Lab – Calculating IPv4 Subnets (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Part 1: Determine IPv4 Address Subnetting

- Determine the network address.
- Determine the broadcast address.
- Determine the number of hosts.

Part 2: Calculate IPv4 Address Subnetting

- Determine the number of subnets created.
- Determine number of hosts per subnet.
- Determine the subnet address.
- Determine the host range for the subnet.
- Determine the broadcast address for the subnet.

Background / Scenario

The ability to work with IPv4 subnets and determine network and host information based on a given IP address and subnet mask is critical to understanding how IPv4 networks operate. The first part is designed to reinforce how to compute network IP address information from a given IP address and subnet mask. When given an IP address and subnet mask, you will be able to determine other information about the subnet such as:

- Network address
- Broadcast address
- Total number of host bits
- Number of hosts per subnet

In the second part of the lab, for a given IP address and subnet mask, you will determine such information as follows:

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

Instructor Note: This activity can be done in class or assigned as homework. If the assignment is done in class, you may wish to have students work alone or in teams of 2 students each. It is suggested that the first problem is done together in class to give students guidance as to how to proceed for the rest of the assignment.

The public IP addresses used in this lab are owned by Cisco.

Required Resources

- 1 PC (Windows 7, Vista, or XP with Internet access)

- Optional: IPv4 address calculator

Part 1: Determine IPv4 Address Subnetting

In Part 1, you will determine the network and broadcast addresses, as well as the number of hosts, given an IPv4 address and subnet mask.

REVIEW: To determine the network address, perform binary ANDing on the IPv4 address using the subnet mask provided. The result will be the network address. Hint: If the subnet mask has decimal value 255 in an octet, the result will ALWAYS be the original value of that octet. If the subnet mask has decimal value 0 in an octet, the result will ALWAYS be 0 for that octet.

Example:

IP Address	192.168.10.10
Subnet Mask	255.255.255.0
	==========
Result (Network)	192.168.10.0

Knowing this, you may only have to perform binary ANDing on an octet that does not have 255 or 0 in its subnet mask portion.

Example:

IP Address	172.30.239.145
Subnet Mask	255.255.192.0

Analyzing this example, you can see that you only have to perform binary ANDing on the third octet. The first two octets will result in 172.30 due to the subnet mask. The fourth octet will result in 0 due to the subnet mask.

IP Address	172.30.239.145
Subnet Mask	255.255.192.0
	==========
Result (Network)	172.30.**?**.0

Perform binary ANDing on the third octet.

	Decimal	**Binary**
	239	11101111
	192	11000000
		=======
Result	**192**	11000000

Analyzing this example again produces the following result:

IP Address	172.30.239.145
Subnet Mask	255.255.192.0
	==========
Result (Network)	172.30.192.0

Continuing with this example, determining the number of hosts per network can be calculated by analyzing the subnet mask. The subnet mask will be represented in dotted decimal format, such as 255.255.192.0, or in

network prefix format, such as /18. 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.

Using our example above, 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:

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

$2^{14} = 16{,}384 - 2 = 16{,}382$ 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

Part 2: Calculate IPv4 Address Subnetting

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

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

a. **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

b. **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

c. **Problem 3**:

Given:	
Host IP Address:	172.22.32.12
Original Subnet Mask	255.255.0.0
New Subnet Mask:	255.255.224.0
Find:	
Number of Subnet Bits	3
Number of Subnets Created	8
Number of Host Bits per Subnet	13
Number of Hosts per Subnet	8,190
Network Address of this Subnet	172.22.32.0
IPv4 Address of First Host on this Subnet	172.22.32.1
IPv4 Address of Last Host on this Subnet	172.22.63.254
IPv4 Broadcast Address on this Subnet	172.22.63.255

d. **Problem 4**:

Given:	
Host IP Address:	192.168.1.245
Original Subnet Mask	255.255.255.0
New Subnet Mask:	255.255.255.252
Find:	
Number of Subnet Bits	6
Number of Subnets Created	64
Number of Host Bits per Subnet	2
Number of Hosts per Subnet	2
Network Address of this Subnet	192.168.1.244
IPv4 Address of First Host on this Subnet	192.168.1.245
IPv4 Address of Last Host on this Subnet	192.168.1.246
IPv4 Broadcast Address on this Subnet	192.168.1.247

e. **Problem 5**:

Given:	
Host IP Address:	128.107.0.55
Original Subnet Mask	255.255.0.0
New Subnet Mask:	255.255.255.0
Find:	
Number of Subnet Bits	8
Number of Subnets Created	256
Number of Host Bits per Subnet	8
Number of Hosts per Subnet	254
Network Address of this Subnet	128.107.0.0
IPv4 Address of First Host on this Subnet	128.107.0.1
IPv4 Address of Last Host on this Subnet	128.107.0.254
IPv4 Broadcast Address on this Subnet	128.107.0.255

f. **Problem 6**:

Given:	
Host IP Address:	192.135.250.180
Original Subnet Mask	255.255.255.0
New Subnet Mask:	255.255.255.248
Find:	
Number of Subnet Bits	5
Number of Subnets Created	32
Number of Host Bits per Subnet	3
Number of Hosts per Subnet	6
Network Address of this Subnet	192.135.250.176
IPv4 Address of First Host on this Subnet	192.135.250.177
IPv4 Address of Last Host on this Subnet	192.135.250.182
IPv4 Broadcast Address on this Subnet	192.135.250.183

Reflection

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

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The subnet mask determines everything about the address: the network, number of host bits, number of hosts and the broadcast address. Merely looking at an IPv4 address tells you nothing. You need the subnet mask to fill in all the important pieces of information.