

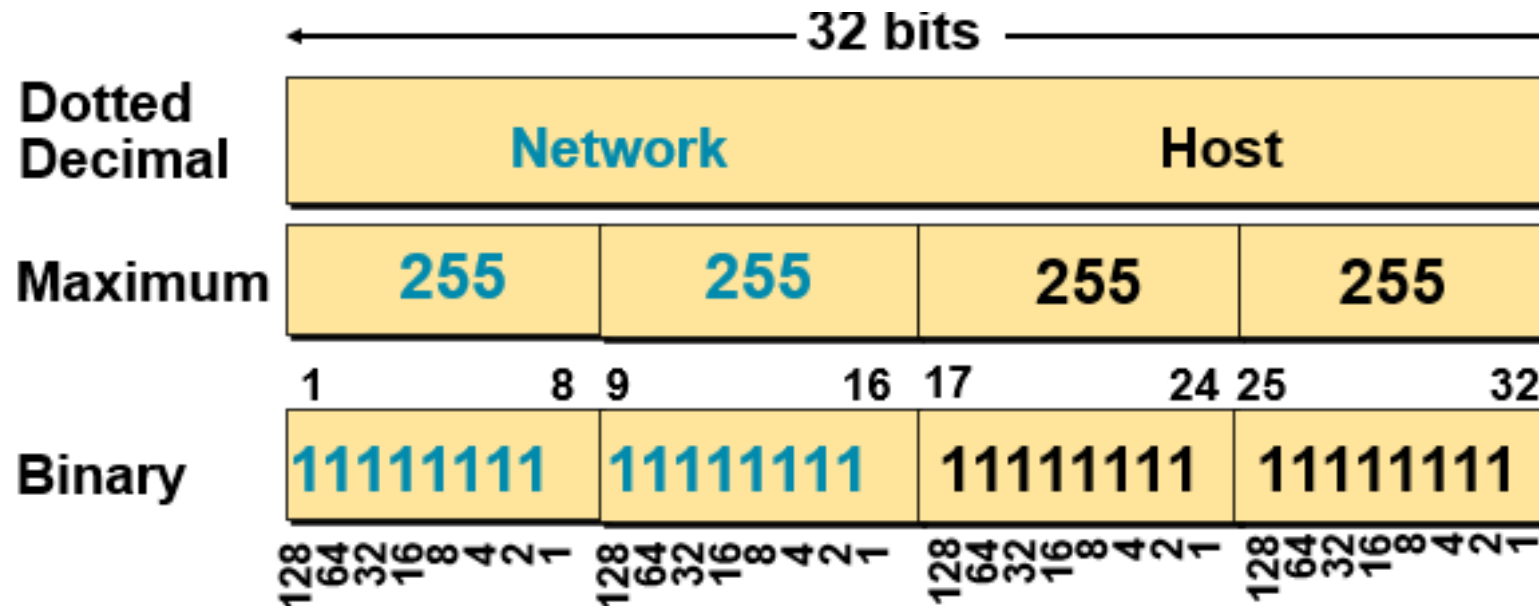
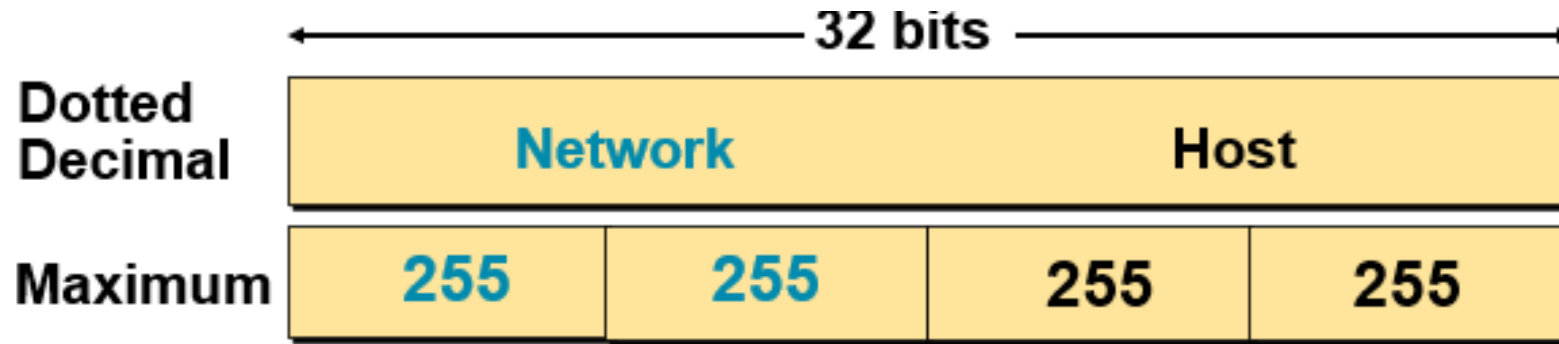
# Week 10: Internet Protocol

# IP Addressing

- An IP address has 32 bits divided into four octets
- To make the address easier to read, people use decimal numbers to represent the binary digits
  - Example: 192.168.1.1
- Dotted decimal notation
  - When binary IP addresses are written in decimal format



# IP addressing



# IP addressing

	← 32 bits →															
Dotted Decimal	Network								Host							
Maximum	255		255		255		255									
	1	8	9	16	17	24	25	32								
Binary	11111111		11111111		11111111		11111111									
	128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
Example Decimal	172		16		122		204									
Example Binary	10101100		00010000		01111010		11001100									

# IP addressing classes

	8 bits	8 bits	8 bits	8 bits
<b>Class A:</b>	Network	Host	Host	Host
<b>Class B:</b>	Network	Network	Host	Host
<b>Class C:</b>	Network	Network	Network	Host
<b>Class D:</b>	Multicast			
<b>Class E:</b>	Research			

Multicasting is a technique developed to send packets from one device to many other devices.

# IP addressing classes

Bits: 1 8 9 16 17 24 25 32

**Class A:**

0NNNNNNN	Host	Host	Host
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Range (1-126)

Bits:	1	8	9	16	17	24	25	32
<b>Class B:</b>	10NNNNNN		Network		Host		Host	
	Range (128-191)							

Bits: 1 8 9 16 17 24 25 32

Class C: 110NNNN Network Network Host

Range (192-223)

Bits: 1 8 9 16 17 24 25 32

Class D: 1110MMMM Multicast Group Multicast Group Multicast Group

Range (224-239)

# IP addressing classes

## ■ Class A

- Reserved for governments and large corporations throughout the world
- Each Class A address supports 16,777,214 hosts

## ■ Class B

- Addresses are assigned to large- and medium-sized companies
- Each Class B address supports 65,534 hosts

# IP addressing classes

Binary Place Values								Decimal Equivalent	Description
128	64	32	16	8	4	2	1		
0	0	0	0	0	0	0	0	= 0	Subnet identifier
0	0	0	0	0	0	0	1	= 1	Bottom of Class A range
0	1	1	1	1	1	1	0	= 126	Top of Class A range
0	1	1	1	1	1	1	1	= 127	Loopback address

**Figure 4-1** Class A addresses begin with a number between 1 and 126

Binary Place Values								Decimal Equivalent	Description
128	64	32	16	8	4	2	1		
1	0	0	0	0	0	0	0	= 128	First Class B address
1	0	1	1	1	1	1	1	= 191	Last Class B address

**Figure 4-2** Class B addresses begin with a number between 128 and 191



# IP addressing classes

- Class C
  - Addresses are assigned to groups that do not meet the qualifications to obtain Class A or B addresses
  - Each Class C address supports 254 hosts
- Class D
  - Addresses (also known as multicast addresses) are reserved for multicasting
  - **Multicasting** is the sending of a stream of data (usually audio and video) to multiple computers simultaneously

# IP addressing classes

Binary Place Values								Decimal Equivalent	Description
128	64	32	16	8	4	2	1		
1	1	0	0	0	0	0	0	= 192	First Class C address
1	1	0	1	1	1	1	1	= 223	Last Class C address

**Figure 4-3** Class C addresses begin with numbers between 192 and 223

Binary Place Values								Decimal Equivalent	Description
128	64	32	16	8	4	2	1		
1	1	1	0	0	0	0	0	= 224	First Class D address
1	1	1	0	1	1	1	1	= 239	Last Class D address

**Figure 4-4** Class D addresses begin with a number between 224 and 239

# IP addressing classes

## ■ Class E

- Addresses are reserved for research, testing, and experimentation
- The Class E range starts where Class D leaves off

## ■ Private IP ranges

- Many companies use private IP addresses for their internal networks
  - Will not be routable on the Internet
- Gateway devices have network interface connections to the internal network and the Internet
  - Route packets between them

# IP addressing classes

Binary Place Values								Decimal Equivalent	Description
128	64	32	16	8	4	2	1		
1	1	1	1	0	0	0	0	= 240	First Class E address
1	1	1	1	1	1	1	1	= 255	Last Class E address

**Figure 4-5** Class E addresses begin with a number between 240 and 255

Class	Private Address Range
A	10.x.x.x
B	172.16.x.x – 172.31.x.x
C	192.168.x.x

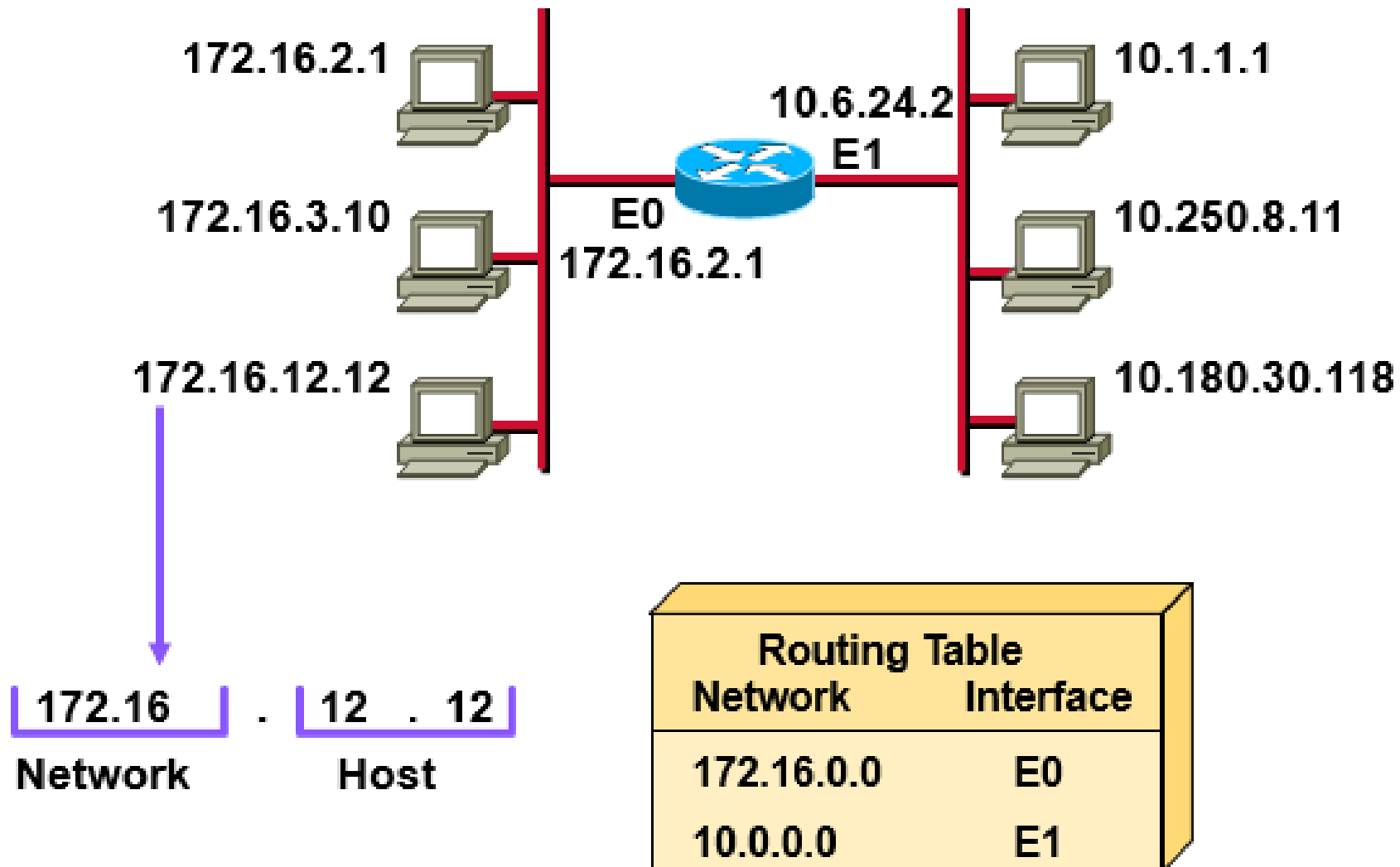
**Table 4-2** The private IP ranges

# IP addressing classes

Class	First Octet decimal (range)	First Octet binary (range)	IP range	Subnet Mask	Hosts per Network ID	# of networks
Class A	0 — 127	<b>0</b> XXXXXXXX	0.0.0.0-127.255.255.255	255.0.0.0	$2^{24} - 2$	$2^7$
Class B	128 — 191	<b>10</b> XXXXXXXX	128.0.0.0-191.255.255.255	255.255.0.0	$2^{16} - 2$	$2^{14}$
Class C	192 — 223	<b>110</b> XXXXXX	192.0.0.0-223.255.255.255	255.255.255.0	$2^8 - 2$	$2^{21}$
Class D (Multicast)	224 — 239	<b>1110</b> XXXX	224.0.0.0-239.255.255.255			
Class E (Experimental)	240 — 255	<b>1111</b> XXXX	240.0.0.0-255.255.255.255			



# Host Addresses



# Determining Available Host Addresses

Network		Host																
172	16	0								0								
		<div> <div>16</div> <div>15</div> <div>14</div> <div>13</div> <div>12</div> <div>11</div> <div>10</div> <div>9</div> <div>8</div> <div>7</div> <div>6</div> <div>5</div> <div>4</div> <div>3</div> <div>2</div> <div>1</div> <div>N</div> </div>																
10101100 00010000		00000000								00000000								1
		00000000								00000001								2
		00000000								00000011								3
		⋮								⋮								⋮
		11111111								11111101								65534
		11111111								11111110								65535
		11111111								11111111								65536
																		- 2
		<div> <div>2<sup>N</sup>-2 = 2<sup>16</sup>-2 = 65534</div> </div>																65534

# Examples

Address	Class	Network	Host
10.2.1.1	A	10.0.0.0	0.2.1.1
128.63.2.100	B	128.63.0.0	0.0.2.100
201.222.5.64	C	201.222.5.0	0.0.0.64
192.6.141.2	C	192.6.141.0	0.0.0.2
130.113.64.16	B	130.113.0.0	0.0.64.16
256.241.201.10	Nonexistent		



# Subnet mask

- IP addresses identify both the network and the host
  - The division between the two is not specific to a certain number of octets
- **Subnet mask**
  - Indicates how much of the IP address represents the network or subnet
- Standard (default) subnet masks:
  - Class A subnet mask is 255.0.0.0
  - Class B subnet mask is 255.255.0.0
  - Class C subnet mask is 255.255.255.0

# Subnetting Formulas

- Consider memorizing the following two formulas:

$2^y = \#$  of usable subnets (where  $y$  is the number of bits borrowed)

$2^x - 2 = \#$  of usable hosts per subnet (where  $x$  is the number of bits remaining in the host field after borrowing)

# Subnetting Formulas

C Address	199.4.10.0	11000111.11000000.01000001.00000000
Standard mask	255.255.255.0	11111111.11111111.11111111.00000000
Mask	255.255.255.240	11111111.11111111.11111111.11110000

y = 4 (borrowed bits)

x = 4 (bits left in host field after borrowing)

Formulas:

$2^y = \#$  of usable subnets

$2^x - 2 = \#$  of usable hosts per subnet

$2^4 = 16$  usable subnets

$2^4 - 2 = 14$  usable hosts per subnet

# Example

	172	16	2	160	
172.16.2.160	10101100	00010000	00000010	10100000	Host 1
255.255.255.192					Mask
					Subnet
					Broadcast
					First
					Last

172	16	2	160
-----	----	---	-----

172.16.2.160    10101100    00010000    00000010    10100000    Host ①

255.255.255.192    11111111    11111111    11111111    11000000    Mask ②

Subnet

Broadcast

First

Last

172	16	2	160
-----	----	---	-----

3

172.16.2.160      10101100    00010000    00000010    10100000 Host 1

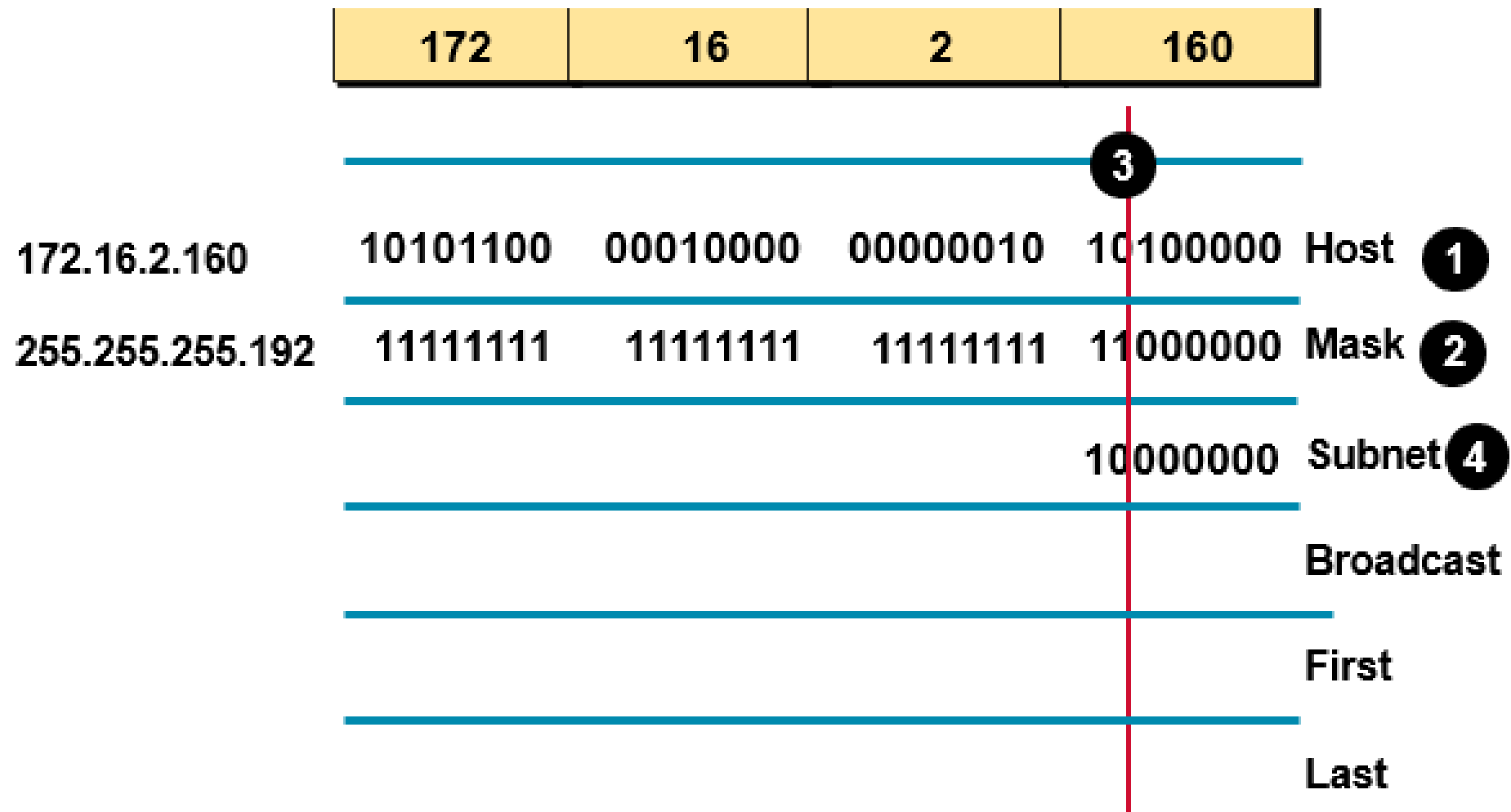
**255.255.255.192    11111111    11111111    11111111    11000000    Mask    2**

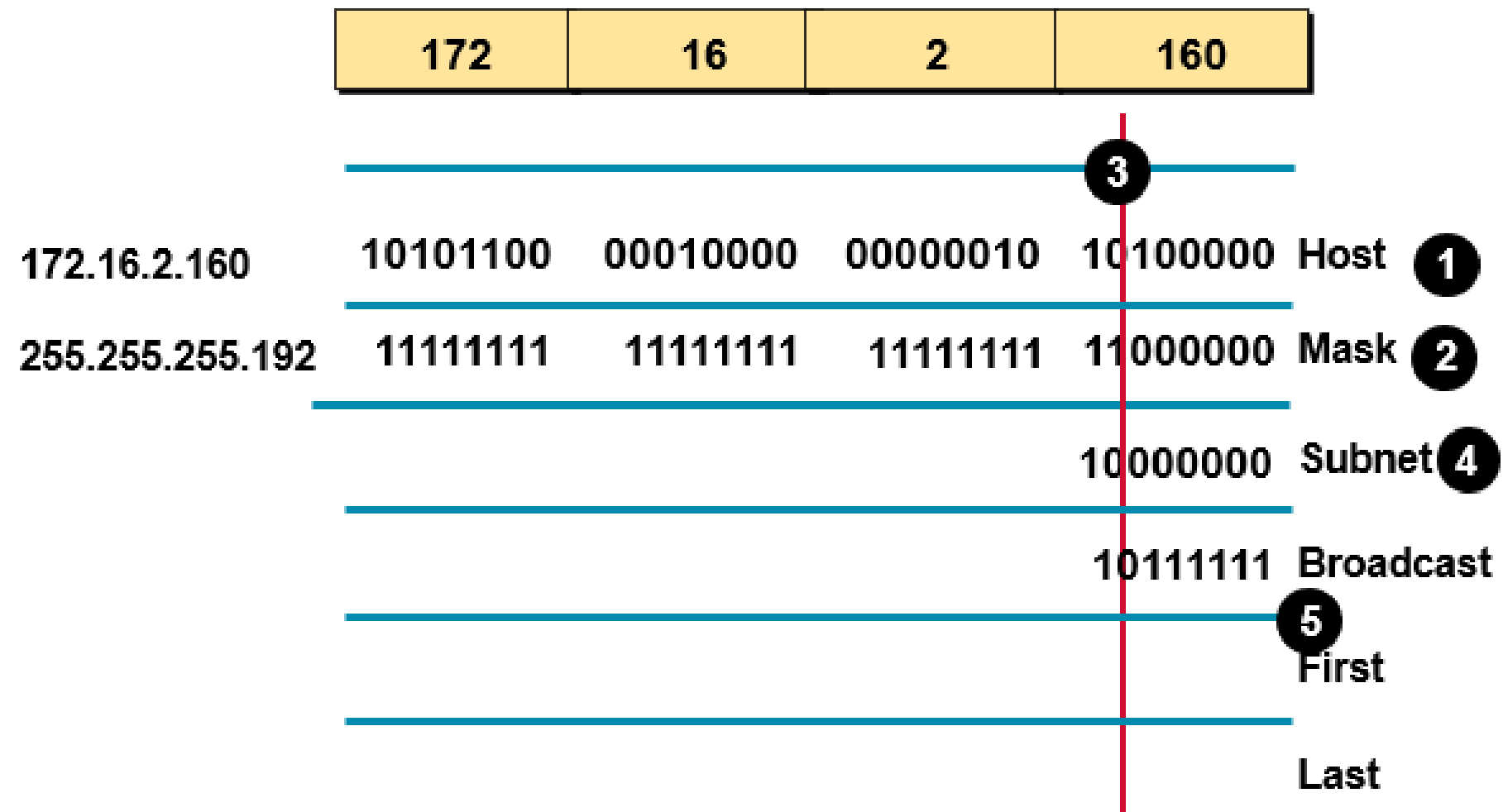
Subnet

## Broadcast

## First

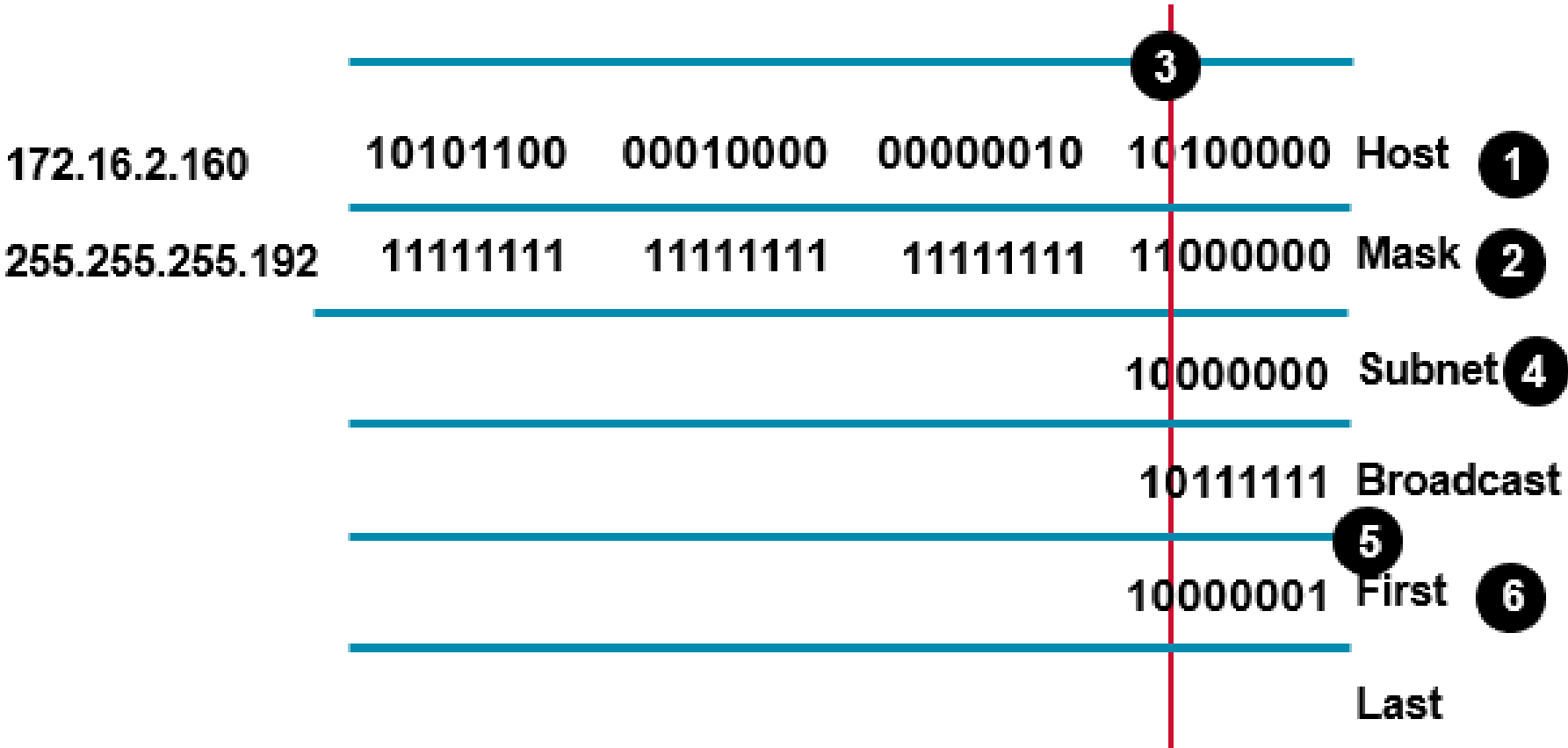
**Last**







172	16	2	160
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172	16	2	160
-----	----	---	-----

				3	
172.16.2.160	10101100	00010000	00000010	10100000	Host 1
255.255.255.192	11111111	11111111	11111111	11000000	Mask 2
8					
	10101100	00010000	00000010	10000000	Subnet 4
	10101100	00010000	00000010	10111111	Broadcast 5
	10101100	00010000	00000010	10000001	First 6
	10101100	00010000	00000010	10111110	Last 7

	172	16	2	160	
	<hr/>				
	<div>3</div>				
172.16.2.160	10101100	00010000	00000010	10100000	Host 1
255.255.255.192	11111111	11111111	11111111	11000000	Mask 2
172.16.2.128	10101100	00010000	00000010	10000000	Subnet 4
172.16.2.191	10101100	00010000	00000010	10111111	Broadcast 5
172.16.2.129	10101100	00010000	00000010	10000001	First 6
172.16.2.190	10101100	00010000	00000010	10111110	Last 7

# CIDR

CIDR notation: **192.168.43.0/26**

- Where the **/26** means 26 bits of the address are used as the network identifier
- In binary, the subnet mask translates to:  
**11111111.11111111.11111111.11000000**  
or **255.255.255.192** in decimal
- This would allow us to divide this address into **4 networks**, each with up to **62 hosts**

# CIDR 192.168.43.0/26 Networks

<b><i>Network Address</i></b>	<b><i>Starting IP Address</i></b>	<b><i>Ending IP Address</i></b>	<b><i>Subnet Mask</i></b>
192.168.43.0	192.168.43.1	192.168.43.62	255.255.255.192
192.168.43.64	192.168.43.65	192.168.43.126	255.255.255.192
192.168.43.128	192.168.43.129	192.168.43.190	255.255.255.192
192.168.43.192	192.168.43.193	192.168.43.254	255.255.255.192

# Public and Private IPv4 Addressing

- Registered IP addresses are not necessary for workstations that merely access resources on the Internet
- The three blocks of addresses allocated for private use are as follows:
  - 10.0.0.0/8
  - 172.16.0.0/12
  - 192.168.0.0/16