MIDOCEAN UNIVERSITY

Cybersecurity Concepts

Prepared by Dr. Diaa Salama

FNT625
VLSM Variable Length Subnet Mask
IP Addressing and Subnetting

Lecture 3

مجموعة جامعة
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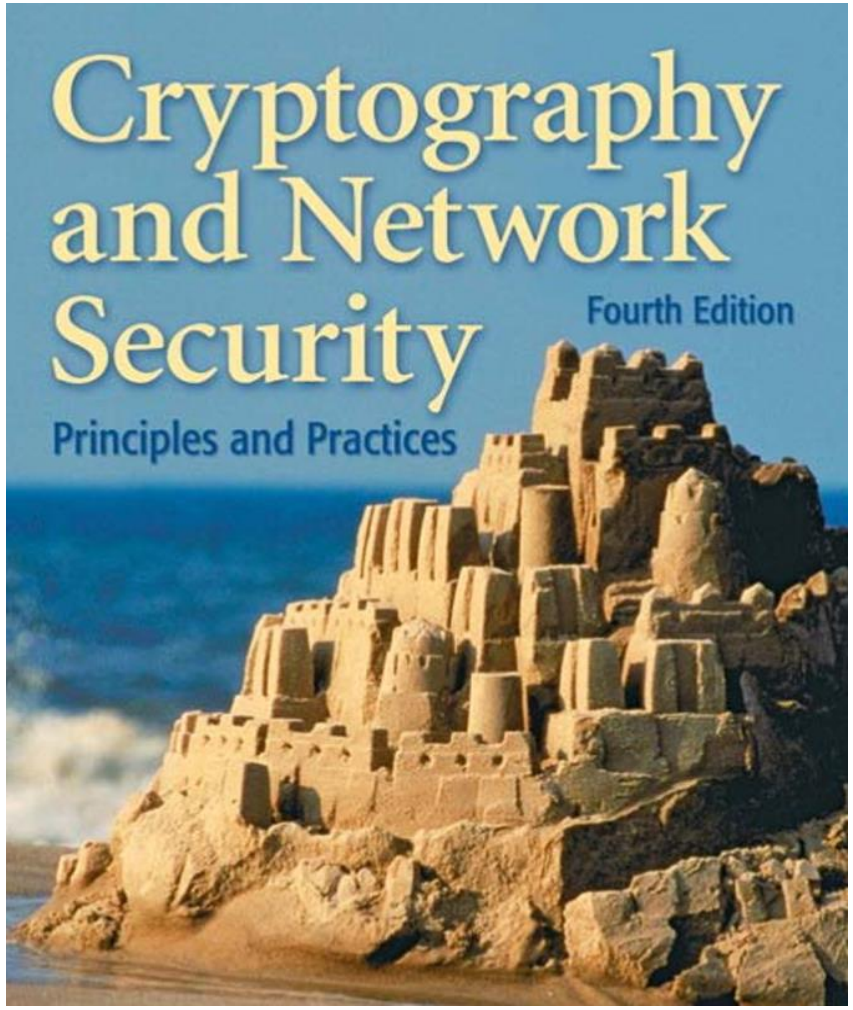
10



Book Title:
Cryptography and Network Security

Authors:
William Stallings

Publisher:
Pearson Education, Inc.

Edition:
Seven edition

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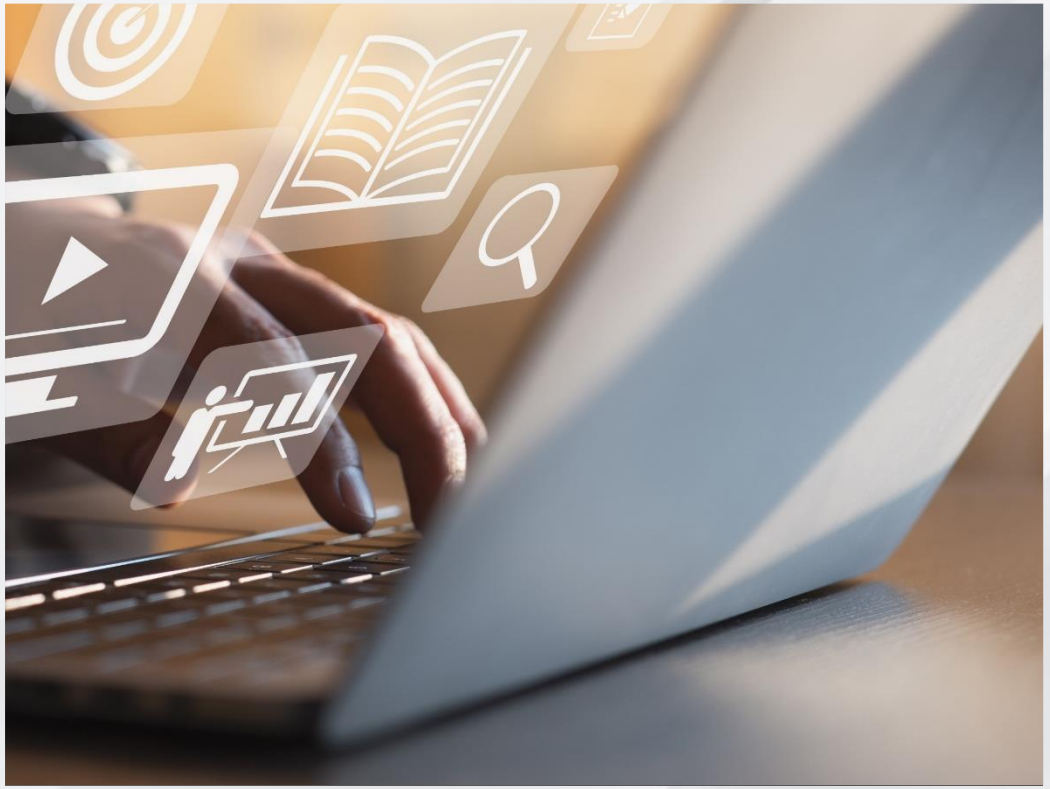
Lecture

03

Lets Start the Third Lecture



IP Addressing and Subnetting

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VLSM Variable Length Subnet Mask IP Addressing and Subnetting

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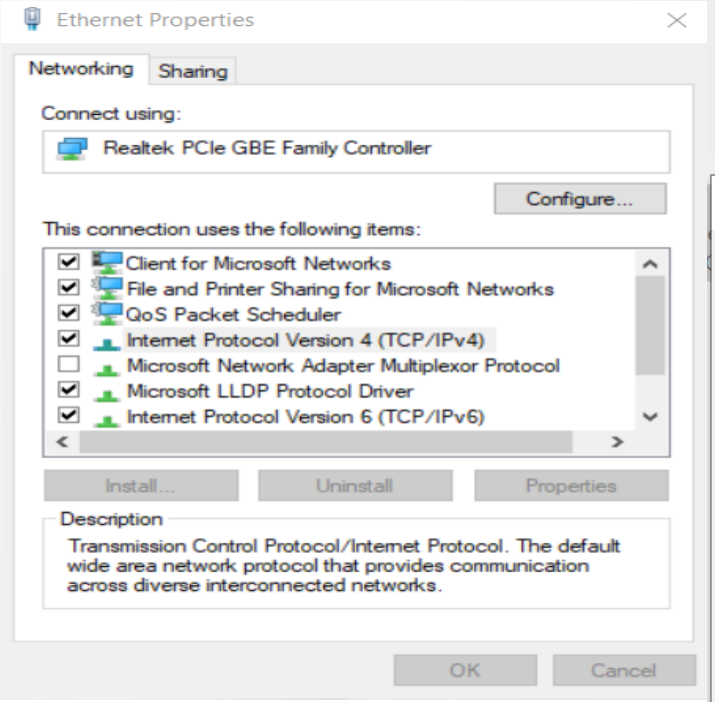
Design a Communications System

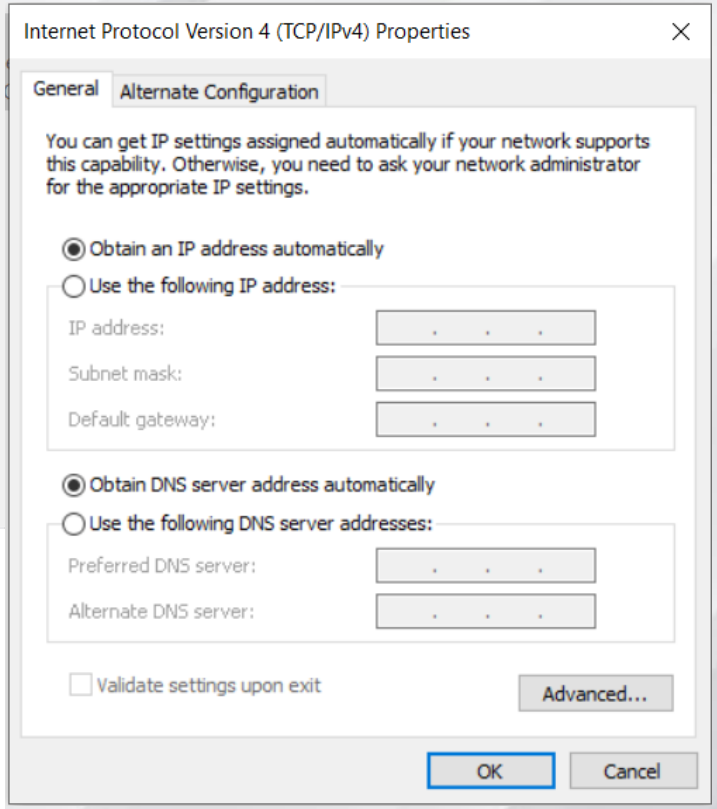
Design a Communications System

Objectives:

- Explain the role of protocols and standards organizations in facilitating interoperability in network communications.

1. IP Addressing & Subnet Mask
2. Protocol
3. Port





Class		Default mask		Host
A	1-126	255.0.0.0		16777771
B	128-191	255.255.0.0		65534
C	192-223	255.255.255.0		254

IP addressing

If a device wants to communicate using TCP/IP, it needs an IP address. When the device has an IP address and the appropriate software and hardware, it can send and receive IP packets. Any device that can send and receive IP packets is called an *IP host.*

Class		Default mask		Host
A	1-126	255.0.0.0		16777771
B	128-191	255.255.0.0		65534
C	192-223	255.255.255.0		254

IP addresses consist of a 32-bit number, usually written in *dotted-decimal notation. The* "decimal" part of the term comes from the fact that each byte (8 bits) of the 32-bit IP address is shown as its decimal equivalent. The four resulting decimal numbers are written in sequence, with "dots," or decimal points, separating the numbers—hence the name *dotted decimal. For* instance, 168.1.1.1 is an IP address written in dotted-decimal form; the actual binary version is 10101000 00000001 00000001 00000001.

Each decimal number in an IP address is called an *octet.*

Finally, note that each network interface uses a unique IP address. Most people tend to think that their computer has an IP address, but actually their computer's network card has an IP address. If you put two Ethernet cards in a PC to forward IP packets through both cards, they both would need unique IP addresses. Also, if your laptop has both an Ethernet NIC and a wireless NIC working at the same time, your laptop will have an IP address for each NIC.

How IP Addresses Are Grouped

The original specifications for TCP/IP grouped IP addresses into sets of consecutive addresses called *IP networks. The addresses in a single network have the same numeric* value in the first part of all addresses in the network.

the following two rules summarize the facts about which IP addresses need to be in the same grouping:

- All IP addresses in the same group must not be separated by a router.
- IP addresses separated by a router must be in different groups.

The organization in charge of universal IP address assignment is the Internet Corporation for Assigned Names and Numbers (ICANN, www.icann.org). (The Internet Assigned Numbers Authority (IANA) formerly owned the IP address assignment process.) ICANN, in turn, assigns regional authority to other cooperating organizations. For example, the American Registry for Internet Numbers (ARIN, www.arin.org) owns the address assignment process for North America.

IP addressing

IP Address Classes

Class A	1 – 127	(Network 127 is reserved for loopback and internal testing)		
		Leading bit pattern	0	00000000.00000000.00000000.00000000 Network . Host . Host . Host
Class B	128 – 191	Leading bit pattern	10	10000000.00000000.00000000.00000000 Network . Network . Host . Host
Class C	192 – 223	Leading bit pattern	110	11000000.00000000.00000000.00000000 Network . Network . Network . Host
Class D	224 – 239	(Reserved for multicast)		
Class E	240 – 255	(Reserved for experimental, used for research)		

Default Subnet Masks

Class A	255.0.0.0
Class B	255.255.0.0
Class C	255.255.255.0

Table 5-5 summarizes the possible network numbers that ICANN and other agencies could have assigned over time.

Table 5-5 *All Possible Valid Network Numbers**

Class	First Octet Range	Valid Network Numbers*	Total Number for This Class of Network	Number of Hosts Per Network
A	1 to 126	1.0.0.0 to 126.0.0.0	$2^7 - 2$ (126)	$2^{24} - 2$ (16,777,214)
B	128 to 191	128.0.0.0 to 191.255.0.0	2^{14} (16,384)	$2^{16} - 2$ (65,534)
C	192 to 223	192.0.0.0 to 223.255.255.0	2^{21} (2,097,152)	$2^8 - 2$ (254)

*The Valid Network Numbers column shows actual network numbers. Networks 0.0.0.0 (originally defined for use as a broadcast address) and 127.0.0.0 (still available for loopback testing) are reserved.

IP Subnetting

IP subnetting takes a single Class A, B, or C network and subdivides it into a number of smaller groups of IP addresses. The Class A, B, and C rules still exist, but now, a single Class A, B, or C network can be subdivided into many smaller groups. Subnetting treats a subdivision of a single Class A, B, or C network as if it were a network itself. In fact, the name “subnet” is just shorthand for “subdivided network.”

Address Class Identification

Address Class Identification

Address	Class
10.250.1.1	A
150.10.15.0	B
192.14.2.0	
148.17.9.1	
193.42.1.1	
126.8.156.0	
220.200.23.1	
230.230.45.58	
177.100.18.4	
119.18.45.0	
249.240.80.78	
199.155.77.56	
117.89.56.45	
215.45.45.0	
199.200.15.0	
95.0.21.90	
33.0.0.0	
158.98.80.0	
219.21.56.0	

Default Subnet Masks

Write the correct default subnet mask for each of the following addresses:

177.100.18.4	255 . 255 . 0 . 0
119.18.45.0	255 . 0 . 0 . 0
191.249.234.191	
223.23.223.109	
10.10.250.1	
126.123.23.1	
223.69.230.250	
192.12.35.105	
77.251.200.51	
189.210.50.1	
88.45.65.35	
128.212.250.254	
193.100.77.83	
125.125.250.1	
1.1.10.50	
220.90.130.45	
134.125.34.9	

Number Systems Conversion

Decimal To Binary Conversion

Use all 8 bits for each problem

128	64	32	16	8	4	2	1	= 255
1	1	1	0	1	1	1	0	238
0	0	1	0	0	0	1	0	34
								123
								50
								255
								200
								10
								138
								1
								13
								250
								107
								224
								114
								192
								172
								100
								119
								57
								98
								179
								2

Scratch Area

238
−128
110
−64
46
−32
14
−8
6
−4
2
−2
0

34
−32
2
−2
0

Binary To Decimal Conversion

128	64	32	16	8	4	2	1	Answers
1	0	0	1	0	0	1	0	146
0	1	1	1	0	1	1	1	119
1	1	1	1	1	1	1	1	
1	1	0	0	0	1	0	1	
1	1	1	1	0	1	1	0	
0	0	0	1	0	0	1	1	
1	0	0	0	0	0	0	1	
0	0	1	1	0	0	0	1	
0	1	1	1	1	0	0	0	
1	1	1	1	0	0	0	0	
0	0	1	1	1	0	1	1	
0	0	0	0	0	1	1	1	
						00011011		
						10101010		
						01101111		
						11111000		
						00100000		
						01010101		
						00111110		
						00000011		
						11101101		
						11000000		

Scratch Area

128 64
16 32
2 16
146 4
2
1
119

Classes of Networks

Table 5-3 *Sizes of Network and Host Parts of IP Addresses with No Subnetting*

Any Network of This Class	Number of Network Bytes (Bits)	Number of Host Bytes (Bits)	Number of Addresses Per Network*
A	1 (8)	3 (24)	$2^{24} - 2$
B	2 (16)	2 (16)	$2^{16} - 2$
C	3 (24)	1 (8)	$2^{8} - 2$

*There are two reserved host addresses per network.

- Network numbers represent the group of all IP addresses in the network.
- Network broadcast address are forwarded to all devices in the network.

Table 5-5 summarizes the possible network numbers that ICANN and other agencies could have assigned over time.

Table 5-5 *All Possible Valid Network Numbers**

Class	First Octet Range	Valid Network Numbers*	Total Number for This Class of Network	Number of Hosts Per Network
A	1 to 126	1.0.0.0 to 126.0.0.0	$2^7 - 2$ (126)	$2^{24} - 2$ (16,777,214)
B	128 to 191	128.0.0.0 to 191.255.0.0	2^{14} (16,384)	$2^{16} - 2$ (65,534)
C	192 to 223	192.0.0.0 to 223.255.255.0	2^{21} (2,097,152)	$2^8 - 2$ (254)

*The Valid Network Numbers column shows actual network numbers. Networks 0.0.0.0 (originally defined for use as a broadcast address) and 127.0.0.0 (still available for loopback testing) are reserved.

Classful IP Networks Before Subnetting

- The addresses have the same value in the network part.
- The addresses have different values in the host part.

The actual sizes of the network and host part of the addresses in a network can be easily predicted, as shown in Figure 12-13.

Figure 12-13 *Format of Unsubnetted Class A, B, and C Networks*

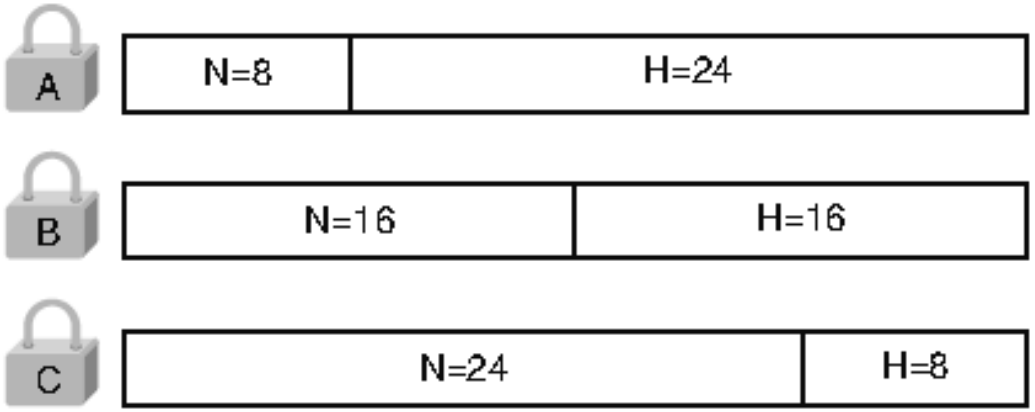
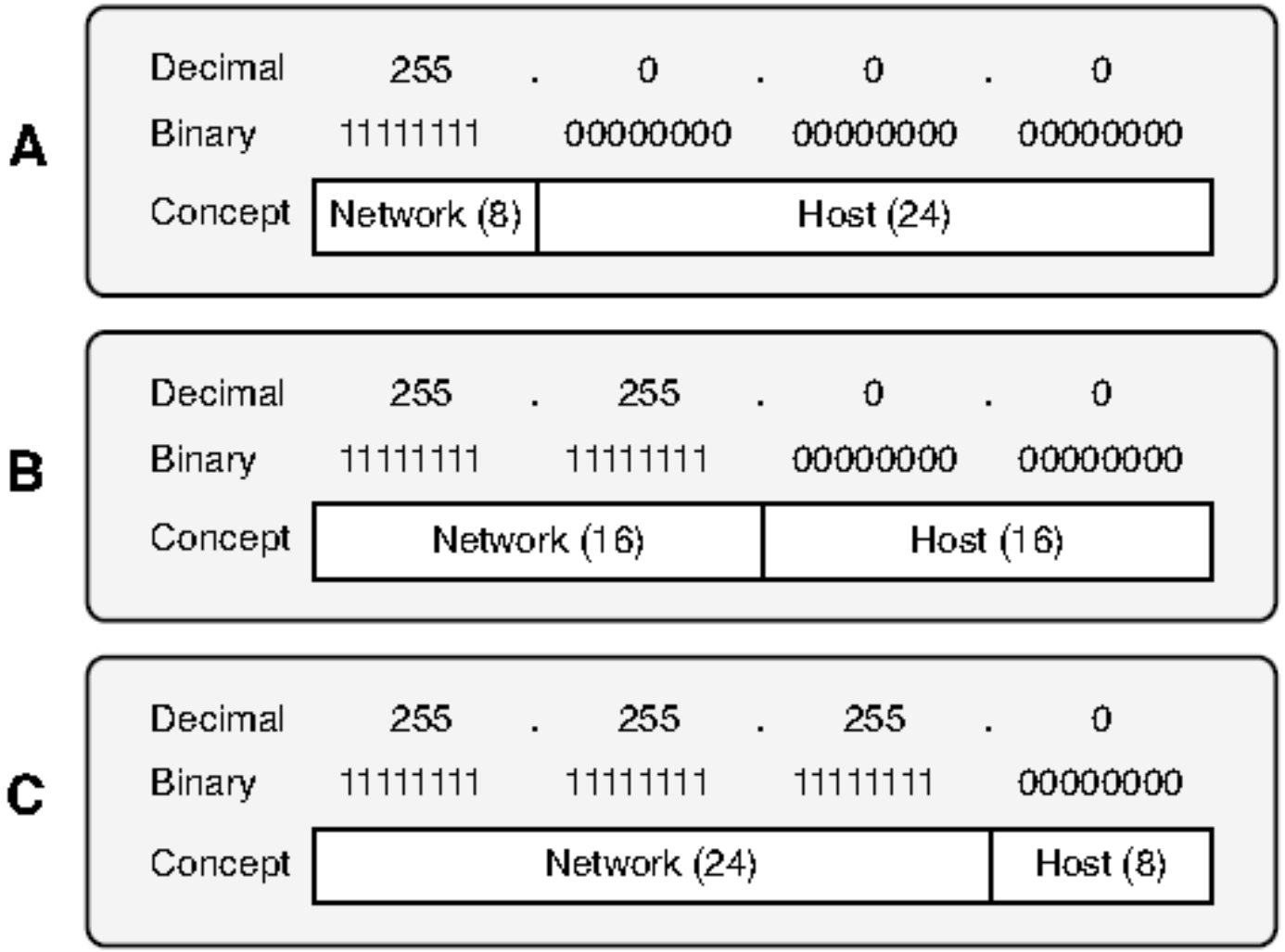


Figure 13-3 *Default Masks for Classes A, B, and C*



Network & Host Identification

Network & Host Identification

Circle the network portion of these addresses:	Circle the host portion of these addresses:
177.100.18.4	10.15.123.50
119.18.45.0	171.2.199.31
209.240.80.78	198.125.87.177
199.155.77.56	223.250.200.222
117.89.56.45	17.45.222.45
215.45.45.0	126.201.54.231
192.200.15.0	191.41.35.112
95.0.21.90	155.25.169.227
33.0.0.0	192.15.155.2
158.98.80.0	123.102.45.254
217.21.56.0	148.17.9.155
10.250.1.1	100.25.1.1
150.10.15.0	195.0.21.98
192.14.2.0	25.250.135.46
148.17.9.1	171.102.77.77
193.42.1.1	55.250.5.5
126.8.156.0	218.155.230.14

Deriving the Network ID and Related Numbers

Each classful network has four key numbers that describe the network. You can derive these four numbers if you start with just one IP address in the network. The numbers are as

follows

- Network number
- First (numerically lowest) usable address
- Last (numerically highest) usable address
- Network broadcast address

Hosts= 5000

11111111.11111111.11100000.00000000

255.255.224.0

Subnet	First valid ip	Last valid ip	Broadcast ip

Deriving the Network ID and Related Numbers

- Network number
- First (numerically lowest) usable address
- Last (numerically highest) usable address
- Network broadcast address

Hosts= 5000

11111111.11111111.11100000.00000000

255.255.224.0

Subnet	First valid ip	Last valid ip	Broadcast ip

Deriving the Network ID and Related Numbers

- Network number
- First (numerically lowest) usable address
- Last (numerically highest) usable address
- Network broadcast address

Hosts= 5000

11111111.11111111.11100000.00000000

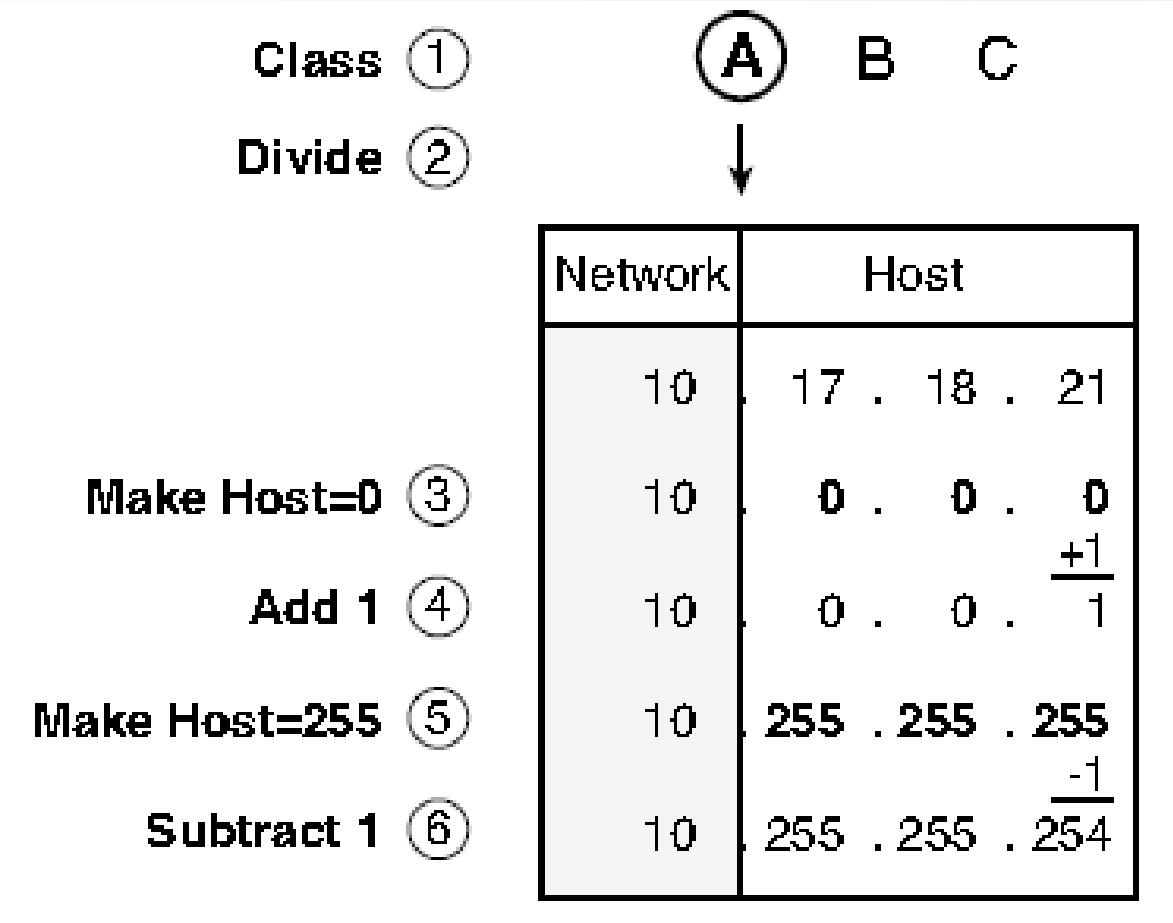
255.255.224.0

Subnet	First valid ip	Last valid ip	Broadcast ip

Block size = 32

Subnet	First valid ip	Last valid ip	Broadcast ip
100.100.96.0	100.100.96.1	100.100.127.254	100.100.127.255
100.100.128.0	100.100.128.1	100.100.159.254	100.100.159.255
100.100.160.0	100.100.160.1	100.100.191.254	100.100.191.255

Figure 13-4 ***Example of Deriving the Network ID and Other Values from 10.17.18.21***



Quiz

Practice Deriving Key Facts Based on an IP Address

	IP Address	Class	Number Network Octets	Number Host Octets	Network ID	Network Broadcast Address
1	1.1.1.1					
2	128.1.6.5					
3	200.1.2.3					
4	192.192.1.1					
5	126.5.4.3					
6	200.1.9.8					
7	192.0.0.1					
8	191.255.1.47					
9	223.223.0.1					

	IP Address	Class	Number Network Octets	Number Host Octets	Network ID	Network Broadcast
1	1.1.1.1	A	1	3	1.0.0.0	1.255.255.255
2	128.1.6.5	B	2	2	128.1.0.0	128.1.255.255
3	200.1.2.3	C	3	1	200.1.2.0	200.1.2.255
4	192.192.1.1	C	3	1	192.192.1.0	192.192.1.255
5	126.5.4.3	A	1	3	126.0.0.0	126.255.255.255
6	200.1.9.8	C	3	1	200.1.9.0	200.1.9.255
7	192.0.0.1	C	3	1	192.0.0.0	192.0.0.255
8	191.255.1.47	B	2	2	191.255.0.0	191.255.255.255
9	223.223.0.1	C	3	1	223.223.0.0	223.223.0.255

three different formats for subnet masks:

Binary

Dotted-decimal notation (DDN)

Prefix (also called *Classless Interdomain Routing* CIDR)

Converting Between Binary and Prefix Masks

Table 14-2 *Example Conversions: Binary to Prefix*

Binary Mask	Logic	Prefix Mask
11111111 11111111 11000000 00000000	Count 8 + 8 + 2 = 18 binary 1s	/18
11111111 11111111 11111111 11110000	Count 8 + 8 + 8 + 4 = 28 binary 1s	/28
11111111 11111000 00000000 00000000	Count 8 + 5 = 13 binary 1s	/13

Table 14-3 *Example Conversions: Prefix to Binary*

Prefix Mask	Logic	Binary Mask
/18	Write 18 1s, then 14 0s, total 32	11111111 11111111 11000000 00000000
/28	Write 28 1s, then 4 0s, total 32	11111111 11111111 11111111 11110000
/13	Write 13 1s, then 19 0s, total 32	11111111 11111000 00000000 00000000

Converting Between Binary and DDN Masks

Table 14-5 *Example Conversions: Binary to Decimal*

Binary Mask	Logic	Decimal Mask
11111111 11111111 11000000 00000000	11111111 maps to 255 11000000 maps to 192 00000000 maps to 0	255.255.192.0
11111111 11111111 11111111 11110000	11111111 maps to 255 11110000 maps to 240	255.255.255.240
11111111 11111000 00000000 00000000	11111111 maps to 255 11111000 maps to 248 00000000 maps to 0	255.248.0.0

Table 14-6 *Example Conversions: Decimal to Binary*

Decimal Mask	Logic	Binary Mask
255.255.192.0	255 maps to 11111111 192 maps to 11000000 0 maps to 00000000	11111111 11111111 11000000 00000000
255.255.255.240	255 maps to 11111111 240 maps to 11110000	11111111 11111111 11111111 11110000
255.248.0.0	255 maps to 11111111 248 maps to 11111000 0 maps to 00000000	11111111 11111000 00000000 00000000

Converting Between Prefix and DDN Masks

/18

↓

11111111 11111111 11000000 00000000

↓ ↓ ↓ ↓

255 . 255 . 192 . 0

/18

↓

8 + 8 + 2 + 0

↓ ↓ ↓ ↓

255 . 255 . 192 . 0

255 . 248 . 0 . 0

↓ ↓ ↓ ↓

11111111 11111000 00000000 00000000

↓

/13

255 . 248 . 0 . 0

↓ ↓ ↓ ↓

8 + 5 + 0 + 0

↓

/13

Quiz

Practice Converting Subnet Masks

Table 14-8 *Practice Problems: Find the Mask Values in the Other Two Formats*

Prefix	Binary Mask	Decimal
	11111111 11111111 11000000 00000000	
		255.255.255.252
/25		
/16		
		255.0.0.0
	11111111 11111111 11111100 00000000	
		255.254.0.0
/27		

Prefix	Binary Mask	Decimal
/18	11111111 11111111 11000000 00000000	255.255.192.0
/30	11111111 11111111 11111111 11111100	255.255.255.252
/25	11111111 11111111 11111111 10000000	255.255.255.128
/16	11111111 11111111 00000000 00000000	255.255.0.0
/8	11111111 00000000 00000000 00000000	255.0.0.0
/22	11111111 11111111 11111100 00000000	255.255.252.0
/15	11111111 11111110 00000000 00000000	255.254.0.0
/27	11111111 11111111 11111111 11100000	255.255.255.224

Quiz

	IP Address	Mask	Subnet ID	Broadcast Address
1	10.77.55.3	255.255.255.0		
2	172.30.99.4	255.255.255.0		
3	192.168.6.54	255.255.255.0		
4	10.77.3.14	255.255.0.0		
5	172.22.55.77	255.255.0.0		
6	1.99.53.76	255.0.0.0		

	IP Address	Mask	Subnet ID	Broadcast Address
1	10.77.55.3	255.255.255.0	10.77.55.0	10.77.55.255
2	172.30.99.4	255.255.255.0	172.30.99.0	172.30.99.255
3	192.168.6.54	255.255.255.0	192.168.6.0	192.168.6.255
4	10.77.3.14	255.255.0.0	10.77.0.0	10.77.255.255
5	172.22.55.77	255.255.0.0	172.22.0.0	172.22.255.255
6	1.99.53.76	255.0.0.0	1.0.0.0	1.255.255.255

Quiz

Problem	IP Address	Mask	Subnet ID
1	10.77.55.3	255.248.0.0	
2	172.30.99.4	255.255.192.0	
3	192.168.6.54	255.255.255.252	
4	10.77.3.14	255.255.128.0	
5	172.22.55.77	255.255.254.0	
6	1.99.53.76	255.255.255.248	

	IP Address	Mask	Subnet ID
1	10.77.55.3	255.248.0.0	10.72.0.0
2	172.30.99.4	255.255.192.0	172.30.64.0
3	192.168.6.54	255.255.255.252	192.168.6.52
4	10.77.3.14	255.255.128.0	10.77.0.0
5	172.22.55.77	255.255.254.0	172.22.54.0
6	1.99.53.76	255.255.255.248	1.99.53.72

Quiz

Problem	IP Address	Mask	*Broadcast Address*
1	10.77.55.3	255.248.0.0	
2	172.30.99.4	255.255.192.0	
3	192.168.6.54	255.255.255.252	
4	10.77.3.14	255.255.128.0	
5	172.22.55.77	255.255.254.0	
6	1.99.53.76	255.255.255.248	

	Subnet ID	Mask	Broadcast Address
1	10.72.0.0	255.248.0.0	10.79.255.255
2	172.30.64.0	255.255.192.0	172.30.127.255
3	192.168.6.52	255.255.255.252	192.168.6.55
4	10.77.0.0	255.255.128.0	10.77.127.255
5	172.22.54.0	255.255.254.0	172.22.55.255
6	1.99.53.72	255.255.255.248	1.99.53.79

Quiz

Practice Problems for This Chapter

The following list shows three separate problems, each with a classful network number and prefix-style mask. Find all subnet IDs for each problem:

1. 192.168.9.0/27
2. 172.30.0.0/20
3. 10.0.0.0/17

Octet	1	2	3	4
Mask	255	255	255	224
Magic Number				32
Classful Network/Subnet Zero	192	168	9	0
First Nonzero Subnet	192	168	9	32
Next Subnet	192	168	9	64
Next Subnet	192	168	9	96
Next Subnet	192	168	9	128
Next Subnet	192	168	9	160
Next Subnet	192	168	9	192
Broadcast Subnet	192	168	9	224
Invalid— Used by Process	192	168	9	256

Octet	1	2	3	4
Mask	255	255	240	0
Magic Number			16	
Classful Network/Subnet Zero	172	30	0	0
First Nonzero Subnet	172	30	16	0
Next Subnet	172	30	32	0
Next Subnet	172	30	48	0
Next Subnet	172	30	64	0
Next Subnet	172	30	Skipping…	0
Next Subnet	172	30	224	0
Broadcast Subnet	172	30	240	0
Invalid— Used by Process	172	30	256	0

Network address

Network Addresses

Using the IP address and subnet mask shown write out the network address:

188.10.18.2 255.255.0.0	188 . 10 . 0 . 0
10.10.48.80 255.255.255.0	10 . 10 . 48 . 0
192.149.24.191 255.255.255.0	
150.203.23.19 255.255.0.0	
10.10.10.10 255.0.0.0	
186.13.23.110 255.255.255.0	
223.69.230.250 255.255.0.0	
200.120.135.15 255.255.255.0	
27.125.200.151 255.0.0.0	
199.20.150.35 255.255.255.0	
191.55.165.135 255.255.255.0	

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