Route Summarization

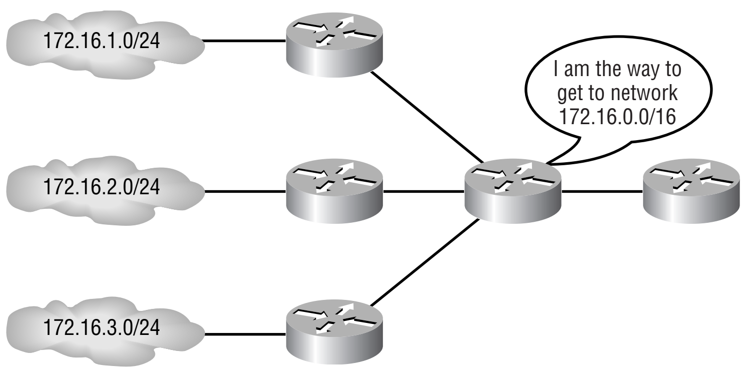
In the "Design Considerations with VLSM" section, we briefly mentioned the concept of route summarization. So, what is it, and why do we need it? On very large networks, there may be hundreds or even thousands of individual networks and subnetworks being advertised. All these routes can be very taxing on a router's memory and processor.

In many cases, the router doesn't even need specific routes to each and every subnet (e.g., 172.16.1.0/24). It would be just as happy if it knew how to get to the major network (e.g., 172.16.0.0/16) and let another router take it from there. A router's ability to take a group of subnetworks and summarize them as one network (i.e., one advertisement) is called *route summarization*, as shown in Figure 3.5.

NOTE

In some of the literature, you may find route summarization referred to as *route aggregation*.

FIGURE 3.5 Route summarization



Besides reducing the number of routing entries that a router must keep track of, route summarization can also help protect an external router from making multiple changes to its routing table, due to instability within a particular subnet. For example, let's say that we were working on a router that connected to 172.16.2.0/24. As we were working on the router, we rebooted it several times. If we were not summarizing our routes, an external router would see each time 172.16.2.0/24 went away and came back. Each time, it would have to modify its own routing table. However, if our external router were receiving only a summary route (i.e., 172.16.0.0/16), then it wouldn't have to be concerned with our work on one particular subnet.

We will get the most benefit from route summarization when the networks or subnetworks that we are summarizing are contiguous. To illustrate this point, let's look at an example.

Route Summarization Example 1

We have the following networks that we want to advertise as a single summary route:

172.16.100.0/24

172.16.101.0/24

172.16.102.0/24

172.16.103.0/24

172.16.104.0/24

172.16.105.0/24

172.16.106.0/24

To determine what the summary route would be for these networks, we can follow a simple two-step process.

1. Write out each of the numbers in binary, as shown in Table 3.14.

TABLE 3.14 Summary Example

IP Network Address	Binary Equivalent
172.16.100.0	**10101100.0001000.01100**100.0
172.16.101.0	**10101100.0001000.01100**101.0
172.16.102.0	**10101100.0001000.01100**110.0
172.16.103.0	**10101100.0001000.01100**111.0
172.16.104.0	**10101100.0001000.01101**000.0
172.16.105.0	**10101100.0001000.01101**001.0
172.16.106.0	**10101100.0001000.01101**010.0

2. Examine the table to determine the maximum number of bits (starting from the left) that all of the addresses have in common (where they stop lining up; we bolded them to make them easier for you to see). The number of common bits is the subnet mask for the summarized address (/20).

In our example, we can see from the table that all of the addresses have the first 20 bits in common. The decimal equivalent of these first 20 bits is 172.16.96.0. So, we can write our new summarized address as 172.16.96.0/20. If we were to later add a network 172.16.98.0, it would need to come off the router summarizing this address space. If we didn't, it could cause problems. Okay, this is confusing, we know. This is why we're going to give you three more examples.

Route Summarization Example 2

In this example, we will summarize 10.1.0.0 through 10.7.0.0. First, put everything into binary, and then follow the bits, starting on the left and stopping when the bits do not line up. Notice where we stopped boldfacing the following:

10.1.0.0	**00001010.00000**001.00000000.00000000
10.2.0.0	**00001010.00000**010.00000000.00000000
10.3.0.0	**00001010.00000**011.00000000.00000000
10.4.0.0	**00001010.00000**100.00000000.00000000
10.5.0.0	**00001010.00000**101.00000000.00000000
10.6.0.0	**00001010.00000**110.00000000.00000000
10.7.0.0	**00001010.00000**111.00000000.00000000

Now, create the network number using only the boldfaced bits. Do not count the bits that are not in boldface. The second octet has no bits on (bits in the bolded section), so we get this:

10.0.0.0

To come up with the summary mask, count all the bolded bits as ones. Because eight bits are boldface in the first octet and five bits in the second, we'll get this:

255.248.0.0

Route Summarization Example 3

This example will show you how to summarize 172.16.16.0 through 172.16.31.0. First, let's put the network addresses into binary and then line up the bits.

172.16.16.0	**10101100.0001000.0001**0000.00000000
172.16.17.0	**10101100.0001000.0001**0001.00000000
172.16.18.0	**10101100.0001000.0001**0010.00000000
172.16.19.0	**10101100.0001000.0001**0011.00000000
172.16.20.0	**10101100.0001000.0001**0100.00000000
172.16.21.0	**10101100.0001000.0001**0101.00000000
172.16.22.0	**10101100.0001000.0001**0110.00000000
172.16.23.0	**10101100.0001000.0001**0111.00000000
172.16.24.0	**10101100.0001000.0001**1000.00000000
172.16.25.0	**10101100.0001000.0001**1001.00000000
172.16.26.0	**10101100.0001000.0001**1010.00000000
172.16.27.0	**10101100.0001000.0001**1011.00000000
172.16.28.0	**10101100.0001000.0001**1100.00000000
172.16.29.0	**10101100.0001000.0001**1101.00000000
172.16.30.0	**10101100.0001000.0001**1110.00000000
172.16.31.0	**10101100.0001000.0001**1111.00000000

Notice where the bits stop lining up (in boldface). Count only the bits that are on (ones) to get the network address:

172.16.0.0

Now, create the summary mask by counting all the bits that are in boldface up to the point where they stop lining up. We have eight bits in the first octet, eight bits in the second octet, and four bits in the third octet. That is a /20 or

`255.255.240.0`

Boy, that sure seems like a pain in the pencil, huh? Try this shortcut. Take the first number and the very last number, and put them into binary:

172.16.16.0	**10101100.0001000.0001**0000.00000000
172.16.31.0	**10101100.0001000.0001**1111.00000000

Can you see that we actually came up with the same numbers? It is a lot easier than writing out possibly dozens of addresses. Let's do another example, but let's use our shortcut.

Route Summarization Example 4

In this example, we will show you how to summarize 192.168.32.0 through 192.168.63.0. By using only the first network number and the last, we'll save a lot of time and come up with the same network address and subnet mask:

First number: 192.168.32.0 =
11000000.10101000.00100000.00000000

Last number: 192.168.63.0 =
11000000.10101000.00111111.00000000

Network address: 192.168.32.0

Subnet mask: 255.255.224.0

Design Considerations for Route Summarization

Keep the following information in mind when designing your network summarization points:

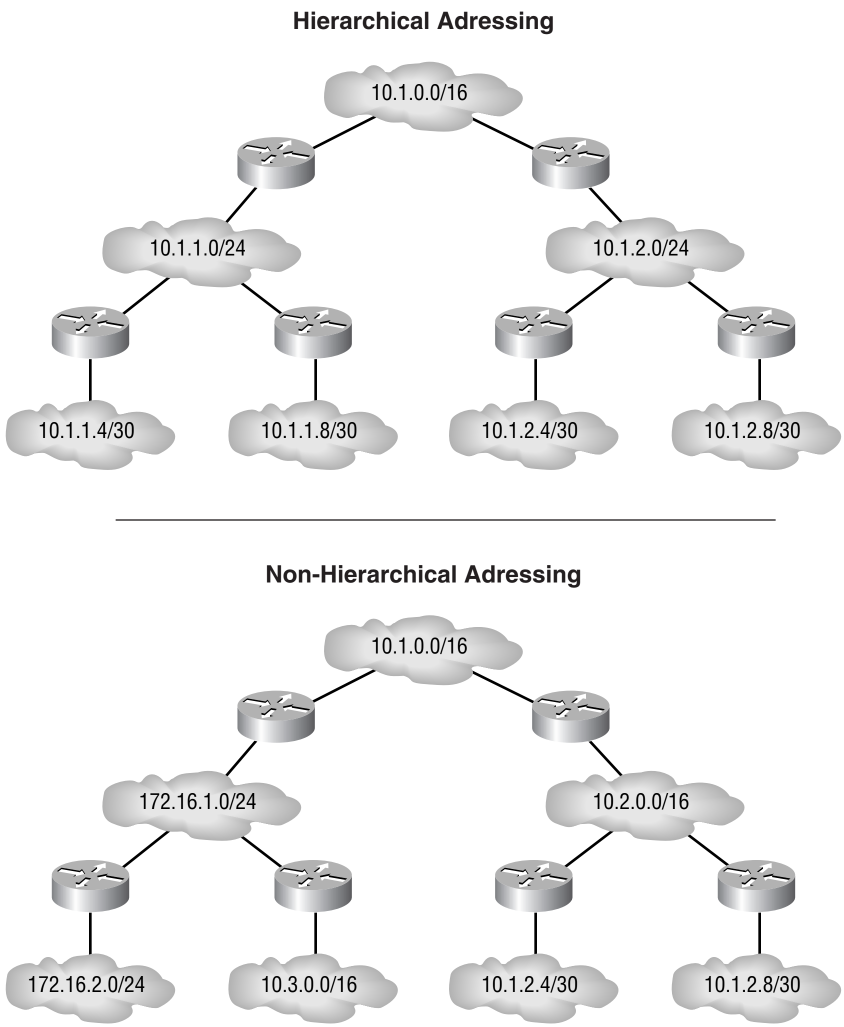
- Only classless routing protocols support route summarization. Examples of classless routing protocols include RIPv2, EIGRP, and OSPF. Therefore, if you are working in a RIPv1 or IGRP environment, route summarization is not going to work for you.

NOTE

Classless and classful protocols were discussed in Chapter 2, "Routing Principles."

- Route summarization is most effective when the addresses have been organized in a hierarchy (i.e., "hierarchical addressing"). When we speak of addresses being hierarchical, we mean that the IP subnets at the "bottom of the tree" (i.e., the ones with the longest subnet masks) are subsets of the subnets at the "top of the tree" (i.e., the ones with the shortest subnet masks). Figure 3.6 will be used to illustrate hierarchical versus non-hierarchical addressing.

FIGURE 3.6 Discontiguous networking example



In the VLSM section of this chapter, we discussed how route summarization in discontiguous networks could cause some hosts to become unreachable, as we saw in Figure 3.4. If both RouterA and RouterB are sending out advertisements to the WAN cloud advertising that they are the path to network 172.16.0.0/16, then devices in the WAN cloud will not know which advertisement to believe.

Remember that you can avoid this situation by proper address planning ahead of time. However, you may find yourself in a situation where you are dealing with a legacy installation, and you need to overcome this issue of discontiguous networks.

One solution is to turn off route summarization on the routers. To keep routing protocols such as RIPv2 and EIGRP from automatically summarizing routes, we can explicitly disable route summarization in the Cisco IOS. Following are examples of IOS configurations, where we are disabling automatic route summarization. As the OSPF chapters will show, OSPF does not automatically summarize.

To turn off auto-summarization for RIP version 2 routed networks, use the following router configuration:

```
router rip
 version 2
 network 10.0.0.0
 network 172.16.0.0
 no auto-summary
```

To turn off auto-summarization for EIGRP routed networks, use the following router configuration:

```
router eigrp 100
 network 10.0.0.0
 network 172.16.0.0
 no auto-summary
```

Another way to allow discontiguous networks to be interconnected over a serial link is to use Cisco's IOS feature called *IP unnumbered*. We'll look at this next.

IP Unnumbered

With IP unnumbered, a serial interface is not on a separate network, as all router interfaces tend to be. Instead, the serial port "borrows" an IP address from another interface. In the following router configuration example, interface Serial 0 is using a borrowed IP address from interface Ethernet 0:

```
interface serial 0
ip unnumbered ethernet 0
```