



CCNA Lab Guide

200-301

Cisco Certified Network Associate
Version 1.0

Labs powered by



Cisco Certified Network Associate

200-301 Lab Guide



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To perform the labs referenced in this book, please download and install the necessary files (refer to your purchase receipt for the download link), navigate to the appropriate lab in the lab menu in the Boson NetSim, and load the lab; all labs should work in NetSim 11 or later. To learn more about the Boson NetSim or to purchase and download the software, please visit www.boson.com/netsim.

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Please visit www.boson.com for more information.

Boson NetSim Overview

The Boson NetSim® Network Simulator®, which includes the Boson Router Simulator®, is unique compared to all others on the market because of the functionality it supports and its features. NetSim utilizes Boson's proprietary Network Simulator, Router Simulator®, and EROUTER® software technologies, along with the Boson Virtual Packet Technology® engine, to create individual packets. These packets are routed and switched through the simulated network, allowing NetSim to build an appropriate virtual routing table and simulate true networking. Other simulation products on the market do not support this level of functionality.

NetSim simulates a wide variety of Cisco® routers, including the 2500 series, 2600 series, 2800 series, and 3600 series routers, as well as the Cisco Catalyst 1900 series, 2900 series, and 3500 series switches. NetSim supports multiple routing protocols, including RIP, IGRP, EIGRP, BGP, and OSPF. It supports different LAN/WAN protocols, including PPP/CHAP, ISDN, and Frame Relay. The labs in NetSim require only the devices and functionality included with NetSim—they do not require access to any external router or switch hardware. NetSim supports many, but not all, of the IOS commands available on a physical router or switch. All of the commands referenced in the available labs are supported by NetSim. The labs included in this book have been selected as companions to the Boson Curriculum. However, for additional practice, you can perform any labs that are unlocked.

Achieving Cisco CCNA® or CCNP® Enterprise-level certification is the goal of many people who use this product. The Boson NetSim product covers many of the new Cisco certifications, including CCNA (200-301), ENCOR (350-401), and ENARSI (300-410). The included labs guide you through the configuration of routers, switches, and workstations in a variety of scenarios.

Activation keys unlock labs and increase the number of available commands. Beginning with the Demo version of NetSim, the command set is limited to those necessary to perform the steps in the lab. For example, if you start your studies with a CCNA activation key, you will have the command set and labs available that are necessary to study for that exam. When you are ready to study for a CCNP exam, you will need to purchase a new activation key and then activate with the new activation key; then, more labs and a larger command set become available.

Each activation key unlocks a selection of labs. A small lock icon (🔒) is displayed next to unavailable labs. Some lab packs are delivered by NetSim to support other products that are sold separately. If you have questions about locked labs, please contact support@boson.com.

After you load and complete an unlocked lab, you can use the grading function in NetSim to grade the lab so that you can determine whether you completed it correctly (click **Lab** > **Grade Lab**). As you progress through the labs, you can master the skills needed to pass the simulation questions in the Cisco certification exams. NetSim has the ability to guide and grade, and using it for practice can actually be more helpful than using real routers and switches. NetSim allows you to gain experience without requiring you to purchase expensive equipment.

You can use the Boson NetSim to work through labs, but you can also use it for additional purposes. For example, you can create your own logical topology to practice designing and planning a network. This tool's functionality goes beyond that of most tools because you can actually create the device configurations that are going to be used, save those configurations, and practice using them on simulated devices.

Routing protocol implementation is one of the more challenging tasks you might encounter. Troubleshooting a production network can be a frustrating experience. Fortunately, you can create a virtual copy of your network by creating a new topology in NetSim and troubleshoot the problems without interfering with your production network. Because NetSim is designed as a study tool for Cisco certification, you should not rely only on NetSim to make decisions about a production network, but you might find it useful in your troubleshooting efforts.

In summary, Boson NetSim is a flexible and powerful product that can help you become certified and, in some cases, can be used to create a simulation of the topology of your corporate network and help you practice troubleshooting without using devices on the production network.

Using NetSim to Prepare for Your Certification

By using NetSim to help you achieve a Cisco certification, you can learn and master the skills necessary to help you successfully complete your certification track. The purpose of NetSim is to help you with the practical, hands-on portion of your education and to ensure that you not only understand the concepts of routing but can actually configure and implement routing on Cisco devices.

Mastering Cisco networking involves two fundamental tasks:

1. Learn the theory of routers and switches.
2. Gain the hands-on experience of implementing that theory by configuring the devices in a network and testing them in a lab.

Self-studying for a Cisco certification can be a daunting task. The amount of information a CCNA candidate is required to know and the skills that candidate is required to possess are quite extensive. To begin learning the theory of configuring a network, you can find a good reference book or listen to an instructor. (Boson Training, www.boson.com/boson-training, offers a full slate of classes and Bootcamps.) But a reference book might not be enough. The book will not give you the practical, hands-on experience of routing and switching that you can learn from NetSim—experience that will help you build on the theoretical knowledge you learned from the reference book.

Real equipment gives you the ability to practice on actual routers and switches, but it also is a very costly way to practice and leaves a lot of room for error. The Boson NetSim, on the other hand, is an excellent tool to help you prepare for the CCNA-level (www.boson.com/certification/CCNA) and CCNP-level (www.boson.com/certification/CCNP) exams. NetSim simulates the behavior of a network and does not just return preprogrammed responses to expected command inputs. It allows you to create virtual packets and virtual frames that will be routed and switched through the simulated network. Aside from physically plugging in the cables and listening to the fan noise, your experience with the simulated network will be much the same as your experience with a fully functional lab rack without the expense of the hardware. NetSim will enable you to practice various configurations and master helpful skills.

Once you feel you have mastered both the theory (www.boson.com/boson-training) and the practical labs, (www.boson.com/netsim-cisco-network-simulator) you can test your knowledge by using the Boson ExSim-Max practice exam products available at the ExSim-Max home page (www.boson.com/exsim-max-practice-exams). Boson ExSim-Max products include complex multiple-choice questions, drag-and-drop questions, and Boson NetSimX simulation questions.

The Boson NetSim Network Simulator is the most comprehensive product on the market for learning how to configure a Cisco router. The Boson NetSim will not only help you become certified, it will help you learn and understand how to configure routers, switches, and networks.

For more information on how to use NetSim, please read the NetSim User Manual by clicking **Help > Users Manual** from within NetSim or by downloading the User Manual from the following link:

<http://www.boson.com/Files/Support/NetSim-13-User-Manual.pdf>

Using NetSim at Home – Single User

The following steps are for installation and activation for a single user license and should not be performed on a classroom workstation.

Downloading and Installing NetSim

You can download NetSim from the Boson.com downloads page (account required):

<http://www.boson.com/download>

You must have a Boson account to download the NetSim Demo. To create a free account, visit the Boson Online Account page (<https://www.boson.com/account/default.aspx>) and enter a valid email address to begin creating an account.

You should download the NetSim installer to your computer before beginning the installation. It is recommended that you disable antivirus and firewall software while installing and activating NetSim and then reactivate when the installation is complete. Double-click the downloaded installation file to begin the installation, and perform the steps described in the prompts during installation.

Activating NetSim – Single User

When you first open NetSim, you will be presented with a NetSim Login dialog box. When prompted, enter the email address and password associated with your Boson.com account. If you have not previously created a Boson.com account, you will need to create one first on Boson.com. If you have any NetSim 13–related products, NetSim will automatically activate those items for you; otherwise, NetSim will launch in Demo mode. If you are using a proxy server to connect to the internet, you must configure the appropriate settings via the Settings icon and click the **Proxy Settings** button.

Loading a Lab

You can open NetSim from the shortcut installed during the download or from the Start menu by clicking **Boson Software > Boson NetSim > Boson NetSim**. If you are a student using NetSim at a learning institution, you should launch NetSim from the Start menu by clicking **Boson Software > Boson NetSim > Boson NetSim LS Client**. This will enable you to configure NetSim to authenticate with the Boson NetSim License Server.

1. You can begin a preloaded Boson NetSim lab by performing one of the following tasks:
 - On the navigation pane, select the appropriate lab tree from the drop-down box; then, double-click the lab you want to open.

- Click to highlight a lab on the **Labs** pane, then click **Lab > Load lab**.
 - Click to highlight a lab on the **Labs** pane, then click **Load Lab** on the **Lab Preview** pane.
 - Select a lab from the list of **Recent Labs** or **Saved Labs** on the **Home** pane.
2. After you have loaded a lab, click the **Lab Instructions** tab and read through the lab instructions.
 3. From the **Devices** drop-down menu on the **Consoles** section, select the device(s) that you need to configure in order to complete the lab and follow the steps in the lab. You can also select the device you want to configure by clicking the **Lab Topology** tab, right-clicking the device, and clicking **Console**.
 4. When you have completed the lab, click **Lab > Grade Lab** to ensure that you have completed it successfully.
 5. You can choose to save your single device configuration or multiple device configurations by selecting the appropriate option in the **File** menu.

You might also be instructed to open labs from a custom lab pack. If any custom labs are available, you should select **Custom** from the drop-down box. To open a custom lab, double-click the lab you want to load.

Module 2

Lab 2.1 – Subnet Configuration

Lab 2.2 – IPv6 Configuration

Lab 2.3 – IPv6 Address Autoconfiguration

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Lab 2.1 – Subnet Configuration

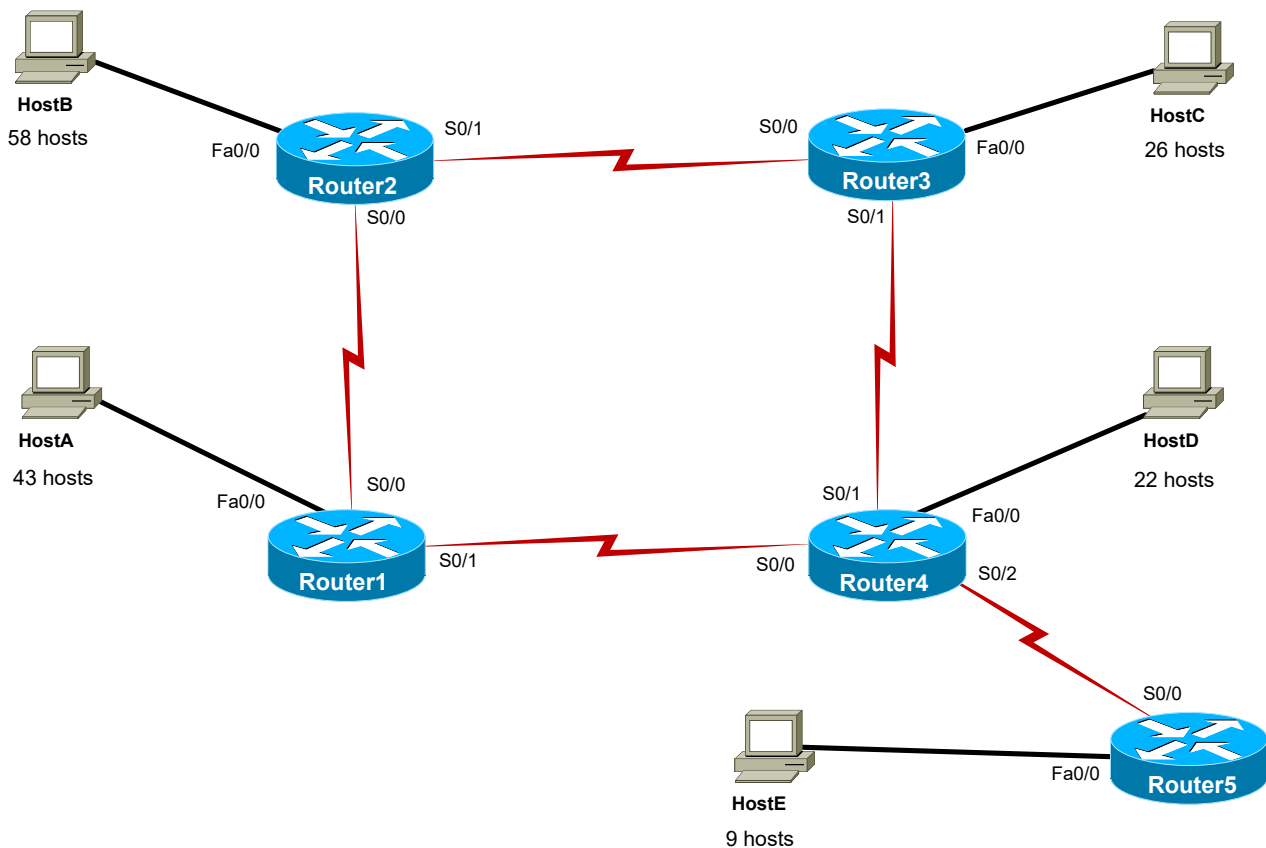
To perform this lab in the Boson NetSim, navigate to the appropriate lab in the lab menu in NetSim, and load the lab. You can then accomplish the tasks below.

Objective

This lab corresponds to Module 2: Network Addressing and Transport of Boson’s CCNA Curriculum. In this lab, you will use variable length subnet masks (VLSMs) to subnet various networks so that you are familiar with how to best use allocated address space. You will then see how those subnets can be allocated to various parts of a network and how errors in IP addressing configuration affect the network.

Lab Topology

The topology diagram below represents the NetMap in the Simulator. The IP addresses have intentionally been omitted from the diagram; you will be required to find the IP addresses in the tasks within this lab.



The commands you will need to perform the tasks in this lab, along with their syntax and descriptions, are shown in the Command Summary table below:

Command Summary

Command	Description
configure terminal	enters global configuration mode from privileged EXEC mode
enable	enters privileged EXEC mode
end	ends and exits configuration mode
exit	exits one level in the menu structure
interface <i>type number</i>	changes from global configuration mode to interface configuration mode
ip address <i>ip-address subnet-mask</i>	assigns an IP address to an interface
ipconfig	is used in NetSim to display the currently configured IP address, subnet mask, and default gateway on a workstation
ping <i>ip-address</i>	sends an Internet Control Message Protocol (ICMP) echo request to the specified address
show cdp neighbors detail	displays information about directly connected neighbor devices, including their device types, interface names, and IP addresses
show interfaces [<i>type number</i>]	displays the interface's Data Link layer status; when the <i>type</i> and <i>number</i> parameters are included, displays detailed information about the specified interface
show ip interface	displays IP information for an interface
show ip interface brief	displays a brief summary of interface status and configuration
show ip protocols	displays information about active routing protocols
show ip route	displays the IP routing table
show running-config	displays the active configuration file

Lab Tasks

Task 1: Create Multiple Subnets from One Network

Your Internet service provider (ISP) has allocated all of the IP addresses in the 172.16.16.0/20 address range for use in this lab. In this task, you will subdivide a network to make the best use of the IP addresses you have been allocated.

- How many host addresses can be assigned on the 172.16.16.0/20 network? _____
- What is the network address of the 172.16.16.0/20 network? _____
- What is the broadcast address of the 172.16.16.0/20 network? _____
- Examine the topology diagram; how many different subnets are represented? _____

5. Create two /26 subnets from the first available addresses in the 172.16.16.0/20 network. What process did you use? _____
6. How many hosts are available for each /26 subnet? _____
7. What are the network and broadcast addresses of each /26 subnet? _____
8. Using the first available addresses from among those remaining in the 172.16.16.0/20 network, create two /27 subnets.
9. How many hosts are available for each /27 subnet? _____
10. What are the broadcast and network addresses of each /27 subnet? _____
11. Using the first available addresses from among those remaining in the 172.16.16.0/20 network, create two /28 subnets.
12. How many hosts are available for each /28 subnet? _____
13. What are the network and broadcast addresses of each /28 subnet? _____
14. Using the first available addresses from among those remaining in the 172.16.16.0/20 network, create eight /30 subnets.
15. How many hosts are available for each /30 subnet? _____
16. What are the broadcast and network addresses of each /30 subnet? _____

Task 2: Assign IP Addresses to Devices on the Network

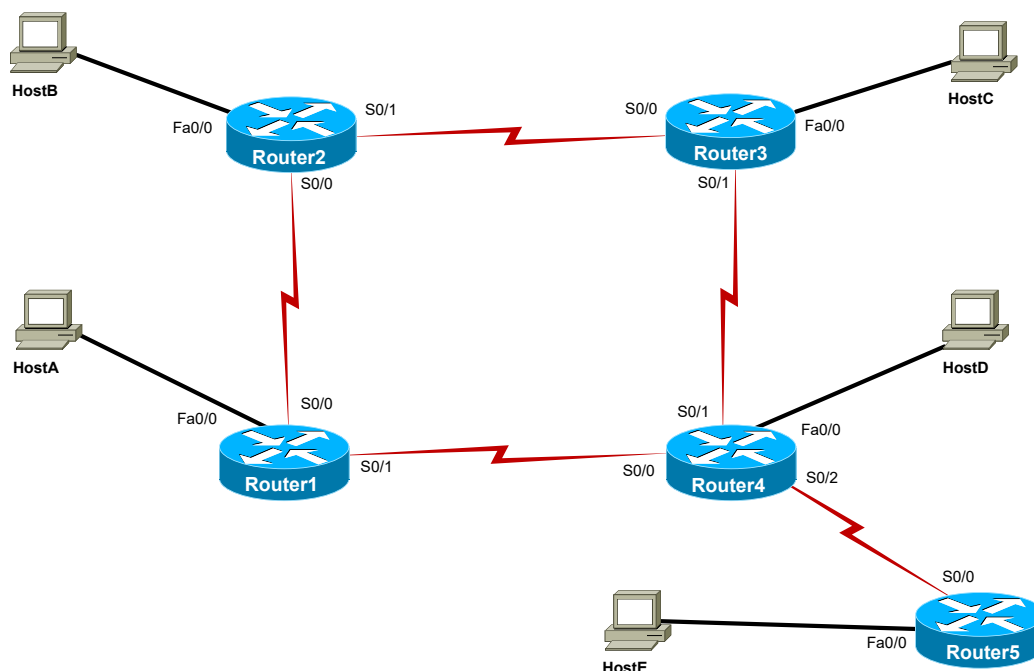
In this task, you will assign IP addresses from the subnets you created in the previous task to unconfigured devices on the network.

1. Document the network by issuing the appropriate **show** commands. Fill in the following tables and diagram with the IP addresses that have been configured on each device:

IP Addresses

Device	Interface	IP Address	Subnet Mask
Router1	Serial 0/0 Serial 0/1 FastEthernet 0/0		
Router2	Serial 0/0 Serial 0/1 FastEthernet 0/0		
Router3	Serial 0/0 Serial 0/1 FastEthernet 0/0		
Router4	Serial 0/0 Serial 0/1 Serial 0/2 FastEthernet 0/0		
Router5	Serial 0/0 FastEthernet 0/0		

Device	IP Address	Subnet Mask	Default Gateway
HostA			
HostB			
HostC			
HostD			
HostE			



2. Document the range of addresses assigned to each subnet in the network by filling in the following tables:

WAN	Router1 to Router4	Router2 to Router1	Router2 to Router3	Router4 to Router3	Router4 to Router5
Network Address					
Subnet Mask (decimal)					
First Host Address					
Last Host Address					
Broadcast Address					
Number of Available Hosts					
CIDR Notation					

LAN	Router1	Router2	Router2	Router4	Router4
Network Address					
Subnet Mask (decimal)					
First Host Address					
Last Host Address					
Broadcast Address					
Number of Available Hosts					
CIDR Notation					

	HostA	HostB	HostC	HostD	HostE
IP Address					
Subnet Mask (decimal)					
CIDR Notation					
Default Gateway					

3. Which interfaces have not been configured? _____
4. What subnet(s) should the unconfigured interfaces be in? _____

- Assign the appropriate IP addresses to the unconfigured interfaces; use the information below to help you assign the appropriate IP addresses:

FastEthernet 0/0	first available host address
Serial 0/0	last available host address
Serial 0/1	first available host address

Task 3: Examine Network Connectivity

- Log on to Router4, and attempt to ping all network devices. Indicate in the table below whether the pings succeed or fail:

Device	IP Address	Result
Router1	172.16.16.238 (Serial 0/0) 172.16.16.245 (Serial 0/0) 172.16.16.65 (FastEthernet 0/0)	
Router2	172.16.16.237 (Serial 0/0) 172.16.16.241 (Serial 0/1)	
Router3	172.16.16.242 (Serial 0/0) 172.16.16.249 (Serial 0/1) 172.16.16.161 (FastEthernet 0/0)	
Router5	172.16.16.254 (Serial 0/0)	
HostA	172.16.16.120	
HostB	172.16.16.60	
HostC	172.16.16.180	
HostD	172.16.16.129	
HostE	172.16.16.200	

- Issue the appropriate commands to perform some basic troubleshooting for the hosts and router interfaces that fail the ping test. Do you see anything obvious, such as interfaces that are administratively down or clocking that is incorrectly configured on the serial interfaces? _____

Task 4: Correct Configuration Issues

In this task, you will verify the current configurations and change any incorrect configurations.

A. Examine the Specific Points of Failure

1. Refer to your network examination. Did a ping from Router4 to HostC (172.16.16.180) succeed? _____

2. Issue a ping from Router3 to HostC (172.16.16.180). Is this ping successful? _____
3. Why would a ping to a directly connected host fail if all interfaces are up and operating properly? _____

4. Examine the routing table on Router3 for clues about why this is happening. What do you observe?

5. From Router4, attempt to ping Router3's FastEthernet 0/0 interface (172.16.16.161). Is this ping successful? _____
6. If this ping is successful and the ping to the PC host connected to this interface fails, what conclusion can you draw? _____
7. From Router4, attempt to ping Router5's FastEthernet 0/0 interface (172.16.16.177). Is this ping successful? _____
8. From Router4, attempt to ping HostE (172.16.16.200). Is this ping successful? _____
9. Based on the information you have gathered so far, briefly explain what you think is the root cause of the connectivity problems that you have observed. _____

10. Are all IP addresses on Router5 configured correctly? _____

B. Correct the Configuration

1. How is Router5's configuration error causing the connectivity problems that you have observed? _____

2. Issue the appropriate commands to correct the configuration error that you have discovered.

Task 5: Verify the Configuration


In this task, you will verify that the devices that should be connected are connected and that the correct routes appear in the routing table.

A. Verify Connectivity

1. Allow time for the network to converge. From Router4, attempt to ping HostC (172.16.16.180) and HostE (172.16.16.200); these pings failed earlier. Are the pings successful now? _____
2. From Router4, attempt to ping all hosts and router interfaces on the network. Do any pings fail? _____

B. Verify Routing

1. From Router4, examine the contents of the IP routing table. How have the contents of the IP routing table changed? _____
2. What effect do the changes to the routing table have on network connectivity? _____

Once you have completed this lab, be sure to check your work by using the grading function. You can do so by clicking the Grade Lab icon () in the toolbar or by pressing Ctrl+G.

Lab Solutions

Task 1: Create Multiple Subnets from One Network

- There are 4,094 host addresses that can be assigned on the 172.16.16.0/20 network. There are a total of 4,096 IP addresses on the 172.16.16.0/20 network. To figure out the number of available IP addresses, or host addresses, on a network, you should first write out the subnet mask in binary notation:

/20 = 11111111.11111111.11110000.00000000

The number of 0s in the binary notation (in this example, 12) is the information you need to know to be able to determine the total number of IP addresses. You can calculate the total number of IP addresses in the subnet by using the formula 2^n , where n is the number of host bits remaining in the subnet mask, which equals 4,096.

You should then use the formula $2^n - 2$, where the 2 you are subtracting represents the IP addresses that are reserved for the network and broadcast addresses. Thus, by using the equation $2^{12} - 2$, you can determine that 4,094 addresses are available as host addresses. However, you can subdivide the network if necessary so that you can more easily address multiple networks.

- The network address for the 172.16.16.0/20 network is 172.16.16.0. The network address is the first available address on the network.
- The broadcast address for the 172.16.16.0/20 network is 172.16.31.255. The broadcast address is the last available address on the network, and there are 4,096 total addresses on the network.
- A total of 10 subnets are represented in the topology diagram: five local area networks (LANs) and five wide area networks (WANs). A single host in each LAN is used to represent the total number of hosts. The 10 networks are listed below:

LAN	WAN
Router1	Router1 to Router4
Router2	Router2 to Router1
Router3	Router2 to Router3
Router4	Router4 to Router3
Router5	Router4 to Router5

- You should use the variable-length subnet masking (VLSM) process to create two /26 subnets from the 172.16.16.0/20 network. VLSM divides a single subnet into several smaller subnets. By using VLSM, you can conserve registered address space. Additionally, by using VLSM, you can create a more logical hierarchy of IP addressing across routers. The two new /26 networks are 172.16.16.0/26 and 172.16.16.64/26.

6. There are 62 hosts available for each /26 subnet. You can determine this by using the formula $2^n - 2$ with six host bits in the subnet mask:

$$/26 = 11111111.11111111.11111111.11000000$$

$$2^6 - 2 = 62$$

7. For the 172.16.16.0/26 subnet, the network address is 172.16.16.0 and the broadcast address is 172.16.16.63. For the 172.16.16.64/26 subnet, the network address is 172.16.16.64 and the broadcast address is 172.16.16.127.
8. You can use VLSM to create two /27 subnets from the first available addresses remaining in the 172.16.16.0/20 network. The first 128 addresses have been used with the two /26 subnets that you created in steps 4 through 6. Therefore, you must start with the 172.16.16.128 address. The two networks would be 172.16.16.128/27 and 172.16.16.160/27.
9. There are 30 hosts available for each /27 network. You can determine this by using the formula $2^n - 2$ with five host bits in the subnet mask:

$$/27 = 11111111.11111111.11111111.11100000$$

$$2^5 - 2 = 30$$

10. For the 172.16.16.128/27 subnet, the network address is 172.16.16.128 and the broadcast address is 172.16.16.159. For the 172.16.16.160/27 subnet, the network address is 172.16.16.160 and the broadcast address is 172.16.16.191.
11. You can use VLSM to create two /28 subnets from the first available addresses remaining in the 172.16.16.0/20 network. The first 192 addresses have been used with the 4 subnets (two /26 subnets and the two /27 subnets) that you have already created. Therefore, you must start with the 172.16.16.192 address. The two networks would be 172.16.16.192/28 and 172.16.16.208/28.
12. There are 14 hosts available for each /28 network. You can determine this by using the formula $2^n - 2$ with four host bits in the subnet mask:

$$/28 = 11111111.11111111.11111111.11110000$$

$$2^4 - 2 = 14$$

13. For the 172.16.16.192/28 subnet, the network address is 172.16.16.192 and the broadcast address is 172.16.16.207. For the 172.16.16.208/28 subnet, the network address is 172.16.16.208 and the broadcast address is 172.16.16.223.

14. You can use VLSM to create eight /30 subnets from the first available addresses remaining in the 172.16.16.0/24 network. You have already allocated the following 224 addresses:

172.16.16.0/26 (64 addresses)
 172.16.16.64/26 (64 addresses)
 172.16.16.128/27 (32 addresses)
 172.16.16.160/27 (32 addresses)
 172.16.16.192/28 (16 addresses)
 172.16.16.208/28 (16 addresses)

Therefore, you must start with the IP address 172.16.16.224.

15. There are two hosts available for each /30 network. The number of host addresses per subnet has been halved twice; instead of 16 (2^4) IP addresses in one subnet, there are now 2 (2^2) hosts available for each /30 subnet using the formula $2^n - 2$. If you write out /30 in binary notation, it looks like this:

/30 = 11111111.11111111.11111111.11111100
 $2^2 - 2 = 2$

16. The following are the network and broadcast addresses for the eight /30 subnets:

Subnet	Network Address	Broadcast Address
172.16.16.224/30	172.16.16.224	172.16.16.227
172.16.16.228/30	172.16.16.228	172.16.16.231
172.16.16.232/30	172.16.16.232	172.16.16.235
172.16.16.236/30	172.16.16.236	172.16.16.239
172.16.16.240/30	172.16.16.240	172.16.16.243
172.16.16.244/30	172.16.16.244	172.16.16.247
172.16.16.248/30	172.16.16.248	172.16.16.251
172.16.16.252/30	172.16.16.252	172.16.16.255

Once you have allocated these addresses, you will have effectively used all 256 available addresses in the 172.16.16.0/24 network. Because your address allocation has managed to stay within the bounds of the 172.16.16.0/24 network, you will be able to efficiently allocate the remainder of the 172.16.16.0/24 address space in a similarly hierarchical fashion.

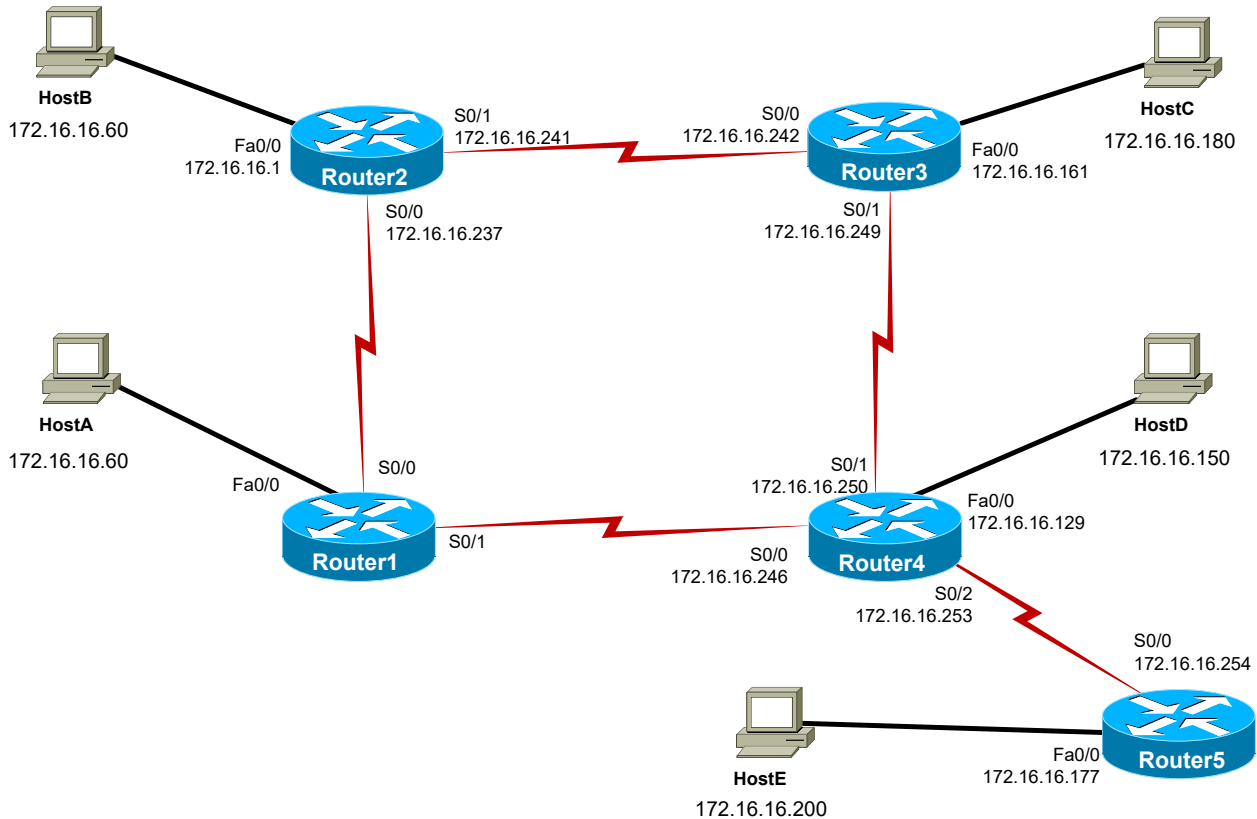
Task 2: Assign IP Addresses to Devices on the Network

- You should document the network configuration by issuing the **show cdp neighbors detail** command, the **show running-config** command, the **show ip interface** command, and the **show interfaces** command, among others, on the routers. You can use the **ipconfig** command on the workstations. Your completed tables should look like the following tables:

Device	Interface	IP Address	Subnet Mask
Router1	Serial 0/0	--	--
	Serial 0/1	--	--
	FastEthernet 0/0	--	--
Router2	Serial 0/0	172.16.16.237	255.255.255.252
	Serial 0/1	172.16.16.241	255.255.255.252
	FastEthernet 0/0	172.16.16.1	255.255.255.192
Router3	Serial 0/0	172.16.16.242	255.255.255.252
	Serial 0/1	172.16.16.249	255.255.255.252
	FastEthernet 0/0	172.16.16.161	255.255.255.224
Router4	Serial 0/0	172.16.16.246	255.255.255.252
	Serial 0/1	172.16.16.250	255.255.255.252
	Serial 0/2	172.16.16.253	255.255.255.252
	FastEthernet 0/0	172.16.16.129	255.255.255.224
Router5	Serial 0/0	172.16.16.254	255.255.255.252
	FastEthernet 0/0	172.16.16.177	255.255.255.240

Device	IP Address	Subnet Mask	Default Gateway
HostA	172.16.16.120	255.255.255.192	172.16.16.65
HostB	172.16.16.60	255.255.255.192	172.16.16.1
HostC	172.16.16.180	255.255.255.224	172.16.16.161
HostD	172.16.16.150	255.255.255.224	172.16.16.129
HostE	172.16.16.200	255.255.255.240	172.16.16.193

Your completed diagram should look like the following:



- Document the subnets assigned to each WAN and LAN subnet. Your completed tables should look similar to the following tables:

WAN	Router1 to Router4	Router2 to Router1	Router2 to Router3	Router4 to Router3	Router4 to Router5
Network Address	172.16.16.244	172.16.16.236	172.16.16.240	172.16.16.248	172.16.16.252
Subnet Mask (decimal)	255.255.255.252	255.255.255.252	255.255.255.252	255.255.255.252	255.255.255.252
First Host Address	172.16.16.245	172.16.16.237	172.16.16.241	172.16.16.249	172.16.16.253
Last Host Address	172.16.16.246	172.16.16.238	172.16.16.242	172.16.16.250	172.16.16.254
Broadcast Address	172.16.16.247	172.16.16.239	172.16.16.243	172.16.16.251	172.16.16.255
Number of Available Hosts	2	2	2	2	2
CIDR Notation	/30	/30	/30	/30	/30

LAN	Router1	Router2	Router2	Router4	Router4
Network Address	172.16.16.64	172.16.16.0	172.16.16.160	172.16.16.128	172.16.16.176
Subnet Mask (decimal)	255.255.255.192	255.255.255.192	255.255.255.224	255.255.255.224	255.255.255.240
First Host Address	172.16.16.65	172.16.16.1	172.16.16.161	172.16.16.129	172.16.16.177
Last Host Address	172.16.16.126	172.16.16.62	172.16.16.190	172.16.16.158	172.16.16.190
Broadcast Address	172.16.16.127	172.16.16.63	172.16.16.191	172.16.16.159	172.16.16.191
Number of Available Hosts	62	62	30	30	14
CIDR Notation	/26	/26	/27	/27	/28

	HostA	HostB	HostC	HostD	HostE
IP Address	172.16.16.120	172.16.16.60	172.16.16.180	172.16.16.150	172.16.16.200
Subnet Mask (decimal)	255.255.255.192	255.255.255.192	255.255.255.224	255.255.255.224	255.255.255.240
CIDR Notation	/26	/26	/27	/27	/28
Default Gateway	172.16.16.65	172.16.16.1	172.16.16.161	172.16.16.129	172.16.16.193

- Router1's FastEthernet 0/0 interface, Serial 0/0 interface, and Serial 0/1 interface have not been configured with an IP address.
- By reviewing the topology diagram, the addressing tables you created, and the output of the **show cdp neighbors detail** command, you can determine that Router1's Serial 0/0 interface is connected to Router2's Serial 0/0 interface, which has an IP address assignment of 172.16.16.237. You can also see that Router1's Serial 0/1 interface is connected to Router4's Serial 0/0 interface, which has an IP address assignment of 172.16.16.246. This information allows you to determine the subnets for Router1's WAN interfaces.

By issuing the **ipconfig** command on HostA, you can determine the subnet used for Router1's LAN interface (FastEthernet 0/0) by the IP address assigned as HostA's default gateway. This information should allow you to select an unassigned IP address from the available address range to assign to Router1's interface. Each of Router1's unconfigured interfaces belongs in a different subnet:

FastEthernet 0/0	172.16.16.64/26 subnet
Serial 0/0	172.16.16.236/30 subnet
Serial 0/1	172.16.16.244/30 subnet

- Using the information gathered in the previous steps, you should assign the unassigned IP addresses in the respective subnets to Router1's WAN interfaces and assign the first host address to Router1's LAN interface. On Router1, you should issue the following commands to configure the appropriate interfaces:

```
Router1#configure terminal
Router1(config)#interface fastethernet 0/0
Router1(config-if)#ip address 172.16.16.65 255.255.255.192
Router1(config-if)#interface serial 0/0
Router1(config-if)#ip address 172.16.16.238 255.255.255.252
Router1(config-if)#interface serial 0/1
Router1(config-if)#ip address 172.16.16.245 255.255.255.252
```

Task 3: Examine Network Connectivity

- Pings from Router4 have the following results:

Device	IP Address	Result
Router1	172.16.16.238 (Serial 0/0)	Succeeds
	172.16.16.245 (Serial 0/0)	Succeeds
	172.16.16.65 (FastEthernet 0/0)	Succeeds
Router2	172.16.16.237 (Serial 0/0)	Succeeds
	172.16.16.241 (Serial 0/1)	Succeeds
Router3	172.16.16.242 (Serial 0/0)	Succeeds
	172.16.16.249 (Serial 0/1)	Succeeds
	172.16.16.161 (FastEthernet 0/0)	Succeeds
Router5	172.16.16.254 (Serial 0/0)	Succeeds
HostA	172.16.16.120	Succeeds
HostB	172.16.16.60	Succeeds
HostC	172.16.16.180	Fails
HostD	172.16.16.129	Succeeds
HostE	172.16.16.200	Fails

- You could issue the **show ip interface brief** command, the **show ip interface** command, the **show interfaces** command, the **show running-config** command, and others to perform basic troubleshooting for the hosts and router interfaces that fail the ping test. The output of the commands should show that all interfaces are up/up, that clocking is correctly configured on all serial links, and that all interfaces are configured with an IP address. The output does not reveal any obvious configuration problems.

Task 4: Correct Configuration Issues

A. Examine the Specific Points of Failure

- A ping from Router4 to HostC (172.16.16.180) fails.

```
Router4#ping 172.16.16.180
```

2. A ping from Router3 to HostC fails.

```
Router3#ping 172.16.16.180
```

3. A ping to a directly connected host could fail if an erroneous route in the routing table diverts the traffic to an invalid destination, where the traffic is ultimately dropped.
4. Sample output from the **show ip route** command on Router3, which displays connected and learned routes, is shown below:

```
Router3#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
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route
```

```
Gateway of last resort is not set
```

```
172.16.0.0/16 is variably subnetted, 10 subnets
D       172.16.16.0/26 [90/5514496] via 172.16.16.241, 01:42:25, Serial0/0
D       172.16.16.64/26 [90/6026496] via 172.16.16.250, 01:12:59, Serial0/1
D       172.16.16.128/27 [90/5514496] via 172.16.16.250, 01:42:26, Serial0/1
C       172.16.16.160/27 is directly connected, FastEthernet0/0
D       172.16.16.176/28 [90/6026496] via 172.16.16.250, 01:42:26, Serial0/1
D       172.16.16.236/30 [90/6023936] via 172.16.16.241, 01:42:26, Serial0/0
C       172.16.16.240/30 is directly connected, Serial0/0
D       172.16.16.244/30 [90/6023936] via 172.16.16.250, 01:42:26, Serial0/1
C       172.16.16.248/30 is directly connected, Serial0/1
D       172.16.16.252/30 [90/6023936] via 172.16.16.250, 01:42:26, Serial0/1
```

All routes to the 172.16.16.176/28 network point toward Router3's Serial 0/1 interface, which sends traffic for this subnet to its next-hop neighbor—Router4. HostC's IP address falls in the 172.16.16.176/28 range, but HostC is not connected to Router4.

5. A ping from Router4 to Router3's FastEthernet 0/0 interface (172.16.16.161) should succeed.

```
Router4#ping 172.16.16.161
```

6. If a ping from Router4 to Router3's FastEthernet 0/0 interface succeeds and a ping from Router4 to HostC fails, you can conclude that there might be an error in the IP address configuration; you have already ruled out, from the output of the **show** commands you issued in Task 1, B, step 2, problems related to interface states and obvious configuration errors.
7. A ping from Router4 to Router5's FastEthernet 0/0 interface (172.16.16.177) should succeed.

```
Router4#ping 172.16.16.177
```

8. A ping from Router4 to HostE (172.16.16.200) fails.

```
Router4#ping 172.16.16.200
```

9. The output of the **show ip route** command issued on Router3 shows that all routes to the 172.16.16.176/28 network point toward Router3’s Serial 0/1 interface, which sends traffic for this subnet to its next-hop neighbor—Router4. This causes a problem with traffic addressed to HostC, which is connected to Router3. Further examination reveals that the IP addresses of Router5’s FastEthernet 0/0 interface and HostE fall into different networks; therefore, traffic addressed to HostE can never be delivered. Sample output is shown below:

On HostE:

```
C:>ipconfig
```

```
<output omitted>
```

```
Ethernet adapter Local Area Connection:
Connection-specific DNS Suffix . :
IP Address. . . . . : 172.16.16.200
Subnet Mask . . . . . : 255.255.255.240
Default Gateway . . . . . : 172.16.16.193
```

```
Router5#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Serial0/0	172.16.16.254	YES	unset	up	up
Serial0/1	unassigned	YES	unset	down	down
FastEthernet0/0	172.16.16.177	YES	unset	up	up
FastEthernet0/1	unassigned	YES	unset	down	down

10. No, all IP addresses on Router5 are not assigned correctly. Router5’s FastEthernet 0/0 interface is configured with an incorrect IP address. Sample output from the **show ip interface brief** command is shown below:

```
Router5#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Serial0/0	172.16.16.254	YES	unset	up	up
Serial0/1	unassigned	YES	unset	down	down
FastEthernet0/0	172.16.16.177	YES	unset	up	up
FastEthernet0/1	unassigned	YES	unset	down	down

B. Correct the Configuration

1. The FastEthernet 0/0 interface on Router5 is configured with an incorrect IP address. This interface is configured with an IP address of 172.16.16.177 and a subnet mask of 255.255.255.240.

```
Router5#show running-config interface fastethernet 0/0
Building configuration...
Current configuration : 125 bytes
!
interface FastEthernet0/0
 description Router5LAN
 ip address 172.16.16.177 255.255.255.240
 no ip directed-broadcast
end
```

This causes two problems. The first problem is that the IP address of Router5's FastEthernet 0/0 interface and the IP address of HostE, which is connected to Router5, are in different networks and therefore cannot communicate. This prevents the rest of the network from reaching HostE.

The second problem is that the IP address currently assigned to Router5's FastEthernet 0/0 interface overlaps the network assigned to the Router3 LAN. The Router3 LAN is configured with a 27-bit prefix (mask 255.255.255.224) and has an address range from 172.16.16.160 through 172.16.16.191. The FastEthernet 0/0 interface on Router5 is configured with an IP address of 172.16.16.177 with a 28-bit prefix (mask 255.255.255.240).

LAN	Router3	Router5
Network Address	172.16.16.160	172.16.16.176
Subnet Mask (decimal)	255.255.255.224	255.255.255.240
First Host Address	172.16.16.161	172.16.16.177
Last Host Address	172.16.16.190	172.16.16.190
Broadcast Address	172.16.16.191	172.16.16.191
Number of Available Hosts	30	14
CIDR Notation	/27	/28

This causes Router5 to announce via EIGRP a network that overlaps half of the Router3 LAN network. The network that Router5 announces has a 28-bit prefix and is preferred over the overlapping network with the shorter prefix, which Router3 advertises. The result is that half of the Router3 LAN's network addresses are unreachable.

- You should issue the following commands to correct the configuration on Router5:

```
Router5#configure terminal
Router5(config)#interface fastethernet 0/0
Router5(config-if)#ip address 172.16.16.193 255.255.255.240
```

The change to the IP addressing of the FastEthernet 0/0 interface on Router5 will prevent the Router5 network from overlapping the Router3 network, as shown in the table below:

LAN	Router3	Router5
Network Address	172.16.16.160	172.16.16.192
Subnet Mask (decimal)	255.255.255.224	255.255.255.240
First Host Address	172.16.16.161	172.16.16.193
Last Host Address	172.16.16.190	172.16.16.206
Broadcast Address	172.16.16.191	172.16.16.207
Number of Available Hosts	30	14
CIDR Notation	/27	/28

Task 5: Verify the Configuration

A. Verify Connectivity

1. After you allow time for the network to converge, pings from Router4 to HostC (172.16.16.180) and HostE (172.16.16.200), which failed before, are now successful.

```
Router4#ping 172.16.16.180
Router4#ping 172.16.16.200
```

2. Router4 should have full connectivity to all other devices on the network. If any of the pings fail, verify your configuration from Task 4, B, step 2.

B. Verify Routing

1. You should issue the **show ip route** command on Router4 to examine the contents of the IP routing table. Sample output is shown below:

```
Router4#show ip route
<output omitted>
```

```
Gateway of last resort is not set
```

```
      172.16.0.0/16 is variably subnetted, 10 subnets
D       172.16.16.0/26 [90/6026496] via 172.16.16.249, 01:55:51, Serial0/1
D       172.16.16.64/26 [90/5514496] via 172.16.16.245, 01:24:24, Serial0/0
C       172.16.16.128/27 is directly connected, FastEthernet0/0
D       172.16.16.160/27 [90/5514496] via 172.16.16.249, 01:55:51, Serial0/1
D       172.16.16.192/28 [90/5514496] via 172.16.16.254, 00:00:57, Serial0/2
D       172.16.16.236/30 [90/6023936] via 172.16.16.245, 01:24:24, Serial0/0
D       172.16.16.240/30 [90/6023936] via 172.16.16.249, 01:55:51, Serial0/1
C       172.16.16.244/30 is directly connected, Serial0/0
C       172.16.16.248/30 is directly connected, Serial0/1
C       172.16.16.252/30 is directly connected, Serial0/2
```

The output of the **show ip route** command issued on Router4 now does not show the route to the 172.16.16.176/28 network, which pointed toward Router5. It has been replaced by the correct route to the 172.16.16.160/27 network, which points toward Router3.

2. The routing table update to Router4 enables the devices on the network to reach HostC and HostE.

Sample Configuration Scripts

Router1	Router1 (continued)
<pre> Router1#show running-config Building configuration... Current configuration : 959 bytes ! Version 12.3 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname Router1 ! ip subnet-zero ! ip cef no ip domain-lookup ! interface Serial0/0 description ToRouter2 ip address 172.16.16.238 255.255.255.252 no ip directed-broadcast bandwidth 512 ! interface Serial0/1 description ToRouter4 ip address 172.16.16.245 255.255.255.252 no ip directed-broadcast bandwidth 512 ! interface FastEthernet0/0 description Router1LAN ip address 172.16.16.65 255.255.255.192 no ip directed-broadcast ! </pre>	<pre> interface FastEthernet0/1 no ip address no ip directed-broadcast ! router eigrp 100 network 172.16.0.0 auto-summary ! ip classless no ip http server ! line con 0 line aux 0 line vty 0 4 ! no scheduler allocate end </pre>

Router4	Router4 (continued)
<pre> Router4#show running-config Building configuration... Current configuration : 1227 bytes ! Version 12.3 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname Router4 ! ip subnet-zero ! ip cef no ip domain-lookup ! interface Serial0/0 description ToRouter1 ip address 172.16.16.246 255.255.255.252 no ip directed-broadcast clock rate 64000 bandwidth 512 ! interface Serial0/1 description toRouter3 ip address 172.16.16.250 255.255.255.252 no ip directed-broadcast clock rate 64000 bandwidth 512 ! interface Serial0/2 description toRouter5 ip address 172.16.16.253 255.255.255.252 ip summary-address eigrp 100 172.16.18.0 255.255.255.0 ip summary-address eigrp 100 172.16.21.0 255.255.255.0 ip summary-address eigrp 100 172.16.23.0 255.255.255.0 ip summary-address eigrp 100 172.16.27.0 255.255.255.0 no ip directed-broadcast clock rate 64000 bandwidth 512 ! interface Serial0/3 no ip address no ip directed-broadcast ! interface FastEthernet0/0 description Router4LAN ip address 172.16.16.129 255.255.255.224 no ip directed-broadcast ! </pre>	<pre> interface FastEthernet0/1 no ip address no ip directed-broadcast ! router eigrp 100 network 172.16.0.0 auto-summary ! ip classless no ip http server ! line con 0 line aux 0 line vty 0 4 ! no scheduler allocate end </pre>

Router5

```
Router5#show running-config
Building configuration...
Current configuration : 889 bytes
!
Version 12.3
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Router5
!
ip subnet-zero
!
ip cef
no ip domain-lookup
!
interface Serial0/0
  description toRouter4
  ip address 172.16.16.254 255.255.255.252
  no ip directed-broadcast
!
interface Serial0/1
  no ip address
  no ip directed-broadcast
!
interface FastEthernet0/0
  description Router5LAN
  ip address 172.16.16.193 255.255.255.240
  no ip directed-broadcast
!
interface FastEthernet0/1
  no ip address
  no ip directed-broadcast
!
router eigrp 100
  network 172.16.0.0
  auto-summary
!
ip classless
no ip http server
!
line con 0
line aux 0
line vty 0 4
!
no scheduler allocate
end
```

Lab 2.2 – IPv6 Configuration

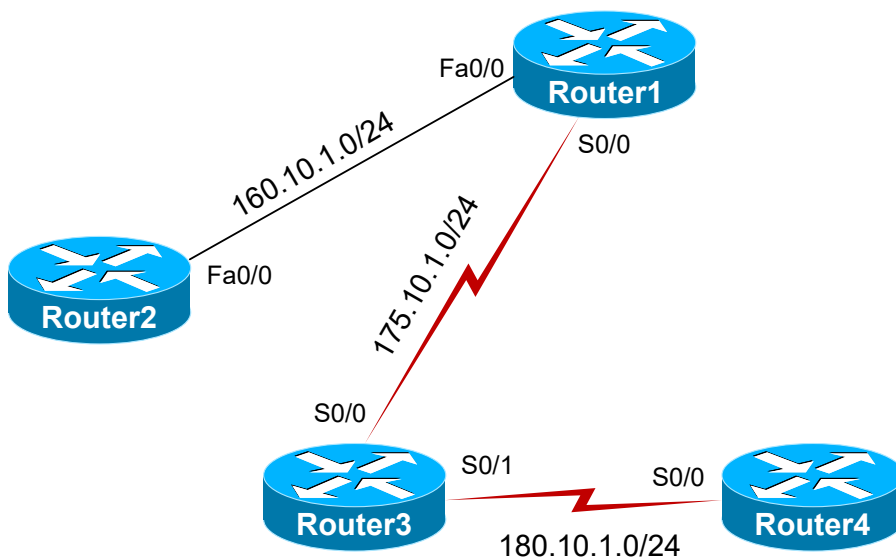
To perform this lab in the Boson NetSim, navigate to the appropriate lab in the lab menu in NetSim, and load the lab. You can then accomplish the tasks below.

Objective

This lab corresponds to Module 2: Network Addressing and Transport of Boson’s CCNA Curriculum. In this lab, you will implement Internet Protocol version 6 (IPv6) addresses. Your implementation should enable router interfaces to ping IPv6 addresses across routers.

Lab Topology

The topology diagram below represents the NetMap in the Simulator:



The commands you will need to perform the tasks in this lab, along with their syntax and descriptions, are shown in the Command Summary table below:

Command Summary

Command	Description
configure terminal	enters global configuration mode from privileged EXEC mode
enable	enters privileged EXEC mode
end	ends and exits configuration mode
exit	exits one level in the menu structure
interface type number	changes from global configuration mode to interface configuration mode
ipv6 address [address/prefix-length autoconfig dhcp]	configures an IPv6 address for an interface; the autoconfig keyword forces the device to dynamically discover its network prefix and to derive an address based on the Media Access Control (MAC) address of the interface; the dhcp keyword forces the device to dynamically obtain an address for the interface from a Dynamic Host Configuration Protocol (DHCP) server
ipv6 unicast-routing	enables IPv6 routing

Lab ID: 13.820AK02.CCNA.1

Command	Description
<code>ping ip-address</code>	sends an Internet Control Message Protocol (ICMP) echo request to the specified address
<code>ping ipv6 ipv6-address</code>	sends an ICMP echo request to the specified IPv6 address
<code>show ip interface brief</code>	displays a brief summary of interface status and configuration
<code>show ip route</code>	displays the IP routing table
<code>show ipv6 interface</code>	displays IPv6 interface information
<code>show ipv6 interface brief</code>	displays a brief summary of each IPv6 interface's configuration and status
<code>show ipv6 protocols</code>	displays information about active IPv6 routing protocols
<code>show ipv6 route</code>	displays the IPv6 routing table
<code>show running-config</code>	displays the active configuration file

The IP addresses and subnet masks used in this lab are shown in the table below:

IP Addresses

Device	Interface	IPv4 Address	IPv6 Address
Router1	Serial 0/0	175.10.1.1/24	2001:0001:0003:0004::2/64
	FastEthernet 0/0	160.10.1.1/24	2001:0001:0003:0006::1/64
Router2	FastEthernet 0/0	160.10.1.2/24	2001:0001:0003:0006::2/64
Router3	Serial 0/0	175.10.1.2/24	2001:0001:0003:0004::1/64
	Serial 0/1	180.10.1.1/24	2001:0001:0003:0001::1/64
Router4	Serial 0/0	180.10.1.2/24	2001:0001:0003:0001::2/64

Lab Tasks

Task 1: Configure IPv6 Addresses

In this task, you will examine the current network configuration and configure the appropriate IPv6 addresses on the interfaces. You will only perform steps on the physical interfaces shown in the IP Addresses table.

A. Examine the Initial Network Configuration

- Examine the running configuration of all routers; do the IP version 4 (IPv4) addresses assigned to each router interface match IP addresses shown in the IP Addresses table? _____
- What types of IP addresses are currently assigned to the routers? _____
- What is the theoretical maximum number of unique IP addresses of this type that can be assigned?

- Why is there a need to change this method of IP addressing? _____

5. Verify IPv4 connectivity between Router3 and Router4 by issuing the **ping 180.10.1.2** command on Router3 and the **ping 180.10.1.1** command on Router4. Do the pings succeed? _____

B. Configure IPv6 Addresses

1. IPv6 addresses will eventually replace the IPv4 addresses currently in use today. What are the expected benefits of this new type of IP addressing? _____

2. What are some of the major differences between IPv4 addressing and IPv6 addressing? _____

3. What is the theoretical maximum number of IPv6 addresses that can be assigned? _____
4. Briefly describe some of the techniques that will allow IPv4 addressing to coexist with IPv6 addressing. _____

5. Enable IPv6 packet forwarding on Router3 and Router4.
6. Configure static IPv6 addresses for Router3's Serial 0/1 interface and Router4's Serial 0/0 interface; refer to the IP Addresses table.

C. Verify Interface Configuration

1. Issue the **show ipv6 interface** command on Router3. What IPv6 addresses have been assigned to Router3's Serial 0/1 interface? _____
2. Issue the **show ipv6 interface brief** command on Router3. What interfaces have IPv6 addresses? _____

3. From Router3, ping Router4's global unicast Serial 0/1 IPv6 address (2001:1:3:1::2). Does the ping succeed? _____
4. From Router4, ping Router3's global unicast Serial 0/1 IPv6 address (2001:1:3:1::1). Does the ping succeed? _____

Task 2: Configure IPv6 between Router1 and Router2


In this task, you will use the commands you learned in the previous task to implement IPv6 on the link between Router1 and Router2. Use the IPv6 addresses in the table.

1. On Router1, enable IPv6 packet forwarding.
2. On Router1, configure the FastEthernet 0/0 interface with the appropriate IPv6 address.
3. Which keyword would you use if you wanted to specify only a network prefix and to have Router1 derive an address based on the MAC address of its FastEthernet 0/0 interface? _____
4. Which keyword would you use if you wanted Router1 to dynamically discover its network prefix and to derive an address based on the MAC address of its FastEthernet 0/0 interface? _____
5. On Router2, enable IPv6 packet forwarding.
6. On Router2, configure the FastEthernet 0/0 interface with the appropriate IPv6 address.
7. From Router2, verify that you can ping Router1's FastEthernet 0/0 IPv6 address (2001:1:3:6::1).

Task 3: Configure IPv6 between Router1 and Router3

In this task, you will use the commands you learned in previous tasks to implement IPv6 on the link between Router1 and Router3. Use the IPv6 addresses in the table.

1. On Router1, configure the Serial 0/0 interface with the appropriate IPv6 address.
2. Which keyword would you use if you wanted Router1 to dynamically obtain an address for the Serial 0/0 interface from a DHCP server? _____
3. On Router3, configure the Serial 0/0 interface with the appropriate IPv6 address.
4. From Router3, verify that you can ping Router1's Serial 0/0 IPv6 address (2001:1:3:4::2).

Once you have completed this lab, be sure to check your work by using the grading function. You can do so by clicking the Grade Lab icon () in the toolbar or by pressing Ctrl+G.

Lab Solutions

Task 1: Configure IPv6 Addresses

A. Examine the Initial Network Configuration

1. Yes, the IP addresses assigned to each router interface match the IP addresses shown in the IP Addresses table. You can verify this by issuing the **show ip interface brief** command, among others. Sample output from Router1 is shown below:

```
Router1>enable
Router1#show ip interface brief
Interface          IP-Address      OK? Method Status          Protocol
Serial0/0          175.10.1.1      YES unset    up              up
Serial0/1          unassigned      YES unset    administratively down down
FastEthernet0/0    160.10.1.1      YES unset    up              up
FastEthernet0/1    unassigned      YES unset    administratively down down
Loopback0          160.10.2.1      YES unset    up              up
```

2. The routers are currently configured with IPv4 addresses.
3. The theoretical maximum number of unique IP addresses that can be assigned in the IPv4 address space is 2^{32} , which equals 4,294,467,295 IP addresses. Due to inefficiencies in the allocation of addresses, it is estimated that there are approximately 1.3 billion usable IPv4 addresses available.
4. A new method of IP addressing is needed because the IPv4 address space is being rapidly exhausted. Address conservation technologies, such as Classless Inter-Domain Routing (CIDR), variable-length subnet masking (VLSM), and private IP addressing combined with Network Address Translation (NAT) and Port Address Translation (PAT), have extended the life of IPv4 addressing long beyond initial predictions. Even so, the growing number of Internet users is rapidly exhausting the remaining available IPv4 addresses. A new IP addressing technique that allows for a much larger number of IP addresses is needed to meet the increasing demand of Internet users and the growth of new Internet-enabled devices, such as wireless phones and other handheld devices.
5. A ping from Router3 to Router4's Serial 0/0 interface (180.10.1.2) and from Router4 to Router3's Serial 0/1 interface (180.10.1.1) should succeed.

```
Router3>enable
Router3#ping 180.10.1.2
```

```
Router4>enable
Router4#ping 180.10.1.1
```


B. Configure IPv6 Addresses

1. The primary benefit of IPv6 is that a dramatically higher number of IP addresses can be assigned. Other benefits of IPv6 over IPv4 include the following:
 - Built-in security
 - Automatic address configuration by using ICMP version 6 (ICMPv6) and DHCP version 6 (DHCPv6)
 - A simpler header structure
 - Reliance on Transport layer protocols rather than header checksums for data integrity
 - Better support for mobile devices
 - Native implementation of IP Security (IPSec)
 - More efficient route aggregation by using multiple subprefixes
2. A major difference between IPv4 and IPv6 addresses is the length of the address. An IPv4 address is 32 bits in length and is usually represented in dotted decimal notation as four decimal octets. An IPv6 address is 128 bits in length and is usually represented as eight 16-bit hexadecimal values. IPv4 addresses are usually assigned with a dotted decimal subnet mask, such as 255.255.255.248. IPv6 addresses are usually assigned with a prefix length in CIDR notation, such as /64.
3. The theoretical maximum number of IPv6 addresses that can be assigned is 3.4×10^{38} IP addresses.
4. The transition to IPv6 will not happen immediately. Several technologies, such as dual stacking, 6to4 tunneling, 4to6 tunneling, and Network Address Translation-Port Translation (NAT-PT), provide interoperability between IPv4 and IPv6.
 - A dual-stack configuration allows a device to be configured with both IPv4 and IPv6 addresses and to participate in IPv4 and IPv6 networks simultaneously.
 - The 6to4 tunneling technology allows an IPv4 network to encapsulate and transport IPv6 traffic.
 - The 4to6 tunneling technology allows an IPv6 network to encapsulate and transport IPv4 traffic.
 - NAT-PT enables communication between IPv6-only hosts and IPv4-only hosts by translating IPv6 packets to IPv4 packets and by translating IPv4 packets to IPv6 packets; NAT-PT relies on address translation, so a NAT-PT router must manage address mappings so that the router can correctly translate IPv4 and IPv6 addresses.
5. You should issue the following commands to enable IPv6 packet forwarding on Router3 and Router4:

```
Router3#configure terminal
Router3(config)#ipv6 unicast-routing
```

```
Router4#configure terminal
Router4(config)#ipv6 unicast-routing
```

6. You should issue the following commands to configure the appropriate static IPv6 addresses on Router3 and Router4:

```
Router3(config)#interface serial 0/1
Router3(config-if)#ipv6 address 2001:1:3:1::1/64

Router4(config)#interface serial 0/0
Router4(config-if)#ipv6 address 2001:1:3:1::2/64
```

C. Verify Interface Configuration

1. Router3's Serial 0/1 interface has been assigned the global unicast IPv6 address 2001:1:3:1::1/64 and the link-local IPv6 address FE80::020C:31FF:FE68:8461. The link-local IPv6 address is automatically generated when you assign a global unicast IPv6 address to an interface. Sample output from the **show ipv6 interface** command is shown below:

```
Router3(config-if)#end
Router3#show ipv6 interface
Serial0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::020C:31FF:FE68:8461
  Global unicast address(es):
  2001:1:3:1::1, subnet is 2001:1:3:1::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
    FF02::1:FF68:8461
<output omitted>
```

2. Router3's Serial 0/1 interface has a global unicast IPv6 address and a link-local IPv6 address. Additionally, the Loopback 6 interface has a global unicast IPv6 address and a link-local IPv6 address. Sample output from the **show ipv6 interface brief** command is shown below:

```
Router3#show ipv6 interface brief
Serial0/0 [up/up]
  unassigned
Serial0/1 [up/up]
  FE80::020C:31FF:FE68:8461
  2001:1:3:1::1
FastEthernet0/0 [administratively down/down]
  unassigned
FastEthernet0/1 [up/up]
  unassigned
FastEthernet0/1.1 [up/up]
  unassigned
FastEthernet0/1.2 [up/up]
  unassigned
FastEthernet0/1.4 [up/up]
  unassigned
```

3. From Router3, a ping to Router4's Serial 0/0 IPv6 address (2001:1:3:1::2) succeeds because the Serial interfaces between the two routers are directly connected and reside on the same subnet.

```
Router3#ping ipv6 2001:1:3:1::2
```

4. From Router4, a ping to Router3's Serial 0/1 IPv6 address (2001:1:3:1::1) succeeds because the Serial interfaces between the two routers are directly connected and reside on the same subnet.

```
Router4(config-if)#end
Router4#ping ipv6 2001:1:3:1::1
```

Task 2: Configure IPv6 between Router1 and Router2

1. On Router1, you should issue the following commands to enable IPv6 packet forwarding:

```
Router1#configure terminal
Router1(config)#ipv6 unicast-routing
```

2. On Router1, you should issue the following commands to configure the FastEthernet 0/0 interface with the appropriate IPv6 address:

```
Router1(config)#interface fastethernet 0/0
Router1(config-if)#ipv6 address 2001:1:3:6::1/64
```

3. You would use the **eui-64** keyword if you wanted to specify only a network prefix and to have Router1 derive an address based on the MAC address of its FastEthernet 0/0 interface. A Cisco device can automatically generate a 64-bit interface ID called an EUI-64 interface ID based on the 48-bit MAC address of an Ethernet interface. To configure an interface to use the EUI-64 interface ID, you should issue the **ipv6 address *prefix/prefix-length eui-64*** command. For example, the **ipv6 address 2001:ABCD:1234::/64 eui-64** command configures an interface with the 64-bit IPv6 prefix 2001:ABCD:1234:0 and an EUI-64 interface ID.
4. You would use the **autoconfig** keyword if you wanted Router1 to dynamically discover its network prefix and to derive an address based on the MAC address of its FastEthernet 0/0 interface. This method of dynamic addressing is referred to as stateless autoconfiguration. With stateless autoconfiguration, a Cisco device can listen to Router Advertisement (RA) messages to dynamically discover the appropriate network prefix for a particular link. The prefix is then combined with the device's EUI-64 interface ID to create a unique IPv6 address. For example, the **ipv6 address autoconfig** command configures an interface to use stateless autoconfiguration.

5. On Router2, you should issue the following commands to enable IPv6 packet forwarding:

```
Router2>enable
Router2#configure terminal
Router2(config)#ipv6 unicast-routing
```

6. On Router2, you should issue the following commands to configure the FastEthernet 0/0 interface with the appropriate IPv6 address:

```
Router2(config)#interface fastethernet 0/0
Router2(config-if)#ipv6 address 2001:1:3:6::2/64
```

7. A ping from Router2 to Router1's FastEthernet 0/0 interface (2001:1:3:6::1) should succeed.

```
Router2(config-if)#end
Router2#ping ipv6 2001:1:3:6::1
```

Task 3: Configure IPv6 between Router1 and Router3

1. On Router1, you should issue the following commands to configure the Serial 0/0 interface with the appropriate IPv6 address:

```
Router1(config-if)#interface serial 0/0
Router1(config-if)#ipv6 address 2001:1:3:4::2/64
```

2. You would use the **dhcp** keyword if you wanted Router1 to dynamically obtain an address for the Serial 0/0 interface from a DHCP server. For example, the **ipv6 address dhcp** command configures an interface to obtain an address dynamically from a DHCP server.

3. On Router3, you should issue the following commands to configure the Serial 0/0 interface with the appropriate IPv6 address:

```
Router3#configure terminal
Router3(config)#interface serial 0/0
Router3(config-if)#ipv6 address 2001:1:3:4::1/64
```

4. A ping from Router3 to Router1's Serial 0/0 interface (2001:1:3:4::2) should succeed.

```
Router3(config-if)#end
Router3#ping ipv6 2001:1:3:4::2
```

Sample Configuration Scripts

Router1	Router1 (<i>continued</i>)
<pre> Router1#show running-config Building configuration... Current configuration : 1282 bytes ! Version 12.3 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname Router1 ! ip subnet-zero ! ip cef no ip domain-lookup ! ipv6 unicast-routing ip host Router2 160.10.1.2 ! interface Loopback0 ip address 160.10.2.1 255.255.255.0 no ip directed broadcast ! interface Serial0/0 description Serial Link to Router3 ip address 175.10.1.1 255.255.255.0 no ip directed-broadcast clock rate 64000 bandwidth 64 ipv6 address 2001:1:3:4::2/64 ! interface Serial0/1 no ip address no ip directed-broadcast shutdown ! </pre>	<pre> interface FastEthernet0/0 ip address 160.10.1.1 255.255.255.0 no ip directed-broadcast ipv6 address 2001:1:3:6::1/64 ! interface FastEthernet0/1 no ip address no ip directed-broadcast shutdown ! router eigrp 100 network 160.10.0.0 network 175.10.0.0 auto-summary ! ip classless no ip http server ! cdp holdtime 20 cdp timer 50 ! banner motd ^C Unauthorized Access Prohibited^C line con 0 line aux 0 line vty 0 4 ! no scheduler allocate end </pre>

Router3	Router3 (continued)
<pre> Router3#show running-config Building configuration... Current configuration : 1143 bytes ! Version 12.3 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname Router3 ! ip subnet-zero ! ip cef no ip domain-lookup ! ipv6 unicast-routing ! interface Serial0/0 ip address 175.10.1.2 255.255.255.0 no ip directed-broadcast ipv6 address 2001:1:3:4::1/64 ! interface Serial0/1 ip address 180.10.1.1 255.255.255.0 no ip directed-broadcast clock rate 64000 ipv6 address 2001:1:3:1::1/64 ! interface FastEthernet0/0 no ip address no ip directed-broadcast shutdown ! </pre>	<pre> interface FastEthernet0/1 no ip address no ip directed-broadcast ! interface FastEthernet0/1.1 encapsulation dot1q 1 ip address 197.10.1.1 255.255.255.0 ! interface FastEthernet0/1.2 encapsulation dot1q 2 ip address 197.10.2.1 255.255.255.0 ! interface FastEthernet0/1.4 encapsulation dot1q 4 ip address 197.10.4.1 255.255.255.0 ! ! router eigrp 100 network 175.10.0.0 network 180.10.0.0 network 197.10.1.0 network 197.10.2.0 network 197.10.4.0 auto-summary ! ip classless no ip http server ! line con 0 line aux 0 line vty 0 4 ! no scheduler allocate end </pre>

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