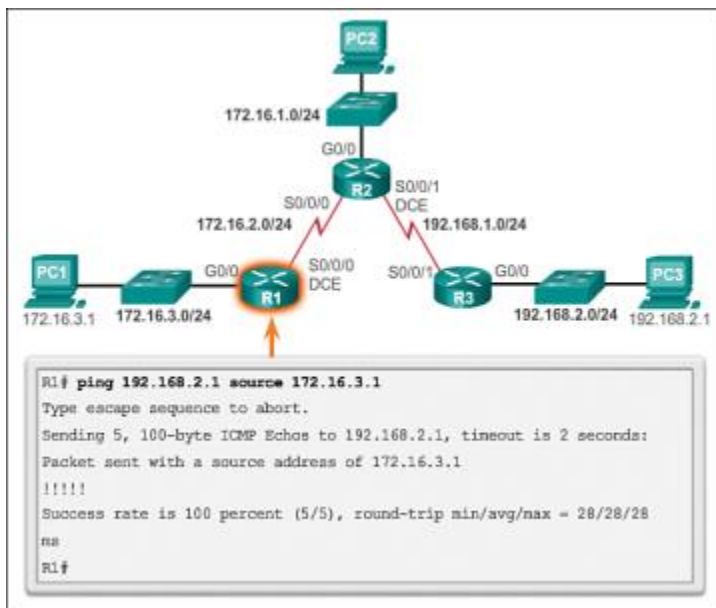
When there is a change in the network, connectivity may be lost. Network administrators are responsible for pinpointing and solving the problem. To find and solve these issues, a network administrator must be familiar with tools to help isolate routing problems quickly.

Common IOS troubleshooting commands include:

- **ping**
- **tracert**

- **show ip route**
- **show ip interface brief**
- **show cdp neighbors detail**

[Figure 6-23](#) displays the result of an extended ping from the source interface of R1 to the LAN interface of R3. An extended ping is when the source interface or source IP address is specified.



[Figure 6-23](#) Extended Ping

The following output displays the result of a traceroute from R1 to the R3 LAN:

```

R1# traceroute 192.168.2.1
Type escape sequence to abort.
Tracing the route to 192.168.2.1
VRF info: (vrf in name/id, vrf out name/id)
 1 172.16.2.2 4 msec 4 msec 8 msec
 2 192.168.1.1 12 msec 12 msec *
R1#
  
```

The following output displays the routing table of R1:

```

R1# show ip route | begin Gateway
Gateway of last resort is not set
 172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
S    172.16.1.0/24 [1/0] via 172.16.2.2
  
```

```
C      172.16.2.0/24 is directly connected, Serial0/0/0
L      172.16.2.1/32 is directly connected, Serial0/0/0
C      172.16.3.0/24 is directly connected, GigabitEthernet0/0
L      172.16.3.1/32 is directly connected, GigabitEthernet0/0
S      192.168.1.0/24 [1/0] via 172.16.2.2
S      192.168.2.0/24 [1/0] via 172.16.2.2
R1#
```

The following output provides a quick status of all interfaces on the router:

```
R1# show ip interface brief
Interface      IP-Address      OK? Method Status      Protocol
Embedded-Service-Engine0/0 unassigned      YES unset  administratively down down
GigabitEthernet0/0      172.16.3.1      YES manual up          up
GigabitEthernet0/1      unassigned      YES unset  administratively down down
Serial0/0/0      172.16.2.1      YES manual up          up
Serial0/0/1      unassigned      YES unset  administratively down down
R1#
```

The **show cdp neighbors** command in the following output provides a list of directly connected Cisco devices. This command validates Layer 2 (and therefore Layer 1) connectivity. For example, if a neighbor device is listed in the command output, but it cannot be pinged, then Layer 3 addressing should be investigated.

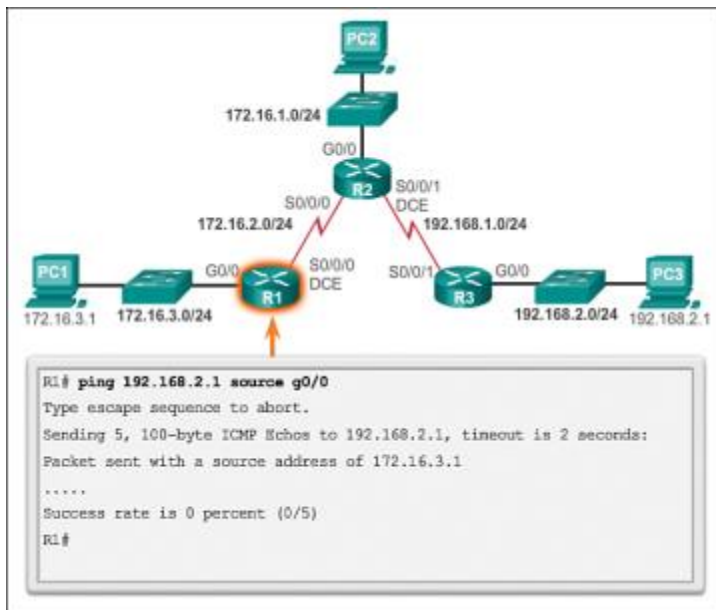
```
R1# show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone,
                  D - Remote, C - CVTA, M - Two-port Mac Relay

Device ID      Local Intrfce    Holdtme    Capability    Platform    Port ID
netlab-cs5      Gig 0/0          156        S I           WS-C2960-   Fas 0/1
R2              Ser 0/0/0        153        R S I         CISCO1941   Ser 0/0/0
R1#
```

## Solve a Connectivity Problem

Finding a missing (or misconfigured) route is a relatively straightforward process, if the right tools are used in a methodical manner.

For instance, in this example, the user at PC1 reports that he cannot access resources on the R3 LAN. This can be confirmed by pinging the LAN interface of R3 using the LAN interface of R1 as the source (see [Figure 6-24](#)). The results show that there is no connectivity between these LANs.



**Figure 6-24** Verify Connectivity to the R3 LAN

A traceroute in the following output reveals that R2 is not responding as expected. For some reason, R2 forwards the traceroute back to R1. R1 returns it to R2. This loop would continue until the time to live (TTL) value decrements to zero, in which case, the router would then send an Internet Control Message Protocol (ICMP) Destination Unreachable message to R1.

```

R1# traceroute 192.168.2.1
Type escape sequence to abort.
Tracing the route to 192.168.2.1
VRF info: (vrf in name/id, vrf out name/id)
 1 172.16.2.2 4 msec 4 msec 8 msec
 2 172.16.2.1 12 msec 12 msec 12 msec
 3 172.16.2.2 12 msec 8 msec 8 msec
 4 172.16.2.1 20 msec 16 msec 20 msec
 5 172.16.2.2 16 msec 16 msec 16 msec
 6 172.16.2.1 20 msec 20 msec 24 msec
 7 172.16.2.2 20 msec
R1#
  
```

The next step is to investigate the routing table of R2, because it is the router displaying a strange forwarding pattern. Using the **show ip route | begin Gateway** command, the routing table in the following output reveals that the 192.168.2.0/24 network is configured incorrectly. A static route to the 192.168.2.0/24 network has been configured using the next-hop address 172.16.2.1. Using the configured next-hop address, packets destined for the 192.168.2.0/24 network are sent back to R1. It is clear from the topology that the 192.168.2.0/24 network is connected to R3, not R1. Therefore, the static route to the 192.168.2.0/24 network on R2 must use next-hop 192.168.1.1, not 172.16.2.1.



```
R2# show ip route | begin Gateway
Gateway of last resort is not set
    172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
C       172.16.1.0/24 is directly connected, GigabitEthernet0/0
L       172.16.1.1/32 is directly connected, GigabitEthernet0/0
C       172.16.2.0/24 is directly connected, Serial0/0/0
L       172.16.2.2/32 is directly connected, Serial0/0/0
S       172.16.3.0/24 [1/0] via 172.16.2.1
    192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.1.0/24 is directly connected, Serial0/0/1
L       192.168.1.2/32 is directly connected, Serial0/0/1
S       192.168.2.0/24 [1/0] via 172.16.2.1
R2#
```

The following shows output from the running configuration that reveals the incorrect **ip route** statement. The incorrect route is removed and the correct route is then entered.

```
R2# show running-config | section ip route
ip route 172.16.3.0 255.255.255.0 172.16.2.1
ip route 192.168.2.0 255.255.255.0 172.16.2.1
R2#
R2# conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)# no ip route 192.168.2.0 255.255.255.0 172.16.2.1
R2(config)# ip route 192.168.2.0 255.255.255.0 192.168.1.1
R2(config)#
```

The following output verifies that R1 can now reach the LAN interface of R3. As a last step in confirmation, the user on PC1 should also test connectivity to the 192.168.2.0/24 LAN.

```
R1# ping 192.168.2.1 source g0/0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
Packet sent with a source address of 172.16.3.1
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
R1#
```

But in the case when the outgoing interface associated with that route goes into a down state, the static route is removed from the routing table.

## Reference:

- <http://www.ciscopress.com/articles/article.asp?p=2180209>