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ECE 407

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Introduction to Computer Networks Laboratory

Practice 6 – IP addressing and Subnetting

Objectives

The goal of this experiment is to:

1. Familiarize students with IPv4 addressing and subnet masks.
2. Familiarize students with fixed size subnetting.
3. Familiarize students with Variable Length Subnet Masks (VLSM).

Background

An IP address is an address used in order to uniquely identify a device on an IP network. The address is made up of 32 binary bits, which can be divisible into a network portion and host portion with the help of a subnet mask. The network portion of an address is the same for all devices that reside in the same network. The host portion identifies a specific host within a given network. The subnet mask is used to determine the network portion of an IP address. Devices on the same network can communicate directly; devices on different networks require an intermediary Layer 3 device, such as a router, to communicate.

The 32 binary bits are broken into four octets (1 octet = 8 bits). Each octet is converted to decimal and separated by a period (dot). For this reason, an IP address is said to be expressed in dotted decimal format (for example, 172.16.81.100). The value in each octet ranges from 0 to 255 decimal, or 00000000 - 11111111 binary. These octets are broken down to provide an addressing scheme that can accommodate large and small networks. There are five different classes of networks, A to E. Given an IP address, its class can be determined from the three high-order bits (the three leftmost bits in the first octet),

1. In a Class A address, the first octet is the network portion, and network addresses range from 1.0.0.0 to 127.255.255.255. Octets 2, 3, and 4 (the next 24 bits) are for the network manager to divide into subnets and hosts as he/she sees fit. Class A addresses are used for networks that have more than 65,536 hosts (actually, up to 16777214 hosts!).
2. In a Class B address, the first two octets are the network portion, and network addresses range from 128.0.0.0 to 191.255.255.255. Octets 3 and 4 (16 bits) are for local subnets and hosts. Class B addresses are used for networks that have between 256 and 65534 hosts.
3. In a Class C address, the first three octets are the network portion, and network addresses range from 192.0.0.0 to 223.255.255.255. Octet 4 (8 bits) is for local subnets and hosts - perfect for networks with less than 254 hosts.

A network mask helps you know which portion of the address identifies the network and which portion of the address identifies the node. Class A, B, and C networks have default masks, also known as natural masks, Class A: 255.0.0.0

Class B: 255.255.0.0

Class C: 255.255.255.0

An IP address on a Class A network that has not been subnetted would have an address/mask pair similar to: 8.20.15.1 255.0.0.0. In order to see how the mask helps you identify the network and node parts of the address, convert the address and mask to binary numbers. After this has been done, we can use the bitwise ANDing operation to determine the network address. As an example,

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

Once you have the address and the mask represented in binary, then identification of the network and host ID is easier. Any address bits which have corresponding mask bits set to 1 represent the network ID. Any address bits that have corresponding mask bits set to 0 represent the node ID.

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

----

net id | host id

netid = 00001000 = 8

hostid = 00010100.00001111.00000001 = 20.15.1

Variable Length Subnet Masking (VLSM) is a technique that allows network administrators to divide an IP address space into subnets of different sizes to create subnets of various sizes based on the number of hosts required in each subnet. With VLSM, you can create multiple logical networks that exist within a single Class A, B, or C network. If you do not subnet, you are only able to use one network from your Class A, B, or C network, which is unrealistic and wasteful of IP addresses.

In order to subnet a network, extend the natural mask with some of the bits from the host ID portion of the address in order to create a subnetwork ID. For example, given a Class C network of 204.17.5.0 which has a natural mask of 255.255.255.0, you can create subnets in this manner:

204.17.5.0 - 11001100.00010001.00000101.00000000

255.255.255.224 - 11111111.11111111.11111111.11100000

----

net id |host id

By extending the mask to be 255.255.255.224, you have taken three bits (indicated by "sub") from the original host portion of the address and used them to make subnets. With these three bits, it is possible to create eight subnets. With the remaining five host ID bits, each subnet can have up to 32 host addresses, 30 of which can actually be assigned to a device *since host ids of all zeros or all ones are not allowed* (it is very important to remember this). So, with this in mind, these subnets have been created.

204.17.5.0 255.255.255.224 host address range 1 to 30

204.17.5.32 255.255.255.224 host address range 33 to 62

204.17.5.64 255.255.255.224 host address range 65 to 94

204.17.5.96 255.255.255.224 host address range 97 to 126

204.17.5.128 255.255.255.224 host address range 129 to 158

204.17.5.160 255.255.255.224 host address range 161 to 190

204.17.5.192 255.255.255.224 host address range 193 to 222

204.17.5.224 255.255.255.224 host address range 225 to 254

There are two ways to denote these masks. First, since you use three bits more than the "natural" Class C mask, you can denote these addresses as having a 3-bit subnet mask of 255.255.255.224. Or, secondly, the mask of 255.255.255.224 can be denoted as /27 as there are 27 bits that are set to one in the mask.

Exercise 1: Network Address Calculations and IPv4 Subnetting (7.1.2.9)

A. Convert the IPv4 addresses to their binary equivalent.

Fill in the table below with the binary equivalent of the addresses provided. To make your answers easier to read, separate the binary octets with a period.

Decimal	Binary
192.168.10.10	11000000.10101000.00001010.00001010
209.165.200.229	11010001.10100101.11001000.11100101
172.16.18.183	10101100.00010000.00010010.10110111
10.86.252.17	00001010.01010110.11111100.00010001
255.255.255.128	11111111.11111111.11111111.10000000
255.255.192.0	11111111.11111111.11000000.00000000

B. Use Bitwise ANDing Operation to Determine Network Addresses

Note: The ANDing process compares the binary value in each bit position of the 32-bit host IP with the corresponding position in the 32-bit subnet mask. If there are two 0s or a 0 and a 1, the ANDing result is 0. If there are two 1s, the result is a 1, as shown in the example here.

1. **Determine the number of bits to use to calculate the network address.**

Description	Decimal	Binary
IP Address	192.168.10.131	11000000.10101000.00001010.10000011
Subnet Mask	255.255.255.192	11111111.11111111.11111111.11000000
Network Address	192.168.10.128	11000000.10101000.00001010.10000000

How do you determine what bits to use to calculate the network address?

There are bits that can be set to 1 for the binary subnet mask which calculate network addresses.

In the example above, how many bits are used to calculate the network address?

26 I believe.

2. **Use the ANDing operation to determine the network address.**

Enter the missing information into the table below:

Description	Decimal	Binary
IP Address	172.16.145.29	10101100.00010000.10010001.00011101
Subnet Mask	255.255.0.0	11111111.11111111.00000000.00000000
Network Address	172.16.0.0	10101100.00010000.00000000.00000000
IP Address	192.168.10.10	11000000.10101000.00001010.00001010
Subnet Mask	255.255.255.0	11111111.11111111.11111111.00000000
Network Address	192.168.10.0	11000000.10101000.00001010.00000000
IP Address	192.168.68.210	11000000.10101000.01000100.11010010
Subnet Mask	255.255.255.128	11111111.11111111.11111111.10000000
Network Address	192.168.68.128	11000000.10101000.01000100.10000000
IP Address	172.16.188.15	10101100.00010000.10111100.00001111
Subnet Mask	255.255.240.0	11111111.11111111.11110000.00000000
Network Address	172.16.176.0	10101100.00010000.10110000.00000000
IP Address	10.172.2.8	00001010.10101100.00000010.00001000
Subnet Mask	255.224.0.0	11111111.11100000.00000000.00000000
Network Address	10.160.0.0	00001010.10100000.00000000.00000000

C. Apply Network Address Calculations

1. Determine whether IP addresses are on the same network.

i. You are configuring two PCs for your network. PC-A is given an IP address of 192.168.1.18, and PC-B is given an IP address of 192.168.1.33. Both PCs receive a subnet mask of 255.255.255.240.

What is the network address for PC-A? 192.168.1.16

What is the network address for PC-B? 192.168.1.32

Will these PCs be able to communicate directly with each other? No

What is the highest address that can be given to PC-B that allows it to be on the same network as PC-A? 192.168.1.30

ii. You are configuring two PCs for your network. PC-A is given an IP address of 10.0.0.16, and PC-B is given an IP address of 10.1.14.68. Both PCs receive a subnet mask of 255.254.0.0.

What is the network address for PC-A? 10.0.0.0

What is the network address for PC-B? 10.0.0.0

Will these PCs be able to communicate directly with each other? Yes

What is the lowest address that can be given to PC-B that allows it to be on the same network as PC-A? 10.0.0.1

2. Identify the default gateway address.

i. Your company has a policy to use the first IP address in a network as the default gateway address. A host on the local-area network (LAN) has an IP address of 172.16.140.24 and a subnet mask of 255.255.192.0.

What is the network address for this network? 172.16.128.0

What is the default gateway address for this host? 172.16.128.1

ii. Your company has a policy to use the first IP address in a network as the default gateway address. You have been instructed to configure a new server with an IP address of 192.168.184.227 and a subnet mask of 255.255.255.248.

What is the network address for this network? 192.168.184.224

What is the default gateway for this server? 192.168.184.225

3. Analyze the table shown below and identify the network portion and host portion of the given IPv4 addresses (7.1.4.9)

The first two rows show examples of how the table should be completed.

Key for table:

N = all 8 bits for an octet are in the network portion of the address

n = a bit in the network portion of the address

H = all 8 bits for an octet are in the host portion of the address

h = a bit in the host portion of the address

IP Address/Prefix	Network/Host N,n = Network, H,h = Host	Subnet Mask	Network Address
192.168.10.10/24	N.N.N.H	255.255.255.0	192.168.10.0
10.101.99.17/23	N.N.nnnnnnnh.H	255.255.254.0	10.101.98.0
209.165.200.227/27	N.N.N.nnnhhhhh	255.255.255.224	209.165.200.224
172.31.45.252/24	N.N.N.H	255.255.255.0	172.31.45.0
10.1.8.200/26	N.N.N.nnhhhhhh	255.255.255.192	10.1.8.192
172.16.117.77/20	N.N.nnnnhhhh.H	255.255.240.0	172.16.112.0
10.1.1.101/25	N.N.N.nhhhhhhh	255.255.255.128	10.1.1.0
209.165.202.140/27	N.N.N.nnnhhhhh	255.255.255.224	209.165.202.128
192.168.28.45/28	N.N.N.nnnnhhhh	255.255.255.240	192.168.28.32

4. **Analyze the table below and list the range of host and broadcast addresses given a network/prefix mask pair (7.1.4.9)**

The first row shows an example of how the table should be completed.

IP Address/Prefix	First Host Address	Last Host Address	Broadcast Address
192.168.10.10/24	192.168.10.1	192.168.10.254	192.168.10.255
10.101.99.17/23	10.101.98.1	10.101.99.254	10.101.99.255
209.165.200.227/27	209.165.200.225	209.165.200.254	209.165.200.255
172.31.45.252/24	172.31.45.1	172.31.45.254	172.31.45.255
10.1.8.200/26	10.1.8.193	10.1.8.254	10.1.8.255

172.16.117.77/20	172.16.112.1	172.16.127.254	172.16.127.255
10.1.1.101/25	10.1.1.1	10.1.1.126	10.1.1.127
209.165.202.140/27	209.165.202.129	209.165.202.158	209.165.202.159
192.168.28.45/28	192.168.28.33	192.168.28.46	192.168.28.47

5. Determining the number of hosts per network (8.1.4.6)

Determining the number of hosts per network can be calculated by analyzing the subnet mask. An IPv4 address always has 32 bits. Subtracting the number of bits used for the network portion (as represented by the subnet mask) gives you the number of bits used for hosts.

For example, the subnet mask 255.255.192.0 is equivalent to /18 in prefix notation. Subtracting 18 network bits from 32 bits results in 14 bits left for the host portion. From there, it is a simple calculation:

$2^{(\text{number of host bits})} - 2 = \text{Number of hosts}$

i.e., $2^{14} = 16{,}384 - 2 = 16{,}382$ hosts

Determine the network and broadcast addresses and number of host bits and hosts for the given IPv4 addresses and prefixes in the following table.

IPv4 Address/Prefix	Network Address	Broadcast Address	Total Number of Host Bits	Total Number of Hosts
192.168.100.25/28	192.168.100.16	192.168.100.31	4	14
172.30.10.130/30	172.30.10.128	172.30.10.131	2	2
10.1.113.75/19	10.1.96.0	10.1.127.255	13	8190
198.133.219.250/24	198.133.219.0	198.133.219.255	8	254
128.107.14.191/22	128.107.12.0	128.107.15.255	10	1022
172.16.104.99/27	172.16.104.96	172.16.104.127	5	30

6. Calculate IPv4 Address Subnets

When given an IPv4 address, the original subnet mask and the new subnet mask, you will be able to determine:

- Network address of this subnet
- Broadcast address of this subnet
- Range of host addresses of this subnet
- Number of subnets created
- Number of hosts per subnet

The following example shows a sample problem along with the solution for solving this problem:

Given:	
Host IP Address:	172.16.77.120
Original Subnet Mask	255.255.0.0
New Subnet Mask:	255.255.240.0
Find:	
Number of Subnet Bits	4
Number of Subnets Created	16
Number of Host Bits per Subnet	12
Number of Hosts per Subnet	4,094
Network Address of this Subnet	172.16.64.0
IPv4 Address of First Host on this Subnet	172.16.64.1
IPv4 Address of Last Host on this Subnet	172.16.79.254
IPv4 Broadcast Address on this Subnet	172.16.79.255

Let's analyze how this table was completed.

The original subnet mask was 255.255.0.0 or /16. The new subnet mask is 255.255.240.0 or /20. The resulting difference is 4 bits. Because 4 bits were borrowed, we can determine that 16 subnets were created because $2^4 = 16$.

The new mask of 255.255.240.0 or /20 leaves 12 bits for hosts. With 12 bits left for hosts, we use the following formula: $2^{12} = 4,096 – 2 = 4,094$ hosts per subnet.

Binary ANDing will help you determine the subnet for this problem, which results in the network 172.16.64.0.

Finally, you need to determine the first host, last host, and broadcast address for each subnet. One method to determine the host range is to use binary math for the host portion of the address. In our example, the last 12 bits of the address is the host portion. The first host would have all significant bits set to zero and the least significant bit set to 1. The last host would have all significant bits set to 1 and the least significant bit set to 0. In this example, the host portion of the address resides in the 3rd and 4th octets.

Description	**1st Octet**	**2nd Octet**	**3rd Octet**	**4th Octet**	**Description**
Network/Host	**nnnnnnnn**	**nnnnnnnn**	**nnnn**hhhh	hhhhhhhh	Subnet Mask
Binary	**10101100**	**00010000**	**0100**0000	00000001	First Host
Decimal	172	16	64	1	First Host
Binary	**10101100**	**00010000**	**0100**1111	11111110	Last Host
Decimal	172	16	79	254	Last Host
Binary	**10101100**	**00010000**	**0100**1111	11111111	Broadcast
Decimal	172	16	79	255	Broadcast

1. Fill out the tables below with appropriate answers given the IPv4 address, original subnet mask, and new subnet mask.

Problem 1:

Given:	
Host IP Address:	192.168.200.139
Original Subnet Mask	255.255.255.0
New Subnet Mask:	255.255.255.224
Find:	
Number of Subnet Bits	3
Number of Subnets Created	8
Number of Host Bits per Subnet	5
Number of Hosts per Subnet	30
Network Address of this Subnet	192.168.200.128
IPv4 Address of First Host on this Subnet	192.168.200.129
IPv4 Address of Last Host on this Subnet	192.168.200.158
IPv4 Broadcast Address on this Subnet	192.168.200.159

Problem 2:

Given:	
Host IP Address:	10.101.99.228
Original Subnet Mask	255.0.0.0
New Subnet Mask:	255.255.128.0
Find:	
Number of Subnet Bits	9
Number of Subnets Created	512
Number of Host Bits per Subnet	15
Number of Hosts per Subnet	32,766
Network Address of this Subnet	10.101.0.0
IPv4 Address of First Host on this Subnet	10.101.0.1
IPv4 Address of Last Host on this Subnet	10.101.127.254
IPv4 Broadcast Address on this Subnet	10.101.127.255

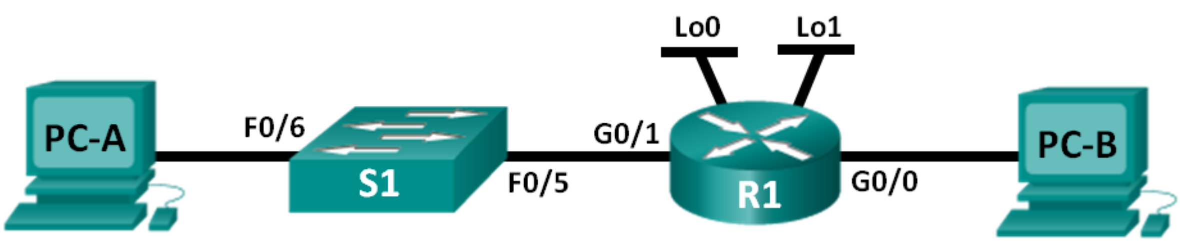
Reflection

Why is the subnet mask so important when analyzing an IPv4 address?

It helps in order to determine all the necessary information of the address. This includes such as broadcast address, number of hosts, host bits, and other network information. The IPv4 is only important for the subnet mask which contains this info.

Exercise 2: Designing and Implementing a Subnetted IPv4 Addressing Scheme (8.1.4.8)

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0			N/A
	G0/1			N/A

	Lo0			N/A
	Lo1			N/A
S1	VLAN 1	N/A	N/A	N/A
PC-A	NIC			
PC-B	NIC			

Scenario

In this exercise, starting from a single network address and network mask, you will subnet the network into multiple subnets. The subnet scheme should be based on the number of host computers required in each subnet, as well as other network considerations, like future network host expansion.

After you have created a subnetting scheme and completed the network diagram by filling in the host and interface IP addresses, you will configure the host PCs and router interfaces, including loopback interfaces. The loopback interfaces are created to simulate additional LANs attached to router R1.

After the network devices and host PCs have been configured, you will use the **ping** command to test for network connectivity.

A. Design a Network Subnetting Scheme

Step 1: Create a subnetting scheme that meets the required number of subnets and required number of host addresses.

In this scenario, you are a network administrator for a small subdivision within a larger company. You must create multiple subnets out of the 192.168.0.0/24 network address space to meet the following requirements:

- The first subnet is the employee network. You need a minimum of 25 host IP addresses.
- The second subnet is the administration network. You need a minimum of 10 IP addresses.
- The third and fourth subnets are reserved as virtual networks on virtual router interfaces, loopback 0 and loopback 1. These virtual router interfaces simulate LANs attached to R1.
- You also need two additional unused subnets for future network expansion.

Note: Variable length subnet masks will not be used. All of the device subnet masks will be the same length.

Answer the following questions to help create a subnetting scheme that meets the stated network requirements:

1) How many host addresses are needed in the largest required subnet?

   25

2) What is the minimum number of subnets required?

Within this one, there are two company networks, two loopback virtual networks, and two additional networks with more expansion which is 6 in total.

3) The network that you are tasked to subnet is 192.168.0.0/24. What is the /24 subnet mask in binary?

   1111111.11111111.11111111.00000000

4) The subnet mask is made up of two portions, the network portion, and the host portion. This is represented in the binary by the ones and the zeros in the subnet mask.

In the network mask, what do the ones represent? Ones are the network

In the network mask, what do the zeros represent? Zeros are the host portion

5) To subnet a network, bits from the host portion of the original network mask are changed into subnet bits. The number of subnet bits defines the number of subnets. Given each of the possible subnet masks depicted in the following binary format, how many subnets and how many hosts are created in each example?

   Hint: Remember that the number of host bits (to the power of 2) defines the number of hosts per subnet (minus 2), and the number of subnet bits (to the power of two) defines the number of subnets. The subnet bits (depicted in bold typeface) are the bits that have been borrowed beyond the original network mask of /24. The /24 is the slash prefix notation and corresponds to a dotted decimal mask of 255.255.255.0.

(/25) 11111111.11111111.11111111.**1**0000000

Dotted decimal subnet mask equivalent: 255.255.255.128

Number of subnets? 2, Number of hosts? 2^7-2 = 126

(/26) 11111111.11111111.11111111.**11**000000

Dotted decimal subnet mask equivalent: 255.255.255.192

Number of subnets? 2^2 = 4, Number of hosts? 2^6-2 = 62

(/27) 11111111.11111111.11111111.**111**00000

Dotted decimal subnet mask equivalent: 255.255.255.224

Number of subnets? 2^3 = 8, Number of hosts? 2^5-2 = 30

(/28) 11111111.11111111.11111111.**1111**0000

Dotted decimal subnet mask equivalent: 255.255.255.240

Number of subnets? 2^4=16, Number of hosts? 2^4-2 = 14

(/29) 11111111.11111111.11111111.**11111**000

Dotted decimal subnet mask equivalent: 255.255.255.248

Number of subnets? 2^5 = 32 Number of hosts? 2^3-2 = 6

(/30) 11111111.11111111.11111111.**111111**00

Dotted decimal subnet mask equivalent: 255.255.255.252

Number of subnets? 2^6 = 64 Number of hosts? 2^2-2 = 2

6) Considering your answers, which subnet masks meet the required number of minimum host addresses?

/25, /26, /27

7) Considering your answers, which subnet masks meet the minimum number of subnets required?

/27,/28,/29,/30

8) Considering your answers, which subnet mask meets both the required minimum number of hosts and the minimum number of subnets required?

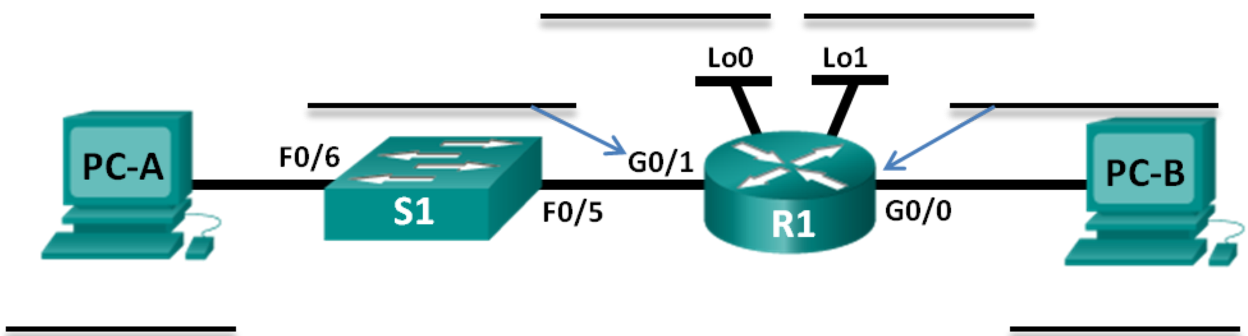
/27

9) When you have determined which subnet mask meets all of the stated network requirements, you will derive each of the subnets starting from the original network address. List the subnets from first to last below. Remember that the first subnet is 192.168.0.0 with the newly acquired subnet mask.

Subnet Address	**/ Prefix**	**Subnet Mask (dotted decimal)**
192.168.0.0 /	/27255.255.255.224	
192.168.0.32/	/27255.255.255.224	
192.168.0.64/	/27255.255.255.224	
192.168.0.96/	/27255.255.255.224	
192.168.0.128	/ /27	255.255.255.224
192.168.0.160	/ /27	255.255.255.224
192.168.0.192	/ /27	255.255.255.224
192.168.0.224	/ /27	255.255.255.224

Step 4: Complete the diagram showing where the host IP addresses will be applied.

On the following lines provided, fill in the IP addresses and subnets masks in slash prefix notation. On the router, use the first usable address in each subnet for each of the interfaces, Gigabit Ethernet 0/0, Gigabit Ethernet 0/1, loopback 0, and loopback 1. Fill in an IP address for both PC-A and PC-B. Also enter this information into the Addressing Table on Page 1.



B. Configure the Devices in Cisco Packet Tracer

Set up the network topology and configure basic settings on the PCs and router, such as the router Gigabit Ethernet interface IP addresses, and the PC's IP addresses, subnet masks, and default gateways. Refer to the Addressing Table for device names and address information.

Note: Appendix A provides configuration details for this part. However, you should attempt to complete it prior to reviewing Appendix A.

Step 1: Configure the router.

a. Enter into privileged EXEC mode and then global config mode.

b. Assign the **R1** as the hostname for the router.

c. Configure both the **G0/0** and **G0/1** interfaces with IP addresses and subnet masks, and then enable them.

d. Loopback interfaces are created to simulate additional LANs on R1 routers. Configure the loopback interfaces with IP addresses and subnet masks. After they are created, loopback interfaces are enabled, by default. (To create the loopback addresses, enter the command **interface loopback 0** at the global config mode)

   Note: You can create additional loopbacks for testing with different addressing schemes, if desired.

e. Save the running configuration to the startup configuration file.

Step 2: Configure the PC interfaces.

a. Configure the IP address, subnet mask, and default gateway settings on PC-A.

f. Configure the IP address, subnet mask, and default gateway settings on PC-B.

C. Test and Troubleshoot the Network

a. Test to see if PC-A can communicate with its default gateway. From PC-A, open a command prompt and ping the IP address of the router Gigabit Ethernet 0/1 interface. Do you get a reply?

Yes if the PC and router interface were configured correctly.

g. Test to see if PC-B can communicate with its default gateway. From PC-B, open a command prompt and ping the IP address of the router Gigabit Ethernet 0/0 interface. Do you get a reply?

Yes if the PC and router interface were configured correctly.

h. Test to see if PC-A can communicate with PC-B. From PC-A, open a command prompt and ping the IP address of PC-B. Do you get a reply?

Yes if the PC and router Gigabit Ethernet interfaces were configured correctly.

i. If you answered "no" to any of the preceding questions, then you should go back and check all of your IP address and subnet mask configurations, and ensure that the default gateways have been correctly configured on PC-A and PC-B.

j. Experiment by purposely misconfiguring the gateway address on PC-A to 10.0.0.1. What happens when you try to ping from PC-B to PC-A? Do you receive a reply?

Nothing, I do not receive a reply.

Reflection

1. Subnetting one larger network into multiple smaller subnetworks allows for greater flexibility and security in network design. However, what do you think some of the drawbacks are when the subnets are limited to being the same size?

   Some subnetworks require a lot of IP addresses and others don't require nearly as much. It is not efficient to have them all require the same amount.

2. Why do you think the gateway/router IP address is usually the first usable IP address in the network?

   The router or gateway may be represented as a door for the network making it the beginning of a network. Although, this is not a requirement but rather just a norm.

Appendix A: Configuration Details for Steps in B

Step 1: **Configure the router.**

k. Console into the router and enable privileged EXEC mode.

Router> **enable**

Router#

l. Enter into configuration mode.

Router# **conf t**

Enter configuration commands, one per line. End with CNTL/Z.

Router(config)#

m. Assign a device name to the router.

Router(config)# **hostname R1**

R1(config)#

n. Configure both the **G0/0** and **G0/1** interfaces with IP addresses and subnet masks, and enable them.

R1(config)# **interface g0/0**

R1(config-if)# **ip address <ip address> <subnet mask>**

R1(config-if)# **no shutdown**

R1(config-if)# **interface g0/1**

R1(config-if)# **ip address <ip address> <subnet mask>**

R1(config-if)# **no shutdown**

o. Loopback interfaces are created to simulate additional LANs off of router R1. Configure the loopback interfaces with IP addresses and subnet masks. When they are created, loopback interfaces are enabled, by default.

R1(config)# **interface loopback 0**

R1(config-if)# **ip address <ip address> <subnet mask>**

R1(config-if)# **interface loopback 1**

R1(config-if)# **ip address <ip address> <subnet mask>**

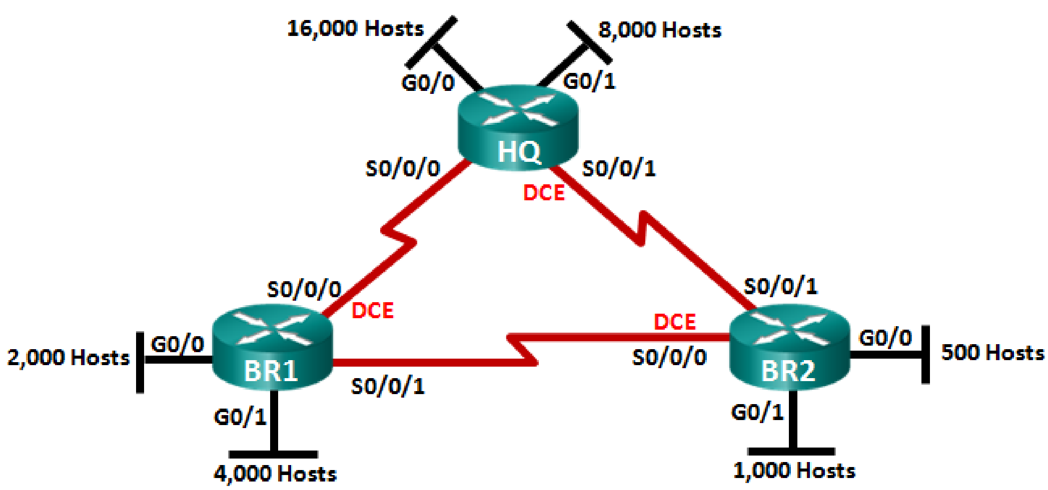
R1(config-if)# **end**

p. Save the running configuration to the startup configuration file.

R1# **copy running-config startup-config**

<u>Exercise 3: Designing and Implementing a VLSM Addressing Scheme (8.2.1.5)</u>

Topology



A. Examine Network Requirements

First, you will examine the network requirements to develop a VLSM address scheme for the network displayed in the topology diagram using the 172.16.128.0/17 network address.

Note: You can use the Windows Calculator application and the www.ipcalc.org IP subnet calculator to help with your calculations.

Step 1: Determine how many host addresses and subnets are available.

How many host addresses are available in a /17 network? 32,766

What is the total number of host addresses needed in the topology diagram? 31,506

How many subnets are needed in the network topology? 9

Step 2: Determine the largest subnet.

What is the subnet description (e.g. BR1 G0/1 LAN or BR1-HQ WAN link)? HQ G0/0 LAN

How many IP addresses are required in the largest subnet? 16,000

What subnet mask can support that many host addresses?

/18

How many total host addresses can that subnet mask support? 16,382

Can you subnet the 172.16.128.0/17 network address to support this subnet? Yes

What are the two network addresses that would result from this subnetting?

172.16.128.0/18

172.16.192.0/18

Use the first network address for this subnet.

Step 3: Determine the second largest subnet.

What is the subnet description? HQ G0/1 LAN

How many IP addresses are required for the second largest subnet? 8,000

What subnet mask can support that many host addresses?

/19

How many total host addresses can that subnet mask support? 8,190

Can you subnet the remaining subnet again and still support this subnet? Yes

What are the two network addresses that would result from this subnetting?

172.16.192.0/19

172.16.224.0/19

Use the first network address for this subnet.

Step 4: Determine the next largest subnet.

What is the subnet description? BR1 G0/1 LAN

How many IP addresses are required for the next largest subnet? 4,000

What subnet mask can support that many host addresses?

/20

How many total host addresses can that subnet mask support? 4,094

Can you subnet the remaining subnet again and still support this subnet? Yes

What are the two network addresses that would result from this subnetting?

172.16.224.0/20

172.16.240.0/20

Use the first network address for this subnet.

Step 5: Determine the next largest subnet.

What is the subnet description? BR1 G0/0 LAN

How many IP addresses are required for the next largest subnet? 2,000

What subnet mask can support that many host addresses?

/21

How many total host addresses can that subnet mask support? 2,046

Can you subnet the remaining subnet again and still support this subnet? Yes

What are the two network addresses that would result from this subnetting?

172.16.240.0/21

172.16.248.0/21

Use the first network address for this subnet.

Step 6: Determine the next largest subnet.

What is the subnet description? BR2 G0/1 LAN

How many IP addresses are required for the next largest subnet? 1,000

What subnet mask can support that many host addresses?

/22

How many total host addresses can that subnet mask support? 1,022

Can you subnet the remaining subnet again and still support this subnet? Yes

What are the two network addresses that would result from this subnetting?

172.16.248.0/22

172.16.252.0/22

Use the first network address for this subnet.

Step 7: Determine the next largest subnet.

What is the subnet description? BR2 G0/0 LAN

How many IP addresses are required for the next largest subnet? 500

What subnet mask can support that many host addresses?

/23

How many total host addresses can that subnet mask support? 510

Can you subnet the remaining subnet again and still support this subnet? Yes

What are the two network addresses that would result from this subnetting?

172.16.252.0/23

172.16.254.0/23

Use the first network address for this subnet.

Step 8: Determine the subnets needed to support the serial links.

How many host addresses are required for each serial subnet link? 2

What subnet mask can support that many host addresses?

/30

a. Continue subnetting the first subnet of each new subnet until you have four /30 subnets. Write the first three network addresses of these /30 subnets below.

   172.16.254.0/30

   172.16.254.4/30

   172.16.254.8/30

a. Enter the subnet descriptions for these three subnets below.

   HQ - BR1 Serial Link

   HQ - BR2 Serial Link

   BR1 - BR2 Serial Link

B. Design the VLSM Address Scheme

Step 1: Calculate the subnet information.

Use the information that you obtained in A to fill in the following table.

Subnet Description	Number of Hosts Needed	Network Address /CIDR	First Host Address	Broadcast Address
HQ G0/0	16,000	172.16.128.0/18	172.16.128.1	172.16.191.255
HQ G0/1	8,000	172.16.192.0/19	172.16.192.1	172.16.223.255
BR1 G0/1	4,000	172.16.224.0/20	172.16.224.1	172.16.239.255
BR1 G0/0	2,000	172.16.240.0/21	172.16.240.1	172.16.247.255
BR2 G0/1	1,000	172.16.248.0/22	172.16.248.1	172.16.251.255
BR2 G0/0	500	172.16.252.0/23	172.16.252.1	172.16.253.255
HQ S0/0/0 – BR1 S0/0/0	2	172.16.254.0/30	172.16.254.1	172.16.254.3
HQ S0/0/1 – BR2 S0/0/1	2	172.16.254.4/30	172.16.254.5	172.16.254.7
BR1 S0/0/1 – BR2 S0/0/0	2	172.16.254.8/30	172.16.254.9	172.168.254.11

Step 4: Complete the device interface address table.

Assign the first host address in the subnet to the Ethernet interfaces. HQ should be given the first host address on the Serial links to BR1 and BR2. BR1 should be given the first host address for the serial link to BR2.

Device	Interface	IP Address	Subnet Mask	Device Interface
HQ	G0/0	172.16.128.1	255.255.192.0	16,000 Host LAN
	G0/1	172.16.192.1	255.255.224.0	8,000 Host LAN
	S0/0/0	172.16.254.1	255.255.255.252	BR1 S0/0/0
	S0/0/1	172.16.254.5	255.255.255.252	BR2 S0/0/1
BR1	G0/0	172.16.240.1	255.255.248.0	2,000 Host LAN
	G0/1	172.16.224.1	255.255.240.0	4,000 Host LAN
	S0/0/0	172.16.254.2	255.255.255.252	HQ S0/0/0
	S0/0/1	172.16.254.9	255.255.255.252	BR2 S0/0/0
BR2	G0/0	172.16.252.1	255.255.254.0	500 Host LAN
	G0/1	172.16.248.1	255.255.252.0	1,000 Host LAN
	S0/0/0	172.16.254.10	255.255.255.252	BR1 S0/0/1
	S0/0/1	172.16.254.6	255.255.255.252	HQ S0/0/1

C. Cable and Configure the IPv4 Network in Cisco Packet Tracer

Step 1: Cable the network as shown in the topology.

Step 2: Configure basic settings on each router.

a. Assign the device name to the router.

b. Disable DNS lookup to prevent the router from attempting to translate incorrectly entered commands as though they were hostnames.

c. Assign **class** as the privileged EXEC encrypted password.

d. Assign **cisco** as the console password and enable login.

e. Assign **cisco** as the VTY password and enable login.

f. Encrypt the clear text passwords.

g. Create a banner that will warn anyone accessing the device that unauthorized access is prohibited.

Step 5: Configure the interfaces on each router.

a. Assign an IP address and subnet mask to each interface using the table that you completed in Part 2.

b. Configure an interface description for each interface.

c. Set the clocking rate on all DCE serial interfaces to 128000.

HQ(config-if)# **clock rate 128000**

d. Activate the interfaces.

Step 6: Save the configuration on all devices.

Step 7: Test Connectivity.

a. From HQ, ping BR1's S0/0/0 interface address.

b. From HQ, ping BR2's S0/0/1 interface address.

c. From BR1, ping BR2's S0/0/0 interface address.

d. Troubleshoot connectivity issues if pings were not successful.

Note: Pings to the GigabitEthernet interfaces on other routers will not be successful. The LANs defined for the GigabitEthernet interfaces are simulated. Because no devices are attached to these LANs they will be in down/down state. A routing protocol needs to be in place for other devices to be aware of those subnets. The GigabitEthernet interfaces also need to be in an up/up state before a routing protocol can add the subnets to the routing table. These interfaces will remain in a down/down state until a device is connected to the other end of the Ethernet interface cable. The focus of this lab is on VLSM and configuring the interfaces.