19
Basic Routing

CERTIFICATION OBJECTIVES

19.01 Static Routes
19.02 Dynamic Routing Protocol Basics
19.03 RIP

✓ Two-Minute Drill
Q&A Self Test
In Chapter 15, you read about routing protocols, including the different types and their advantages and disadvantages. You performed a basic configuration of a router from the command-line interface (CLI) in Chapter 16 and Security Device Manager (SDM) in Chapter 18. This chapter covers the basic configuration of static routes and distance vector protocols, specifically the IP Routing Information Protocol (RIP). The section on RIP focuses on the basics of this protocol; advanced configuration of RIP is beyond the scope of this book. However, by the end of the chapter, you'll be able to configure routers using static routes or a running RIP that will route traffic in a network between the router's interfaces.

CERTIFICATION OBJECTIVE 19.01

Static Routes

A static route is a manually configured route on your router. Static routes are typically used in smaller networks and when few networks or subnets exist, or with WAN links that have little available bandwidth. With a network that has hundreds of routes, static routes are not scalable, since you would have to configure each route and any redundant paths for that route on each router. This section covers the configuration of static routes and some of the issues associated with them.

Dynamic routing protocols are preferred over static routes when many networks or subnets exist in a network, since the configuration of static routes would be prone to misconfiguration given the number of destinations. Static routes are typically used in small networks with few segments and little bandwidth, such as WAN links.
Static Route Configuration

To configure a static route for IP, use one of these two commands:

```
Router(config)# ip route destination_network_# [subnet_mask]
  IP_address_of_next_hop_neighbor
  [administrative_distance] [permanent]
```

or

```
Router(config)# ip route destination_network_# [subnet_mask]
  interface_to_exit
  [administrative_distance] [permanent]
```

The first parameter that you must specify is the destination network number. If you omit the subnet mask for the network number, it defaults to the Class A (255.0.0.0), B (255.255.0.0), or C (255.255.255.0) default subnet mask, depending on the network number of the destination.

After the subnet mask parameter, you can specify how to reach the destination network in one of two ways: you can tell the router the next hop neighbor's IP address or the interface the router should exit to reach the destination network. You should use the former method if the link is a multi-access link (the link has more than two devices on it—three routers, for instance). You can use the latter method if it is a point-to-point link. In this instance, you must specify the name of the interface on the router, like so: `serial0`.

Optionally, you can change the administrative distance of a static route. If you omit this value, it will have one of two defaults, depending on the configuration of the previous parameter. If you specified the next hop neighbor’s IP address, then the administrative distance defaults to 1. If you specified the interface on the router it should use to reach the destination, the router treats the route as a connected route and assigns an administrative distance of 0 to it.

Note that you can create multiple static routes to the same destination. For instance, you might have primary and backup paths to the destination. For the primary path, use the default administrative distance value. For the backup path, use a number higher than this, such as 2. Once you have configured a backup path, the router will use the primary path, and if the interface on the router fails for the primary path, the router will use the backup route.

The `permanent` parameter will keep the static route in the routing table even when the interface the router uses for the static route fails. If you omit this parameter, and the interface used by the static route fails, the router will remove this route from its routing table and attempt to find an alternative path to place in the routing table.
You might want to use the `permanent` parameter if you never want packets to use another path to a destination, perhaps because of security reasons.

**Default Route Configuration**

A default route is a special type of static route. Where a static route specifies a path a router should use to reach a specific destination, a default route specifies a path the router should use if it doesn’t know how to reach the destination. Note that if a router does not have any path in its routing table telling it how to reach a destination, and the router receives a packet destined for this network, the router will drop the packet. This is different from a switch, which will flood unknown destinations. Therefore, a default route can serve as a catch-all: if no path to the destination is specified, the router will use the default route to reach it.

To set up a default route, use the following syntax for a static route:

```
Router(config)# ip route 0.0.0.0 0.0.0.0
   IP_address_of_next_hop_neighbor [administrative_distance] [permanent]
```

or

```
Router(config)# ip route 0.0.0.0 0.0.0.0
   interface_to_exit [administrative_distance] [permanent]
```

The network number of 0.0.0.0/0 at first appears a bit strange. Recall from Chapter 7, however, that network 0.0.0.0 represents all networks, and a mask of all 0s in the bit position represents all hosts in the specified network.
Default Routes and Distance Vector Protocols

A default route sometimes causes problems for certain routing protocols. A routing protocol can fall under two additional categories: classful and classless. Examples of classful protocols include RIPv1 and IGRP (no longer supported by Cisco). Examples of classless protocols include RIPv2, Open Shortest Path First (OSPF), Enhanced Interior Gateway Routing Protocol (EIGRP), Intermediate System-Intermediate System (IS-IS), and Border Gateway Protocol (BGP).

A classful routing protocol understands only class subnets. For instance, if you have 192.168.1.0/23 in a routing update, a classful routing protocol wouldn’t understand it, since a Class C network requires 24 bits of network numbers. This can create problems with a default route, which has a /0 mask.

Also, when a classful router advertises a route out its interface, it does not include the subnet mask. For example, you might have 192.168.1.1/26 configured on your router’s interface, and the router receives a routing updated with 192.168.1.0. With a classful routing protocol, the router will comprehend subnet masks only for network numbers configured on its interfaces. In this example, the router assumes that for 192.168.1.0, the only valid mask is /26. Therefore, if the routers sees the 192.168.1.0/26 as the network number, but the network is really 192.168.1.0/27, a lot of routing confusion results.

Classless protocols, on the other hand, do not have any issues accepting routing updates with any bit value for a subnet mask. However, for classful protocols, you must configure the following command to accept nonconforming subnet masks, such as a default route:

```
Router(config) # ip classless
```

This command is also used to deal with discontiguous subnets in a network that is using a classful protocol: subnets separated by a different class network. For example, assume that you have networks 172.16.1.0/24, 172.16.2.0/24, and 172.16.3.0/24. However, a different class network, 192.168.1.0/24, sits between the first two Class B subnets and 172.16.3.0/24. In this situation, the router connected to 172.16.1.0/24 and 172.16.2.0/24, when it receives 172.16.0.0 from the side of the network connected to the discontiguous subnet, will ignore this routing entry.

Remember that when routes cross a class boundary in a classful protocol, the network number is sent as its classful number. Therefore, the router connected to 192.168.1.0/24 and 172.16.3.0/24, when it advertises updates across the 192.168.1.0/24 subnet, will advertise 172.16.0.0—not the actual subnet number.
Since the router connected to 172.16.1.0/24 and 172.16.2.0/24 ignores the 172.16.0.0 routing information, it will not be able to reach 172.16.3.0. On top of this problem, even if you have a default route configured, since the router is connected to the 172.16.0.0 subnets, it assumes that 172.16.3.0 must also be connected; and if it isn’t in the routing table, then the route cannot be reached. This topic was discussed in Chapter 8.

By using the \texttt{ip classless} command, you are overriding this behavior; you’re allowing your classful router to use a default route to reach discontiguous subnets. Not that this is a recommended design practice, but it does allow you to solve reachability problems for discontiguous subnets.

\textbf{Static Route Verification and Troubleshooting}

To verify the configuration of static and default routes on your router, use the \texttt{show ip route} command:

\begin{verbatim}
Router# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP,
      M - mobile, B - BGP, D - EIGRP, EX - EIGRP external,
      O - OSPF, IA - OSPF inter area, N1 - OSPF NSSA external type 1,
      N2 - OSPF NSSA external type 2, E1 - OSPF external type 1, E2 - OSPF external type 2,
      E - EGP, i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
      * - candidate default, U - per-user static route, o - ODR,
      T - traffic engineered route
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

172.16.0.0/24 is subnetted, 3 subnets
C 172.16.1.0 is directly connected, Ethernet0
C 172.16.2.0 is directly connected, Serial0
S 172.16.3.0 is directly connected, Serial1
*S 0.0.0.0/0 is directly connected, Serial1
\end{verbatim}
This command displays the IP routing table on your router and can contain directly connected subnets, static and default routes, and dynamically learned routes from a routing protocol. The top portion of the display for this command has a table of codes. These codes, which describe a type of route that may appear in the routing table, are shown in the first column at the bottom part of the display. In this example, there are two connected routes (C) and two static routes (S). The first static route is treated as a directly connected route, since it was created by specifying the interface to exit the router. The second static route is a default route—the asterisk (*) indicates the gateway of last resort: the path the router should use if no other specific path is available.

19.01. The CD contains a multimedia demonstration of setting up static routes on a router.

Be familiar with the output of the show ip route command and be able to determine, based on a router’s configuration, what routes should appear in a router’s routing table.

EXERCISE 19-1

Static Route Configuration

These last few sections have dealt with static routes and their configuration. This exercise will help you reinforce this material for the configuration of static routes. You’ll perform this lab using Boson’s NetSim simulator. In this exercise, you’ll set static routes on the two routers (2600-1 and 2600-2). You can find a picture of the network diagram for Boson’s NetSim simulator in the Introduction of this book. After starting up the simulator, click the LabNavigator button. Next, double-click Exercise 19-1 and then click the Load Lab button. This will load the lab configuration based on the exercises in Chapters 11 and 16.

1. Access the 2600-1 router. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1.
2. On the 2600-1, verify that the fa0/0 and s0 interfaces are up. If not, bring them up. Examine the IP addresses configured on the 2600-1.
Use the `show interfaces` command to verify your configuration. If `fa0/0` and `s0` are not up, go into the interfaces (`fa0/0` and `s0`) and enable them using the `no shutdown` command. Use the `show interfaces` command to verify that the IP addresses you configured in Chapter 16 are still there.

3. Examine the routing table on the 2600-1.
   Use the `show ip route` command. You should have two connected networks: 192.168.1.0 connected to `fa0/0` and 192.168.2.0 connected to `s0`.

4. Access the 2600-2 router. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2.

5. On the 2600-2, verify that the `fa0/0` and `s0` interfaces are up. If not, bring them up. Examine the IP addresses configured on the 2600-2 and look at its routing table.
   On the 2600-2, use the `show interfaces` command to verify your configuration. If `fa0/0` and `s0` are not up, go into the interfaces (`fa0/0` and `s0`) and enable them using the `no shutdown` command. Use the `show interfaces` command to verify that the IP addresses you configured in Chapter 16 are still there.

6. Examine the routing table on the 2600-2 router.
   Use the `show ip route` command. You should have two connected networks: 192.168.3.0 connected to `fa0/0` and 192.168.2.0 connected to `s0`.

7. Test connectivity between Host-1 and the 2600-1.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. From Host-1, ping the 2600-1: `ping 192.168.1.1`. The ping should be successful. If it is not, you may have used the configuration from the VLAN lab in Chapter 13 and may have a VLAN configuration problem.

8. Test connectivity between Host-3 and the 2600-2.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-3. From Host-3, ping the 2600-2 router: `ping 192.168.3.1`. The ping should be successful.

9. Test connectivity between Host-3 and Host-1.
   From Host-3, ping Host-1: `ping 192.168.1.10`. The ping should fail: there is no route from the 2600-2 to this destination.

10. Look at the 2600-2's routing table: `show ip route`. It doesn't list 192.168.1.0/24.
11. On the 2600-2, configure a static route to 192.168.1.0/24, which is connected to the 2600-1.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. Configure a static route to reach 192.168.1.0/24 via the 2600-1 router.
   Configure the static route: configure terminal, ip route 192.168.1.0 255.255.255.0 192.168.2.1, and end.

12. View the routing table on the 2600-2 router.
   View the connected and static routes: show ip route. Make sure that 192.168.1.0/24 shows up in the routing table as a static route (S).

13. On the 2600-1, configure a static route to 192.168.3.0/24, which is connected to the 2600-2.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. Configure the static route: configure terminal, ip route 192.168.3.0 255.255.255.0 192.168.2.2, and end.

14. View the routing table on the 2600-1.
   View the connected and static routes: show ip route. Make sure that 192.168.3.0/24 shows up in the routing table as a static route (S).

15. From Host-3, ping the fa0/0 interface of the 2600-1.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-3. Access Host-3 and ping the fa0/0 interface of the 2600-1 router: ping 192.168.1.1. The ping should be successful.

16. From Host-3, ping Host-1.
   Ping Host-1: ping 192.168.1.10. The ping should be successful.

Now you should be more comfortable with configuring static routes.

EXERCISE 19-2

Basic IP and Routing Troubleshooting

This chapter has covered the basics of routers and routing. This exercise is a troubleshooting exercise and is different from the other exercises you have performed so far. In previous exercises, you were given a configuration task.
In this exercise, the network is already configured; however, three problems exist in this network and you’ll need to find and fix them to make it operate correctly. All of these problems deal with IP (layer 3) connectivity.

You’ll perform this exercise using Boson’s NetSim simulator. You can find a picture of the network diagram for Boson’s NetSim simulator in the Introduction of this book. The addressing scheme is the same. After starting up the simulator, click the LabNavigator button. Next, double-click Exercise 19-2 and click the Load Lab button. This will load the lab configuration based on the exercises in Chapters 11 and 16 and static routing, with problems, of course.

Let’s start with your problem: Host-1 cannot ping Host-3. Your task is to find the three problems causing this problem and fix them. You should try this troubleshooting process on your own first; if you have problems, come back to the steps and solutions provided here.

1. Use ping to test connectivity from Host-1 to Host-3.
   
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. On Host-1, ping Host-3: **ping 192.168.3.10**. Note that the ping fails.

2. Examine the IP configuration on Host-1.
   
   Execute **ipconfig /all**. Make sure the IP addressing information is correct: IP address of 192.168.1.10, subnet mask of 255.255.255.0, and default gateway address of 192.168.1.1.

3. Test connectivity from Host-1 to its default gateway by using ping.
   
   Ping the default gateway address: **ping 192.168.1.1**. The ping should be successful, indicating that at least layer 3 is functioning between Host-1 and the 2600-1.

4. Verify Host-3’s IP configuration.
   
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-3. Examine the IP configuration on Host-3 by executing **ipconfig /all**. Make sure the IP addressing information is correct: IP address of 192.168.3.10, subnet mask of 255.255.255.0, and default gateway address of 192.168.3.1.

5. Test connectivity from Host-3 to its default gateway by using ping.
   
   Ping the default gateway address: **ping 192.168.3.1**. The ping should fail, indicating that there is a problem between Host-3 and the 2600-2. In this example, assume layer 2 is functioning correctly; therefore, it must be a problem with the 2600-2.
6. Check the 2600-2's IP configuration.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. From the 2600-2, ping Host-3: `ping 192.168.3.10`. The ping should fail. Examine the interface on the 2600-2: `show interface fa0/0`. The interface is disabled, but it has the correct IP address: 192.168.3.1. Enable the interface: `configure terminal`, `interface fa0/0`, `no shutdown`, and `end`. The interface should come up. Retry the ping test: `ping 192.168.3.10`. The ping should be successful.

7. Access Host-1 and retry pinging Host-3.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. Test connectivity to Host-3: `ping 192.168.3.10`. The ping should still fail. So far, there is connectivity within 192.168.1.0 and 192.168.3.0, but there is still a problem between these two networks.

8. Check the interface statuses on the 2600-1 and verify connectivity to the 2600-2.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. Check the status of the interfaces: `show ip interface brief`. Notice that the `fa0/0` and `s0` are both up. Try pinging the 2600-2's `s0` interface: `ping 192.168.2.2`. The ping fails. Examine CDP information that the 2600-1 has learned about the 2600-2: `show cdp entry 2600-2`. Notice that the 2600-2 has no IP address.

9. Fix the IP addressing problem on the 2600-2 and retest connectivity across the serial connection.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. Fix the IP address: `configure terminal`, `interface s0`, `ip address 192.168.2.2 255.255.255.0`, and `end`. Retest the connection to the 2600-1: `ping 192.168.2.1`. The ping should be successful.

10. Examine the routing table on the 2600-2 and verify that 192.168.1.0/24 shows up as a static route.
    Examine the routing table: `show ip route`. As you can see, 192.168.1.0 shows up as a static route and points to 192.168.2.1.

11. Access Host-3 and try connectivity between its default gateway and the 2600-1 router.
    At the top of the simulator in the menu bar, click the eStations icon and choose Host-3. Test the connection to the 2600-2: `ping 192.168.3.1`. The ping should be successful, considering you already tested it. Test connectivity to the 2600-1: `ping 192.168.2.1`. The ping should fail.
This presents an interesting problem. Host-1 can ping the 2600-1. The 2600-1 can ping the 2600-2. Host-3 can ping the 2600-2. Therefore, on a hop-by-hop basis, you have IP connectivity. And the 2600-2 can even ping Host-1, indicating that some routing functioning is working.

12. Access the 2600-1 router and examine its routing table. Fix the problem. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. Examine the routing table: `show ip route`. Does the 2600-1 know how to reach 192.168.3.0/24? It does not. The 2600-2 router could ping Host-1 since the 2600-1 router is directly connected to these segments, but any traffic from the 2600-1 to 192.168.3.0/24 will fail since the router doesn’t have a path. Add a static route to 192.168.3.0/24: `configure terminal, ip route 192.168.3.0 255.255.255.0 192.168.2.2`, and `end`. Test connectivity to Host-3: `ping 192.168.3.10`. The ping should be successful.

13. Now test connectivity between Host-1 and Host-3. At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. Test connectivity to Host-3: `ping 192.168.3.10`. The ping should be successful.

You should now feel comfortable troubleshooting routers that are using static routes for routing.

**CERTIFICATION OBJECTIVE 19.02**

**Dynamic Routing Protocol Basics**

Before learning about how to configure a dynamic routing protocol such as RIP, consider some basic configuration tasks that are required no matter what dynamic
routing protocol you are running. You need to perform two basic steps when setting up IP routing on your router:

■ Enable the routing protocol.
■ Assign IP addresses to your router’s interfaces.

Note that the order of these tasks is not important. You already know how to configure an IP address on the router’s interface: this was discussed in Chapter 16. The following sections cover the first bullet point in more depth.

The router Command

Enabling an IP routing protocol is a two-step process. First, you must go into Router Subconfiguration mode. This mode determines the routing protocol that you’ll be running. Within this mode, you’ll configure the characteristics of the routing protocol. To enter the routing protocol’s configuration mode, use the following command:

```
Router(config)# router name_of_the_IP_routing_protocol
Router(config-router)#
```

The `router` command is used to access the routing protocol that you want to configure; it doesn’t enable it. If you are not sure of the name of the routing protocol that you want to enable, use the context-sensitive help feature:

```
Router(config)# router ?
    bgp Border Gateway Protocol (BGP)
    eigrp Enhanced Interior Gateway Routing Protocol (EIGRP)
    isis ISO IS-IS
    iso-igrp IGRP for OSI networks
    mobile Mobile routes
    odr On Demand stub Routes
    ospf Open Shortest Path First (OSPF)
    rip Routing Information Protocol (RIP)
```

As you can see from the context-sensitive help output, you have a lot of IP routing protocols at your disposal.
One important item to point out is that the `router` command doesn't turn on the routing protocol. This process is done in the protocol's Router Subconfiguration mode, indicated by the `(config-router)` prompt.

The network Command

Once in the routing protocol, you need to specify what interfaces are to participate in the routing process. By default, no interfaces participate in the routing process. To specify which interfaces will participate, use the `network` Router Subconfiguration mode command:

```
Router(config-router)# network IP_network_#
```

As soon as you enter a network number, the routing process becomes active. For distance vector protocols such as RIP, you need to enter only the Class A, B, or C network number or numbers that are associated with your interface or interfaces. In other words, if you have subnetted 192.168.1.0 with a subnet mask of 255.255.255.192 (/26), and you have subnets 192.168.1.0/26, 192.168.1.64/26, 192.168.1.128/26, and 192.168.1.192/26, you don't need to enter each specific subnet. Instead, just enter `192.168.1.0`, and this will accommodate all interfaces that are associated with this Class C network. If you specify a subnet, the router will convert it to the class address, because RIP is a classful protocol.

Let's take a look at a simple example of the configuration, shown in Figure 19-1. This example focuses on the configuration of the `network` commands, assuming...
that the routing protocol is a classful protocol, such as RIP. In this example, the router is connected to a Class B network (172.16.0.0) and a Class C network (192.168.1.0), both of which are subnetted.

Assume that you forgot that you need to enter only the classful network numbers, and you entered the subnetted values instead, like this:

```
Router(config-router)# network 172.16.1.0
Router(config-router)# network 172.16.2.0
Router(config-router)# network 192.168.1.64
Router(config-router)# network 192.168.1.128
```

When entering your network statements, you need to include any network that is associated with your router's interfaces; if you omit a network, your router will not include the omitted interface in the routing process. As you can see from the preceding example, all the subnets were included. Remember, however, that the router requires only that you enter the class addresses. If you were to execute a `show running-config` command, you would not see the four networks just listed, but only the Class B and C network numbers. You shouldn't worry about this; it's just that you entered more commands than were necessary. In reality, you needed to enter only these two network commands:

```
Router(config-router)# network 172.16.0.0
Router(config-router)# network 192.168.1.0
```

Both ways of entering your statements are correct, but the latter is what the router will use if you type in all of the specific subnets.

19.02. The CD contains a multimedia demonstration of an introduction to basic IP routing protocol configuration.

**On the exam, you should enter the class networks instead of the subnets on the simulator questions that deal with classful routing protocols.**

**Remember that the simulator is just that—a simulator. It's not a full-functioning IOS router.**
CERTIFICATION OBJECTIVE 19.03

RIP

IP RIP comes in two different versions: 1 and 2. Version 1 is a distance vector protocol and is defined in RFC 1058. Version 2 is a hybrid protocol and is defined in RFCs 1721 and 1722. The CCNA exam now primarily focuses on version 2. However, you still need to know a few things about RIPv1, specifically its characteristics. This section covers the basics of configuring and troubleshooting your network using IP RIP.

RIP Operation

As you'll recall from Chapter 15, RIP is a distance vector protocol. RIP is an old protocol and therefore is very stable—in other words, Cisco doesn’t do that much development on the protocol, unlike other, more advanced protocols. Therefore, you can feel safe that when you upgrade your IOS to a newer version, RIP will function the same way it did in the previous release. This section includes brief overviews of both versions of RIP.

RIPv1

RIPv1 uses local broadcasts to share routing information. These updates are periodic in nature, occurring, by default, every 30 seconds, with a hold-down period of 180 seconds. Both versions of RIP use hop count as a metric, which is not always the best metric to use. For instance, if you had two paths to reach a network, where one was a two-hop Ethernet connection and the other was a one-hop 64 Kbps WAN connection, RIP would use the slower 64 Kbps connection because it has a lesser accumulated hop-count metric. You have to remember this little tidbit when looking at how RIP will populate your router’s routing table. To prevent packets from circling around a loop forever, both versions of RIP solve counting to infinity by placing a hop-count limit of 15 hops on packets. Any packet that reaches the sixteenth hop will be dropped.

And as mentioned in the last section, RIPv1 is a classful protocol. This is important for configuring RIP and subnetting your IP addressing scheme: you can use only one subnet mask value for a given Class A, B, or C network. For instance, if you have a Class B network such as 172.16.0.0, you can subnet it with only one mask. As an example, you couldn’t use 255.255.255.0 and 255.255.255.128 on 172.16.0.0—you can choose only one.
Another interesting feature is that RIP supports up to six equal-cost paths to a single destination, where all six paths can be placed in the routing table and the router can load-balance across them. The default is actually four paths, but this can be increased up to a maximum of six. Remember that an equal-cost path is where the metric for the multiple paths to a destination is the same. RIP will not load-balance across unequal-cost paths.

Figure 19-2 illustrates equal-cost-path load balancing. In this example, RouterA has two equal-cost paths to 10.0.0.0 (with a hop count of 1) via RouterB and RouterC. Putting both of these paths in RouterA’s routing table offers two advantages:

- The router can perform load balancing to 10.0.0.0, taking advantage of the bandwidth on both of these links.
- Convergence is sped up if one of the paths fails. For example, if the connection between RouterA and RouterB fails, RouterA can still access network 10.0.0.0 via RouterC and has this information in its routing table; therefore, convergence is instantaneous.

For these two reasons, many routing protocols support parallel paths to a single destination. Some protocols, such as EIGRP, even support unequal-cost load balancing, which is discussed in Chapter 21.
RIPv2

One thing you should keep in the back of your mind when dealing with RIPv2 is that it is based on RIPv1 and is, at heart, a distance vector protocol with routing enhancements built into it. Therefore, it is commonly called a hybrid protocol. You read about some of the characteristics that both versions of RIP have in common in the preceding section. This section focuses on the characteristics unique to RIPv2.

One major enhancement to RIPv2 pertains to how it deals with routing updates. Instead of using broadcasts, RIPv2 uses multicasts: updates are advertised to 224.0.0.9, which all RIPv2 routers will process. And to speed up convergence, RIPv2 supports triggered updates—when a change occurs, a RIPv2 router will immediately propagate its routing information to its connected neighbors.

A second major enhancement in RIPv2 is that it is a classless protocol. RIPv2 supports variable-length subnet masking (VLSM), which allows you to use more than one subnet mask for a given class network number. VLSM allows you to maximize the efficiency of your addressing design as well as summarize routing information to create very large, scalable networks. VLSM is discussed in Chapter 8.

As a third enhancement, RIPv2 supports authentication. You can restrict what routers you want to participate in RIPv2. This is accomplished using a clear-text or hashed password value.

Cisco hash values aren’t the most secure security measures on the planet, and cracking any password assigned to a Cisco device is relatively easy (even MD5 with a password cracking program). You should still assign these kinds of passwords as an added level of security, but don’t rely on them totally: physical security is still paramount.
RIP Configuration

As you will see in this section, configuring RIP is an easy and straightforward process. The basic configuration of RIP involves the following two commands:

```
Router(config)# router rip
Router(config-router)# network IP_network_
```

As explained in the preceding section, RIPv1 is classful and RIPv2 is classless. However, whenever you configure either version of RIP, the `network` command assumes classful: You need to enter only the Class A, B, or C network number, not the subnets, as was discussed earlier in this chapter. If you refer back to Figure 19-1, the router's RIPv1 configuration would look like this:

```
Router(config)# router rip
Router(config-router)# network 172.16.0.0
Router(config-router)# network 192.168.1.0
```

19.03. The CD contains a multimedia demonstration of a basic RIP configuration on a router.

---

**Exam Watch**

Even with all of its advanced characteristics, RIPv2 is still, at heart, a distance vector protocol. It uses hop count as a metric, supports the same solutions to solve routing loop problems, has a 15-hop count limit, and shares other characteristics of RIPv1. RIPv2 is a hybrid protocol, based on RIPv1. It uses multicasts to disseminate routing information and supports triggered updates. Unlike RIPv1, RIPv2 supports VLSM (advertises subnet masks with associated network numbers), which allows you to summarize routing information, and authentication of routing updates. Otherwise, its characteristics are like those of RIPv1.

---

**Exam Watch**

Use the `router rip` and `network` commands to configure RIP routing. Remember to put the class address (not the subnetted network number) in the `network` statement.
Specifying RIP Version 1 and 2

By default, the IOS accepts both RIPv1 and RIPv2 routing updates; however, it generates only RIPv1 updates. You can configure your router to

- accept and send RIPv1 only
- accept and send RIPv2 only
- use a combination of the two, depending on your interface configuration

To accomplish either of the first two items in the list, you need to set the version in your RIP configuration:

Router(config)# router rip
Router(config-router)# version 1|2

When you specify the appropriate version number, your RIP routing process will send and receive only the version packet type that you configured.

You can also control which version of RIP is running on an interface-by-interface basis. For instance, suppose a bunch of new routers at your site support both versions and a remote office understands only RIPv1. In this situation, you can configure your routers to generate RIPv2 updates on all their LAN interfaces, but for the remote access connection at the corporate site, you could set the interface to run only RIPv1.

To control which version of RIP should handle generating updates on an interface, use the following configuration:

Router(config)# interface type [slot_#/]port_#
Router(config-router)# ip rip send version 1 | version 2 | version 1 2

With the ip rip send command, you can control which version of RIP the router should use on the specified interface when generating RIP updates. You can be specific by specifying version 1 or 2, or you can specify both.

To control what version of RIP should be used when receiving RIP updates on a particular interface, use the following configuration:

Router(config)# interface type [slot_#/]port_#
Router(config-router)# ip rip receive version 1 | version 2 | version 1 2

Unless you need to run RIPv1 because of backward compatibility with an older router or host running RIP, you should use version 2 because of some of its enhancements over version 1, such as classless routing, multicasts, and triggered updates.
19.04. The CD contains a multimedia demonstration of RIPv2 configuration on a router.

**Configuration Example**

Let’s use a simple network example, shown in Figure 19-3, to illustrate configuring RIPv2. Here’s RouterA’s configuration:

```
RouterA(config)# router rip
RouterA(config-router)# network 192.168.1.0
RouterA(config-router)# network 192.168.2.0
RouterA(config-router)# version 2
```

Here’s RouterB’s configuration:

```
RouterB(config)# router rip
RouterB(config-router)# network 192.168.2.0
RouterB(config-router)# network 192.168.3.0
RouterB(config-router)# version 2
```

As you can see, configuring RIPv2 is very easy.

A Cisco router running RIP, by default, generates only RIPv1 updates but processes received version 1 and 2 updates.
RIP Verification and Troubleshooting

Once you have configured IP RIP, a variety of commands are available to view and troubleshoot your RIP configuration and operation:

- clear ip route
- show ip protocols
- show ip route
- debug ip rip

The following sections cover these commands in more depth.

The clear ip route Command

The clear ip route * is a Privilege EXEC mode command. This command clears and rebuilds the IP routing table. Any time you make a change to a routing protocol, you should clear and rebuild the routing table with this command. You can replace the asterisk (*) with a specific network number; if you choose to do so, this will only clear the specified route from the routing table. Note that the clear command clears only routes learned from a routing protocol (dynamic routes); static and directly connected routes cannot be cleared from the routing table using the clear command. Static routes must be cleared manually using the no ip route command, and directly connected routes are persistent and cannot be removed from the routing table unless the interface they are associated with is not operational.

The show ip protocols Command

The show ip protocols command displays all the IP routing protocols, including RIP, which you have configured and are running on your router. Here’s an example of this command:

```
Router# show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 5 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 2, receive version 2

<table>
<thead>
<tr>
<th>Interface</th>
<th>Send</th>
<th>Recv</th>
<th>Triggered RIP Key-chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet0</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ethernet1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
```
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
  192.168.1.0
  192.168.2.0
Routing Information Sources:

<table>
<thead>
<tr>
<th>Gateway</th>
<th>Distance</th>
<th>Last Update</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.2.2</td>
<td>120</td>
<td>00:00:22</td>
</tr>
<tr>
<td>192.168.3.2</td>
<td>120</td>
<td>00:03:30</td>
</tr>
</tbody>
</table>

Distance: (default is 120)

In this example, RIPv2 is running on the router. The routing update interval is 30 seconds, with the next update being sent in 5 seconds. You can see that two interfaces are participating: Ethernet0 and Ethernet1. On these interfaces, RIPv2 is being used to generate and receive updates on these two interfaces. You can see the two networks specified with the network commands: 192.168.1.0 and 192.168.2.0. In this example, this router received an update 22 seconds ago from a neighboring router: 192.168.2.2. For the second gateway, 192.168.3.2, the router hasn’t seen an update from it in 210 seconds. Given that the flush timer is 240 seconds, if the local router doesn’t receive an update from 192.168.3.2 within 30 seconds, 192.168.3.2 and its associated routes are removed from the local router (flushed). And last, the default administrative distance of RIP is 120.

19.05. The CD contains a multimedia demonstration of the show ip protocols command for RIP on a router.

**Exam Watch**

RIP advertises routes every 30 seconds. Its hold-down period is 180 seconds, and its flush period is 240 seconds. Be familiar with the output of the show ip protocols command: the version of RIP and when routes are flushed.

**The show ip route Command**

Your router keeps a list of the best paths to destinations in a routing table. A separate routing table is kept for each routed protocol. For instance, if you are running IP and IPX, your router will have two routing tables: one for each. However, if you are running two routing protocols for a single routed protocol, such as IP RIP and EIGRP, your router will have only one routing table for IP, with both sets of routes, possibly, in the same table.
To view the routing table, use the `show ip route` command. Here’s an example of a RIPv2 router’s table:

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

Gateway of last resort is not set
172.16.0.0/24 is subnetted, 2 subnets
   C       172.16.1.0 is directly connected, Ethernet0
   R       172.16.2.0 [120/1] via 172.16.1.2, 00:00:21, Ethernet0
192.168.1.0/24 is subnetted, 2 subnets
   C       192.168.1.0 is directly connected, Serial0
   R       192.168.2.0/24 [120/2] via 192.168.1.2, 00:00:02, Serial2
```

In this example, you can see that two types of routes are in the routing table: `R` is for RIP and `C` is for a directly connected route. For the RIP entries, you can see two numbers in brackets: the administrative distance of the route and the metric. For instance, 172.16.2.0 has an administrative distance of 120 and a hop count of 1. Following this information is the neighboring RIP router that advertised the route (172.16.1.2), how long ago an update for this route was received from the neighbor (21 seconds), and on which interface this update was learned (Ethernet0).

**19.06. The CD contains a multimedia demonstration of the show ip route command for RIP on a router.**
The debug ip rip Command

Remember that the `show` commands show a static display of what the router knows, and they sometimes don’t display enough information concerning a specific issue or problem. For instance, you might be looking at your routing table with the `show ip route` command and expect a certain RIP route to appear from a connected neighbor, but this network is not shown. Unfortunately, the `show ip route` command won’t tell you why a route is or isn’t in the routing table. However, you can resort to `debug` commands to assist you in your troubleshooting.

For more detailed troubleshooting of IP RIP problems, you can use the `debug ip rip` command, shown here:

```
Router# debug ip rip
RIP protocol debugging is on
Router#
00:12:16: RIP: received v1 update from 192.168.1.2 on Serial0
00:12:16:      192.168.2.0 in 1 hops
00:12:25: RIP: sending v1 update to 255.255.255.255 via Ethernet0 (172.16.1.1)
00:12:26:      network 192.168.1.0, metric 0
00:12:26:      network 192.168.2.0, metric 1
```

This command displays the routing updates sent and received on the router’s interfaces. In this code example, the router received a V1 update from 192.168.1.2 on Serial0. This update contained one network, 192.168.2.0, indicating that this network is reachable from this and the advertising routers. After this update, you can see that your router generated a RIP update (local broadcast—255.255.255.255) on its Ethernet0 interface. This update contains two networks: 192.168.1.0 and 192.168.2.0. Also notice the metrics associated with these routes: 192.168.1.0 is connected to this router, while 192.168.2.0 is one hop away. When the neighboring router connected to Ethernet0 receives this update, it will increment the hop count by 1 for each route in the update.

```
Be familiar with the output of the `debug ip rip` command to troubleshoot problems with RIP, such as a mismatch in the RIP versions. Remember that `debug` commands can create performance problems on routers and should be used only for troubleshooting and then disabled.
```
If the two routers are running different RIP versions—v1 and v2—you’ll see output like the following on your router when running the preceding `debug` command:

```
00:12:25: RIP: sending v1 update to 255.255.255.255
     via Ethernet0 172.16.1.1)
00:12:26:      network 192.168.1.0, metric 0
00:12:26:      network 192.168.2.0, metric 1
00:12:32: RIP: ignored v2 packet from 192.168.2.1
     (illegal version)
```

When using `debug` commands, you must be at Privilege EXEC mode.
To disable a specific `debug` command, negate it with the `no` parameter. To turn off debugging for all `debug` commands, use either the `undebug all` or `no debug all` command.

**EXERCISE 19-3**

**Configuring RIP**

These last few sections dealt with configuring RIP on a router. This exercise will help you reinforce the material for setting up and troubleshooting RIP. You'll perform this lab using Boson's NetSim simulator. You can find a picture of the network diagram for Boson's NetSim simulator in the Introduction of this book. In this exercise, you set IP RIPv1 on the two routers (2600-1 and 2600-2). After starting up the simulator, click the LabNavigator button. Next, double-click Exercise 19-3 and click the Load Lab button. This will load the lab configuration based on the exercises in Chapters 11 and 16.

1. On the 2600-1, verify that the `fa0/0` and `s0` interfaces are up. If not, bring them up. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. On the 2600-1, use the `show interfaces` command to verify your configuration. If `fa0/0` and `s0` are not up, go into the interfaces (`fa0/0` and `s0`) and enable them: `configure terminal, interface type [slot_#/]port_#, no shutdown, and end.`
2. Examine the IP addresses configured on the 2600-1.
   Use the `show ip interface brief` command to verify that the IP addresses you configured in Chapter 16 are still there.

3. Examine the routing table on the 2600-1.
   Use the `show ip route` command. You should have two connected networks: 192.168.1.0 connected to `fa0/0` and 192.168.2.0 connected to `s0`.

4. On the 2600-2, verify that the `fa0/0` and `s0` interfaces are up. If not, bring them up.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. On the 2600-2, use the `show interfaces` command to verify your configuration. If `fa0/0` and `s0` are not up, go into the interfaces (`fa0/0` and `s0`) and enable them: `configure terminal`, `interface type port_#`, `no shutdown`, and `end`. Use the `show interfaces` command to verify your interface configuration.

5. Examine the IP addresses configured on the 2600-2.
   Use the `show ip interface brief` command to verify that the IP addresses you configured in Chapter 16 are still there.

6. Examine the routing table on the 2600-2.
   Use the `show ip route` command. You should have two connected networks: 192.168.3.0 connected to `fa0/0` and 192.168.2.0 connected to `s0`.

7. Test connectivity between Host-1 and the 2600-1.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. From Host-1, ping the 2600-1 router (the default gateway): `ping 192.168.1.1`. The ping should be successful.

8. Test connectivity between Host-3 and the 2600-2.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-3. From the Host-3, ping the 2600-2 router (the default gateway): `ping 192.168.3.1`. The ping should be successful.

9. Test connectivity between Host-3 and Host-1.
   From the Host-3, ping Host-1: `ping 192.168.1.10`. The ping should fail. Why? There is no route from the 2600-2 to this destination. (Look at the 2600-2's routing table: it doesn’t list 192.168.1.0/24.)
10. Access the 2600-2 and examine the routing table to see why the ping failed. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. Examine the routing table: `show ip route`. Notice that it doesn't list 192.168.1.0/24, which explains why Host-3 can't reach Host-1.

11. Enable RIPv1 on the 2600-1 router. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. On the 2600-1, execute the following: `configure terminal, router rip, network 192.168.1.0, network 192.168.2.0, and end.`

12. Enable RIPv1 on the 2600-2 router. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. On the 2600-2, execute the following: `configure terminal, router rip, network 192.168.2.0, network 192.168.3.0, and end`.

13. On the 2600-1, verify the operation of RIP. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. Use the `show ip protocols` command to make sure that RIP is configured—check for the neighboring router's IP address. Use the `show ip route` command and look for the remote LAN network number as a RIP (R) entry in the routing table. On the 2600-1, you should see 192.168.3.0, which was learned from the 2600-2.

14. On the 2600-2, verify the operation of RIP. At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. Use the `show ip protocols` command to make sure that RIP is configured—check for the neighboring router's IP address. Use the `show ip route` command and look for the remote LAN network number as a RIP (R) entry in the routing table. On the 2600-2, you should see 192.168.1.0, which was learned from the 2600-1.

15. On Host-1, test connectivity to Host-3. At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. On Host-1, test connectivity: `ping 192.168.3.10`. The ping should be successful.
EXERCISE 19-4

Basic RIP Troubleshooting

This exercise is a troubleshooting exercise and is similar to Exercise 19-3, in which you were given a configuration task to set up RIP. In this exercise, the network is already configured; however, three problems exist in this network and you’ll need to find and fix them in order for the network to operate correctly. All of these problems deal with IP (layer 3) connectivity. You’ll perform this exercise using Boson’s NetSim simulator. You can find a picture of the network diagram for Boson’s NetSim simulator in the Introduction of this book. The addressing scheme is the same as that configured in Chapter 16. After starting up the simulator, click the LabNavigator button. Next, double-click Exercise 19-4 and click the Load Lab button. This will load the lab configuration based on Chapter 16’s exercises (with problems, of course).

Let’s start with your problem: Host-1 cannot ping Host-3. Your task is to identify and fix the three problems. In this example, RIPv2 has been preconfigured on the routers. Try this troubleshooting process on your own first; if you have problems, come back to the steps and solutions provided here.

1. Use the ping tool to test connectivity from Host-1 to Host-3.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. On Host-1, ping Host-3: ping 192.168.3.10. Note that the ping fails.

2. Examine the IP configuration on Host-1.
   Execute ipconfig /all. Make sure the IP addressing information is correct: IP address of 192.168.1.10, subnet mask of 255.255.255.0, and default gateway address of 192.168.1.1.

3. Use the ping tool to test connectivity from Host-1 to its default gateway.
   Ping the default gateway address: ping 192.168.1.1. The ping should fail, indicating that at least layer 3 is not functioning between Host-1 and the 2600-1.

4. Check the 2600-1’s IP configuration.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. From the 2600-1, ping Host-1: ping 192.168.1.10.
The ping should fail. Examine the interface on the 2600-1: `show interface fa0/0`. The interface is enabled, but it has an incorrect IP address: 192.168.11.1. Fix the IP address: `configure terminal, interface fa0/0, ip address 192.168.1.1 255.255.255.0`, and `end`. Verify the IP address: `show interface fa0/0`.

5. Retest connectivity with ping.

Retry the ping test: `ping 192.168.1.10`. The ping should be successful. Save the configuration on the router: `copy running-config startup-config`.

6. Test connectivity from Host-1 to Host-3 with ping, as well as to the default gateway.

At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. On Host-1, ping Host-3: `ping 192.168.3.10`. Note that the ping still fails.

7. Examine Host-3’s IP configuration.

At the top of the simulator in the menu bar, click the eStations icon and choose Host-3. Examine the IP configuration on Host-3 by executing `ipconfig /all`. Make sure the IP addressing information is correct: IP address of 192.168.3.10, subnet mask of 255.255.255.0, and default gateway address of 192.168.3.1.

8. Test connectivity from Host-3 to its default gateway.

Ping the default gateway address: `ping 192.168.3.1`. The ping should fail, indicating that there is a problem between Host-3 and the 2600-2. In this example, assume layer 2 is functioning correctly; therefore, it must be a problem with the 2600-2.

9. Check the interface statuses and IP configuration on the 2600-2.

At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-2. Check the status of the interfaces: `show interfaces`. Notice that the `fa0/0` is disabled, but `s0` is enabled (up and up). Go into `fa0/0` and enable it: `configure terminal, interface fa0/0, no shutdown`, and `end`. Verify the status of the `fa0/0` interface: `show interface fa0/0`.

10. Verify connectivity from the 2600-2 to the 2600-1.

Try pinging Host-3: `ping 192.168.3.10`. The ping should succeed. Try pinging the 2600-1’s `s0` interface: `ping 192.168.2.1`. The ping succeeds.
11. Verify RIP’s configuration on the 2600-2.
   Examine the RIP configuration: `show ip protocol`. You should see RIP as the routing protocol and networks 192.168.2.0 and 192.168.3.0 included. From the output, it looks like RIP is configured correctly on the 2600-2. Save the configuration on the router: `copy running-config startup-config`.

12. Test connectivity from the 2600-2 to Host-1. Examine the routing table.
   Test the connection to Host-1: `ping 192.168.1.10`. The ping should fail. This indicates a layer 3 problem between the 2600-2 and Host-1.

13. View the routes in the 2600-2’s routing table.
   Examine the routing table: `show ip route`. Notice that there are only two connected routes (192.168.2.0/24 and 192.168.1.0/24), but no RIP routes.

14. Access the 2600-1 router and examine RIP’s configuration.
   At the top of the simulator in the menu bar, click the eRouters icon and choose 2600-1. Examine the routing table: `show ip protocol`. What networks are advertised by the 2600-1? You should see 192.168.1.0 and 192.168.11.0. Obviously, serial0’s interface isn’t included since 192.168.2.0 is not configured.

15. Fix the problem with the 2600-1’s RIP configuration.
   Fix this configuration problem: `configure terminal, router rip, no network 192.168.11.0, network 192.168.2.0, and end`. Examine the routing protocol configuration: `show ip protocol`.

16. Test connectivity to Host-3 using ping.
   Test connectivity to Host-3: `ping 192.168.3.10`. The ping should be successful. Save the configuration on the router: `copy running-config startup-config`.

17. Now test connectivity between Host-1 and Host-3.
   At the top of the simulator in the menu bar, click the eStations icon and choose Host-1. Test connectivity to Host-3: `ping 192.168.3.10`. The ping should be successful.

Now you should be more comfortable with configuring IP RIP on your IOS router.
You should be familiar with troubleshooting connectivity problems. Look for incorrect static routes, incorrect or missing network commands, running different routing protocols on connected routers, misconfigured addresses on interfaces (addresses in different subnets), no addresses on interfaces, disabled interfaces, different RIP versions on routers, and misconfigured VLANs on switches, for example.

**Static Routes**

Be familiar with when static routes are used versus a dynamic routing protocol. Understand the syntax of the `ip route` command and the default values, if omitted. Know how to configure a default route. Be able to find misconfigured static routes in a router's configuration. Know how to read the output of the `show ip route` command and to find the administrative distance and metric values of dynamic routing protocols in this output.

**Dynamic Routing Protocol Basics**

Remember the two things that need to happen to enable routing on a router: enabling the routing protocol by assigning networks to it and activating interfaces by enabling and assigning addresses to them. Don’t be surprised if you see a simulation question on the exam for which you have to configure or troubleshoot a dynamic routing protocol—RIPv2, OSPF, or EIGRP—on multiple routers.

**RIP**

Understand the differences between RIPv1 and RIPv2 and be able to compare and contrast these protocols. Be able to configure RIPv2 successfully on a router. Understand the output of the `show ip protocols` and `debug ip rip` commands to troubleshoot routing and connectivity problems. Understand the problems `debug` commands can create on a router and how to disable `debug`.

INSIDE THE EXAM
CERTIFICATION SUMMARY

Two types of routing protocols can be used to define or learn destination networks: static and dynamic. To create a static route, use the `ip route` command. For a default route, use 0.0.0.0/0 as the network number and subnet mask. To view your router's routing table, use the `show ip route` command.

When setting up IP routing, you must enable the routing protocol and configure IP routing on your router's interfaces. The `router` command takes you into the routing process, while the `network` command specifies what interfaces will participate in the routing process. Use the `ip address` command to assign IP addresses to your router's interfaces.

RIPv1 generates local broadcasts every 30 seconds to share routing information, with a hold-down period of 180 seconds. Hop count is used as the metric for choosing paths. RIP can load-balance across six equal-cost paths to a single destination. RIPv2 uses multicasts instead of broadcasts and also supports VLSM for hierarchical routing and route summarization. RIPv2, to speed up convergence, uses triggered updates. Use the `router rip` command to go into the routing process and the `network` command to specify your connected networks. When specifying your connected networks, specify only the Class A, B, or C network number (not subnet numbers), since RIPv1 is classful: even though RIPv2 is classless, configure it as a classful protocol. Use the `version` command to enable RIPv2. The `debug ip rip` command will display the actual routing contents that your router advertises in its updates or receives in neighbors' updates.

The `show ip protocols` command displays information about the IP routing protocols currently configured and running on your router. It shows metric information, administrative distances, neighboring routers, and routes that are being advertised. The `show ip route` command displays the IP routing information currently being used by your router. An R in the left-hand column indicates a RIP route.
Chapter 19: Basic Routing

TWO-MINUTE DRILL

Static Routes
- Use the `ip route` command to configure a static route.
- After the subnet mask parameter, you have two ways of specifying how to reach the destination network: you can tell the router either the next hop neighbor's IP address or the interface the router should exit to reach the destination network. The former has an administrative distance of 1 and the latter, 0 (a directly connected route).

Dynamic Routing Protocol Basics
- To set up IP on your router, you need to enable the routing protocol and assign IP addresses to your router's interfaces.
- Use the `router` and `network` commands to enable routing. With classful protocols, use the class address in the `network` command.

RIP
- RIP uses hop count as a metric and has a hop-count limit of 15. IP RIP supports up to six equal-cost paths to a single destination.
- RIPv1 sends out periodic routing updates as broadcasts every 30 seconds. The hold-down timer is 180 seconds. It is a classful protocol.
- RIPv2 uses triggered updates and sends its updates out as multicasts. It is a classless protocol and supports VLSM and route summarization. Optionally, RIPv2 updates can be authenticated.
- Use the `router rip` and `network` commands to set up RIP. Use the `version` command to hard code the version. Use the following commands for troubleshooting: `show ip protocols`, `show ip route`, and `debug ip rip`.
- After making a change to an IP routing protocol, use the `clear ip route *` command to clear the IP routing table and rebuild it.
SELF TEST

The following Self Test questions will help you measure your understanding of the material presented in this chapter. Read all the choices carefully, as there may be more than one correct answer. Choose all correct answers for each question.

Static Routes

1. Enter the command to set up a static route to 192.168.1.0/24, where the next hop address is 192.168.2.2: __________.

2. What subnet mask would you use to set up a default route?
   A. 0.0.0.0
   B. 255.255.255.255
   C. Depends on the type of network number
   D. None of these answers

3. What is the default administrative distance of a static route where the next hop specified is the IP address of a neighboring router?
   A. 0
   B. 1
   C. 90
   D. 120

Dynamic Routing Protocol Basics

4. You have a distance vector protocol such as RIP. You’ve entered the RIP process by executing: router rip. On one of your router’s interfaces, you have the following IP address: 192.168.1.65 255.255.255.192. Enter the command to include this interface in the RIP routing process: __________.

RIP

5. RIP generates routing updates every __________ seconds.
   A. 15
   B. 30
   C. 60
   D. 90
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6. RIP has a hold-down period of _________ seconds.
   A. 60
   B. 120
   C. 180
   D. 280

7. RIP has a maximum hop count of _________ hops.
   A. 10
   B. 15
   C. 16
   D. 100

8. RIP supports load balancing for up to _________ _________ paths.
   A. Six, unequal-cost
   B. Four, unequal-cost
   C. Four, equal-cost
   D. Six, equal-cost

9. Which of the following is true concerning RIPv2?
   A. It uses triggered updates.
   B. It uses broadcasts.
   C. It is classful.
   D. It doesn’t support route summarization.

10. Enter the router command used to view which routing protocols are active on your router, as well as their characteristics and configuration: _________.

SELF TEST ANSWERS

Static Routes
1.  ✓  ip route 192.168.1.0 255.255.255.0 192.168.2.2
2.  ✓  A. A default route is set up with an IP address and mask of 0.0.0.0 0.0.0.0.
   ✗  B is incorrect because this number indicates that the complete IP address is a network
   number, commonly called a host route. C is incorrect because the network number would use
   a standard subnet mask based on the network you’re trying to reach: 0.0.0.0 as a subnet mask
   indicates all hosts. And since there is a correct answer, D is incorrect.
3.  ✓  B. The default administrative distance of a static route pointing to a neighbor’s IP address is 1.
   ✗  A is incorrect because 0 is the value of a static route with an interface or a connected
   route. C is incorrect because 90 is EIGRP’s administrative distance and D, 120, is RIP’s
   administrative distance.

Dynamic Routing Protocol Basics
4.  ✓  network 192.168.1.0. Remember that RIPv1 is classful.

RIP
5.  ✓  B. RIP generates routing updates every 30 seconds.
   ✗  A, C, and D are invalid update intervals.
6.  ✓  C. RIP has a hold-down period of 180 seconds.
   ✗  A, B, and D are invalid hold-down periods.
7.  ✓  B. RIP has a maximum hop count of 15 hops.
   ✗  A, C, and D are invalid maximum hop-count values.
8.  ✓  D. RIP supports load-balancing for up to six equal-cost paths.
   ✗  A and B are invalid because RIP doesn’t support unequal-cost paths. C is incorrect because
   four is the default, but six is the maximum.
9.  ✓  A. RIPv2 supports triggered updates.
   ✗  B is incorrect because RIPv2 uses multicasts. C is incorrect because RIPv2 is classless. D is
   incorrect because RIPv2 supports VLSM and route summarization.
10.  ✓  To view the IP routing protocols running on your router, use show ip protocols.