Connecting Networks with Routers

Routers expand networks by allowing you to create multiple subnets or subnetworks. Routers are the traffic cops on a network that direct all the traffic from one subnetwork to another. At the very least, you need a router to access the Internet, and most networks in organizations include multiple routers.

Although the administration of routers is minimal in small networks, you should know some basics. For example, a router needs to know the path to all subnets in your network and the path to the Internet. Routers include a routing table that lists all of these paths, and the routing table can be updated manually or automatically. This chapter covers these topics and shows you how you can configure a Windows Server 2008 server as a software router.

- **Connecting multiple networks**
- **Routing traffic on a network**
- **Identifying transmission speeds**
- **Routing software in Windows Server 2008**
- **Understanding other routing protocols**

Connecting Multiple Networks

Chapter 8 covered switches and showed how switches connect multiple computers. In contrast, routers connect multiple networks so that computers on different networks can communicate with each other.

When talking about routers, you should understand some basic terms. These are explored throughout the chapter, but as introduction, they are defined here:

Hardware Router This is a dedicated hardware device that routes packets. For example, Cisco makes several different models of routers used on internal networks and the Internet.

Steps later in this chapter show how to configure Windows Server 2008 as a software router.

Software Router This is a server that includes software used to route packets. For example, you can configure Windows Server 2008 as a software router.

Routing Interface This is the interface where packets are received and transmitted. A router will have multiple interfaces but must have at least two.

Static Routing *Static routing* means that routes to different subnets in the network are manually (statically) added to the router. If there are any changes to the network affecting the routes, an administrator must manually modify the routes.

Dynamic Routing *Dynamic routing* means that routes to different subnets in the network are automatically (dynamically) updated on the router. Administrators need to configure routing protocols, but after that, the routers take care of keeping routes up to date themselves.

Routing Protocols These protocols allow routers to communicate with each other and share routing information. Two primary *routing protocols* used on internal networks are *Routing Information Protocol version 2 (RIPv2)* and *Open Shortest Path First (OSPF)*.

Routing Table This is a table maintained within a router that identifies all known subnetworks. The *routing table* also includes the path to these subnetworks.

Consider Figure 9.1. This shows a single router connecting four networks (labeled as A, B, C, and D). In this context, each of the networks is joined into a single local area network (LAN), and you can think of these joined networks as subnetworks in the overall LAN.

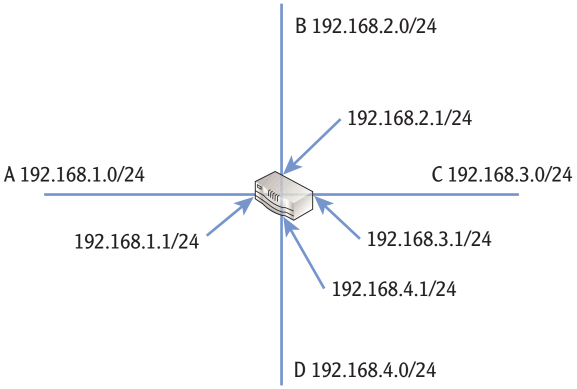

FIGURE 9.1 Using a router to connect networks

Each of the subnetworks has its own network ID that is different from the others. Additionally, the router has four separate interfaces with a single interface connected to each subnetwork.

Notice that the IP address assigned to the router interface in each of these subnetworks is the first IP address available. In other words, in the 192.168.1.0/24 subnetwork, the router interface is assigned the address of 192.168.1.1/24. It's common to assign the first address within a range to the router interface, but it is not required. No matter what address is assigned, though, it must have the same network ID as other devices in the subnetwork.

Figure 9.1 doesn't show network devices. However, each of these subnetworks would host computers, servers, or other network devices.

Comparing Hardware Routers and Software Routers

Routers can be dedicated hardware routers, or they can be software routers. Although most routers in production networks are hardware routers, it is possible to configure Windows Server 2008 as a software router.

Sections later in this chapter show how to configure a Windows Server 2008 server as a software router.

Windows Server 2008 includes all the software components to configure it as a software router. You don't need to purchase any additional software. The only item that is required is to have at least two network interface cards (NICs) installed. One NIC would connect to one network, and the other NIC would connect to another network. You then configure the server as a router, and it takes care of the rest.

Although it's much more common to use hardware routers, here are some examples of when you may want to use Windows Server 2008 as a software router:

Development Environment You can create a temporary subnetwork without purchasing additional hardware. For example, if you want to isolate some computers in a separate subnet for testing or development purposes, a software router is an inexpensive alternative.

Replacement of Failed Router If a hardware router fails, in smaller environments you may temporarily replace it with a software router until you purchase and receive a replacement.

Understanding Default Routes

A default route is the path that IP traffic takes when another path isn't identified. Most computers determine default routes based on their configured default gateway settings. Chapter 5 covered some basics of how TCP/IP determines whether traffic should go through a router. As a reminder, consider Figure 9.2 for the following scenarios.

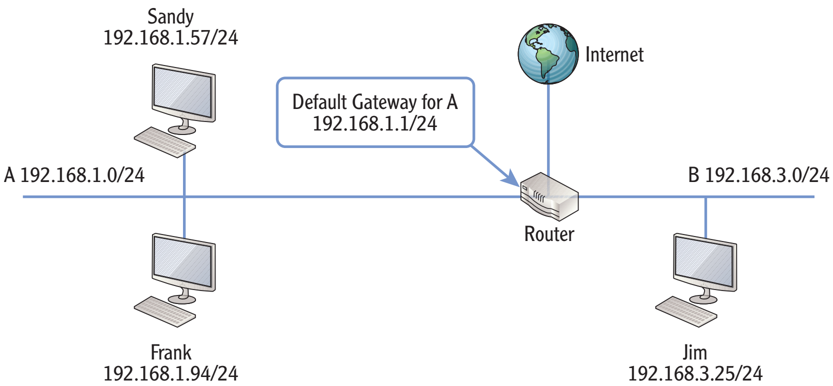

FIGURE 9.2 Moving traffic on a network

Imagine that Sandy wants to send data to Frank. TCP/IP will determine Sandy and Frank's network ID as shown in Table 9.1. Since the network IDs of both computers are the same (192.168.1.0), TCP/IP sends the traffic directly to Frank's computer.

TABLE 9.1 Determining the network ID of local computers

Computer	IP address	Subnet mask	Network ID
Sandy	192.168.1.57	255.255.255.0	192.168.1.0
Frank	192.168.1.94	255.255.255.0	192.168.1.0

Later, Sandy wants to send data to Jim. As you can see in Figure 9.2, Sandy and Jim's computers are on different subnetworks. TCP/IP determines this by calculating the network ID as shown in Table 9.2. Since the network IDs are different, TCP/IP realizes it must send the data to another network.

TABLE 9.2 Determining the network ID of remote computers

Computer	IP address	Subnet mask	Network ID
Sandy	192.168.1.57	255.255.255.0	192.168.1.0
Jim	192.168.3.25	255.255.255.0	192.168.3.0

More specifically, since the destination is on a different network, it must forward the data to the addresses of the default gateway. In Figure 9.2, the interface on router 2 with an IP address of 192.168.1.1 is the default gateway for subnetwork A. Notice that the default gateway has the same network ID as other computers on subnetwork A.

Some people call the router the default gateway. This is only partially correct. That's like calling an automobile a car door. Sure, an automobile does have a door, but the door is just one component. An automobile has much more to it. Similarly, the default gateway is one component of the router, and there is much more to the router.

Similarly, any traffic destined for the Internet goes through the default gateway.

The router in Figure 9.2 has three interfaces. The interface on subnetwork A is the default gateway for this network. The interface on subnetwork B is the default gateway for that network.

Identify the Default Gateway and Routers

You can use the command-line tool `ipconfig` to determine your default gateway. You can launch the command prompt in most Windows systems by clicking Start Run, typing **`cmd`** in the Run box, and pressing Enter.

At the command prompt, enter **`ipconfig`**. The output will include information similar to the following:

```
Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . :
   IPv4 Address. . . . . . . . . . . : 192.168.1.57
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.1.1
```

The default gateway identifies the IP address of the near side of the router. Note this doesn't show the IP addresses of all the router's interfaces. It shows only the IP address of the interface on the same subnetwork.

Understanding Directly Connected Routes

Any subnetwork that is directly connected to a router is a *directly connected route*. For example, each of the subnetworks in Figures 9.1 and 9.2 is directly connected to a single router. Since the router is directly connected to these subnetworks, it inherently knows the path to them.

However, routers don't automatically know the paths to other subnetworks within a LAN. If a LAN includes multiple routers with multiple subnetworks connected to these different routers, you need to teach these routers about the other subnetworks. This is done either statically or dynamically. The next section discusses both static routing and dynamic routing.

Routing Traffic on a Network

Figure 9.3 shows a larger network with three routers and six subnetworks. This network includes both directly connected routes for each of the routers and indirectly connected routes. Can you name the directly connected routes for each of the routers?

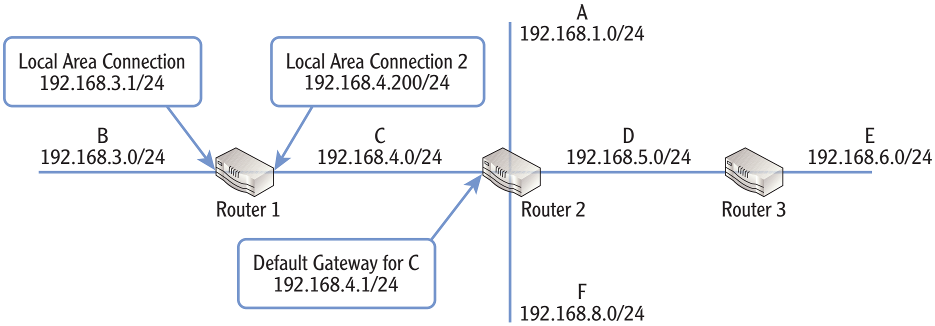

FIGURE 9.3 Multiple router network

- Router 1 knows about the directly connected subnetworks of B and C.
- Router 2 knows about the directly connected subnetworks of subnetworks A, C, D, and F.
- Router 3 knows about the directly connected subnetworks of subnetworks D and E.

For the network to be fully routed, each of the routers needs to know the paths to other networks. For example, if a computer in the F subnetwork needs to send data to a computer in the B subnetwork, router 2 needs to know how to get it there.

Creating Static Routes

When your network includes multiple routers, routers can be statically configured or dynamically configured. Administrators may manually add routes to a router to create statically configured routes. In a dynamically configured router, the administrator configures routing protocols, and these routing protocols automatically discover subnets on the network.

If you have only a few routes to add and you don't anticipate them changing, static routes can be the simplest method. It's also common to deploy some routers with some static routes, while others are configured dynamically.

Figure 9.4 shows the Routing and Remote Access (RRAS) console on a Windows Server 2008 server that has been configured as a router. In the figure, one static route to the 192.168.5.0 destination has been created. The dialog box in the foreground is adding a second static route to the 192.168.8.0 destination subnet. These routes support the network shown in Figure 9.3 earlier and are two of the routes that are needed on router 1.

Procedures at the end of this chapter show how to add RRAS to a Windows Server 2008 server and configure it as a software router.

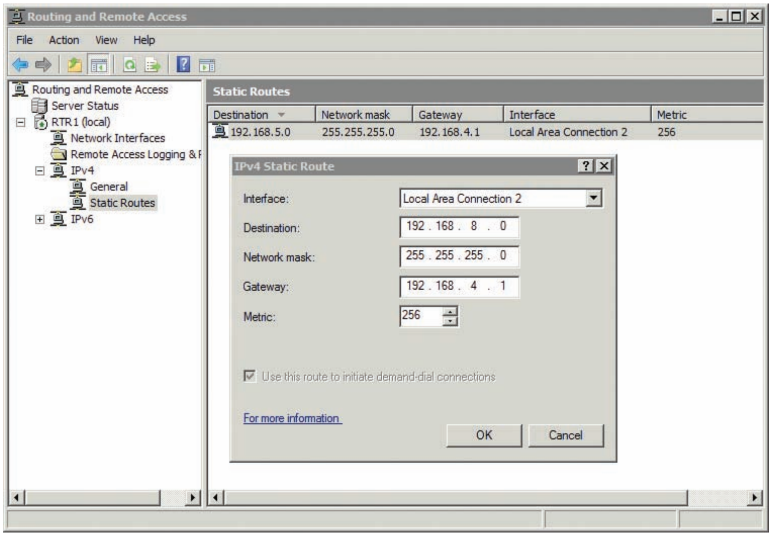

FIGURE 9.4 Configuring static routes

There are several key pieces of information in this figure worth pointing out:

Destination This identifies the destination subnetwork. The router doesn't name these by letters like you saw in Figure 9.3 but instead uses the network ID. If you look back at Figure 9.3, you can see these networks are identified by both a letter (such as A, D, E, and F) and a network ID.

Netmask This is the subnet mask of the network ID. Each of the subnetworks in Figure 9.3 has a CIDR notation of /24, indicating a subnet mask of 255.255.255.0.

Gateway This is the IP address of the destination router's network interface. Notice in Figure 9.3 that the path to other subnetworks from router 1 is through router 2 (except for the directly connected routes of B and C). The IP address of the router's NIC on subnetwork C is 192.168.4.1, so its IP address is entered here. It becomes the default gateway from router 1 and is also the default gateway for any computers on subnetwork C.

You can also enter routes to specific computers instead of to subnetworks. Routes to specific computers use a network mask of 255.255.255.255.

Interface This identifies the NIC that should be utilized to connect to the specified destination by name. In this example, the NIC named Local Area Connection is on subnetwork B. The NIC named Local Area Connection 2 is on subnetwork C.

Metric A metric represents a cost value to the route. If there are multiple paths to a network, the router calculates the least cost path to determine which path to take. In our example here, the metric doesn't matter since there is only one path to any of the networks.

In large networks with multiple routers and multiple paths, the metric is important. It helps routers identify the best routes to different subnetworks.

While the figure shows the creation of two static routes, many more static routes must be created to support the network shown in Figure 9.3 earlier. Can you identify all the static routes that need to be created on each router?

- Router 1 needs four static routes (to A, D, E, and F) since it knows only about the two directly connected routes of B and C.
- Router 2 needs two static routes (to B and E) since it knows only about the directly connected routes of A, C, D, and F.
- Router 3 needs four static routes (to A, B, C, and F) since it knows only about the directly connected routes of D and E.
- This network has 10 static routes.

Instead of typing these static routes in manually, you can choose to configure dynamic routing instead.

Configuring Dynamic Routing

You can enable dynamic routing protocols on routers to enable them to learn the paths to other routers dynamically. After you configure the protocols, the routers talk to each other. Each router lets other routers know what it knows, and after a short time, each router knows the paths to all subnetworks on the network.

Table 9.3 briefly compares static and dynamic routing. In short, static routing has very few features. Dynamic routing provides more benefits.

TABLE 9.3 Comparison of static and dynamic routing

Features	Static routing	Dynamic routing
Discovery of remote networks (including new or changed networks)	Must be done manually	Done automatically

(Continues)

TABLE 9.3 *(Continued)*

Features	Static routing	Dynamic routing
Information exchange with other routers	None	Information exchanged with routing protocol
Fault tolerance	None	Failure of routers can be detected and paths to networks modified (when multiple paths exist)

Since dynamic routing provides so many features over static routing, you may wonder why you'd ever use static routing. It depends in part on how many routers you have. If you have only two routers, it's much easier to configure the static routes once rather than adding and configuring a routing protocol.

A primary routing protocol used on Windows Server 2008 is Routing Information Protocol version 2 (RIPv2). RIPv2 is very easy to add and configure on a Windows Server 2008 server running RRAS. You simply add it, identify the NICs you want it to operate on, and you're done. The routers will automatically share their routing information with each other.

Many advanced routing protocols are available in larger networks and the Internet. This section focuses primarily on protocols used on smaller to medium-sized networks.

RIPv2 has replaced RIPv1 in most networks because of its many benefits. Table 9.4 compares RIPv1 and RIPv2.

TABLE 9.4 A comparison of RIPv1 and RIPv2

Features	RIPv1	RIPv2
Multicasting	Not supported	Supported
Classless routes	Supports only routes to classful networks	Supports routes to classful and classless networks
Authentication	None available	Allows routers to authenticate between each other prior to sharing routing data

Figure 9.5 shows the Windows Server 2008 RRAS console with RIPv2 added. Both the Local Area Connection and Local Area Connection 2 NICs have been added to the RIP node so that RIP operates on both. This router will now listen for RIP information from other routers and send RIP information to them through both of its interfaces.

RRAS will send RIPv2 data and listen for RIPv1 and RIPv2 data by default. However, it can be configured for any combination of RIPv1 and RIPv2.

Although you can do more advanced configuration of RIPv2, the default configuration will work for most networks as long as the settings are configured in the same on other routers in the network. However, two settings are of primary importance:

- The Outgoing Packet Protocol is configured to use RIP version 2 broadcast by default. However, you can change this to RIP version 2 multicast (as shown in Figure 9.5) for better network performance.
- You can configure authentication by clicking the Activate Authentication check box and adding a password. All routers will need the same password. This ensures that only routers that can authenticate can access the routing information.

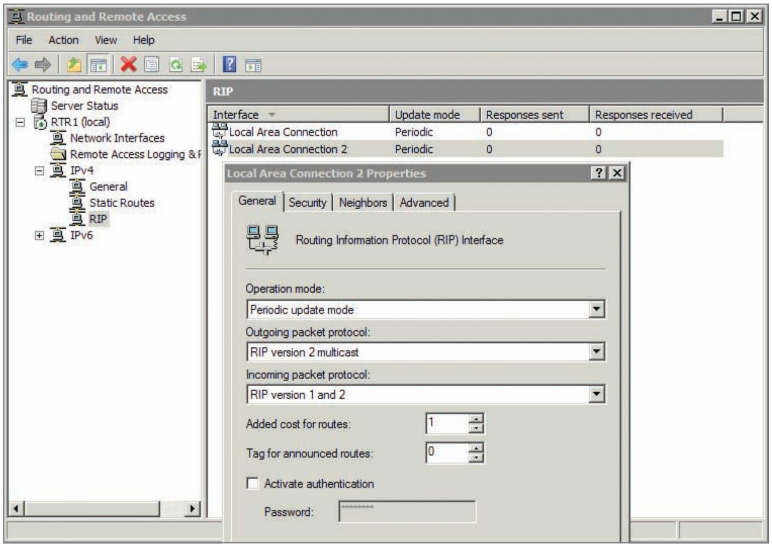

FIGURE 9.5 Configuring RIPv2 properties on a NIC

Open Shortest Path First

Open Shortest Path First (OSPF) is a common routing protocol used on internal networks with hardware routers. The method it uses to share routes between routers on the network is different from RIPv2. However, the result is the same. With OSPF, routers on the network will learn all routes and be dynamically updated when the network changes. RIPv2 and OSPF are not compatible with each other.

(Continues)

Open Shortest Path First *(Continued)*

Even though OSPF was available in Windows Server 2003, it was removed in Windows Server 2008. At the time I'm writing this, it remains out of Windows Server 2008 R2, though it's possible it may return in a future service pack.

If you have an existing network using OSPF and you want to add a Windows Server 2008 server as a router, you'll either need to configure the Windows server with static routing or need to convert the other routers to use RIPv2.

Understanding the Routing Table

Routers maintain routing tables that identify the path to other networks. Routing tables include the primary components shown in the "Creating Static Routes" section earlier in this chapter such as destination, interface, and gateway.

Figure 9.6 shows the routing table in a Windows Server 2008 RRAS console with a few key items highlighted. This computer has two NICs with IP addresses of 192.168.3.1 and 192.168.4.200.

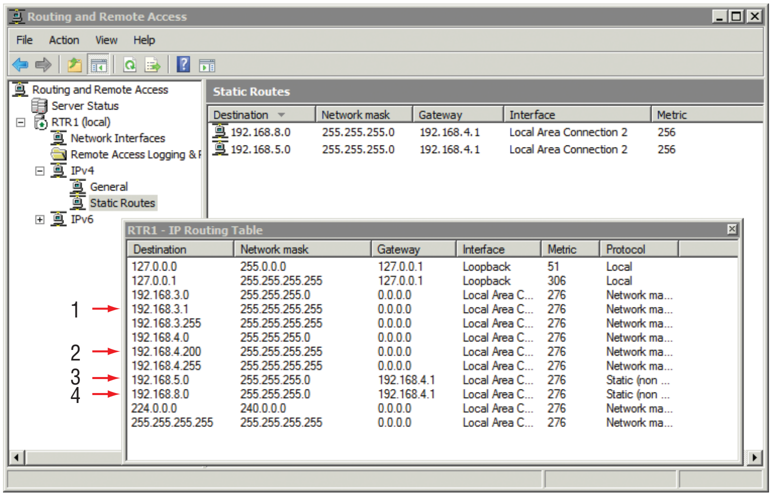

FIGURE 9.6 Viewing static routes in RRAS

The following list identifies the numbered items in Figure 9.6:

1. The NIC connected to the 192.168.3.0/24 subnetwork has an IP address of 192.168.3.1. Notice the network mask is 255.255.255.255, and the gateway is 0.0.0.0. This helps identify it as a directly connected route.

2. The NIC connected to the 192.168.4.0/24 subnetwork has an IP address of 192.168.4.200. Notice the network mask is 255.255.255.255, and the gateway is 0.0.0.0. This helps identify it as a directly connected route.

3. The path to the 192.168.5.0 subnetwork is via the 192.168.4.1 default gateway.

4. The path to the 192.168.8.0 subnetwork is via the 192.168.4.1 default gateway.

You can execute the `route print` command at the command prompt of any Windows system to view the full routing table.

You can also view a routing table for any individual system. For example, Listing 9.1 shows a partial output of the `route print` command executed at the command prompt on a Windows Server with two NICs. The server is configured as a router connecting the 192.168.1.0/24 network and the 192.168.9.0/24 network.

Listing 9.1 Partial output of command `C:\>route print`

```
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          127.0.0.0        255.0.0.0         On-link         127.0.0.1    306
          127.0.0.1  255.255.255.255         On-link         127.0.0.1    306
    127.255.255.255  255.255.255.255         On-link         127.0.0.1    306
        192.168.3.0    255.255.255.0         On-link       192.168.3.1    276
        192.168.3.1  255.255.255.255         On-link       192.168.3.1    276
      192.168.3.255  255.255.255.255         On-link       192.168.3.1    276
        192.168.4.0    255.255.255.0         On-link     192.168.4.200    276
      192.168.4.200  255.255.255.255         On-link     192.168.4.200    276
      192.168.4.255  255.255.255.255         On-link     192.168.4.200    276
        192.168.5.0    255.255.255.0     192.168.4.1     192.168.4.200    276
        192.168.8.0    255.255.255.0     192.168.4.1     192.168.4.200    276
          224.0.0.0        240.0.0.0         On-link         127.0.0.1    306
          224.0.0.0        240.0.0.0         On-link     192.168.4.200    276
          224.0.0.0        240.0.0.0         On-link       192.168.3.1    276
    255.255.255.255  255.255.255.255         On-link         127.0.0.1    306
    255.255.255.255  255.255.255.255         On-link     192.168.4.200    276
    255.255.255.255  255.255.255.255         On-link       192.168.3.1    276
===========================================================================
```

Routing Tables and Memory

The information for routing tables is stored in the router's memory. The routing tables shown in this chapter are trivial in size. They don't consume much memory. However, routing tables on Internet routers can contain tens of thousands of entries. These tables consume a significant amount of memory.

Identifying Transmission Speeds

Chapter 8 presented information on the speed of switches. As a reminder, the maximum speed of a switch determines the maximum speed that computers can send data through the switch. Switch speeds are measured in bits per second (bps, such as 100 Mbps).

Similarly, routers are also measured in bits per second, and the maximum speed of the router is the maximum speed that switches can send data through the network. One important consideration is the speed of routers that accept traffic from multiple switches.

Consider Figure 9.7. It shows a network with multiple routers and switches. Different routers will have to accommodate different amounts of data. For example, the router to the Internet may have high usage if all users regularly access the Internet. Even the router right below it (which is central to the network) will likely be substantially busier than other routers. The activity depends on where resources are placed in the network and the amount of usage for each of the subnetworks.

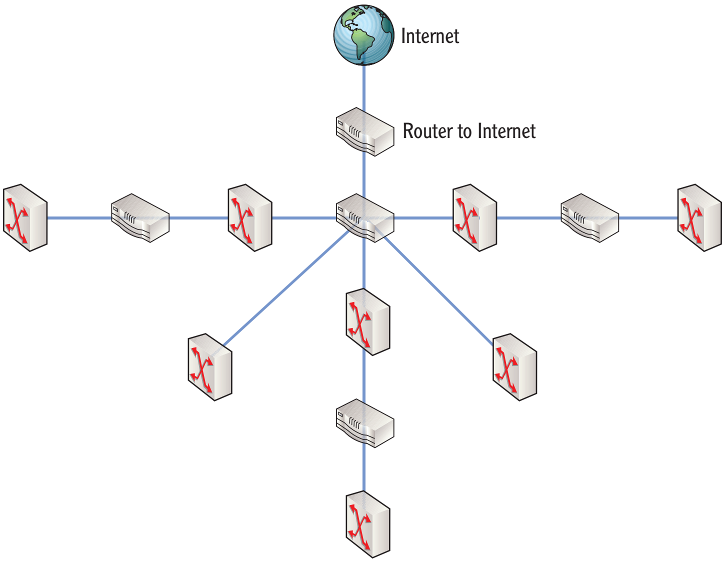

FIGURE 9.7 Multiple router network with access to the Internet

Common speeds for wired routers are 100 Mbps and 1000 Mbps. However, just as switches have increased in their speed capabilities, you can also buy higher-performance routers in the 10 Gbps range. Of course, higher speeds cost more money.

Routing Software in Windows Server 2008

> The Routing and Remote Access Services service is built into Windows Server 2008. In other words, you don't have to purchase an additional server product to use it.

You can add routing capabilities to a Windows Server 2008 server by enabling the Routing and Remote Access Services service. This is part of the Network Policy and Access Services role. Once the role is added, you can configure the service so that the server functions as a router.

Routing and Remote Access

The Network Policy and Access Services role has multiple uses. In addition to using it as a router as shown in this chapter, you can also use it to enable remote access for a network. Chapter 13 touches on using Network Policy and Access Services to create a dial-up or a virtual private network (VPN) server for remote access.

It's worthwhile repeating the obvious here. A router must have at least two separate interfaces. If you're creating a software router on a server, the server must have at least two network interface cards. Not all servers start with more than one NIC, but you can add NICs to most servers without too much problem.

Imagine that you manage a network with multiple computers and one or more servers. You decide that you want to move some of the computers from the primary network to a separate subnetwork for testing. This will create separate broadcast domains, and traffic on the testing network won't interfere with traffic on the primary network. Unfortunately, you don't have funding for a new hardware router. However, you do have a server and an extra NIC that you can use.

You can redesign the network so that it looks like Figure 9.8. You add the second NIC to the server, configure the server as a router, and rerun some of the cables.

Adding Routing Services to Windows Server 2008

> These steps will also work on a Windows Server 2008 R2 server.

The following steps show how to add the Routing and Remote Access Services service to Windows Server 2008:

1. Click Start ➢ Administrative Tools ➢ Server Manager.
2. Click Roles, and select Add Roles.
3. Review the information on the Before You Begin page, and click Next.

4. Select Network Policy And Access Services. Click Next.
5. Review the information on the Network Policy And Access Services page, and click Next.
6. Click the Routing check box.

   A dialog box will appear as shown in Figure 9.9, prompting you to add the role services required for routing.

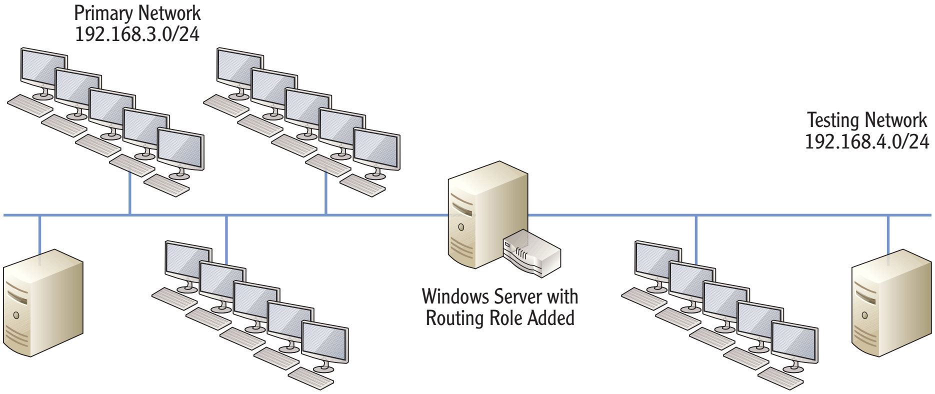

FIGURE 9.8 Adding routing to Windows Server 2008

Figure 9.8 doesn't show switches. However, switches are implied in both subnetworks. Even if you used a hardware router, you'd use two switches.

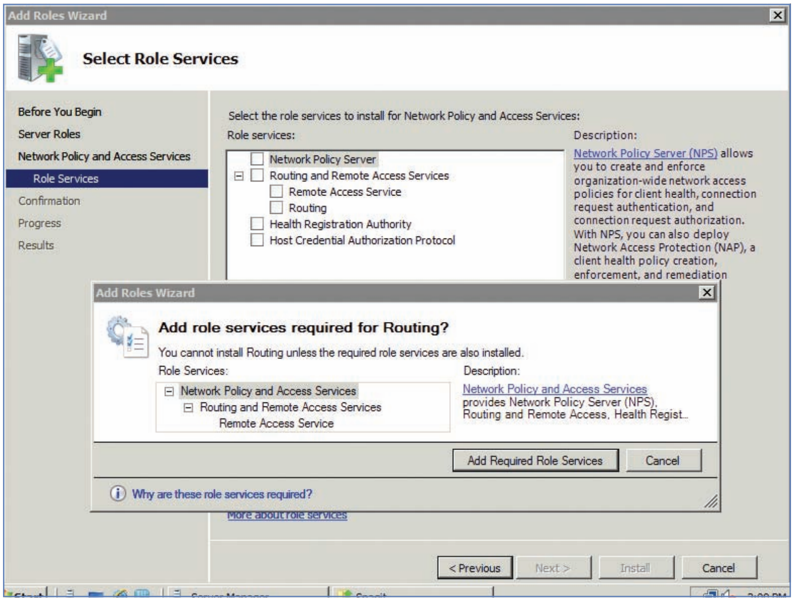

FIGURE 9.9 Adding routing to Windows Server 2008

Even though you selected the Routing check box, it doesn't appear selected until you make a decision about adding the required role services.

Using Virtual Systems for Testing

You don't always have to use physical systems for testing. In fact, most IT professionals do a lot of testing, experimenting, and learning with virtual systems.

For example, if you're using Windows 7, you can use Windows Virtual PC. You can then install Server 2008 as a virtual machine running within Windows 7. You can even run multiple virtual systems at the same time (as long as you have enough memory), creating your own virtual network.

The Windows Server 2008 screenshots in this chapter were captured from a single Windows Server 2008 virtual server running within a Windows 7 operating system.

7. Click the Add Required Role Services button.

   Check boxes will appear next to Routing And Remote Access Services, Remote Access Service, and Routing.
8. Click Next.
9. Click Install on the Confirmation page.
10. After a moment, the install will complete. Click Close.

Configuring a Router on Windows Server 2008

Once you've added the RRAS service to a Windows Server 2008 server, you can then configure it. The following steps show the basic configuration:

1. Launch Routing and Remote Access by clicking Start ➢ Administrative Tools ➢ Routing And Remote Access.
2. Right-click the server, and select Configure And Enable Routing And Remote Access.
3. Review the information on the Welcome screen, and click Next.
4. On the Configuration page, select Custom Configuration, as shown in Figure 9.10. Click Next.
5. On the Custom Configuration page, select LAN Routing, as shown in Figure 9.11. Click Next, and then click Finish.
6. When prompted to start the Routing and Remote Access service, click Start Service.

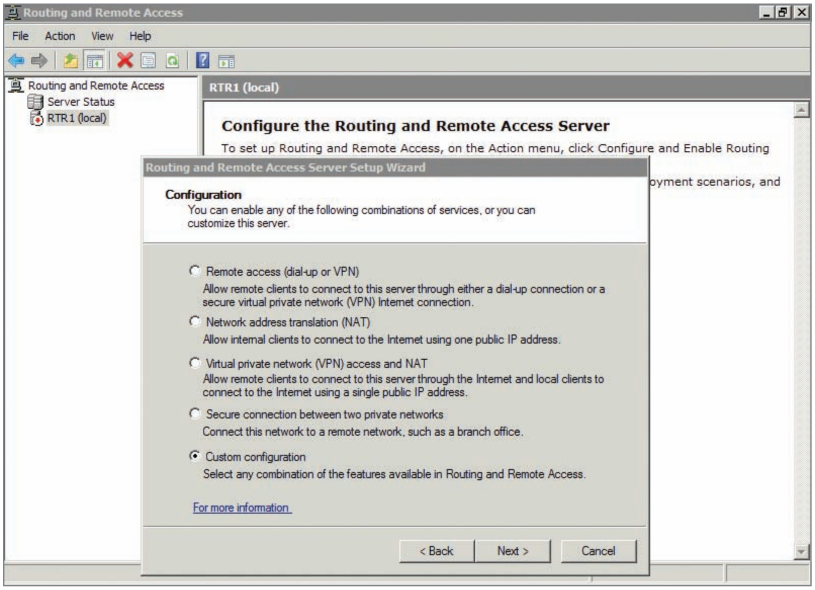

FIGURE 9.10 Selecting Custom Configuration to create a router

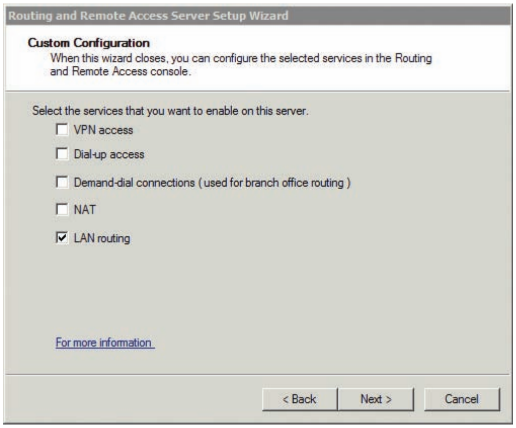

FIGURE 9.11 Selecting LAN routing when creating a router

At this point, the server is configured as a router. It will route traffic between the primary network and the testing network, and it will also create separate broadcast domains between the two networks.

Figure 9.12 shows the RRAS console with Network Interfaces selected. Notice the names of the interfaces are Loopback, Testing, PrimaryNetwork, and Internal. Loopback and Internal are part of the RRAS. However, Testing and PrimaryNetwork reflect the names of the networks directly connected to the router.

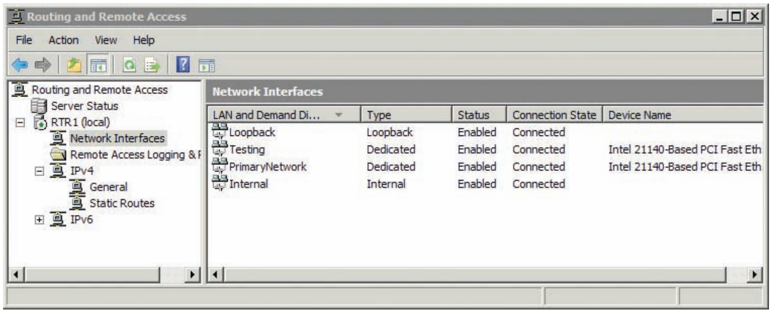

FIGURE 9.12 Selecting LAN routing when creating a router

You may wonder how the directly connected networks were named, since none of the previous steps named them. These names are derived from the names of the network connections on the computer.

The default names of a network connection are Local Area Connection, Local Area Connection 2, and so on. However, you can rename them. These connections were renamed before creating the RRAS console. Local Area Connection was renamed to PrimaryNetwork, and Local Area Connection 2 was renamed to Testing.

You can rename NICs on a Windows Server 2008 server with the following steps:

1. Click Start, right-click Network, and select Properties.
2. Click Manage Network Connections.
3. Right-click a connection, and select Rename.
4. Type the name you want, and press Enter. The connection is displayed with a new name.

If you rename the NIC, you may have to refresh the RRAS console before the new name appears.

The name that will appear in the RRAS console is the same as the name of the NIC.

Even though the server is configured as a router, it can still be used for other services. Servers typically will be used for several roles simultaneously.

This is the same dialog box used to add the RIP protocol. After the RIP protocol was added to RRAS, it's no longer available to add as a new routing protocol.

Understanding Other Routing Protocols

Primarily when you're talking about routing protocols in the context of internal routers, you're talking about RIPv2 or OSPF. However, other routing protocols that you can add to a Windows Server 2008 RRAS server are worth mentioning.

Figure 9.13 shows the dialog box within a Windows Server 2008 RRAS server you can access to add new routing protocols.

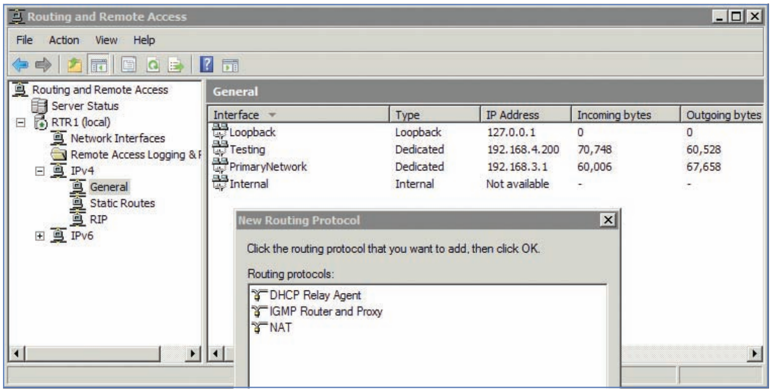

FIGURE 9.13 **Adding a new routing protocol to Windows Server 2008**

If you've installed RRAS on a server, you can access this dialog box with the following steps:

> After adding the protocol, you also have to add the interface to the protocol node and configure it.

1. Launch RRAS by clicking Start ➢ Administrative Tools and selecting Routing And Remote Access.
2. Expand the server and IPv4.
3. Right-click General, and select New Routing Protocol.

Notice that there are several choices. The following section explains these additional protocols.

Using a DHCP Relay Agent

Chapter 1 introduced the Dynamic Host Configuration Protocol (DHCP), and Chapter 5 described DHCP in depth. As a reminder, a DHCP server provides DHCP clients with TCP/IP configuration such as an IP address, subnet mask, and more. DHCP automatically configures the DHCP client when the DHCP client first turns on and then again are various intervals.

DHCP uses special types of broadcasts known as BootP broadcasts. BootP broadcasts pass through routers using UDP ports 67 and 68. That is, of course, if the router is RFC 1542 compliant and can be programmed to allow these BootP broadcasts through.

> Routers that can pass DHCP broadcasts through UDP ports 67 and 68 are compliant with RFC 1542. Older routers are not RFC 1542 compliant and can't pass these broadcasts.

Consider Figure 9.14. It shows a network with two subnets and one DHCP server. The router connecting the subnets is not RFC 1542 compliant. However, instead of installing a DHCP server on each subnet, you can install a DHCP relay agent on subnet B.

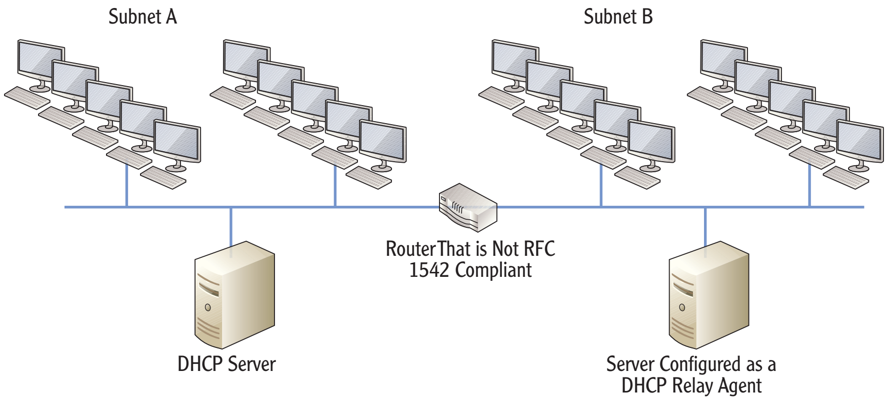

FIGURE 9.14 Using a DHCP relay agent

When a DHCP client in subnet B turns on, the following actions will occur:

1. The DHCP client sends a DHCP Discover message.
2. The DHCP relay agent hears the broadcast and forwards it to the DHCP server.
3. The DHCP server sends back a DHCP Offer to the relay agent.
4. The relay agent broadcasts the DHCP Offer on subnet B.
5. The DHCP client responds to the offer with a DHCP Request.
6. The relay agent hears the request and forwards it to the DHCP server.
7. The DHCP server sends back a DHCP Acknowledge to the relay agent.
8. The relay agent broadcasts the DHCP Acknowledge back to the DHCP client.

This is similar to the DORA process described in Chapter 5. The difference is that the proxy agent repeats the messages back and forth between the client and server.

The default lease length for a Windows DHCP server is eight days, and clients renew the lease every four days. In other words, the DHCP relay agent won't have a lot of activity. If it's needed, you can easily install it on another server that is performing another role such as file or print server.

Using an IGMP Router and Proxy

You can add the IGMP Router and Proxy service to your router to have it act as a proxy for multicast traffic. For example, Microsoft's Windows Media Services generates multicast traffic on the network. With this service added, traffic from Windows Media Services (and other multicast traffic) can cross the routers to other subnetworks.

Using NAT

You probably remember that the Internet uses public IP addresses and that internal networks use private IP addresses. If you're using a router between the Internet and your internal network, you need to translate these addresses between private and public.

Network Address Translation (NAT) translates private IP addresses to public IP addresses and translates public ones back to private. You can add NAT within RRAS if the server will be used for Internet access.

If you look back at Figure 9.10 where the system was configured for LAN routing, you'll see you can also select the NAT check box to include NAT.

Chapter 11 covers firewalls and proxy servers. It also includes an in-depth explanation on how NAT translates IP addresses.

The Essentials and Beyond

Networks with Internet access include at least one router that provides a path to the Internet. Most networks include more than one router that provides paths to multiple other subnetworks. Each router includes a routing table that includes the paths to these other subnetworks. The routing table can be updated manually by an administrator (static routes), or routing protocols can update the routing table automatically (dynamic routing). Two common routing protocols used on internal networks are RIPv2 and OSPF. You can configure a Microsoft server as a software router by adding and configuring RRAS. RRAS supports RIPv2 but not OSPF.

Additional Exercises

- View the routing table on a Windows computer.
- Determine the metric for the default path of your computer.
- Identify the IP address of the default gateway used in your subnetwork.
- Locate a router in your network. Identify as many directly connected routes as you can.

To compare your answers to the author's, please visit **`www.sybex.com/go/networkingessentials`**.

Review Questions

1. A router is configured in a network that includes multiple other routers. What routes does a router know by default?

   A. Directly connected routes
   B. Static routes
   C. Dynamic routes
   D. Routes added to the routing table

(Continues)

The Essentials and Beyond *(Continued)*

2. You have added a second router to your network that includes three subnets. What's the easiest way to ensure that both routers know the routes to all subnets?
   - **A.** Add OSPF to each router.
   - **B.** Add RIPv2 to each router.
   - **C.** Add dynamic routes.
   - **D.** Add static routes.
3. True or false. A router determines the best path to another subnet based on the highest cost metric.
4. Where are routes known by a router?
5. Your network includes more than 50 hardware routers. What can you configure on these routers so that they will share routing information with each other? (Choose all that apply.)
   - **A.** RIPv2
   - **B.** OSPF
   - **C.** Routing protocols
   - **D.** ARP
6. True or False. Windows Server 2008 supports RIPv2 and OSPF routing protocols.
7. A network includes a router that is not RFC 1542 compliant. Computers on one subnet use DHCP. What should you add to ensure computers on other subnets connected to the router can use DHCP?
   - **A.** Another DHCP server
   - **B.** DHCP relay agent
   - **C.** RIPv2
   - **D.** OSPF
8. You are adding a Windows Media Services server to your network that is using a Windows Server 2008 server as a router. You want to ensure that IP multicast traffic passes through the router. What would you add?
   - **A.** OSPF
   - **B.** RIPv2
   - **C.** IGMP Router and Proxy service
   - **D.** DHCP relay agent