CHAPTER 2

Single-Area OSPF

The Study Guide portion of this chapter uses a combination of matching, fill in the blank, open-ended questions, and unique custom exercises to test your knowledge on the theory of link-state routing protocols, single-area OSPF concepts, and single-area OSPF configuration.

The Lab Exercises portion of this chapter includes all the online curriculum labs as well as a comprehensive lab and a challenge lab to ensure that you have mastered the practical, hands-on skills needed about single-area OSPF.

Study Guide

Link-State Routing Overview

In this section of the Study Guide, you complete exercises that solidify your knowledge of the features, benefits, and limitations of link-state routing protocols. You also work on your OSPF vocabulary. The following exercises build on each other and are best done in sequence.

Vocabulary Exercise: Matching

Match the definition on the left with a term on the right. This exercise is not necessarily a one-to-one matching. Some definitions may be used more than once and some terms may have multiple definitions. Finally, some terms may not be used at all.

Definition

- **a.** A collection of networks under a common administration that share a common routing strategy
- **b.** Link-state routing protocol
- **c.** Attaches to multiple areas, maintains separate link-state databases for each area it is connected to, and routes traffic destined for or arriving from other areas
- **d.** Describes the details of OSPF link-state concepts and operations
- **e.** A listing of links used by the SPF algorithm to calculate the best paths through the network and build the SPF tree
- **f.** A group of contiguous subnets that is a logical subdivision of an autonomous system
- **g.** Flooded throughout an area when a failure occurs in the network, such as when a neighbor becomes unreachable
- **h.** An open-standard, link-state routing protocol designed to address the limitations of RIP
- **i.** Calculates and maintains a complex database of topology information
- **j.** Within each autonomous system, a contiguous transition area through which all other areas communicate
- **k.** Connects to an external routing domain that uses a different routing policy
- **l.** The part of the network through which multiple OSPF areas connect
- **m.** When this is not equal, the router with the highest will be the DR regardless of router ID values
- **j.** The Router ID for an OSPF router if no loopbacks are configured

Term

____ link-state database

____ Intermediate System-to-Intermediate System (IS-IS)

____ area

____ link-state advertisements

____ highest IP address

____ Open Shortest Path First (OSPF)

____ router priority

____ area 0

____ RFC 2328

____ Shortest Path First algorithm

____ autonomous system

____ Area Border Router (ABR)

____ topological database

_____ the backbone

____ Autonomous System Boundary Router (ASBR)

____________lowest IP address

____ Dijkstra

Vocabulary Exercise: Completion

Complete the paragraphs that follow by filling in appropriate words and phrases.

____________________________ and ____ protocols are classified as link-state routing protocols. RFC _____ describes OSPF link-state concepts and operations. Link-state routing protocols were designed to overcome the limitations of __________ routing protocols. When a failure occurs in the network, such as when a neighbor becomes unreachable, link-state protocols flood _____ (acronym) using a special _________ address throughout an area. A _____ is the same as an interface on a router. The state of the _____ is a description of an interface and the relationship to its neighboring routers. The collection of _______ forms a _________ database, sometimes called a topological database.

Link-state routers find the best paths to destinations by applying the _________________________ algorithm against the link-state database to build the shortest-path first (SPF) tree, with the _____ router as the root. The best paths are then selected from the SPF tree and placed in the _________________________

An ____________________ consists of a collection of networks under a common administration that share a common routing strategy. The __________ area is the transition point between areas in an AS because all other areas communicate through it.

Compare and Contrast Exercise

In the following table, list the benefits and limitations of link-state routing protocols. You should have at least four entries for each side of the table.

Benefits	Limitations

Concept Questions

What two names refer to the same algorithm used by all link-state routing protocols?

____

____

____

What is the difference between the way link-state routing protocols view the network and the way distance vector routing protocols view the network?

____

____

____

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____

____

Journal Entry

Describe a network implementation where a distance vector routing protocol would be preferred over a link-state routing protocol.

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Single-Area OSPF Concepts

One of the main limitations of OSPF is its sheer complexity. Although you are only responsible for understanding single-area OSPF concepts and configurations, it is still the most complex routing protocol you will use at the CCNA level. The exercises in the section focus on the conceptual framework of OSPF. It is important to have a good grasp of these concepts before proceeding into the configuration of OSPF. The following exercises build on each other and are best done in sequence.

Vocabulary Exercise: Completion

Complete the paragraphs that follow by filling in appropriate words and phrases.

OSPF is a routing protocol developed for IP networks by the OSPF working group of the ____________________________ OSPF has two primary characteristics. The first is that the protocol is an open _________________ which means that its specification is in the public domain, described in RFC 2328. The second principal characteristic is that OSPF is based on the _________________ algorithm.

OSPF is a ____________ routing protocol, whereas _______and _______ are distance vector routing protocols. Routers that are running distance vector algorithms send all or a portion of their _____________ in routing-update messages to their neighbors.

The term *link* simply refers to the ___________ on a router and its relationship to its neighboring _______ The collection all of these states forms the link-state database, which is an overall picture of networks in relation to routers.

The ability of OSPF to separate a large internetwork into multiple _______ is also referred to as hierarchical routing. Routing still occurs between _______ but recalculating databases can be isolated to the _______ where the change occurred.

The SPF algorithm is used to calculate the _______ of links. The OSPF _______ of an interface is inversely proportional to the _______ of that interface, so a higher _______ indicates a lower _______ The default formula used to calculate OSPF _______ is

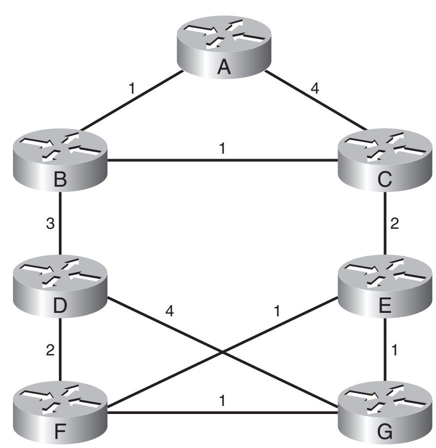
____

The SPF algorithm calculates a _______ topology using the _________________ as the starting point and examining, in turn, information it has about adjacent nodes.

Build the SPF Loop-Free Topology

A physical topology is shown in Figure 2-1. All seven routers are running OSPF in the same single area network. The OSPF cost value has been simplified for this exercise. Each link is labeled with its cost. Each router will use the SPF algorithm to construct a loop-free topology with the local router as the root. In the space provided or on a separate sheet of paper, draw the logical spanning-tree topology for each router. (Hint: Use a pencil. You will make mistakes.)

Figure 2-1 Build the SPF Loop-Free Topology



Example: The following describes how you would draw the spanning-tree topology in Figure 2-1a showing Router A as the local or root router. Start by drawing router A at the top. Router A can send traffic to both router B and router C. You can see that router A will always send traffic destined for router B directly to router B, so draw router B and connect it to router A. Label the link with the cost, which is 1. But will router A send traffic destined for router C directly to router C? No. The cost of 4 is too high compared to the path through router B, which has a cumulative cost of only 2. So, attach router C to router B and label the link with its cost. Now, how would router A send traffic to router D? It would send it to router B, which would forward the traffic directly to router D because the cumulative cost of 4 is lower than the cumulative cost to forward the traffic to router C. So, attach router D to router B and label the link with its cost. Now router B has three routers attached to it. Continue adding routers. Router E would receive traffic from router A via router C. Both router F and router G would receive traffic from router A via router E.

Figure 2-1a Loop-free Topology for Router A

Figure 2-1b Loop-free Topology for Router B

Figure 2-1c Loop-free Topology for Router C

Figure 2-1d Loop-free Topology for Router D

Figure 2-1e Loop-free Topology for Router E

Figure 2-1f Loop-free Topology for Router F

Figure 2-1g Loop-free Topology for Router G

Concept Questions

What is the formula Cisco IOS uses to calculate the cost metric for OSPF?

____

What is the OSPF cost of a T1 link?

____

What is the OSPF cost of a Fast Ethernet link?

____

What is the OSPF cost of a 56-kps dialup link?

____

The routers within an OSPF area have converged. What can you safely assume about the link-state databases of all the routers within the area?

____

____

____

Name at least three advantages of OSPF that relate to its hierarchical routing characteristic.

____

- ____
- ____
- ____

Single-Area OSPF Configuration

Now that you have a good understanding of how OSPF works, it is time to learn the configuration commands that you use in a single-area OSPF network. The first exercise in this section takes you step-by-step through an OSPF configuration. The second exercise focuses on a topic that often causes problems for students: the DR/BDR election. The final exercise is a journal entry. These exercises build on each other and are best done in sequence.

Learn the OSPF Commands Exercise

1. Document the command syntax, including router prompt, to configure the OSPF routing process.

   ____

2. The value for *process-id* can be any number between __ and ______
3. True or False: All routers in an area must have the same *process-id*.

   ____

   ____

4. The command syntax, including router prompt, for adding network statements to the OSPF routing process is

   ____

5. For single area OSPF configurations, the *area-id* should always be __
6. The *wildcard-mask* argument works the same way as wildcard masks in access control list statements. List the corresponding wildcard mask for each of the following subnet masks:

   255.255.255.0 ______________________

   255.255.255.128 ______________________

   255.255.255.192 ______________________

   255.255.255.240 ______________________

   255.255.0.0 ______________________

   255.255.252.0 ______________________

   255.255.240.0 ______________________

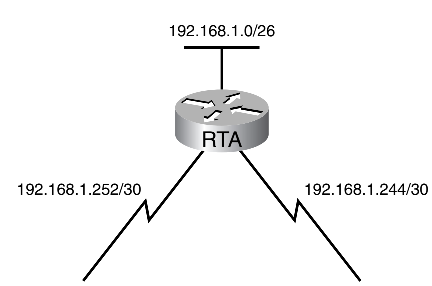
   255.0.0.0 ______________________

   255.224.0.0 ______________________

   255.248.0.0 ______________________

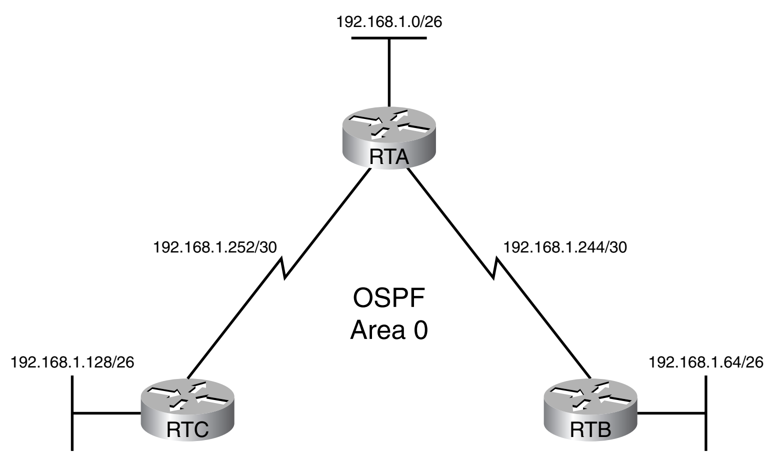
7. Refer to Figure 2-2. In the space provided, document the correct commands, including router prompt, to configure RTA to advertise all directly connected networks in OSPF.

Figure 2-2 RTA OSPF Configuration



8. OSPF routers that share a common link become ____________ on that link. In Figure 2-3, RTB and RTC are ____________of RTA, but not of each other. These routers send each other OSPF _________ packets to establish adjacency. These packets also act as ____________ so that each router knows that adjacent routers are still functional.

Figure 2-3 Establishing OSPF Adjacency



9. Using Figure 2-3, document the correct commands, including router prompt, to configure RTB and RTC to advertise all directly connected networks in OSPF.

Note: Now is a good time to complete Curriculum Lab 2-1: Configuring the OSPF Routing Process (2.3.1).

10. On ______________ networks (networks supporting more than two routers) such as ______________ and Frame-Relay networks, the Hello protocol elects a ________________________ and a ____ Among other things, the ______________is

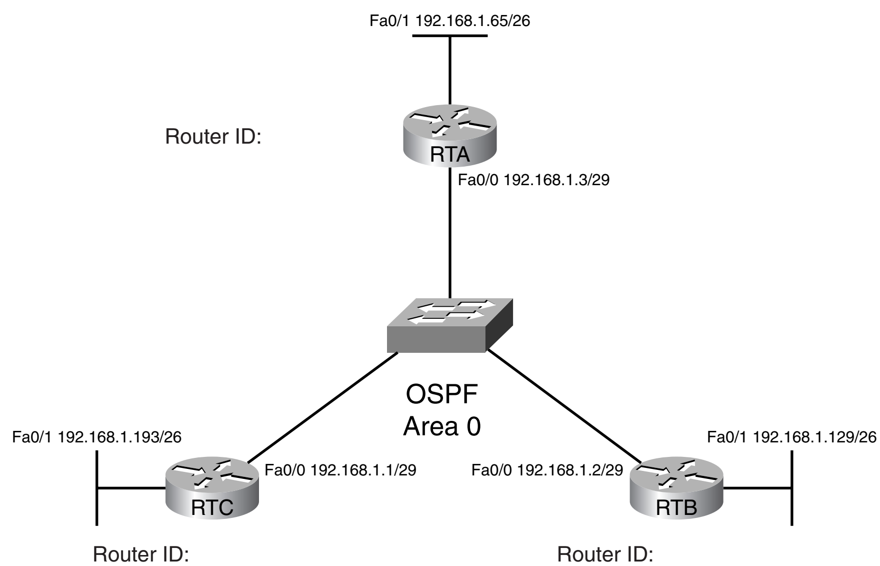
responsible for generating LSAs for the entire multiaccess network, which reduces both routing-update traffic and management of ______________ synchronization.

11. The DR/BDR election is based on OSPF ____________ and OSPF ______________ By default, all OSPF routers have a _________ of ___ If all OSPF routers have the same _________ the highest ______________ determines the DR and BDR.

12. Unless a loopback interface is configured, the __________ IP address on an active interface at the moment of OSPF process startup is used as the ___________

13. In Figure 2-4, label each router with its router ID. Assume that all routers came up simultaneously and that all interfaces are active.

Figure 2-4 Determine the Router ID



14. In Figure 2-4, which router would be the DR? _________ BDR? ________

15. You can override the Router ID that OSPF chooses by configuring an IP address on a ________ interface. This will provide stability to your OSPF network, because ________ interfaces do not become inactive.

16. The syntax for configuring a loopback interface with an IP address is

____

____

17. Assume that network policy has determined that RTA is best suited to be the DR. In addition, the policy states that all OSPF routers will be configured with a loopback interface, as follows, to provide stability to OSPF:

- 10.0.0.3/32 for RTA
- 10.0.0.2/32 for RTB
- 10.0.0.1/32 for RTC

18. Document the correct commands, including router prompt, to configure loopback interfaces on each router.

____
____
____
____
____
____

19. With loopback interfaces now configured on each router, what must you do to change which router is DR?

____
____
____
____
____

Note: Now is a good time to complete Curriculum Lab 2-2: Configuring OSPF with Loopback Addresses (2.3.2).

20. In addition to configuring loopbacks, it would be a good idea to configure RTA with an OSPF priority that ensures that it always wins the DR/BDR election. The syntax for configuring OSPF priority is

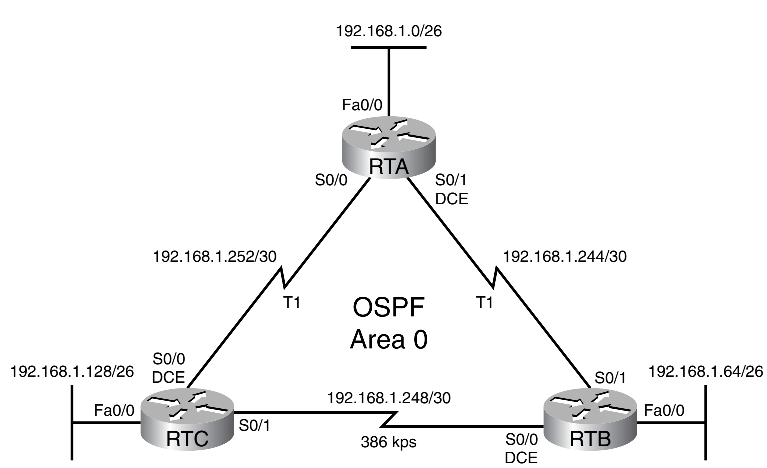
____

21. Document the commands you would configure on RTA to make sure its priority always wins the DR/BDR election.

____
____
____

22. In Figure 2-5, note the differences in bandwidth. If OSPF uses the default bandwidth on the serial interfaces to calculate the cost, RTB will send traffic destined for the LAN on RTC directly to RTC, and RTC will send traffic destined for the LAN on RTB directly to RTB. However, the path through RTA is faster. There are two ways to force RTB and RTC to send traffic to RTA. Explain the two different ways to configure the correct cost. In what situations would one be better than the other?

Figure 2-5 Configure OSPF Cost Metric



23. RTB and RTC are both Cisco 2600 series routers. The default bandwidth on serial interfaces for 2600 routers is 1544 kbps (T1). What command would you enter to verify the default or configured bandwidth on an interface? _____ _______ Referring to Figure 2-5, document the commands needed to configure the bandwidth correctly so that OSPF uses an accurate cost metric.

Note: Now is a good time to complete Curriculum Lab 2-3: Modifying OSPF Cost Metric (2.3.3).

24. By default, a router trusts that information arriving from another router is "believable." However, to avoid malicious or inadvertent misinformation, you should configure authentication. The Cisco IOS has two methods for authenticating OSPF routing updates: simple authentication and encrypted authentication. With simple authentication, passwords are sent in clear text, affording no protection from sniffer programs. Document the command syntax, including router prompt, to configure simple authentication (two commands).

25. You should use encrypted authentication whenever possible. Document the command syntax, including router prompt, to configure encrypted authentication (two commands).

26. Document the commands necessary to configure encrypted authentication of OSPF routing updates for the routers in Figure 2-5. Because the commands are the same for all three routers, it is only necessary that you document the commands for RTA. Use "allrouters" as the key.

Note: Now is a good time to complete Curriculum Lab 2-4: Configuring OSPF Authentication (2.3.4).

27. The DR, BDR, and every other router in an OSPF network sends out Hellos using _______________ as the destination address. If a DRother (a router that is not the DR) needs to send an LSA, it will send it using _______________ as the destination address. The DR and the BDR will receive LSAs at this address.

28. Complete the following table by listing the four types of OSPF networks and whether they have a DR/BDR election.

Network Type Election?	Characteristics	DR/BDR
	Ethernet, Token Ring, or FDDI	
	Frame Relay, X.25, SMDS	
	PPP, HDLC	
_	Configured by an administrator	

29. OSPF routers must use matching ________ intervals and ________ intervals on the same link. These are used to time the exchange of link-state information as well as to determine when a link is down.

30. On broadcast OSPF networks, the default ________ interval is ____ seconds and the default ________ interval is ___ seconds. On nonbroadcast networks, the default ________ interval is _____ seconds and the default ________ interval is ____ seconds.

31. These default interval values result in efficient OSPF operation and seldom need to be modified. However, you can change them. Document the command syntax, including router prompt, to change these values.

____

____

32. Again, refer to Figure 2-5. Assuming that the current intervals are 10 and 40, document the commands necessary to change these intervals on the link between RTB and RTC to a value four times greater than the current value.

____

____

____

____

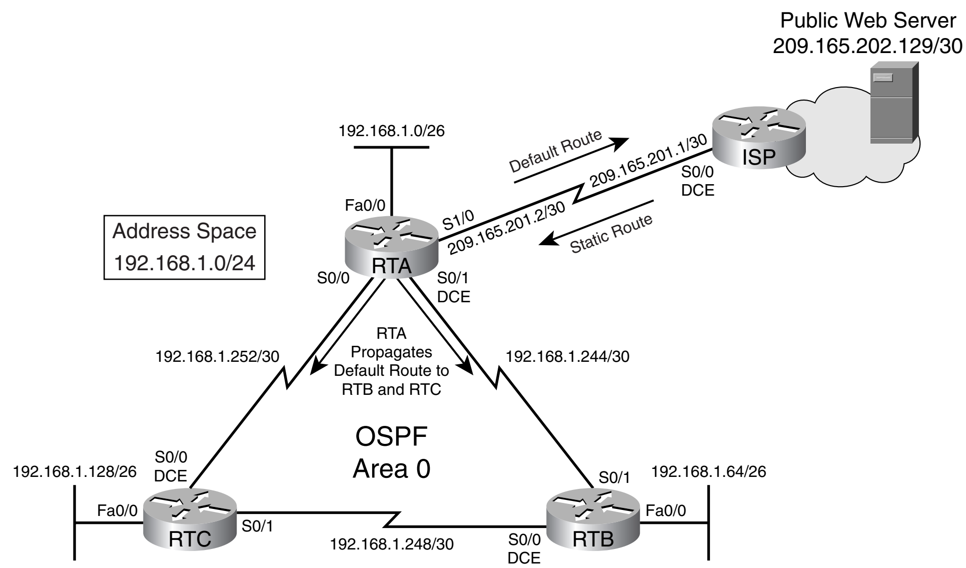
____

____

Note: Now is a good time to complete Curriculum Lab 2-5: Configuring OSPF Timers (2.3.5).

33. Refer to Figure 2-6 for the remaining questions in this section. RTA is your gateway router because it provides access outside the area. In OSPF terminology, RTA is called the _______________________ _________________________ because it connects to an external routing domain that uses a different routing policy.

Figure 2-6 Propagating a Default Route



34. Each routing protocol handles the propagation of default routing information a little differently. For OSPF, the gateway router must be configured with two commands. First, RTA needs a static default route (also known as the "quad-zero" route) pointing to ISP. Document the command syntax to configure a static default route on RTA.

____

35. Using the *interface* argument, document the command necessary to configure RTA with a static default route pointing to ISP.

____

36. At this point, RTA can send pings to ISP, and ISP will respond as long as the pings are sourced from the serial 1/0 interface on RTA. However, any ping coming from the 192.168.1.0/24 address space will be discarded by ISP. Why?

____

37. Document the command syntax used to configure a static route.

____

38. Using the *next-hop-address* argument, document the command necessary to configure ISP with a static route pointing to the 192.168.1.0/24 address space.

____

39. At this point, any host on the LAN attached to RTA will be able to access ISP and ping the Public Web Server at 209.165.202.129. However, RTB and RTC still cannot ping outside the 192.168.1.0/24 address space. Why?

____

40. Document the command that needs to be configured on RTA to fix this problem.

____

Note: Now is a good time to complete Curriculum Lab 2-6: Propagating Default Routes in an OSPF Domain (2.3.6).

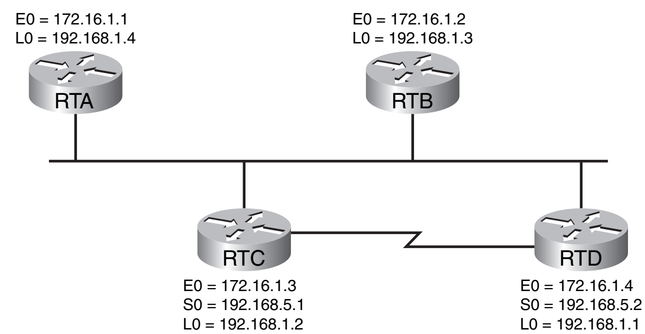
DR/BDR Election Exercise

In the following exercises, assume that all routers are simultaneously booted. Determine the network type, if applicable, and label which router is elected as the DR and which router is elected as the BDR.

Hint: Remember, if priority is equal, router ID determines DR and BDR.

Refer to Figure 2-7 and answer the following questions:

Figure 2-7 DR/BDR Election Exercise 1 Topology



What is the router ID for RTA? ____________________

What is the router ID for RTB? ____________________

What is the router ID for RTC? ____________________

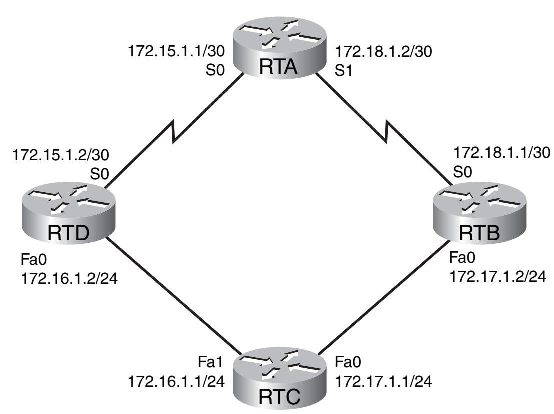
What is the router ID for RTD? ____________________

Which router will be elected R? ____________________

Which router will be elected BDR? ____________________

Refer to Figure 2-8 and determine whether there will be a DR/BDR election. If applicable, designate which router is DR and which router is BDR.

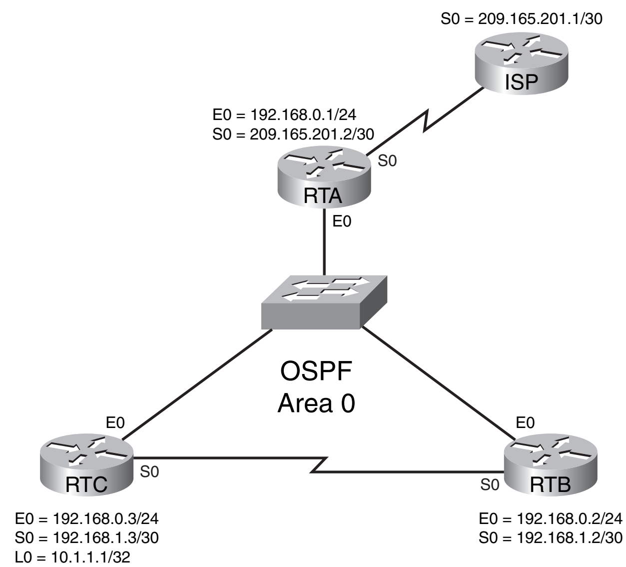
Figure 2-8 DR/BDR Election Exercise 2 Topology



Network	DR/BDR Election?	Which Router Is the DR?	Which Router Is the BDR?
172.15.1.0/30			
172.16.1.0/24			
172.17.1.0/24			
172.18.1.0/30			

Refer to Figure 2-9 and answer the following questions:

Figure 2-9 DR/BDR Election Exercise 3 Topology



What is the router ID for RTA? ______________________________

What is the router ID for RTB? ______________________________

What is the router ID for RTC? ______________________________

Which router is DR for the 192.168.0.0/24 network? ______________________________

Which router is BDR for the 192.168.0.0/24 network? ______________________________

Assuming a priority of zero on RTA, which router is DR for the 192.168.1.0/24 network? ______________

What will happen if another router, RTD, joins the 192.168.1.0/24 network with a router ID of 209.165.201.9?

____

Journal Entry

In a simple three-router topology, it may not be necessary to run OSPF as your routing protocol. Under what circumstances would you choose to use OSPF instead of RIPv2?

____

____

____

____

Lab Exercises

Command Reference

In the table that follows, record the command, including the correct router prompt, that fits the description. Fill in any blanks with the appropriate missing information.

Command	Description
	Turns on OSPF process number 123. The process ID is any value between ___ and _____ The process ID *does not equal* the OSPF area.
	OSPF advertises interfaces, not networks. Uses the wildcard mask to determine which interfaces to advertise. The command shown reads: any interface with an address of 172.16.10.x is to be put into area 0.
	Creates the virtual interface loopback 0.
	Changes the OSPF priority for an interface to 50.
	Changes the bandwidth of an interface to 128 kbps.
	Changes the cost to a value of 1564.
	Turns on simple authentication within the OSPF routing process.
	Sets the simple authentication key (password) to fred on an interface.
	Turns on MD5 authentication within the OSPF routing process.
	Sets 1 as the *key-id* and fred as the *key* on an interface.
	Changes the Hello Interval timer to 20 seconds.
	Changes the Dead Interval timer to 80 seconds.
	Creates a static default route pointing out the serial 0/0 interface. This route will have an administrative distance of
	Creates a static default route pointing to the next-hop IP address of 192.168.1.1. This route will have an administrative distance of
	Sets the default route to be propagated to all OSPF routers.
	Displays parameters for all routing protocols running on the router.

Command	Description
	Displays complete IP routing table.
	Displays basic OSPF information for all OSPF processes running on the router.
	Displays OSPF information as it relates to all interfaces.
	List all the OSPF neighbors and their states.
	Displays a detailed list of neighbors.
	Clears entire routing table, forcing it to rebuild.
	Resets OSPF counters.
	Resets *entire* OSPF process, forcing OSPF to re-create neighbors, the database, and the routing table.
	Displays *all* OSPF events.
	Displays the various OSPF states as neighbors form adjacencies as well as the DR and BDR election between adjacent routers.
	Displays OSPF packets as they are sent and received.

Curriculum Lab 2-1: Configuring the OSPF Routing Process (2.3.1)

Figure 2-10 Topology for Lab 2-1

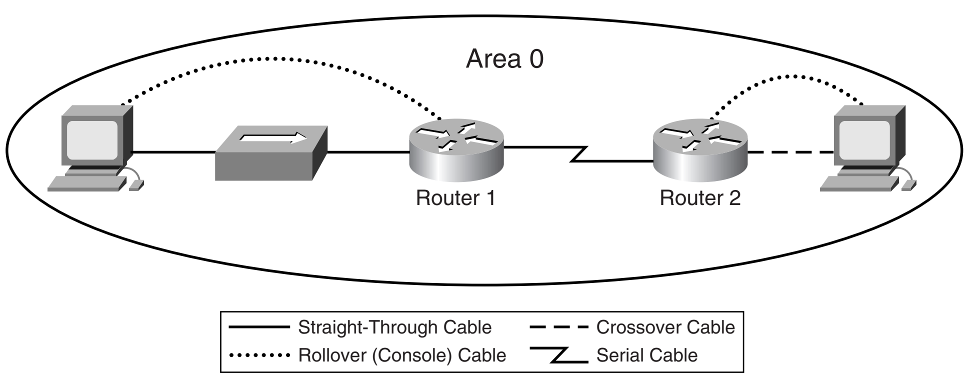


Table 2-1 Lab Equipment Configuration

Router Designation	Router Name	Routing Protocol	Network Statements
Router 1	BERLIN	OSPF	192.168.1.128
			192.168.15.0
Router 2	ROME	OSPF	192.168.15.0
			192.168.0.0

The enable secret password for both routers is **class**.

The enable, VTY, and console password for both routers is **cisco**.

Table 2-2 Lab Equipment Interface/IP Address Configurations

Router Designation	IP Host Table Entry	Fast Ethernet 0 Address/Subnet Mask	Interface Type Serial 0	Serial 0 Address/ Subnet Mask
Router 1	ROME	192.168.1.129/26	DCE	192.168.15.1/30
Router 2	BERLIN	192.168.0.1/24	DTE	192.168.15.2/30

The interface type and address/subnet mask for the serial 1 interface on both routers is not applicable for this lab.

The "IP Host Table Entry" column contents indicate the names of the other routers in the IP host table.

Objectives

- Set up an IP addressing scheme for OSPF area 0.
- Configure and verify OSPF routing.

Background/Preparation

Cable a network that is similar to the one in Figure 2-10. You can use any router that meets the interface requirements in Figure 2-10 (that is, 800, 1600, 1700, 2500, and 2600 routers or a combination). Refer to the information in Appendix A, "Router Interface Summary Chart," to correctly specify the interface identifiers based on the equipment in your lab. The 1721 series routers produced the configuration output in this lab. Another router might produce slightly different output. You should execute the following steps on each router unless you are specifically instructed otherwise. Start a HyperTerminal session.

Implement the procedure documented in Appendix C, "Erasing and Reloading the Router," before you continue with this lab.

Task 1: Configure the Routers

On the routers, enter global configuration mode and configure the hostname as shown in Table 2-1. Then, configure the console, virtual terminal, and enable passwords. Next, configure the interfaces according to Table 2-2. Finally, configure the IP hostnames. Do not configure the routing protocol until you are specifically told to. If you have problems configuring the router basics, refer to Lab 1-2, "Review of Basic Router Configuring with RIP."

Note: You may need to add the command **ip subnet-zero** because of the use of the ZERO subnet with VLSM on the 192.168.1.0/30 and 192.168.1.128/26 networks.

Task 2: Save the Configuration Information from Privileged EXEC Command Mode

```
BERLIN#copy running-config startup-config
Destination filename [startup-config]? [Enter]
```

Why save the running configuration to the startup configuration?

____

Task 3: Configure the Hosts

Step 1. Configure the hosts with the proper IP address, subnet mask, and default gateway.

Step 2. Each workstation should be able to ping the attached router. Troubleshoot as necessary. Hint: Remember to assign a specific IP address and default gateway to the workstation. If you are running Windows 98, check using **Start > Run > winipcfg**. If you are running Windows 2000, check using **ipconfig** in a DOS window.

Step 3. At this point, the workstations will not be able to communicate with each other. The following tasks will demonstrate the process that is required to get communication working while using OSPF as the routing protocol.

Task 4: View the Router's Configuration and Interface Information

Step 1. At the privileged EXEC mode prompt, type the following:

```
BERLIN#show running-config
```

Step 2. Using the **show ip interface brief** command, check the status of each interface.

What is the state of the interfaces on each router?

BERLIN:

Fast Ethernet 0: ____

Serial 0: ____

Serial 1: ____

ROME:

Fast Ethernet 0: ____

Serial 0: ____

Serial 1: ____

Step 3. Ping from one of the connected serial interfaces to the other.

Was the ping successful? ____

Step 4. If the ping was not successful, troubleshoot the router configuration until the ping is successful.

Task 5: Configure OSPF Routing on Router BERLIN

Step 1. Configure an OSPF routing process on router BERLIN. Use OSPF process number 1 and ensure that all networks are in area 0.

```
BERLIN(config)#router ospf 1
BERLIN(config-router)#network 192.168.1.128 0.0.0.63 area 0
BERLIN(config-router)#network 192.168.15.0 0.0.0.3 area 0
BERLIN(config-router)#end
```

Step 2. Examine the routers that are running configuration files.

Did the IOS version automatically add any lines under router OSPF 1? ____________________

If so, what did it add? ____

Step 3. If there were no changes to the running configuration, type the following commands:

```
BERLIN(config)#router ospf 1
BERLIN(config-router)#log-adjacency-changes
BERLIN(config-router)#end
```

Step 4. Show the routing table for the BERLIN router.

```
BERLIN#show ip route
```

Do entries exist in the routing table? ____

Why?

____

Task 6: Configure OSPF Routing on Router ROME

Step 1. Configure an OSPF routing process on router ROME. Use OSPF process number 1 and ensure that all networks are in area 0.

```
ROME(config)#router ospf 1
ROME(config-router)#network 192.168.0.0 0.0.0.255 area 0
ROME(config-router)#network 192.168.15.0 0.0.0.3 area 0
ROME(config-router)#end
```

Step 2. Examine the ROME router running configuration files.

Did the IOS version automatically add lines under router OSPF 1? ________________________

If so, what did it add? ____

Step 3. If there were no changes to the running configuration, type the following commands:

```
ROME(config)#router ospf 1
ROME(config-router)#log-adjacency-changes
ROME(config-router)#end
```

Step 4. Show the routing table for the ROME router.

```
ROME#show ip route
```

Are there OSPF entries in the routing table now? ______________________________________

What is the metric value of the OSPF route?

____

What is the VIA address in the OSPF route? ______________________________

Are routes to all networks shown in the routing table? ______________________

What does the O mean in the first column of the routing table?

____

Task 7: Test Network Connectivity

Ping the BERLIN host from the ROME host. Was it successful? ______________________

If not, troubleshoot as necessary.

After you complete the previous steps, log off (by typing **exit**) and turn the router off. Then, remove and store the cables and adapter.

Curriculum Lab 2-2: Configuring OSPF with Loopback Addresses (2.3.2)

Figure 2-11 Topology for Lab 2-2

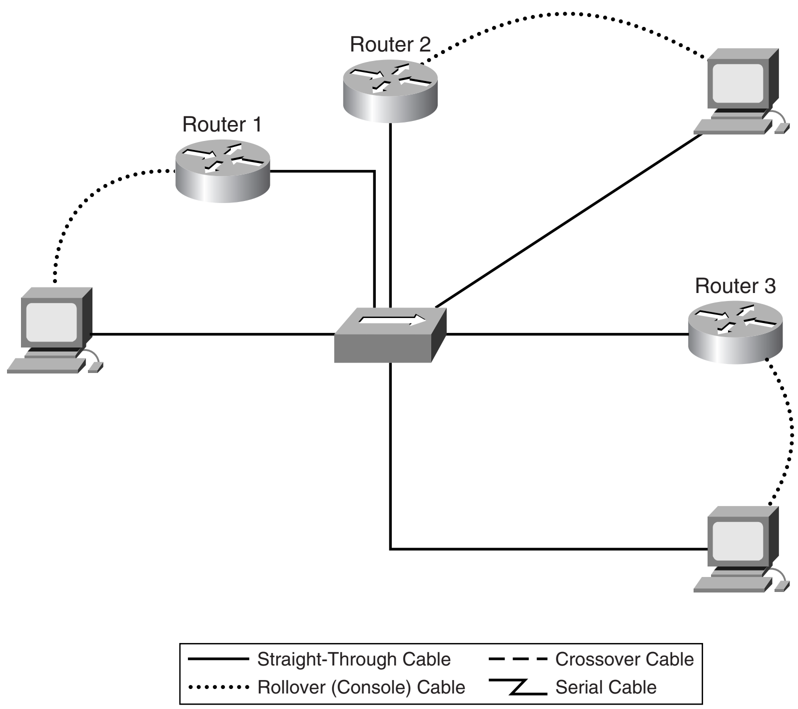


Table 2-3 Lab Equipment Configuration: Part I

Router Designation	Router Name	Routing Protocol	OSPF Routing ID	Network Statements
Router 1	London	OSPF	1	192.168.1.0
Router 2	Ottawa	OSPF	1	192.168.1.0
Router 3	Brasilia	OSPF	1	192.168.1.0

The enable secret password for all routers is **class**.

The enable, VTY, and console passwords for each router is **cisco**.

Table 2-4 Lab Equipment Configuration: Part II

Router Designation	IP Host Table Entry	Fast Ethernet 0 Address/Subnet Mask	Loopback Interface/ Subnet Mask
Router 1	Ottawa Brasilia	192.168.1.1/24	192.168.31.11/32
Router 2	London Brasilia	192.168.1.2/24	192.168.31.22/32
Router 3	London Ottawa	192.168.1.3/24	192.168.31.33/32

The "IP Host Table Entry" column contents indicate the names of the other routers in the IP host table.

Objectives

- Configure routers with a Class C IP addressing scheme.
- Observe the election process for designated routers (DR) and backup designated routers (BDR) on the multiaccess network.
- Configure loopback addresses for OSPF stability.
- Assign each OSPF interface a priority to force the election of a specific router as DR.

Background/Preparation

Cable a network that is similar to the one in Figure 2-11. You can use any router that meets the interface requirements in Figure 2-11 (that is, 800, 1600, 1700, 2500, and 2600 routers or a combination). Refer to the information in Appendix A to correctly specify the interface identifiers based on the equipment in your lab. The 1721 series routers produced the configuration output in this lab. Another router might produce slightly different output. You should execute the following steps on each router unless you are specifically instructed otherwise. Start a HyperTerminal session.

Implement the procedure documented in Appendix C on all routers before continuing with this lab.

Task 1: Configure the Routers

On the routers, enter global configuration mode and configure the hostname as shown in Table 2-3. Then, configure the console, virtual terminal, and enable passwords. Next, configure the interfaces and the IP hostnames according to the Lab Equipment Configuration tables, Tables 2-3 and 2-4. If you have problems configuring the router basics, refer to Lab 1-2, "Review of Basic Router Configuring with RIP."

Note: Do not configure loopback interfaces and routing protocols yet.

Task 2: Save the Configuration Information for All the Routers

Why should you save the running configuration to the startup configuration?

____

Task 3: Configure the Hosts

Step 1. Configure the hosts with the proper IP address, subnet mask, and default gateway.

Step 2. Each workstation should be able to ping all the attached routers, because they are all part of the same subnetwork. Troubleshoot as necessary. Hint: Remember to assign a specific IP address and default gateway to the workstation. If you are running Windows 98, check using **Start > Run > winipcfg**. If you are running Windows 2000, check using **ipconfig** in a DOS window.

Step 3. At this point, the workstations will not be able to communicate with each other. The following tasks demonstrate the process required to get communication working by using OSPF as the routing protocol.

Task 4: View the Router's Configuration and Interface Information

Step 1. At the privileged EXEC mode prompt, type **show running-config**.

Step 2. Using the **show ip interface brief** command, check the status of each interface.

What is the state of the interfaces on each router?

London:

- Fast Ethernet 0: ______________________________
- Serial 0: ______________________________
- Serial 1: ______________________________

Ottawa:

- Fast Ethernet 0: ______________________________
- Serial 0: ______________________________
- Serial 1: ______________________________

Brasilia:

- Fast Ethernet 0: ______________________________
- Serial 0: ______________________________
- Serial 1: ______________________________

Task 5: Verify Connectivity of the Routers

Ping all the connected Fast Ethernet interfaces from each other.

Were the pings successful? ______________________________

If the pings were not successful, troubleshoot the router configuration until the ping is successful.

Task 6: Configure OSPF Routing on Router London

Step 1. Configure an OSPF routing process on router London. Use OSPF process number 1 and ensure that all networks are in area 0.

```
London(config)#router ospf 1
London(config-router)#network 192.168.1.0 0.0.0.255 area 0
London(config-router)#end
```

Step 2. Examine the London router running the configuration file.

Did the IOS version automatically add lines under router OSPF 1? ________________________

Step 3. If there were no changes to the running configuration, type the following commands:

```
London(config)#router ospf 1
London(config-router)#log-adjacency-changes
London(config-router)#end
```

Step 4. Show the routing table for the London router:

```
London#show ip route
```

Are entries in the routing table? ________________________

Why?

____

Task 7: Configure OSPF Routing on Router Ottawa

Step 1. Configure an OSPF routing process on router Ottawa. Use OSPF process number 1 and ensure that all networks are in area 0.

```
Ottawa(config)#router ospf 1
Ottawa(config-router)#network 192.168.1.0 0.0.0.255 area 0
Ottawa(config-router)#end
```

Step 2. Examine the Ottawa router running configuration files.

Did the IOS version automatically add lines under router OSPF 1? ________________________

Step 3. If no changes were made to the running configuration, type the following commands:

```
Ottawa(config)#router ospf 1
Ottawa(config-router)#log-adjacency-changes
Ottawa(config-router)#end
```

Task 8: Configure OSPF Routing on Router Brasilia

Step 1. Configure an OSPF routing process on router Brasilia. Use OSPF process number 1 and ensure that all networks are in area 0.

```
Brasilia(config)#router ospf 1
Brasilia(config-router)#network 192.168.1.0 0.0.0.255 area 0
Brasilia(config-router)#end
```

Step 2. Examine the Brasilia router running configuration files.

Did the IOS version automatically add lines under router OSPF 1? ________________________

What did it add? ________________________

Step 3. If there were no changes to the running configuration, type the following commands:

```
Brasilia(config)#router ospf 1
Brasilia(config-router)#log-adjacency-changes
Brasilia(config-router)#end
```

Task 9: Test Network Connectivity

Ping the Brasilia router from the London router. Was it successful? ______________________________

If not, troubleshoot as necessary.

Task 10: Show OSPF Adjacencies

Type the command **show ip ospf neighbor** on all routers to verify that the OSPF routing has formed adjacencies.

Is there a designated router identified? ______________________________

Is there a backup designated router? ______________________________

Type the command **show ip ospf neighbor detail** for more information.

What is the neighbor priority of 192.168.1.1 from router Brasilia? ______________________________

What interface is identified as being part of area 0? ______________________________

Task 11: Configure the Loopback Interfaces

Configure the loopback interface on each router to allow for an interface that will not go down due to network change or failure. You can accomplish this by typing **interface loopback #** at the global configuration mode prompt, where the # represents the number of the loopback interface from 0 to 2,147,483,647.

```
London(config)#interface loopback 0
London(config-if)#ip address 192.168.31.11 255.255.255.255
London(config-router)#end

Ottawa(config)#interface loopback 0
Ottawa(config-if)#ip address 192.168.31.22 255.255.255.255
Ottawa(config-router)#end

Brasilia(config)#interface loopback 0
Brasilia(config-if)#ip address 192.168.31.33 255.255.255.255
Brasilia(config-router)#end
```

Task 12: Save the Configuration Information for All the Routers

After you save the configurations on all the routers, power them down and back up again.

Task 13: Show OSPF Adjacencies

Step 1. Type the command **show ip ospf neighbor** on all routers to verify that the OSPF routing has formed adjacencies.

Is a designated router identified? ______________________________

What are the Router ID and link address of the DR?

____

Is there a backup designated router? ______________________________

What are the Router ID and link address of the BDR?

____

What is the third router referred to as? ______________________________

What is that router's ID and link address?

____

Step 2. Type the command **show ip ospf neighbor detail** for more information.

What is the neighbor priority of 192.168.1.1 from router Brasilia? ______________

Which interface is identified as being part of area 0? ______________________

Task 14: Verify OSPF Interface Configuration

Type **show ip ospf interface fastethernet 0** on the London router.

What is the OSPF state of the interface? ______________________________

What is the default priority of the interface? ___________________________

What is the network type of the interface? _____________________________

Task 15: Configure London to Always Be the DR

Step 1. To ensure that the London router always becomes the DR for this multiaccess segment, you must set the OSPF priority. London is the most powerful router in the network, so it is best suited to become the DR. Giving London's loopback a higher IP address is not advised because the numbering system has advantages for troubleshooting. Also, London is not to act as the DR for all segments to which it might belong.

Step 2. Set the priority of the interface to 50 on the London router only.

```
London(config)#interface fastethernet 0/0
London(config-if)#ip ospf priority  50
London(config-router)#end
```

Step 3. Display the priority for interface FastEthernet 0/0.

```
London#show ip ospf interface fastethernet 0/0
```

Task 16: Watch the Election Process

To watch the OSPF election process, restart all the routers. As soon as the router prompt is available, type the following:

```
Ottawa>enable
Ottawa#debug ip ospf events
```

Which router was elected DR? __________________________________

Which router was elected BDR? _________________________________

Why?

____

To turn off all debugging, type **undebug all**.

Task 17: Show OSPF Adjacencies

Type the command **show ip ospf neighbor** on the Ottawa router to verify that the OSPF routing has formed adjacencies.

What is the priority of the DR? ____

After you complete the previous steps, log off (by typing **exit**) and turn the router off. Then, remove and store the cables and adapter.

Curriculum Lab 2-3: Modifying OSPF Cost Metric (2.3.3)

Figure 2-12 Topology for Lab 2-3

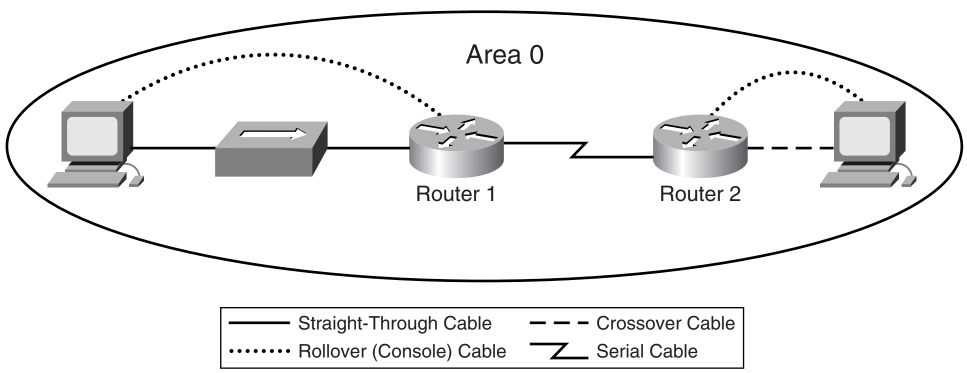


Table 2-5 Lab Equipment Configuration: Part I

Router Designation	Router Name	Routing Protocol	Network Statements
Router 1	Cairo	OSPF	192.168.1.0
Router 2	Moscow	OSPF	192.168.1.0 192.168.0.0

The enable secret password for both routers is **class**.

The enable, VTY, and console password for both routers is **cisco**.

Table 2-6 Lab Equipment Configuration: Part II

Router Designation	IP Host Table Entry	Fast Ethernet 0 Address/Subnet Mask	Interface Type Serial 0	Serial 0 Address/ Subnet Mask
Router 1	Moscow	192.168.1.129/26	DCE	192.168.1.1/30
Router 2	Cairo	192.168.0.1/24	DTE	192.168.1.2/30

The interface type and address/subnet mask for the serial 1 interface on both routers are not applicable for this lab.

The "IP Host Table Entry" column contents indicate the names of the other routers in the IP host table.

Objectives

- Set up an IP addressing scheme for the OSPF area.
- Configure and verify OSPF routing.
- Modify the OSPF cost metric on an interface.

Background/Preparation

Cable a network that is similar to the one in Figure 2-12. You can use any router that meets the interface requirements in Figure 2-12 (that is, 800, 1600, 1700, 2500, and 2600 routers or a combination). Refer to the information in Appendix A to correctly specify the interface identifiers based on the equipment in your lab. The 1721 series routers produced the configuration output in this lab. Another router might produce slightly different output. You should execute the following steps on each router unless you are specifically instructed otherwise.

Start a HyperTerminal session.

Implement the procedure documented in Appendix C on all routers before you continue with this lab.

Task 1: Configure the Routers

On the routers, enter the global configuration mode and configure the hostname, console, virtual terminal, and enable passwords. Next, configure the interfaces and IP hostnames according to the Lab Equipment Configuration tables, Tables 2-5 and 2-6. If you have problems configuring the router basics, refer to Lab 1-2, "Review of Basic Router Configuring with RIP."

Note: You may need to add the command **ip subnet-zero** because of the use of the ZERO subnet with VLSM on the 192.168.1.0/30 and 192.168.1.128/26 networks.

Note: Do not configure the routing protocol until you are specifically told to.

Task 2: Save the Configuration Information from Privileged EXEC Command Mode

```
Cairo#copy running-config startup-config
Destination filename [startup-config]?[Enter]
Moscow#copy running-config startup-config
Destination filename [startup-config]?[Enter]
```

Why should you save the running configuration to the startup configuration?

____

Task 3: Configure the Hosts

Step 1. Configure the hosts with the proper IP address, subnet mask, and default gateway.

Default gateway: 192.168.0.1

Step 2. Each workstation should be able to ping the attached router. Troubleshoot as necessary. Hint: Remember to assign a specific IP address and default gateway to the workstation. If you are running Windows 98, check using **Start > Run > winipcfg**. If you are running Windows 2000, check using **ipconfig** in a DOS window.

Step 3. At this point, the workstations will not be able to communicate with each other. The following tasks demonstrate the process that is required to get communication working while using OSPF as the routing protocol.

Task 4: View the Router's Configuration and Interface Information

Step 1. At the privileged EXEC mode prompt, type the following:

```
Cairo#show running-config
```

Step 2. Using the **show ip interface brief** command, check the status of each interface.

What is the state of the interfaces on each router?

Cairo:

- Fast Ethernet 0: ______________________________
- Serial 0: ______________________________

Moscow:

- Fast Ethernet 0: ______________________________
- Serial 0: ______________________________

Step 3. Ping from one of the connected router serial interfaces to the other.

Was the ping successful? ______________________________

If the ping was not successful, troubleshoot the router configuration until the ping is successful.

Task 5: Configure OSPF Routing on Router Cairo

Step 1. Configure OSPF routing on each router. Use OSPF process number 1 and ensure that all networks are in area 0.

```
Cairo(config)#router ospf 1
Cairo(config-router)#network 192.168.1.128 0.0.0.63 area 0
Cairo(config-router)#network 192.168.1.0 0.0.0.3 area 0
Cairo(config-router)#end
```

Step 2. Examine the running configuration file.

Did the IOS version automatically add lines under router OSPF 1? ______________________________

What did it add? ______________________________

Step 3. If there were no changes to the running configuration, type the following commands:

```
Cairo(config)#router ospf 1
Cairo(config-router)#log-adjacency-changes
Cairo(config-router)#end
```

Step 4. Show the routing table for the Cairo router.

```
Cairo#show ip route
```

Do entries exist in the routing table? ____________________

Why?

____

Task 6: Configure OSPF Routing on the Moscow Router

Step 1. Configure OSPF routing on each router. Use OSPF process number 1 and ensure that all networks are in area 0.

```
Moscow(config)#router ospf 1
Moscow(config-router)#network 192.168.0 .0 0.0.0.255 area 0
Moscow(config-router)#network 192.168.1.0 0.0.0.3 area 0
Moscow(config-router)#end
```

Step 2. Examine the running configuration file.

Did the IOS version automatically add lines under router OSPF 1? ____________________

Step 3. If there were no changes to the running configuration, type the following commands:

```
Moscow(config)#router ospf 1
Moscow(config-router)#log-adjacency-changes
Moscow(config-router)#end
```

Task 7: Show the Routing Table Entries

Show the routing table entries for the Cairo router.

```
Cairo#show ip route
```

Does the routing table have OSPF entries now? ____________________

What is the metric value of the OSPF route?____________________

What is the VIA address in the OSPF route? ____________________

Are routes to all networks shown in the routing table? ____________________

What does the O mean in the first column of the routing table?

____

Task 8: Test Network Connectivity

Ping the Cairo host from the Moscow host. Was it successful? ____________________

If not, troubleshoot as necessary.

Task 9: Look at the OSPF Cost on the Cairo Router Interfaces

Show the properties of the Cairo router serial and Fast Ethernet interfaces by using the **show interfaces** command.

What is the default bandwidth of the interfaces?

- Serial interface: ______________________________
- Fast Ethernet interface: ______________________________

Calculate the OSPF cost.

- Serial interface: ______________________________
- Fast Ethernet interface:

Table 2-7 OSPF Cost Calculations for Common Link Types

Link Bandwidth	Default OSPF Cost
56 kbps	1785
T1	64
10-Mbps Ethernet	10
16-Mbps Token Ring	6
FDDI/Fast Ethernet	1

Task 10: Record the OSPF Cost of the Serial and Fast Ethernet Interfaces

Using the **show ip ospf interface** command, record the OSPF cost of the serial and Fast Ethernet interfaces:

- OSPF cost of serial interface: ______________________________
- OSPF cost of Ethernet interface: ______________________________

Do these agree with the calculations? ______________________________

The clock rate set for the interface should have been 64,000. This is what has been used as a default to this point and specified in Lab 1-2, "Review of Basic Router Configuring with RIP." Therefore, to calculate the cost of this bandwidth, you need to divide 10^8 by 64,000.

Task 11: Manually Set the Cost on the Serial Interface

On the serial interface of the Cairo router, set the OSPF cost to 1562 by typing **ip ospf cost 1562** at the serial interface configuration mode prompt.

____

____

____

Task 12: Verify Cost

Note that it is essential that all connected links agree about the cost for consistent calculation of the SPF in an area.

Step 1. Verify that the interface OSPF cost was successfully modified.

____

Step 2. Reverse the effect of this command by entering the command **no ip ospf cost** in interface configuration mode**.**

Step 3. Verify that the default cost for the interface has returned.

Step 4. Enter the command **bandwidth 2000** at the serial 0 interface configuration mode prompt.

Record the new OSPF cost of the serial interface. ______________________________

Can the OSPF cost of an Ethernet interface be modified in this way? ____________________

You can set the speed on an Ethernet interface. Will this affect the OSPF cost of that interface?

____

Step 5. Verify or explain the previous answer.

Step 6. Reset the bandwidth on the serial interface by using **no bandwidth 2000** at the serial 0 interface configuration mode prompt.

After you complete the previous steps, log off (by typing **exit**) and turn the router off. Then, remove and store the cables and adapter.

Curriculum Lab 2-4: Configuring OSPF Authentication (2.3.4)

Figure 2-13 Topology for Lab 2-4

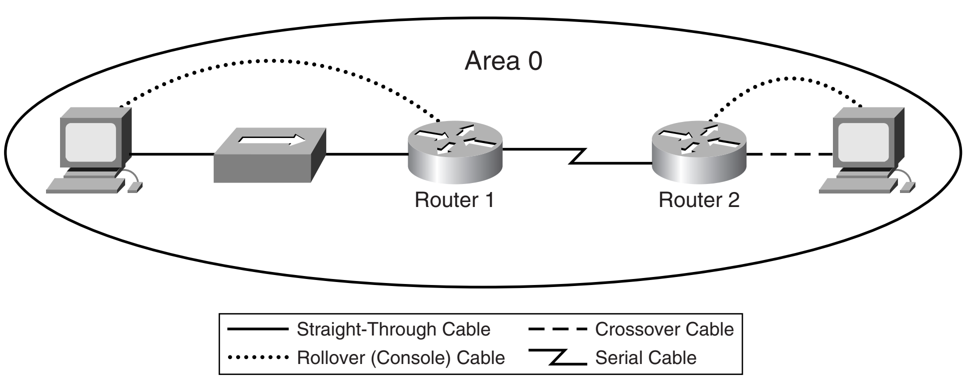


Table 2-8 Lab Equipment Configuration: Part I

Router Designation	Router Name	Routing Protocol	Network Statements
Router 1	Dublin	OSPF	192.168.1.0
Router 2	Washington	OSPF	192.168.1.0 192.168.0.0

The enable secret password for both routers is **class**.

The enable, VTY, and console password for both routers is **cisco**.

Table 2-9 Lab Equipment Configuration: Part II

Router Designation	IP Host Table Entry	Fast Ethernet 0 Address/Subnet Mask	Inter-face Type Serial 0	Serial 0 Address/ Subnet Mask	Loopback 0 Address/ Subnet Mask
Router 1	Washington	192.168.1.129/26	DCE	192.168.1.1/30	192.168.31.11/32
Router 2	Dublin	192.168.0.1/24	DTE	192.168.1.2/30	192.168.31.22/32

The interface type and address/subnet mask for the serial 1 interface on both routers is not applicable for this lab.

The "IP Host Table Entry" column contents indicate the names of the other routers in the IP host table.

Objectives

- Set up an IP addressing scheme for the OSPF area.
- Configure and verify OSPF routing.
- Introduce OSPF authentication into the area.

Background/Preparation

Cable a network that is similar to the one in Figure 2-13. You can use any router that meets the interface requirements in Figure 2-13 (that is, 800, 1600, 1700, 2500, and 2600 routers or a combination). Refer to the information in Appendix A to correctly specify the interface identifiers based on the equipment in your lab. The 1721 series routers produced the configuration output in this lab. Another router might produce slightly different output. You should execute the following steps on each router unless you are specifically instructed otherwise.

Start a HyperTerminal session.

Implement the procedure documented in Appendix C on all routers before you continue with this lab.

Task 1: Configure the Routers

On the routers, enter global configuration mode and configure the hostname, console, virtual terminal, and enable passwords. Next, configure the interfaces and IP hostnames according to the Lab Equipment Configuration tables, Tables 2-8 and 2-9. If you have problems configuring the router basics, refer to Lab 1-2, "Review of Basic Router Configuring with RIP."

Note: You may need to add the command **ip subnet-zero** because of the use of the ZERO subnet with VLSM on the 192.168.1.0/30 and 192.168.1.128/26 networks.

Note: Do not configure the routing protocol until you are specifically told to.

Task 2: Save the Configuration Information from Privileged EXEC Command Mode

```
Dublin#copy running-config startup-config
Destination filename [startup-config]? [Enter]

Washington#copy running-config startup-config
Destination filename [startup-config]? [Enter]
```

Why should you save the running configuration to the startup configuration?

____

Task 3: Configure the Hosts

Step 1. Configure the hosts with the proper IP address, subnet mask, and default gateway.

Step 2. Each workstation should be able to ping the attached router. Troubleshoot as necessary. Hint: Remember to assign a specific IP address and default gateway to the workstation. If you are running Windows 98, check using **Start > Run > winipcfg**. If you are running Windows 2000, check using **ipconfig** in a DOS window.

Step 3. At this point, the workstations will not be able to communicate with each other. The following tasks demonstrate the process required to get communication working by using OSPF as the routing protocol.

Task 4: Verify Connectivity

Ping from one of the connected router serial interfaces to the other.

Was the ping successful? ____

If the ping was not successful, troubleshoot the router's configurations until the ping is successful.

Task 5: Configure OSPF Routing on Both Routers

Step 1. Configure OSPF routing on each router. Use OSPF process number 1 and ensure that all networks are in area 0. Refer to Lab 2-2, "Configuring OSPF with Loopback Addresses," for a review on configuring OSPF routing.

Step 2. Examine the Dublin router running the configuration file. Did the IOS version automatically add lines under router OSPF 1? ____

Step 3. Show the routing table for the Dublin router.

```
Dublin#show ip route
```

Do entries exist in the routing table? ____

Why?

____

Task 6: Test Network Connectivity

Ping the Dublin host from the Washington host. Was it successful? ______________________________

If not, troubleshoot as necessary.

Task 7: Set Up OSPF Authentication

OSPF authentication is being established on the routers in the network. First, introduce authentication only on the Dublin router.

In interface configuration mode on serial 0, enter the command **ip ospf message-digest-key 1 md5 7 asecret**.

```
Dublin(config)#interface Serial 0
Dublin(config-if)#ip ospf message-digest-key 1 md5 ?
<0-7> Encryption type (0 for not yet encrypted, 7 for proprietary)
Dublin(config-if)#ip ospf message-digest-key 1 md5 7 ?
LINE The OSPF password (key)
Dublin(config-if)#ip ospf message-digest-key 1 md5 7 asecret
```

What is the OSPF password that is being used for MD5 authentication? ______________________________

What encryption type is being used? ______________________________

Task 8: Enable OSPF Authentication in this Area, Area 0

```
Dublin(config-if)#router ospf 1
Dublin(config-router)#area 0 authentication
```

Step 1. Wait for a few seconds. Does the router generate output? ______________________________

Step 2. Enter the command **show ip ospf neighbor**.

Are there OSPF neighbors? ______________________________

Step 3. Examine the routing table by entering **show ip route**.

Are there OSPF routes in the Dublin router routing table? ______________________________

Can the Dublin host ping the Washington host? ______________________________

Step 4. Enter configuration commands, one per line. End with **Ctrl-Z**.

```
Washington#configure terminal
Washington(config)#interface serial 0
Washington(config-if)#ip ospf message-digest-key 1 md5 7 asecret
Washington(config-if)#router ospf 1
Washington(config-router)#area 0 authentication
```

Step 5. Verify that there is an OSPF neighbor by entering the **show ip ospf neighbor** command.

Step 6. Show the routing table by typing **show ip route**.

Step 7. Ping the Washington host from Dublin. If it is not successful, troubleshoot as necessary.

After you complete the previous steps, log off (by typing **exit**) and turn the router off. Then, remove and store the cables and adapter.

Curriculum Lab 2-5: Configuring OSPF Timers (2.3.5)

Figure 2-14 Topology for Lab 2-5

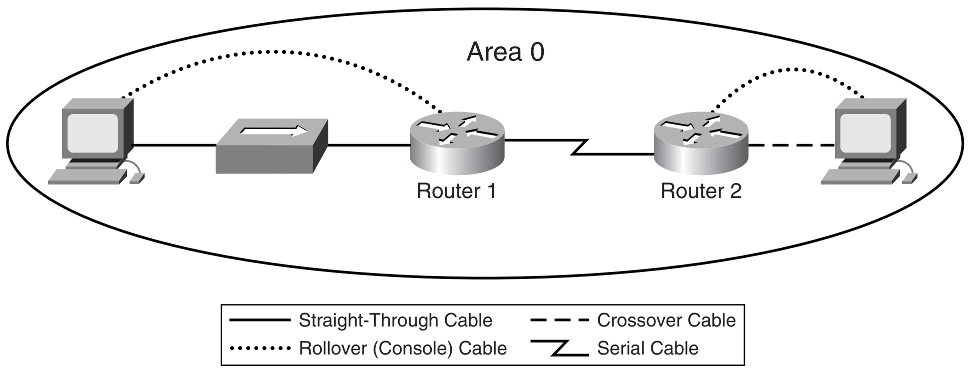


Table 2-10 Lab Equipment Configuration: Part I

Router Designation	Router Name	Routing Protocol	Network Statements
Router 1	Sydney	OSPF	192.168.1.0
Router 2	Rome	OSPF	192.168.1.0 192.168.0.0

The enable secret password for both routers is **class**.

The enable, VTY, and console password for both routers is **cisco**.

Table 2-11 Lab Equipment Configuration: Part II

Router Designation	IP Host Table Entry	Fast Ethernet 0 Address/Subnet Mask	Inter-face Type Serial 0	Serial 0 Address/ Subnet Mask	Loopback 0 Address/ Subnet Mask
Router 1	Rome	192.168.1.129/26	DCE	192.168.1.1/30	192.168.31.11/32
Router 2	Sydney	192.168.0.1/24	DTE	192.168.1.2/30	192.168.31.22/32

The interface type and address/subnet mask for the serial 1 interface on both routers is not applicable for this lab.

The "IP Host Table Entry" column contents indicate the names of the other routers in the IP host table.

Objectives

- Set up an IP addressing scheme for the OSPF area.
- Configure and verify OSPF routing.
- Modify OSPF interface timers to adjust efficiency of the network.

Background/Preparation

Cable a network that is similar to the one in Figure 2-14. You can use any router that meets the interface requirements in Figure 2-14 (that is, 800, 1600, 1700, 2500, and 2600 routers or a combination). Refer to the information in Appendix A to correctly specify the interface identifiers based on the equipment in your lab. The 1721 series routers produced the configuration output in this lab. Another router might produce slightly different output. You should execute the following steps on each router unless you are specifically instructed otherwise. Start a HyperTerminal session.

Implement the procedure documented in Appendix C on all routers before you continue with this lab.

Task 1: Configure the Routers

On the routers, enter global configuration mode and configure the hostname, console, virtual terminal, and enable passwords. Next, configure the interfaces and IP hostnames according to the Lab Equipment Configuration tables, Tables 2-10 and 2-11. If you have problems configuring the router basics, refer to Lab 1-2, "Review of Basic Router Configuring with RIP."

Note: You may need to add the command **ip subnet-zero** because of the use of the ZERO subnet with VLSM on the 192.168.1.0/30 and 192.168.1.128/26 networks.

Note: Do not configure the routing protocol until you are specifically told to.

Task 2: Save the Configuration Information from Privileged EXEC Command Mode

```
Sydney#copy running-config startup-config
Destination filename [startup-config]? [Enter]

Rome#copy running-config startup-config
Destination filename [startup-config]? [Enter]
```

Why should you save the running configuration to the startup configuration?

____

Task 3: Configure the Hosts

Step 1. Configure the hosts with the proper IP address, subnet mask, and default gateway.

Step 2. Each workstation should be able to ping the attached router. Troubleshoot as necessary. Hint: Remember to assign a specific IP address and default gateway to the workstation. If you are running Windows 98, check using **Start > Run > winipcfg**. If you are running Windows 2000, check using **ipconfig** in a DOS window.

Step 3. At this point, the workstations will not be able to communicate with each other. The following tasks demonstrate the process that is required to get communication working by using OSPF as the routing protocol.

Task 4: Verify Connectivity

Ping from one of the connected serial interfaces to the other.

Was the ping successful? ____________________

If the ping was not successful, troubleshoot the router configurations until the ping is successful.

Task 5: Configure OSPF Routing on both Routers

Step 1. Configure OSPF routing on each router. Use OSPF process number 1 and ensure that all networks are in area 0. Refer to Lab 2-2, "Configuring OSPF with Loopback Interfaces," for a review on configuring OSPF routing.

Did the IOS version automatically add lines under router OSPF 1? ____________________

Step 2. Show the routing table for the Sydney router.

```
Sydney#show ip route
```

Do entries exist in the routing table? ____________________

Task 6: Test Network Connectivity

Ping the Sydney host from the Rome host. Was it successful? ____________________

If not, troubleshoot as necessary.

Task 7: Observe OSPF Traffic

Step 1. At privileged EXEC mode, type the command **debug ip ospf events** and observe the output.

How frequently are Hello messages sent? ____________________

Where are Hello messages coming from?

____

____

Step 2. Turn off debugging by typing **no debug ip ospf events** or **undebug all**.

Task 8: Show Interface Timer Information

Show the hello and dead interval timers on the Sydney router Ethernet and serial interfaces by entering the command **show ip ospf interface** in privileged EXEC mode.

Record the Hello and Dead interval timers for these interfaces:

- Hello interval: ______________________________
- Dead interval: ______________________________

What is the purpose of the dead interval?

____

____

Task 9: Modify the OSPF Timers

Step 1. Modify the Hello and Dead interval timers to smaller values to try to improve performance. On the Sydney router only, enter the commands **ip ospf hello-interval 5** and **ip ospf dead-interval 20** for interface serial 0.

```
Sydney(config)#interface Serial 0
Sydney(config-if)#ip ospf hello-interval 5
Sydney(config-if)#ip ospf dead-interval 20
```

Step 2. Wait for a minute and then enter the command **show ip ospf neighbor**.

Do OSPF neighbors exist? ______________________________

Task 10: Examine the Routing Table

Examine the Sydney router routing table by entering **show ip route**.

Do OSPF routes exist in the table? ______________________________

Can the Sydney host ping the Rome host? ______________________________

Task 11: Look at the OSPF Data Transmissions

Enter the command **debug ip ospf events** in privileged EXEC mode.

Is there an issue that is identified?______________________________

If there is, what is the issue?

____

Task 12: Check the Rome Router Routing Table Status

On the Rome router, check the routing table by typing **show ip route**.

Do OSPF routes exist in the table? ______________________________

Task 13: Set the Rome Router Interval Timers

Step 1. Match the timer values on the Rome serial link with the Sydney router.

```
Rome(config)#interface serial 0
Rome(config-if)#ip ospf hello-interval 5
Rome(config-if)#ip ospf dead-interval 20
```

Step 2. Verify the OSPF neighbor by entering the **show ip ospf neighbor** command.

Step 3. Show the routing table by typing **show ip route**.

Do OSPF routes exist in the table? ____________________

Step 4. Ping the Rome host from Sydney. If this is not successful, troubleshoot the configurations.

Task 14: Reset the Router's Interval Timers to the Default Values

Use the **no** form of the **ip ospf hello-interval** and the **ip ospf dead-interval** to reset the OSPF timers back to their default values.

Task 15: Verify that the Interval Timers Are Returned to the Default Values

Use the **show ip ospf interface** command to verify that the timers are reset to their default values.

Are the values back to the default? ____________________

If not, repeat Task 14 and verify again.

After you complete the previous steps, log off (by typing **exit**) and turn the router off. Then, remove and store the cables and adapter.

Curriculum Lab 2-6: Propagating Default Routes in an OSPF Domain (2.3.6)

Figure 2-15 Topology for Lab 2-6

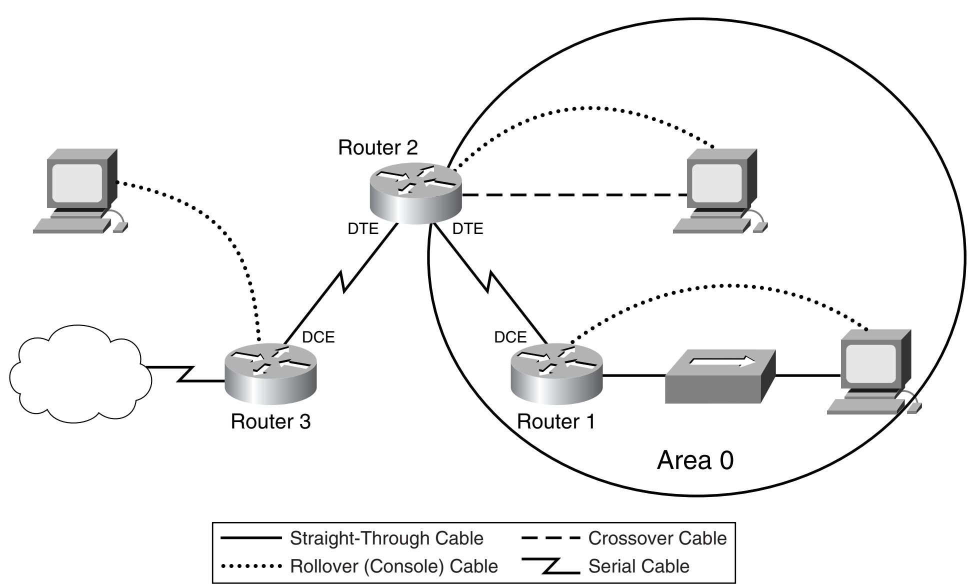


Table 2-12 Lab Equipment Configuration: Part I

Router Designation	Router Name	Routing Protocol	Network Statements	Loopback 0	Address/ Subnet Mask
Router 1	Tokyo	OSPF	192.168.1.0	192.168.31.11/32	
Router 2	Madrid	OSPF	192.168.1.0	192.168.0.0	192.168.31.22/32

The enable secret password for all routers is **class**.

The enable, VTY, and console passwords for each router is **cisco**.

Table 2-13 Lab Equipment Configuration: Part II

Router Designation	IP Host Table Entry	Fast Ethernet 0 Address/Subnet Mask	Interface Type Serial 0	Serial 0 Address/ Subnet Mask	Inter-face Type Serial 1	Serial 1 Address/ Subnet Mask
Router 1	Madrid	192.168.1.129/26	DCE	192.168.1.1/30	N/A	N/A
Router 2	Tokyo	192.168.0.1/24	DTE	192.168.1.2/30	DTE	200.20.20.2/30

The “IP Host Table Entry” column contents indicate the names of the other routers in the IP host table.

Objectives

- Set up an IP addressing scheme for the OSPF area.
- Configure and verify OSPF routing.
- Configure the OSPF network so that all hosts in an OSPF area can connect to outside networks.

Background/Preparation

Cable a network that is similar to the one in Figure 2-15. You can use any router that meets the interface requirements in Figure 2-15 (that is, 800, 1600, 1700, 2500, and 2600 routers or a combination). Refer to the information in Appendix A to correctly specify the interface identifiers based on the equipment in your lab. The 1721 series routers produced the configuration output in this lab. Another router might produce slightly different output. You should execute the following steps on each router unless you are specifically instructed otherwise. Start a HyperTerminal session.

Implement the procedure documented in Appendix C on all routers before you continue with this lab.

Task 1: Configure the ISP Router

Normally, the ISP would configure the ISP router (Router 3). For the purpose of this lab, after you erase the old configuration, configure the ISP router (Router 3) by typing the following:

```
Router>enable
Router#configure terminal
Router(config)#hostname ISP
ISP(config)#line vty 0 4
ISP(config-line)#password cisco
ISP(config-line)#login
ISP(config-line)#interface serial 1
ISP(config-if)#ip address 200.20.20.1 255.255.255.252
ISP(config-if)#clock rate 64000
ISP(config-if)#no shutdown
```

```
ISP(config-if)#interface loopback 0
ISP(config-if)#ip address 138.25.6.33 255.255.255.255
ISP(config-if)#exit
ISP(config)#ip route 192.168.1.0 255.255.255.0 200.20.20.2
ISP(config)#ip route 192.168.0.0 255.255.255.0 200.20.20.2
ISP(config)#end
ISP#copy running-config startup-config
Destination filename [startup-config]? [Enter]
Building configuration...
[OK]
ISP#
```

Task 2: Configure the Area 0 OSPF Routers

On the routers, enter global configuration mode and configure the hostname, console, virtual terminal, and enable passwords. Next, configure the interfaces and IP hostnames according to the Lab Equipment Configuration tables, Tables 2-12 and 2-13. If you have problems configuring the router basics, refer to Lab 1-2, "Review of Basic Router Configuring with RIP."

Note: Do not configure the routing protocol until you are specifically told to.

Task 3: Save the Configuration Information from Privileged EXEC Command Mode

```
Tokyo#copy running-config startup-config
Destination filename [startup-config]? [Enter]

Madrid#copy running-config startup-config
Destination filename [startup-config]? [Enter]
```

Why should you save the running configuration to the startup configuration?

____

Task 4: Configure the Hosts

Step 1. Configure the hosts with the proper IP address, subnet mask, and default gateway.

Step 2. Each workstation should be able to ping the attached router. Troubleshoot as necessary. Hint: Remember to assign a specific IP address and default gateway to the workstation. If you are running Windows 98, check using **Start > Run > winipcfg**. If you are running Windows 2000, check using **ipconfig** in a DOS window.

Step 3. At this point, the workstations will not be able to communicate with each other. The following tasks demonstrate the process that is required to get communication working by using OSPF as the routing protocol.

Task 5: Verify Connectivity

Ping from the Madrid router to both the Tokyo and ISP routers.

Were the pings successful? ____

If the ping was not successful, troubleshoot the router configurations until the ping is successful.

Task 6: Configure OSPF Routing on Both Area 0 Routers

Step 1. Configure OSPF routing on each router. Use OSPF process number 1 and ensure that all networks are in area 0. Refer to Lab 2-2, "Configuring OSPF with Loopback Addresses," for a review on configuring OSPF routing.

Did the IOS version automatically add lines under router OSPF 1? ________________

Step 2. Show the routing table for the Tokyo router.

```
Tokyo#show ip route
```

Do entries exist in the routing table? ______________________________________

Task 7: Test Network Connectivity

Ping the Tokyo host from the Madrid host. Was it successful? __________________________

If not, troubleshoot as necessary.

Task 8: Observe OSPF Traffic

Step 1. At privileged EXEC mode, type the command **debug ip ospf events** and observe the output.

Is there OSPF traffic? ____

Step 2. Turn off debugging by typing **no debug ip ospf events** or **undebug all**.

Task 9: Create a Default Route to the ISP

On the Madrid router only, type a static default route via the serial 1 interface.

```
Madrid(config)#ip route 0.0.0.0 0.0.0.0 200.200.200.1
```

Task 10: Verify the Default Static Route

Verify the default static route by looking at the Madrid routing table.

Is the default route in the routing table? ______________________________________

Task 11: Verify Connectivity from the Madrid Router

Step 1. Verify connectivity from the Madrid router by pinging the ISP serial 1 interface from the Madrid router.

Can the interface be pinged? ______________________________

Step 2. Ping from a DOS window on the host that is attached to the Madrid router Fast Ethernet interface to the ISP router serial 1 interface.

Can the interface be pinged? ______________________________

Step 3. Ping again from the host to the loopback address on the ISP router, which represents the ISP connection to the Internet.

Can the loopback interface be pinged? ______________________________

Step 4. All these pings should be successful. If they are not, troubleshoot the configurations on the host and the Madrid and ISP routers.

Task 12: Verify Connectivity from the Tokyo Router

Verify connectivity from the Tokyo router by pinging the ISP router serial 1 interface from the Tokyo router.

Can the interface be pinged? ______________________________

If yes, why? If not, why not?

____

Task 13: Redistribute the Static Default Route

Propagate the gateway of last resort to the other routers in the OSPF domain. At the configure router prompt on the Madrid router, type **default-information originate**.

```
Madrid(config-router)#default-information originate
```

Does a default route now exist on the Tokyo router? ______________________________

What is the address of the gateway of last resort? ______________________________

There is an O*E2 entry in the routing table. What type of route is it?

____

Can the ISP server address at 138.25.16.33 be pinged from both workstations? ______________

If not, troubleshoot both hosts and all three routers.

After you complete the previous steps, log off (by typing **exit**) and turn the router off. Then, remove and store the cables and adapter.

Comprehensive Lab 2-7: OSPF Configuration

Figure 2-16 OSPF Configuration

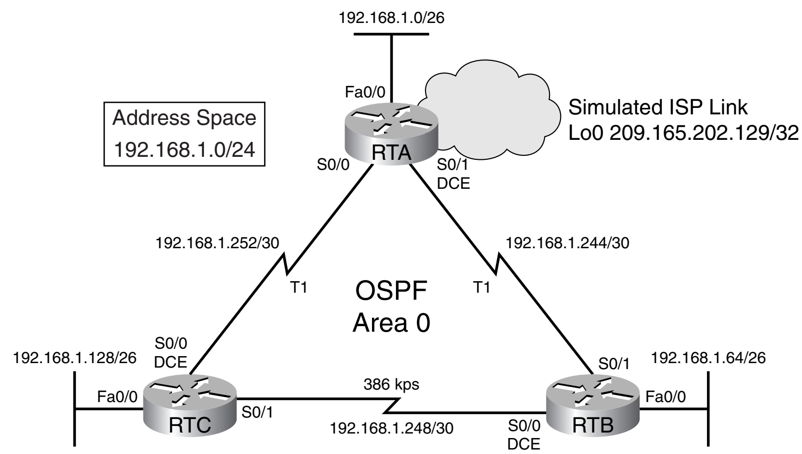


Table 2-14 Lab 2-7 Addressing Scheme

Device	Interface	IP Address	Subnet Mask
RTA	Fa0/0	192.168.1.1	255.255.255.192
	S0/1	192.168.1.245	255.255.255.252
	S0/0	192.168.1.254	255.255.255.252
	Lo0	209.165.202.129	255.255.255.255
RTB	S0/1	192.168.1.246	255.255.255.192
	Fa0/0	192.168.1.65	255.255.255.192
	S0/0	192.168.1.249	255.255.255.252
RTC	S0/1	192.168.1.250	255.255.255.252
	Fa0/0	192.168.1.129	255.255.255.192
	S0/0	192.168.1.253	255.255.255.252

Objectives

- Configure OSPF routing
- Modify OSPF cost
- Configure MD5 authentication
- Adjust OSPF timers
- Configure and propagate a default route

Equipment

The topology shown in Figure 2-16 is using 2600 series routers. This lab can be done with any combination of 1700, 2500, and 2600 series routers. Connectivity to an ISP is simulated with a loopback interface on RTA.

NetLab Compatibility Notes

This lab is fully compatible with a standard NetLab three router pod.

Task 1: Cable the Topology and Basic Configurations

Step 1. Cable the topology as shown. If DCE/DTE connections and interfaces are different from those shown in Figure 2-16 and the table, relabel the figure to match your connections.

Step 2. Configure the routers with basic router configurations, including

- Hostnames and host tables
- Enable secret password and MOTD banner
- Line configurations
- IOS-specific commands (e.g. **ip subnet-zero** with IOS versions prior to 12)

Step 3. The following is a basic configuration for RTA:

```
Router(config)#hostname RTA
RTA(config)#ip subnet-zero
RTA(config)#no ip domain-lookup
RTA(config)#ip host RTC 192.168.1.253 192.168.1.254
RTA(config)#ip host RTB 192.168.1.246 192.168.1.249
RTA(config)#banner motd &
***********************************
  !!!AUTHORIZED ACCESS ONLY!!!
***********************************
&
RTA(config)#line con 0
RTA(config-line)#exec-timeout 30 0
RTA(config-line)#password cisco
RTA(config-line)#logging synchronous
RTA(config-line)#login
RTA(config-line)#line aux 0
RTA(config-line)#exec-timeout 30 0
RTA(config-line)#password cisco
RTA(config-line)#logging synchronous
RTA(config-line)#login
```

```
RTA(config-line)#line vty 0 4
RTA(config-line)#exec-timeout 30 0
RTA(config-line)#password cisco
RTA(config-line)#logging synchronous
RTA(config-line)#login
RTA(config-line)#end
RTA#copy run start
```

Task 2: Configure Interfaces and OSPF Routing

Step 1. Use Table 2-14 and the topology shown in Figure 2-16 to configure each router with the correct interface addresses. To simulate an ISP connection, use the following configuration on RTA:

```
RTA(config)#interface Loopback0
RTA(config-if)#description Simulated Link to ISP
RTA(config-if)#ip address 209.165.202.129 255.255.255.255
```

Step 2. Configure OSPF routing on RTA, RTB, and RTC. *Do not* configure the simulated ISP loopback interface as part of OSPF. The configuration for RTA is as follows:

```
RTA(config)#router ospf 1
RTA(config-router)#network 192.168.1.0 0.0.0.63 area 0
RTA(config-router)#network 192.168.1.244 0.0.0.3 area 0
RTA(config-router)#network 192.168.1.252 0.0.0.3 area 0
```

Task 3: Verify Connectivity

Step 1. You should now have full connectivity between RTA, RTB, and RTC. Issue the **show ip route** command to verify full convergence.

Routing table on RTA:

```
RTA#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, ia - IS-IS inter
area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     209.165.202.0/32 is subnetted, 1 subnets
C       209.165.202.129 is directly connected, Loopback0
     192.168.1.0/24 is variably subnetted, 6 subnets, 2 masks
O       192.168.1.64/26 [110/65] via 192.168.1.246, 00:00:48, Serial0/1
C       192.168.1.0/26 is directly connected, FastEthernet0/0
O       192.168.1.248/30 [110/128] via 192.168.1.246, 00:00:48, Serial0/1
                         [110/128] via 192.168.1.253, 00:00:48, Serial0/0
C       192.168.1.252/30 is directly connected, Serial0/0
C       192.168.1.244/30 is directly connected, Serial0/1
O       192.168.1.128/26 [110/65] via 192.168.1.253, 00:00:49, Serial0/0
```

Step 2. Notice that RTA has four connected routes (including the simulated ISP link) and three OSPF routes. RTB and RTC should both have three connected routes and three OSPF routes.

Step 3. Pings sourced from any router to a LAN interface on another router should succeed.

```
RTA#ping 192.168.1.65

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.65, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/32 ms
RTA#ping 192.168.1.129

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
```

Task 4: Modify OSPF Cost

Step 1. At this point, all routers are using the default bandwidth for serial interfaces: for 2500s and 2600s, 1544 kbps; for 1700s, 128 kbps. Use the **show interface serial** command to view the bandwidth used to calculate cost.

```
RTB#show interface s0/0
Serial0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Description: Link to RTC
  Internet address is 192.168.1.249/30
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
(output omitted)
```

Step 2. When RTB pings the LAN interface on RTC, it sends it directly to RTC even though the path through RTA is faster.

```
RTB#traceroute 192.168.1.129

Type escape sequence to abort.
Tracing the route to 192.168.1.129

  1 RTC (192.168.1.250) 16 msec *  12 msec
RTB#
```

Step 3. Configure both RTB and RTC with the correct bandwidth.

```
RTB(config)#interface s0/0
RTB(config-if)#bandwidth 386
!
RTC(config)#interface s0/1
RTC(config-if)#bandwidth 386
```

Step 4. Verify that RTB sends pings destined for the LAN on RTC to RTA, which then routes the ping to RTC.

```
RTB#traceroute 192.168.1.129
```

```
Type escape sequence to abort.
Tracing the route to 192.168.1.129

  1 RTA (192.168.1.245) 16 msec 12 msec 16 msec
  2 RTC (192.168.1.253) 28 msec *  16 msec
RTB#
```

Task 5: Configure MD5 Authentication

Step 1. To make sure routing updates come from trusted sources, configure each router to use MD5 authentication. The configuration for RTA follows:

```
RTA(config)#interface serial 0/0
RTA(config-if)#ip ospf message-digest-key 1 md5 7 allrouters
RTA(config)#interface serial 0/1
RTA(config-if)#ip ospf message-digest-key 1 md5 7 allrouters
RTA(config-if)#router ospf 1
RTA(config-router)#area 0 authentication message-digest
```

Step 2. After configuring authentication on each router, neighbor adjacency will go to the DOWN state and then reinitialize. Make sure that all routing tables have reconverged by issuing the **show ip route** command. The table for RTA follows:

```
RTA#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, ia - IS-IS inter
area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     209.165.202.0/32 is subnetted, 1 subnets
C       209.165.202.129 is directly connected, Loopback0
     192.168.1.0/24 is variably subnetted, 6 subnets, 2 masks
O       192.168.1.64/26 [110/65] via 192.168.1.246, 00:06:25, Serial0/1
C       192.168.1.0/26 is directly connected, FastEthernet0/0
O       192.168.1.248/30 [110/323] via 192.168.1.246, 00:06:25, Serial0/1
                         [110/323] via 192.168.1.253, 00:06:25, Serial0/0
C       192.168.1.252/30 is directly connected, Serial0/0
C       192.168.1.244/30 is directly connected, Serial0/1
O       192.168.1.128/26 [110/65] via 192.168.1.253, 00:06:26, Serial0/0
```

Step 3. You can verify authentication by using the **show ip ospf** command or the **show ip ospf interface** command.

```
RTA#show ip ospf
 Routing Process "ospf 1" with ID 209.165.202.129
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x0
 Number of opaque AS LSA 0. Checksum Sum 0x0
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has message digest authentication
        SPF algorithm executed 2 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x1F45E
        Number of opaque link LSA 0. Checksum Sum 0x0
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

RTA#show ip ospf interface s0/0
Serial0/0 is up, line protocol is up
  Internet Address 192.168.1.254/30, Area 0
  Process ID 1, Router ID 209.165.202.129, Network Type POINT_TO_POINT, Cost:
64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.0.0.1
  Suppress hello for 0 neighbor(s)
  Message digest authentication enabled
    Youngest key id is 1
```

Task 6: Adjust OSPF Timers

Step 1. Notice in the previous output for **show ip ospf interface** that the Hello and dead interval timers are shown as 10 and 40, respectively. Configure these intervals to be 40 and 160 on all three routers.

```
RTA(config)#interface s0/0
RTA(config-if)#ip ospf hello-interval 40
RTA(config-if)#ip ospf dead-interval 160
```

```
RTA(config)#interface s0/1
RTA(config-if)#ip ospf hello-interval 40
RTA(config-if)#ip ospf dead-interval 160
```

Step 2. Verify that all routers have full routing tables and have re-established neighbor adjacencies. If adjacency has not been re-established, you can use the **debug ip ospf events** command to find where there might be a timing mismatch.

```
RTA#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, ia - IS-IS inter
area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     209.165.202.0/32 is subnetted, 1 subnets
C       209.165.202.129 is directly connected, Loopback0
     192.168.1.0/24 is variably subnetted, 6 subnets, 2 masks
O       192.168.1.64/26 [110/65] via 192.168.1.246, 00:00:04, Serial0/1
C       192.168.1.0/26 is directly connected, FastEthernet0/0
O       192.168.1.248/30 [110/323] via 192.168.1.246, 00:00:04, Serial0/1
                         [110/323] via 192.168.1.253, 00:00:04, Serial0/0
C       192.168.1.252/30 is directly connected, Serial0/0
C       192.168.1.244/30 is directly connected, Serial0/1
O       192.168.1.128/26 [110/65] via 192.168.1.253, 00:00:05, Serial0/0
RTA#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.1.253     1   FULL/  -        00:02:19    192.168.1.253   Serial0/0
192.168.1.249     1   FULL/  -        00:02:16    192.168.1.246   Serial0/1
```

Task 7: Configure and Propagate a Default Route

Step 1. Because the ISP is only simulated, RTA does not have a real default route. However, you can simulate a default route by configuring it to forward to a null interface.

```
RTA(config)#ip route 0.0.0.0 0.0.0.0 null 0
```

Step 2. Now, you can configure RTA to propagate the default route to RTB and RTC.

```
RTA(config)#router ospf 1
RTA(config-router)#default-information originate
```

Step 3. RTB and RTC should now be able to successfully ping the 209.165.202.129 interface, which verifies that both routers have a working default route.

```
RTB#ping 209.165.202.129

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.202.129, timeout is 2 seconds:
!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
RTC#ping 209.165.202.129

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.202.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/33/48 ms
```

Challenge Lab 2-8: OSPF Design and Configuration

Figure 2-17 OSPF Design and Configuration

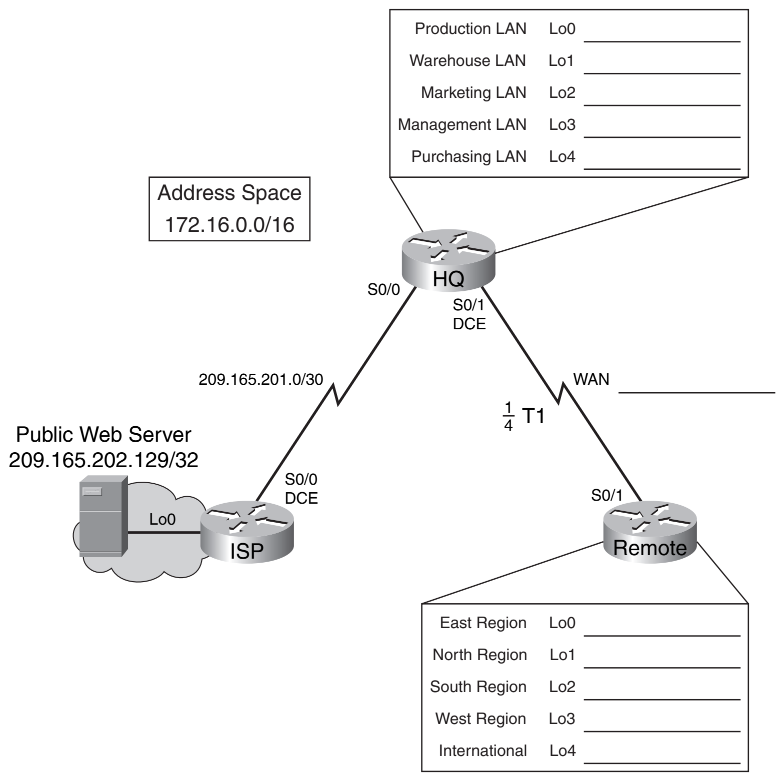


Table 2-15 Lab 2-8 Addressing Scheme

Device	Interface	IP Address	Subnet Mask
ISP	Lo0	209.165.202.129	255.255.255.255
	S0/0	209.165.201.1	255.255.255.252
HQ	S0/0	209.165.201.2	255.255.255.252
	S0/1		
	Lo0		
	Lo1		
	Lo2		
	Lo3		
	Lo4		
REMOTE	S0/1		
	Lo0		
	Lo1		
	Lo2		
	Lo3		
	Lo4		

Objectives

- Design a VLSM addressing scheme.
- Configure routers with basic configurations using your addressing scheme.
- Configure dynamic, static, and default routing.
- Verify connectivity and troubleshoot problems.

Equipment

The topology shown in Figure 2-17 uses 2600 series routers. This lab can be done with any combination of 1700, 2500, and 2600 series routers.

NetLab Compatibility Notes

This lab can be completed on a standard NetLab three router pod.

Task 1: Design the Addressing Scheme

You are given the address space, 172.16.0.0/16. The five loopback interfaces on HQ and five loopback interfaces on REMOTE are used to simulate different parts of a global network. Use the following specifications to design your addressing scheme.

Table 2-16 LAN Addressing Specifications

HQ	Hosts Needed
Production LAN	16,000
Warehousing LAN	8000
Marketing LAN	4000
Management LAN	2000
Purchasing LAN	1000

REMOTE	Hosts Needed
Eastern Region	4000
Northern Region	4000
Western Region	4000
Southern Region	4000
International	4000

Label the topology in Figure 2-17 with the networks and finish filling in the IP addresses in Table 2-16 with your chosen addressing scheme. Use the first IP address in each subnet for the interface address. For the WAN link between HQ and REMOTE, assign HQ the first address.

Task 2: Cable the Topology and Basic Configuration

Step 1. Choose three routers and cable them according to the topology. You will not need any LAN interfaces or switches for this lab. (If using NetLab, choose a three router pod).

Step 2. Configure the routers with basic configurations including interface addresses.

Task 3: Configure OSPF Routing and Default Routing

Step 1. Configure both HQ and REMOTE to use OSPF as the routing protocol. Enter the simulated LAN subnets and the WAN link between HQ and REMOTE. *Do not* advertise the 209.165.201.0/30 network.

Step 2. Configure ISP with a static route pointing the 172.16.0.0/16 Address Space. Configure HQ with a default route pointing to ISP. Configure HQ to advertise the default route to REMOTE.

Step 3. Verify HQ and REMOTE routing tables.

- HQ should have seven directly connected routes, five OSPF routes, and one static route.
- REMOTE should have six directly connected routes, five OSPF routes, and one OSPF E2 route.
- Verify that REMOTE can ping the Simulated Web Server at 209.165.202.129.

Task 4: Other OSPF Configurations

Step 1. Change the OSPF hello interval to 20 seconds.

Step 2. The link between HQ and REMOTE is a 1/4 T1. Change the bandwidth on both HQ and REMOTE to match the actual link speed.

Step 3. Configure OSPF authentication with MD5 between HQ and REMOTE. Use "allrouters" as the key.

Task 5: Verification and Documentation

Step 1. **Capture the following verifications to a text file called verify.txt:**

- Ping output from REMOTE pinging the Simulated Web Server.
- Capture **show ip route** on all three routers: ISP, HQ, and REMOTE.
- Capture **show ip ospf**, **show ip ospf neighbor**, and **show ip ospf interface** on HQ and REMOTE.

Step 2. Capture the running configurations on all three routers to separate text files. Use the hostname of the router to name each text file.

Step 3. Clean up the verify.txt, HQ.txt, REMOTE.txt, and ISP.txt files. Add appropriate notes to assist in your studies.