OSPF

This lab shows how to configure OSPF using several different styles of OSPF **network** commands, both for a single area and for multiple areas. In particular, the objectives of this lab are the following:

- Configure the OSPF **network** command to correctly match an interface and place it into the correct area
- Describe generally how the wildcard mask controls how the OSPF **network** command works
- Configure an Area Border Router (ABR) by placing different interfaces in different areas
- Distinguish between intra-area and interarea OSPF-learned routes
- Describe how a router picks its router ID (RID)

Scenario

This lab contains three main steps, as follows:

Step 1. Examine the single-area OSPF configuration on three routers (R1, R2, and R3)

Step 2. Configure an Area Border Router (ABR) to be connected to multiple OSPF areas

Step 3. Analyze how a router chooses its OSPF RID and verify the RID chosen by a router

Initial Configurations: Lab Step 1

Examples 1-1 through 1-3 show the pertinent initial configurations of routers R1, R2, and R3. All routers begin with all pertinent IP addresses configured, all necessary links up, and OSPF configured to put all links into area 0, as illustrated in Figure 1-1. As usual, the parts of the configurations not relevant to this lab have been omitted.

Example 1-1 Initial Configuration for R1

```
hostname R1
!
interface FastEthernet 0/0
 ip address 172.22.11.1 255.255.255.0
!
interface FastEthernet 0/1
 ip address 172.22.10.1 255.255.255.0
!
interface loopback 1
 ip address 11.11.11.11 255.255.255.0
!
interface loopback 2
 ip address 1.1.1.1 255.255.255.0
!
router ospf 1
 network 172.22.11.1 0.0.0.0 area 0
 network 172.22.10.1 0.0.0.0 area 0
```

Example 1-2 Initial Configuration for R2

```
interface FastEthernet 0/0
 ip address 172.22.12.2 255.255.255.0
!
interface FastEthernet 0/1
 ip address 172.22.10.2 255.255.255.0
!
interface loopback 1
 ip address 2.2.2.2 255.255.255.0
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

Example 1-3 Initial Configuration for R3

```
interface FastEthernet 0/0
 ip address 172.22.13.3 255.255.255.0
!
interface FastEthernet 0/1
 ip address 172.22.10.3 255.255.255.0
!
router ospf 2
 network 172.22.0.0  0.0.255.255 area 0
```

Initial Configurations: Lab Step 2

Lab 1's second step adds routers R5 and R6 to the network topology. Examples 1-4 and 1-5 show the initial configurations on these routers needed to begin Step 2. Both routers begin with all pertinent IP addresses configured and all necessary links up, but OSPF is configured on R6 only. The OSPF configuration matches the design shown in Figure 1-1.

Example 1-4 R5 Initial Configuration Needed to Begin Step 2

```
hostname R5
!
interface Serial0/0
 ip address 172.22.115.5 255.255.255.0
!
interface FastEthernet0/0
 ip address 172.22.15.5 255.255.255.0
```

Example 1-5 R6 Initial Configuration Needed to Begin Step 2

```
hostname R6
!
interface Serial0/0
 ip address 172.22.116.6 255.255.255.0
!
interface FastEthernet0/0
 ip address 172.22.16.6 255.255.255.0
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 6
```

Ending Configurations

This lab video ends with R1 having added configuration to support areas 5 and 6 and with OSPF configuration having been added to router R5. Example 1-6 shows the configuration added to R1, with Example 1-7 showing all pertinent configuration of R5.

Example 1-6 Configuration Added to R1 During the Video

```
interface Serial0/1/0
 ip address 172.22.115.1 255.255.255.0
 clock rate 1536000
 no shutdown
!
```

Example 1-6 Configuration Added to R1 During the Video *continued*

```
interface Serial0/1/1
 ip address 172.22.116.1 255.255.255.0
 clock rate 1536000
 no shutdown
!
router ospf 1
 network 172.22.115.1 0.0.0.0 area 5
 network 172.22.116.1 0.0.0.0 area 6
```

Example 1-7 Configuration Added to R5 During the Video

```
router ospf 1
 network 0.0.0.0 255.255.255.255 area 5
```

Video Presentation Reference

This video includes several figures and one table that both help explain the scenario in the lab and list important reference information.

Because the video is organized into three separate steps, the reference materials have been organized into three separate sections. Each section simply lists these figures and tables for reference.

Step 1 Reference

Figure 1-1 Three Routers and Four LAN Subnets Used in Step 1

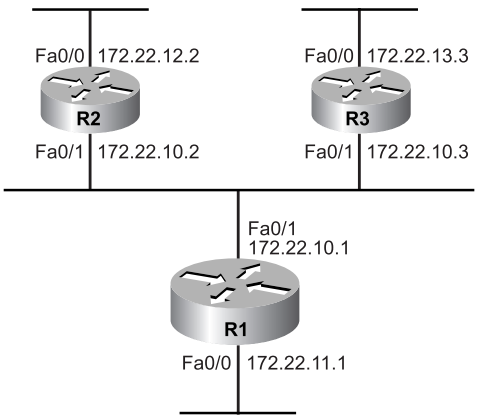


Figure 1-2 **Subnets and OSPF Areas Used in Step 1**

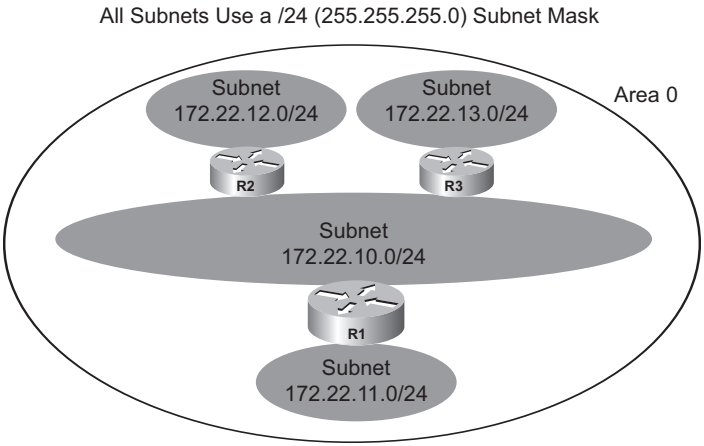


Figure 1-3 **Format of the OSPF network Command**

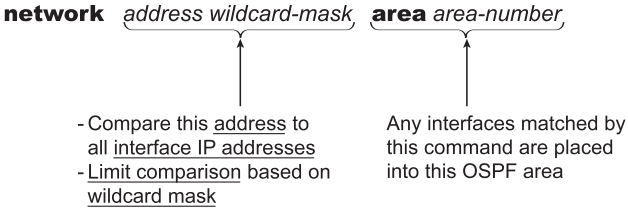


Table 1-1 **Sample OSPF network Command Wildcard Masks and Their Meanings**

Wildcard Mask	Meaning
0.0.0.0	Compare the entire address
0.0.0.255	Compare the first 3 octets only
0.0.255.255	Compare the first 2 octets only
0.255.255.255	Compare the first octet only
255.255.255.255	No need to compare anything—all addresses are considered to match

Step 2 Reference

Figure 1-4 Expanded Topology for Step 2

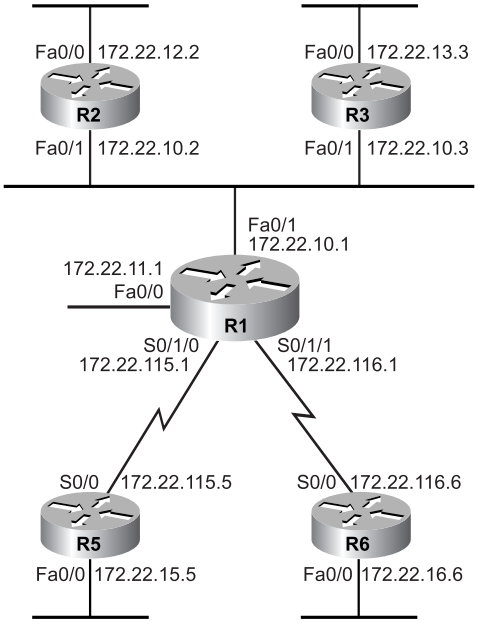


Figure 1-5 Subnet Numbers in Step 2

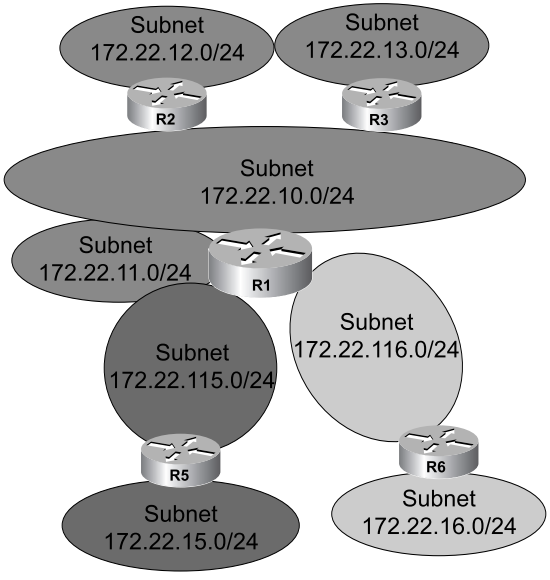
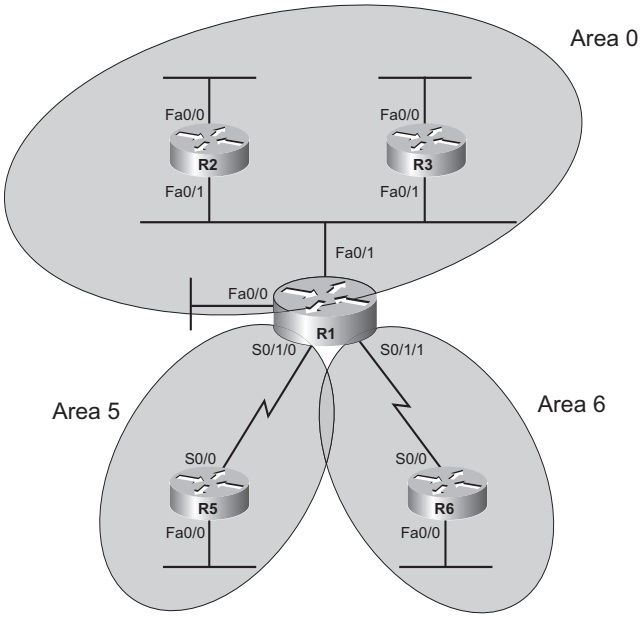


Figure 1-6 Area Design for Expanded Topology

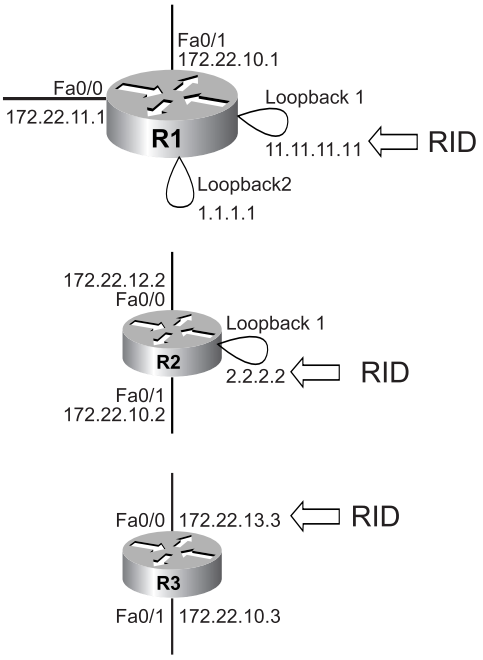


Step 3 Reference

OSPF chooses its router ID using the following sequence of choices:

1. As configured with the OSPF **router-id** command (as configured under the **router ospf** command).
2. If the **router-id** command is not configured, the router uses the highest IP address of all "up/up" loopback interfaces.
3. If steps 1 and 2 do not define the OSPF RID, the router uses the highest IP address of all "up/up" non-loopback interfaces.

Figure 1-7 Examples of OSPF Router ID Choices



EIGRP

This lab shows how to configure EIGRP in an internetwork having one Class B network that uses variable-length subnet masks (VLSM). The objectives of this lab are as follows:

- Configure the EIGRP **network** command
- Confirm on which interfaces a router has enabled EIGRP
- Interpret the **show ip route** command output when VLSM are used

Scenario

This lab contains two main steps, as follows:

Step 1. Configure EIGRP in a network that uses only subnets of the Class B network 172.22.0.0

Step 2. Discover the impact when a router does not enable EIGRP on an interface

Initial Configurations

Examples 2-1 through 2-3 show the pertinent initial configurations of routers R1, R2, and R3 in the lab video. Note that this lab begins with these three routers having the correct IP addresses configured, but only router R2 has been configured for EIGRP. As usual, the parts of the configurations not relevant to this lab have been omitted.

Example 2-1 Initial Configuration for R1

```
hostname R1
!
interface FastEthernet 0/0
 ip address 172.22.11.1 255.255.255.128
!
interface serial 0/1/0
 ip address 172.22.112.101 255.255.255.252
 clock rate 1536000
!
interface serial 0/1/1
 ip address 172.22.113.209 255.255.255.252
 clock rate 1536000
```

Example 2-2 Initial Configuration for R2

```
hostname R2
!
interface FastEthernet 0/0
 ip address 172.22.12.202 255.255.255.192
!
interface serial 0/1/0
 ip address 172.22.112.102 255.255.255.252
!
interface serial 0/1/1
 ip address 172.22.123.97 255.255.255.252
!
router eigrp 1
 network 172.22.0.0
```

Example 2-3 Initial Configuration for R3

```
hostname R3
!
interface FastEthernet 0/0
 ip address 172.22.13.103 255.255.255.224
!
interface serial 0/1/0
 ip address 172.22.123.98 255.255.255.252
 clock rate 1536000
!
interface serial 0/1/1
 ip address 172.22.113.210 255.255.255.252
```

Ending Configurations

This lab does not change any of the initial configurations in routers R1, R2, or R3. However, it does add to the configurations of R1 and R3, as shown in Examples 2-4 and 2-5.

Example 2-4 Configuration Added to R1 During the Lab

```
router eigrp 1
 network 172.22.0.0
```

Example 2-5 Configuration Added to R3 During the Lab

```
router eigrp 1
 network 172.22.113.0 0.0.0.255
 network 172.22.123.0 0.0.0.255
 network 172.22.13.0 0.0.0.255
```

Video Presentation Reference

This video includes several figures that contain the same images used in the lab video. Because the video is organized into two separate steps, the reference materials have been organized into two separate sections. Each section simply lists these figures and tables for reference.

Step 1 Reference

Figure 2-1 Three Routers, Six Subnets of Class B Network 172.22.0.0

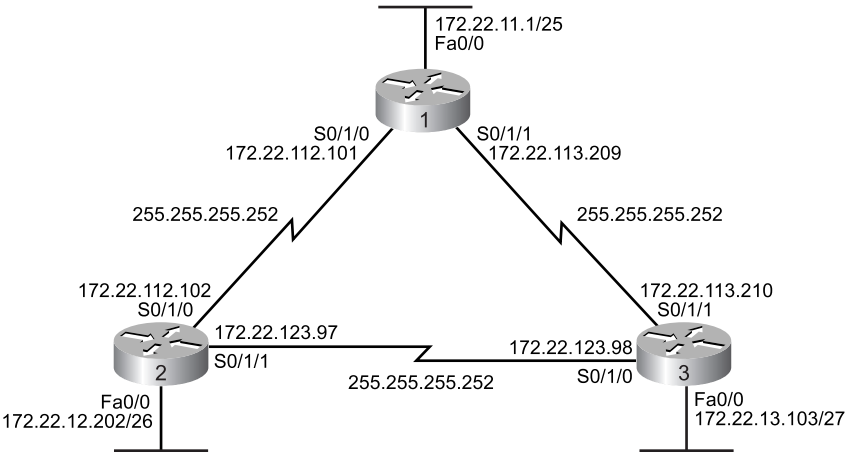


Table 2-1 lists the subnets shown in Figure 2-1.

Table 2-1 Four Key Internet Layer Protocols

Location	Subnet Number	Range of IP Addresses	Subnet Broadcast Address
R1 LAN	172.22.11.0/25	172.22.11.1–172.22.11.126	172.22.11.127
R2 LAN	172.22.12.192/26	172.22.12.193–172.22.12.254	172.22.12.255
R3 LAN	172.22.13.96/27	172.22.13.97–172.22.13.126	172.22.13.127
R1-R2 Serial	172.22.112.100/30	172.22.112.101–172.22.112.102	172.22.112.103
R1-R3 Serial	172.22.113.208/30	172.22.113.209–172.22.113.210	172.22.113.211
R2-R3 Serial	172.22.123.96/30	172.22.123.97–172.22.123.98	172.22.123.99

Figure 2-2 **Subnet Reference for Step 1**

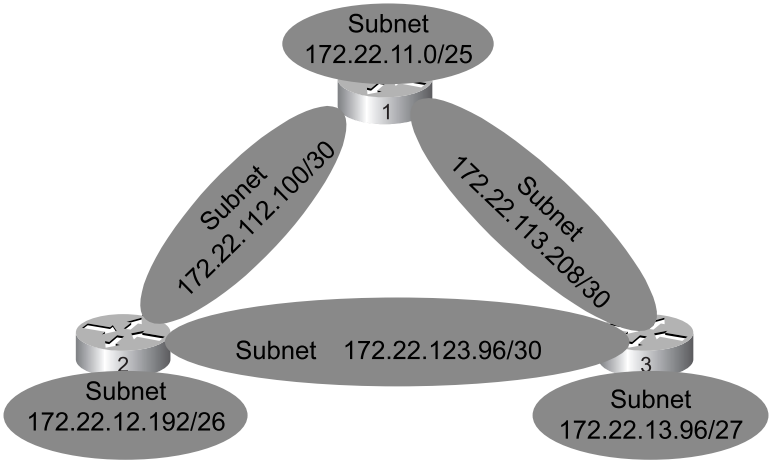


Figure 2-3 **The Original Format of the EIGRP `network` Command**

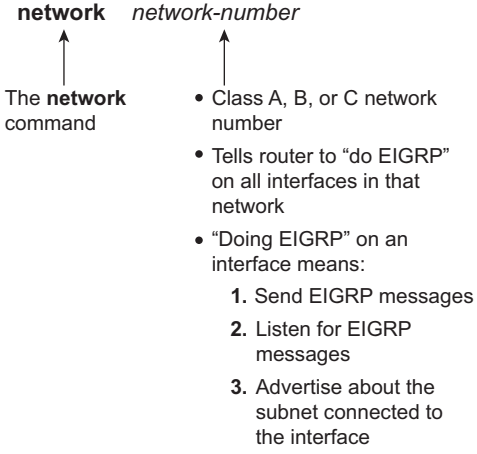


Figure 2-4 **The Newer Format of the EIGRP `network` Command**

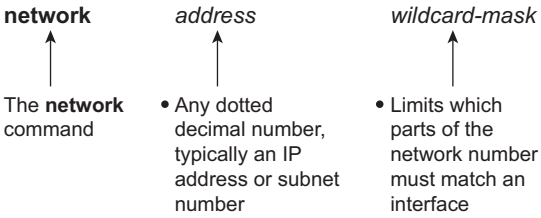
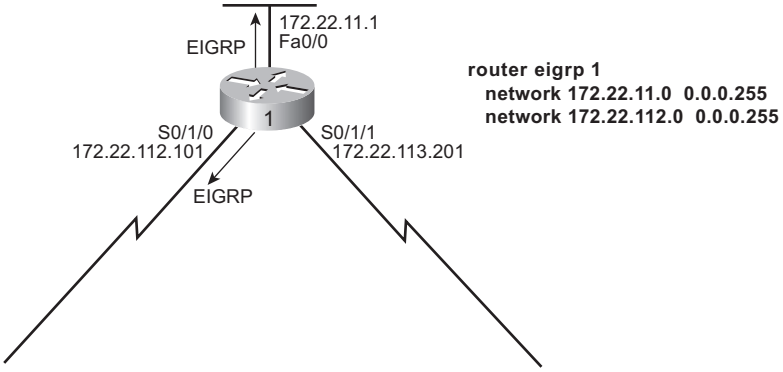
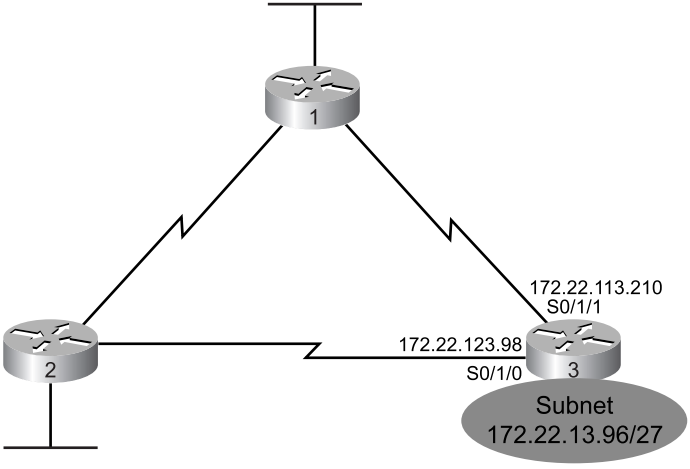


Figure 2-5 The Impact of the EIGRP network Command – R1, Step 1



Step 2 Reference

Figure 2-6 Problem of Not Advertising Subnet 172.22.13.96/27



EIGRP Metrics

This lab helps you understand the bandwidth and delay settings on router interfaces and how they impact the metric calculated by the EIGRP routing protocol. In particular, this lab covers the following:

- Determines which interface's bandwidth and delay settings impact EIGRP's metric calculation for a given route.
- Explains how EIGRP uses constraining (slowest) bandwidth but cumulative interface delay.
- Predicts the impact of changing an interface's bandwidth setting on the EIGRP metric calculation.

Scenario

This lab contains two main steps, as follows:

Step 1. Analyze the differences between the EIGRP metrics for two possible routes to reach a single subnet.

Step 2. Predict the change in EIGRP metrics based on a change to an interface's bandwidth setting.

Initial Configurations

Examples 3-1, 3-2, and 3-3 show the pertinent initial configurations of Routers R1, R2, and R3 in the lab video. Note that this lab begins with these three routers having the correct IP addresses configured, and with EIGRP configured and enabled on all interfaces—but with default bandwidth and delay settings. As usual, the parts of the configurations not relevant to this lab have been omitted.

Example 3-1 Initial Configuration for R1

```
hostname R1
!
interface FastEthernet 0/0
 ip address 172.22.11.1 255.255.255.128
!
interface serial 0/1/0
 ip address 172.22.112.101 255.255.255.252
 clock rate 1536000
!
interface serial 0/1/1
 ip address 172.22.113.209 255.255.255.252
 clock rate 1536000
!
router eigrp 1
 network 172.22.0.0
```

Example 3-2 Initial Configuration for R2

```
hostname R2
!
interface FastEthernet 0/0
 ip address 172.22.12.202 255.255.255.192
!
interface serial 0/1/0
 ip address 172.22.112.102 255.255.255.252
!
interface serial 0/1/1
 ip address 172.22.123.97 255.255.255.252
!
router eigrp 1
 network 172.22.0.0
```

Example 3-3 Initial Configuration for R3

```
hostname R3
!
interface FastEthernet 0/0
 ip address 172.22.13.103 255.255.255.224
!
interface serial 0/1/0
 ip address 172.22.123.98 255.255.255.252
 clock rate 1536000
!
interface serial 0/1/1
 ip address 172.22.113.210 255.255.255.252
```

```
!
router eigrp 1
 network 172.22.0.0
```

Ending Configurations

This lab does not change any of the initial configuration, but it does override the default bandwidth setting on R1's S0/1/0 interface. For easy reference, Example 6-4 lists the configuration added during the video.

Example 3-4 Configuration Added to R1 During the Video

```
interface serial 0/1/0
 bandwidth 64
```

Video Presentation Reference

This video presents several figures that describe the internetwork used in the video and how the bandwidth and delay settings impact EIGRP's choice of routes. This section simply lists these figures for reference. Because the video is organized into two separate steps, the reference materials have been organized into two separate sections.

Step 1 Reference

Figure 3-1 Lab 1 Topology and IP Addresses

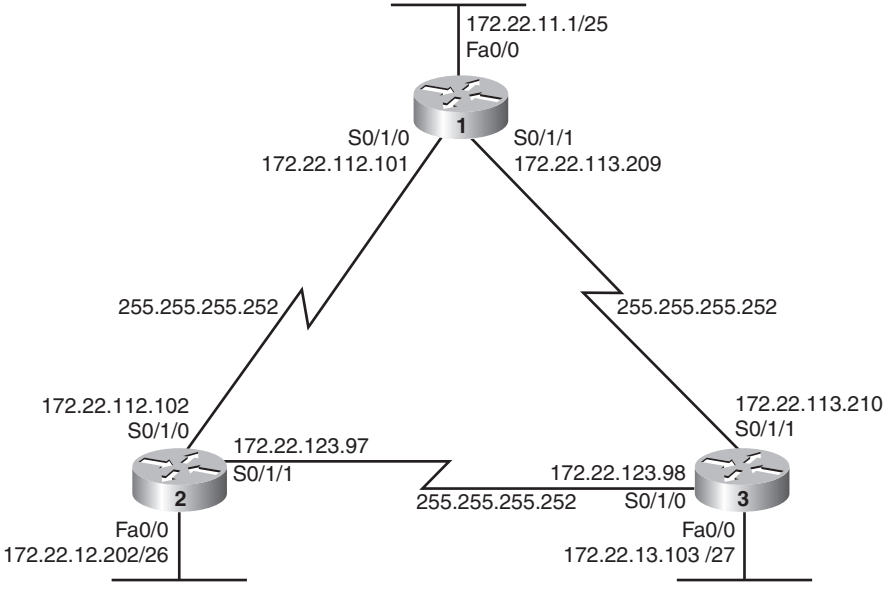


Figure 3-2 Lab 3 Subnet Number Reference

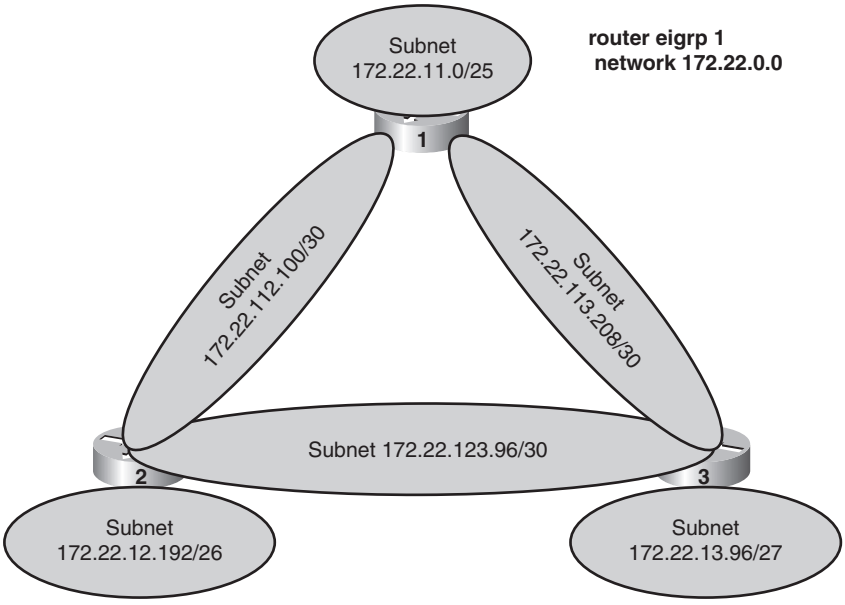


Figure 3-3 Bandwidth Settings That Impact R1's route to Subnet 172.22.12.192/26

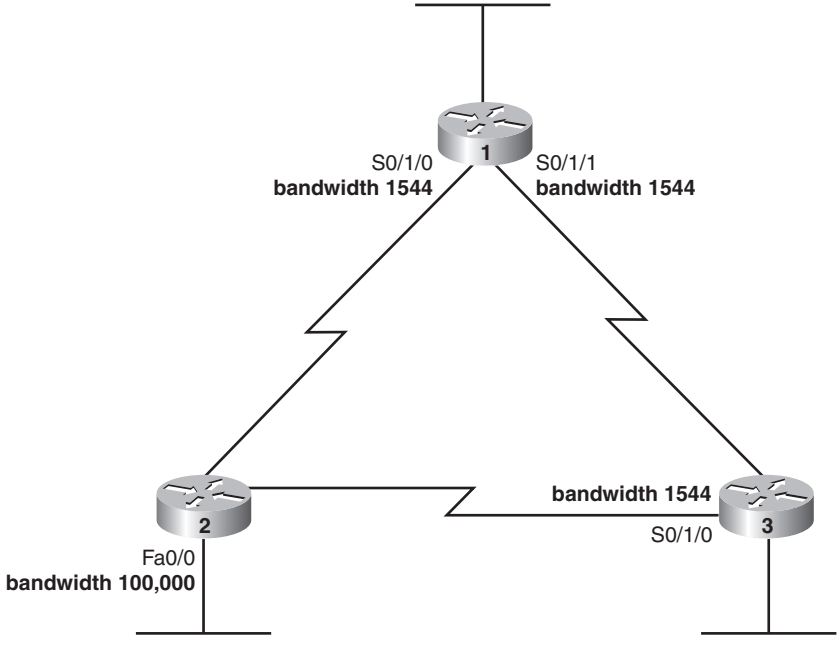


Figure 3-4 Bandwidth and Delay Inputs into R1's Two Competing Routes for 172.22.12.192/26

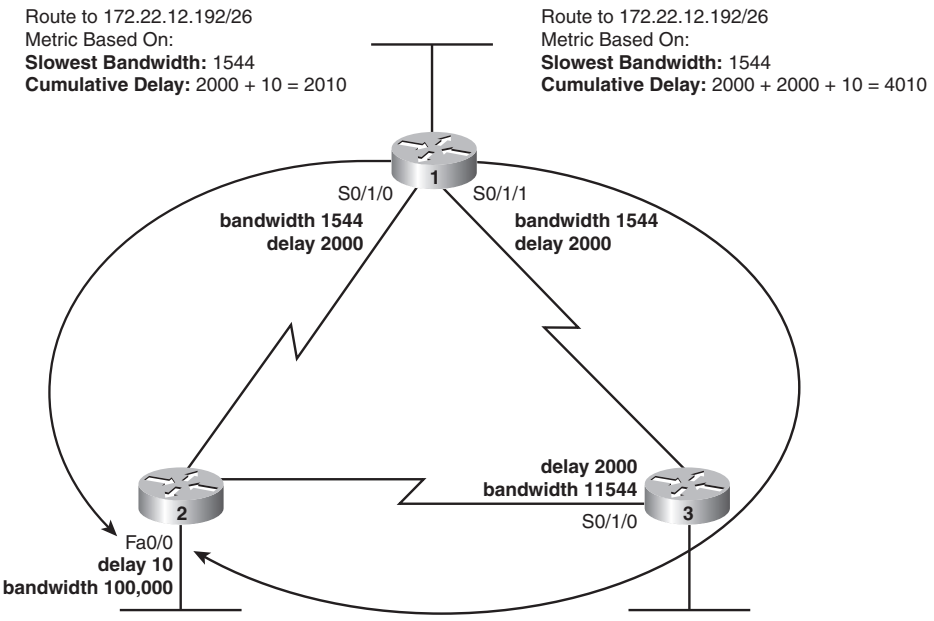
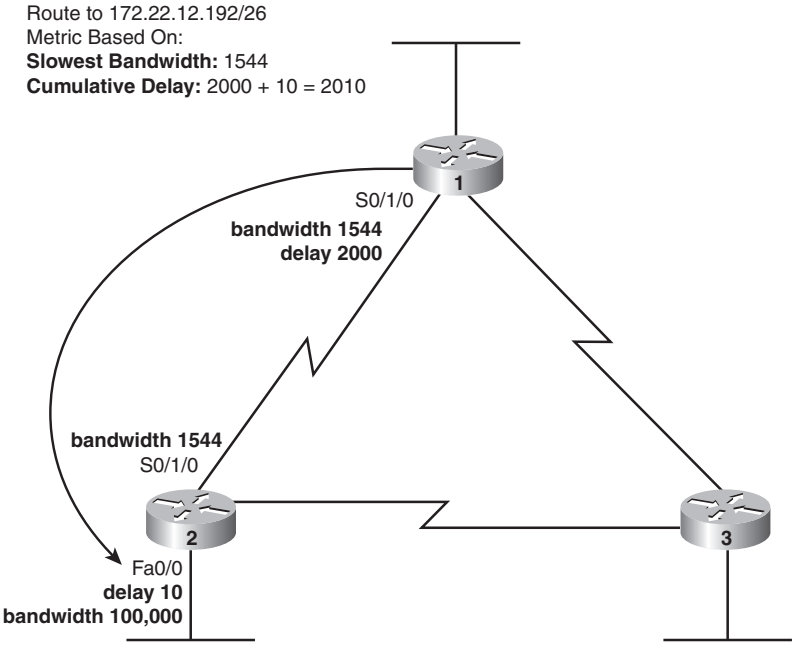


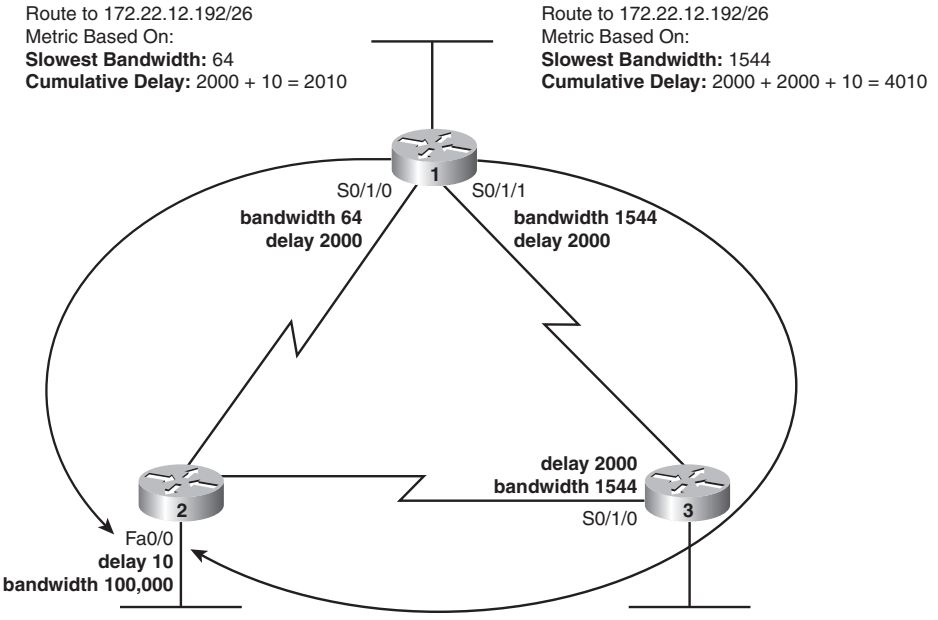
Figure 3-5 Metric Calculation Reference

Metric = 256 (10^7/bandwidth) + 256(delay) = 2,172,416



Step 2 Reference

Figure 3-6 Revised Bandwidth and Delay Inputs



PPP and CHAP

This lab shows how to configure Point-to-Point Protocol (PPP) and Challenge Handshake Authentication Protocol (CHAP). The objectives of this lab are as follows:

- Configure PPP
- Describe the meaning of the two interface status codes
- Configure CHAP
- Explain how CHAP does not send the password over the link when performing authentication

Scenario

This lab contains two main steps, as follows:

Step 1. Migrate from HDLC to PPP

Step 2. Add CHAP authentication to a PPP link

Initial Configurations

Examples 4-1 and 4-2 show the pertinent initial configurations of routers R1 and R2 in the lab video. The lab begins with a working network, using the default of High-Level Data Link Control (HDLC) as the data link protocol on the serial link. As usual, the parts of the configurations not relevant to this lab have been omitted.

Example 4-1 Initial Configuration for R1

```
hostname R1
!
interface FastEthernet 0/0
 ip address 172.16.1.1 255.255.255.0
!
interface serial 0/1/0
 ip address 172.22.2.1 255.255.255.0
 clock rate 1536000
 shutdown
!
router rip
 network 172.16.0.0
```

Example 4-2 Initial Configuration for R2

```
hostname R2
!
interface FastEthernet 0/0
 ip address 172.16.3.2 255.255.255.0
!
interface serial 0/1/0
 ip address 172.16.2.2 255.255.255.0
!
router rip
 network 172.16.0.0
```

Ending Configurations

This lab ends with both routers having migrated to using PPP and CHAP. Examples 4-3 and 4-4 show the configurations added to R1 and R2 during the lab.

Example 4-3 Configuration Added to R1 During the Lab

```
username R2 password depth
!
interface serial 0/1/0
 no shutdown
 encapsulation ppp
 ppp authentication chap
```

Example 4-4 Configuration Added to R2 During the Lab

```
username R1 password depth
!
interface serial 0/1/0
 encapsulation ppp
 ppp authentication chap
```

Video Presentation Reference

This video includes several figures that contain the same images used in the lab video. Because the video is organized into two separate steps, the reference materials have been organized into two separate sections. Each section simply lists these figures and tables for reference.

Step 1 Reference

Figure 4-1 Two Routers Using a Point-to-Point Serial Link

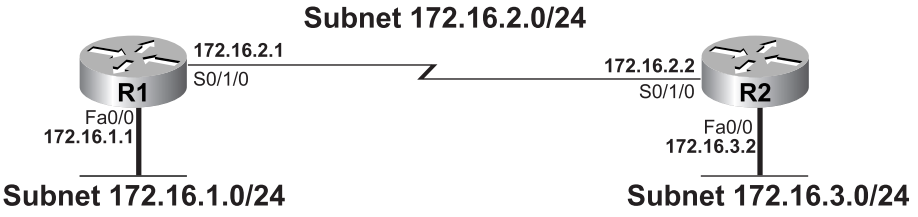


Table 4-1 lists the interface status code combinations and their meanings.

Table 4-1 Cisco Router Interface Status Code Combinations

First Interface Status Code	Second Interface Status Code	Most Likely Meaning
Administratively down	Down	Interface has been shut down
Down	Down	Layer 1 problem
Up	Down	Layer 2 problem
Up	Up	Interface is working

Step 2 Reference

Figure 4-2 Three-way CHAP Authentication Message Flow

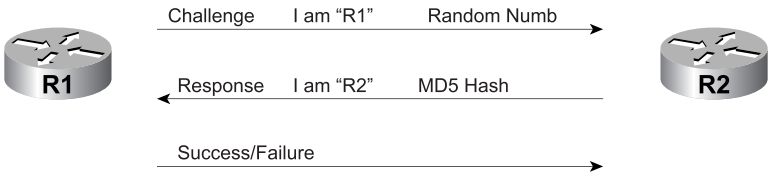


Figure 4-3 Comparing CHAP Configuration with CHAP Message Flow