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Introduction

Routing is at the core of every data network, moving information across an internetwork from source to destination. Routers are the devices responsible for the transfer of packets from one network to the next.

Routers learn about remote networks either dynamically, using routing protocols, or manually, using static routes. In many cases, routers use a combination of both dynamic routing protocols and static routes. This chapter focuses on static routing.

Static routes are very common and do not require the same amount of processing and overhead as dynamic routing protocols.

In this chapter, sample topologies will be used to configure IPv4 and IPv6 static routes and to present troubleshooting techniques. In the process, several important IOS commands and the resulting output will be examined. An introduction to the routing table using both directly connected networks and static routes will be included.

This chapter will also contrast classful routing and the widely implemented classless routing methods. It will cover Classless Inter-Domain Routing (CIDR) and the variable-length subnet mask (VLSM) methods. CIDR and VLSM have helped conserve the IPv4 address space using subnetting and summarization techniques.

Which Way Should We Go?

A huge sporting event is about to take place in your city. To attend the event, you make concise plans to arrive at the sports arena on time to see the entire game.

There are two routes you can take to drive to the event:

- **Highway route:** It is easy to follow and fast driving speeds are allowed.
- **Alternative, direct route:** You found this route using a city map. Depending on conditions, such as the amount of traffic or congestion, this just may be the way to get to the arena on time!

With a partner, discuss these options. Choose a preferred route to arrive at the arena in time to see every second of the huge sporting event.

Compare your optional preferences to network traffic, which route would you choose to deliver data communications for your small- to medium-sized business? Would your network route be the fastest, easiest route or the alternative, direct route? Justify your choice.

Static Routing Implementation (2.1)

As previously stated, static routes are widely used in networks today. Static routes are used in networks of all sizes, and are used along with a dynamic routing protocol. For this reason, a good understanding of static routes is a requirement for implementing routing on a network.

Reach Remote Networks (2.1.1.1)

A router can learn about remote networks in one of two ways:

- **Manually:** Remote networks are manually entered into the route table using static routes.
- **Dynamically:** Remote routes are automatically learned using a dynamic routing protocol.

Figure 2-1 provides a sample scenario of static routing. Figure 2-2 provides a sample scenario of dynamic routing using EIGRP.

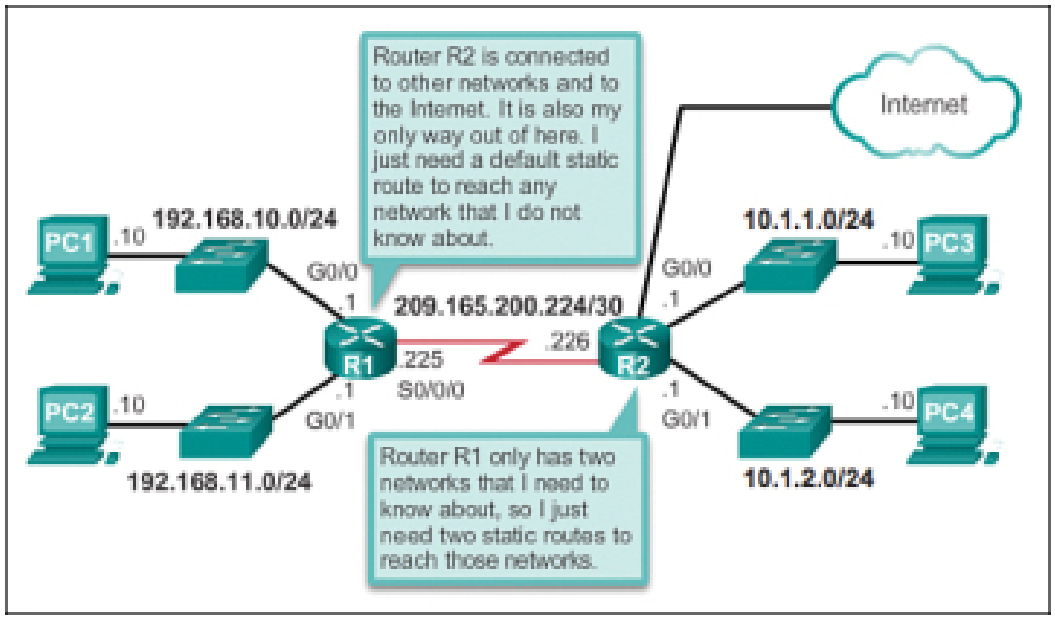

Figure 2-1 Static and Default Route Scenario

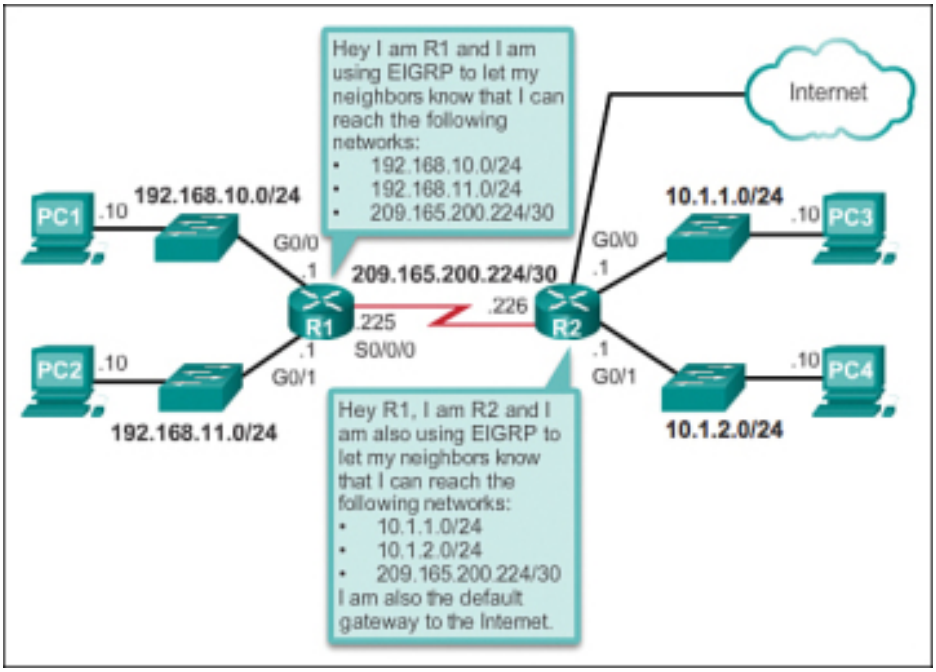

Figure 2-2 Dynamic Routing Scenario

A network administrator can manually configure a static route to reach a specific network. Unlike a dynamic routing protocol, static routes are not automatically updated and must be manually reconfigured any time the network topology changes. A static route does not change until the administrator manually reconfigures it.

Enhanced Interior Gateway Routing Protocol (EIGRP) is an interior gateway protocol suited for many different topologies and media. In a well designed network, EIGRP scales well and provides extremely quick convergence times with minimal network traffic.

Some of the many advantages of EIGRP are:

- very low usage of network resources during normal operation; only hello packets are transmitted on a stable network
- when a change occurs, only routing table changes are propagated, not the entire routing table; this reduces the load the routing protocol itself places on the network
- rapid convergence times for changes in the network topology (in some situations convergence can be almost instantaneous)

EIGRP is an enhanced distance vector protocol, relying on the Diffused Update Algorithm (DUAL) to calculate the shortest path to a destination within a network.

Why Use Static Routing? (2.1.1.2)

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.

In Table 2-1, dynamic and static routing features are compared. Notice that the advantages of one method are the disadvantages of the other.

Table 2-1 Dynamic Routing Versus Static Routing

	Dynamic Routing	**Static Routing**
Configuration Complexity	Generally independent of the network size	Increases with the network size
Topology Changes	Automatically adapts to topology changes	Administrator intervention required
Scaling	Suitable for simple and complex topologies	Suitable for simple topologies
Security	Less secure	More secure
Resource Usage	Uses CPU, memory, link bandwidth	No extra resources needed
Predictability	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 (2.1.1.3)

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 2-3 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.

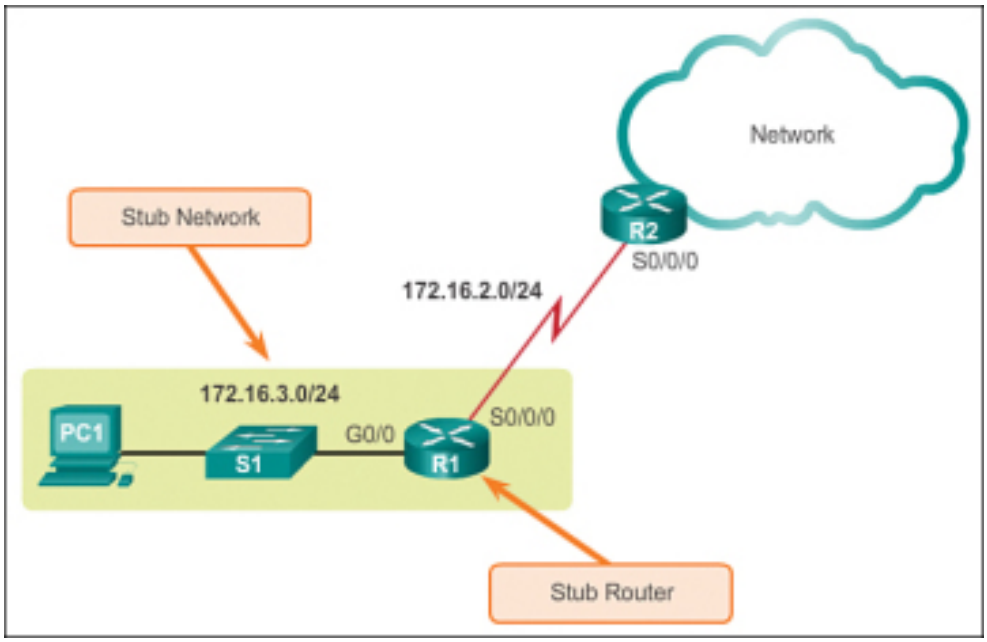

Figure 2-3 Stub Networks and Stub Routers

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 configured on R1 to point to R2 as the next hop for all other networks.

Static Route Applications (2.1.2.1)

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 (2.1.2.2)

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

Figure 2-4 shows that R2 can be configured with a static route to reach the stub network 172.16.3.0/24.

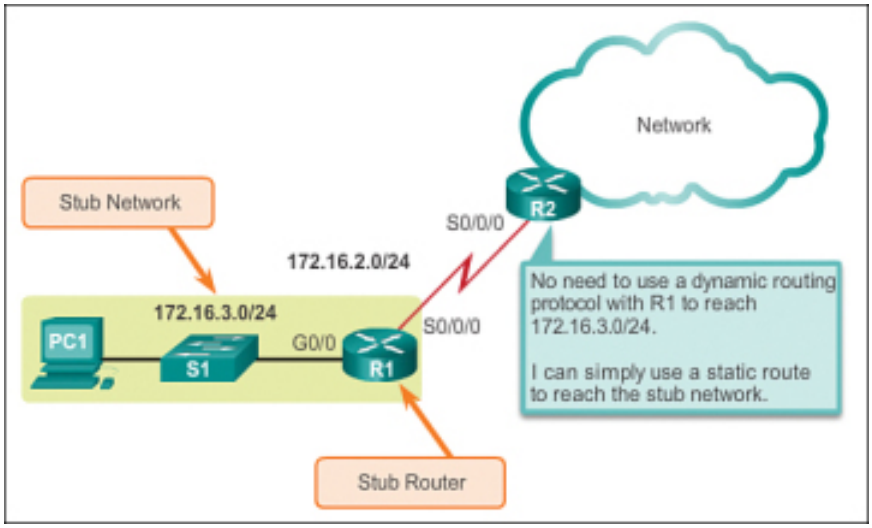

Figure 2-4 Connecting to a Stub Network

NOTE

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

Default Static Route (2.1.2.3)

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.

NOTE

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 2-5 for a sample scenario of implementing default static routing.

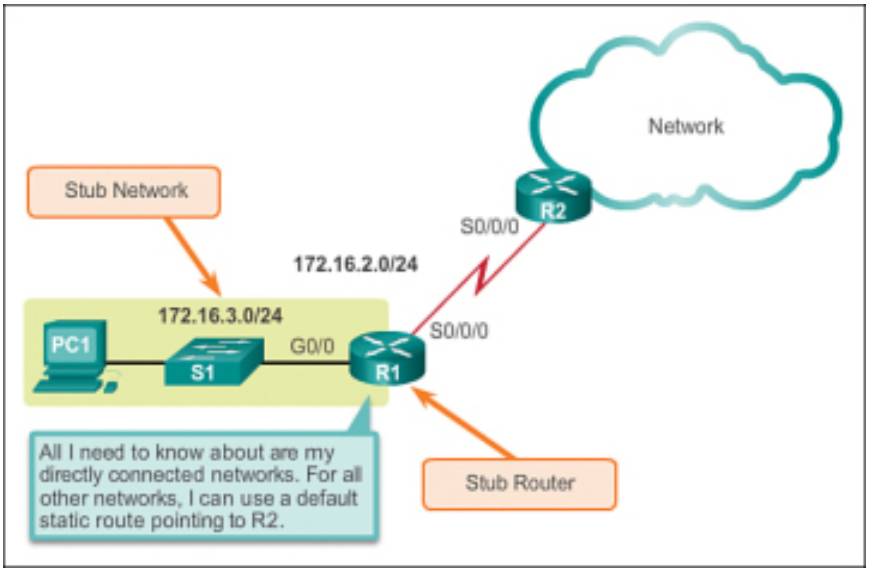

Figure 2-5 Connecting to a Stub Router

Summary Static Route (2.1.2.4)

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 2-6, 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.

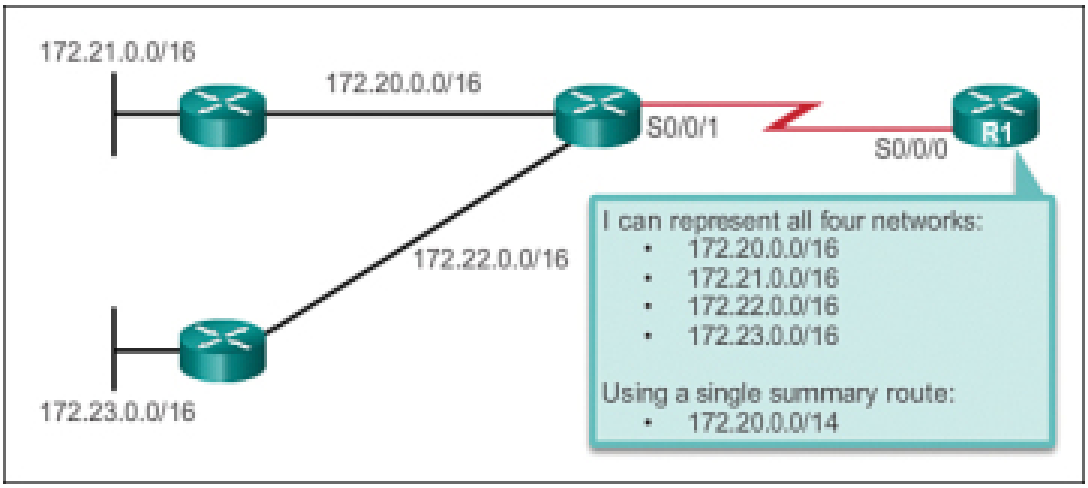

Figure 2-6 Using One Summary Static Route

Floating Static Route (2.1.2.5)

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 2-7, 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.

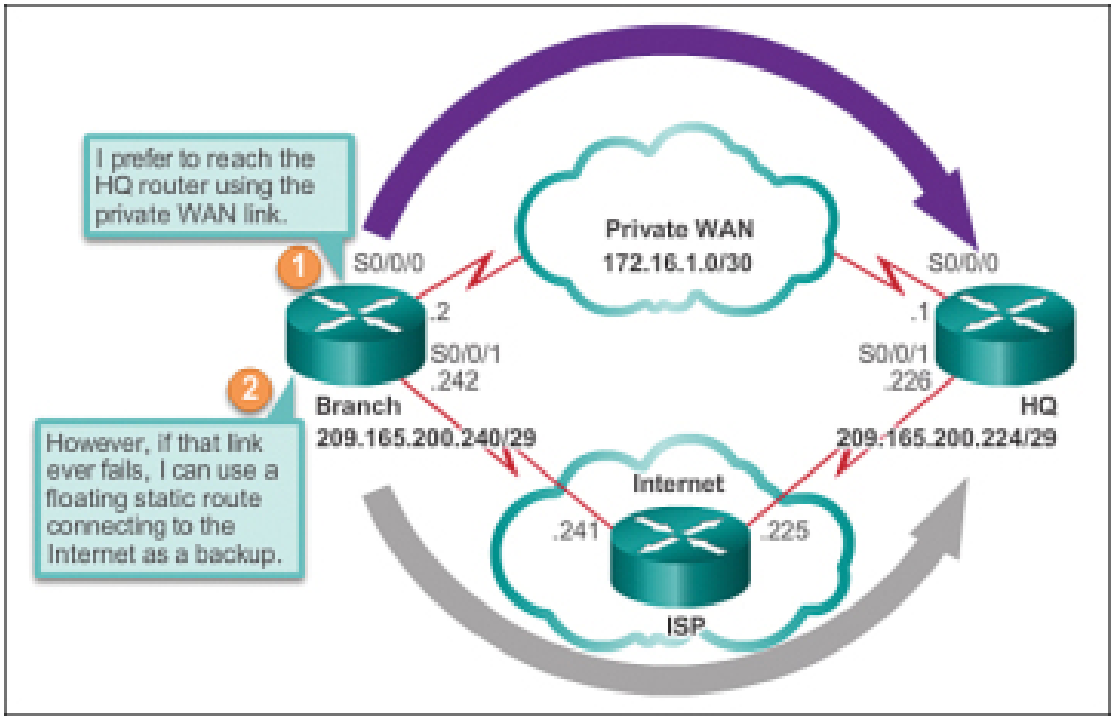

Figure 2-7 Configuring a Backup Route