



Computer Networks II

Lecture No. 3

“IP Addressing” Examples and Exercises”

4th Year/ 1st semester

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Figure 1 *Finding the classes in binary and dotted-decimal notation*

	First byte	Second byte	Third byte	Fourth byte
Class A	0			
Class B	10			
Class C	110			
Class D	1110			
Class E	1111			

a. Binary notation

	First byte	Second byte	Third byte	Fourth byte
Class A	0-127			
Class B	128-191			
Class C	192-223			
Class D	224-239			
Class E	240-255			

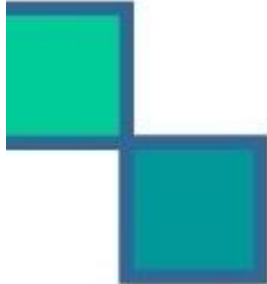
b. Dotted-decimal notation

Table 1 Default masks for classful addressing


<i>Class</i>	<i>Binary</i>	<i>Dotted-Decimal</i>	<i>CIDR</i>
A	11111111 00000000 00000000 00000000	255.0.0.0	/8
B	11111111 11111111 00000000 00000000	255.255.0.0	/16
C	11111111 11111111 11111111 00000000	255.255.255.0	/24



Special Addresses (Cont.)




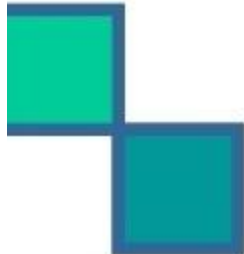
Special IP Addresses			
<i>Network Address</i>	<i>Host Address</i>	<i>Description</i>	<i>Example</i>
0's	0's	Default Cisco Route	0.0.0.0
0's	Host Address	Local Network Hosts	0.0.0.115
1's	1's	Broadcast to Local Network	255.255.255.255
Network Address	1's	Broadcast to Network Address	192.21.12.255
127	Anything	Loopback Testing	127.0.0.1





Class A Subnet Masks (Cont.)

A sample of subnet mask options available for Class A addresses.



Class A Subnet Masks			
<i>Subnet Mask</i>	<i>Number of 1 Bits in Mask</i>	<i>Number of Subnets</i>	<i>Number of Hosts per Subnet</i>
255.0.0.0	8	0	16,777,214
255.192.0.0	10	2	4,194,302
255.240.0.0	12	14	1,048,574
255.255.0.0	16	254	65,534
255.255.128.0	17	510	32,766
255.255.240.0	20	4,094	4,094
255.255.255.128	25	131,070	126
255.255.255.240	28	1,048,574	14
255.255.255.252	30	4,192,302	2

Subnetting Class B & Class C (Cont.)

A sample of the subnet masks available for Class B networks.

Class B Subnet Masks				
<i>Subnet Mask</i>	<i>No. of 1 Bits in Mask</i>	<i>No. of Subnets</i>	<i>No. of Hosts per Subnet</i>	<i>Binary Subnet Mask</i>
255.255.0.0	16	0	65,534	11111111.11111111. 00000000.00000000
255.255.192.0	18	2	16,382	11111111.11111111. 11000000.00000000
255.255.240.0	20	14	4,094	11111111.11111111. 11110000.00000000
255.255.255.0	24	254	254	11111111.11111111. 11111111.00000000
255.255.255.240	28	4,094	14	11111111.11111111. 11111111.11110000
255.255.255.252	30	16,382	2	11111111.11111111. 11111111.11111100

Subnetting Class B & Class C (Cont.)

A list of the subnet masks available for Class C networks.

Class C Subnet Masks				
<i>Subnet Mask</i>	<i>No. of 1 Bits in Mask</i>	<i>No. of Subnets</i>	<i>No. of Hosts per Subnet</i>	<i>Binary Subnet Mask</i>
255.255.255.0	24	0	254	11111111.11111111. 11111111.00000000
255.255.255.192	26	2	62	11111111.11111111. 11111111.11000000
255.255.255.224	27	6	30	11111111.11111111. 11111111.11100000
255.255.255.240	28	14	14	11111111.11111111. 11111111.11110000
255.255.255.248	29	30	6	11111111.11111111. 11111111.11111000
255.255.255.252	30	62	2	11111111.11111111. 11111111.11111100

Figure 2 *A frame in a character-oriented protocol*

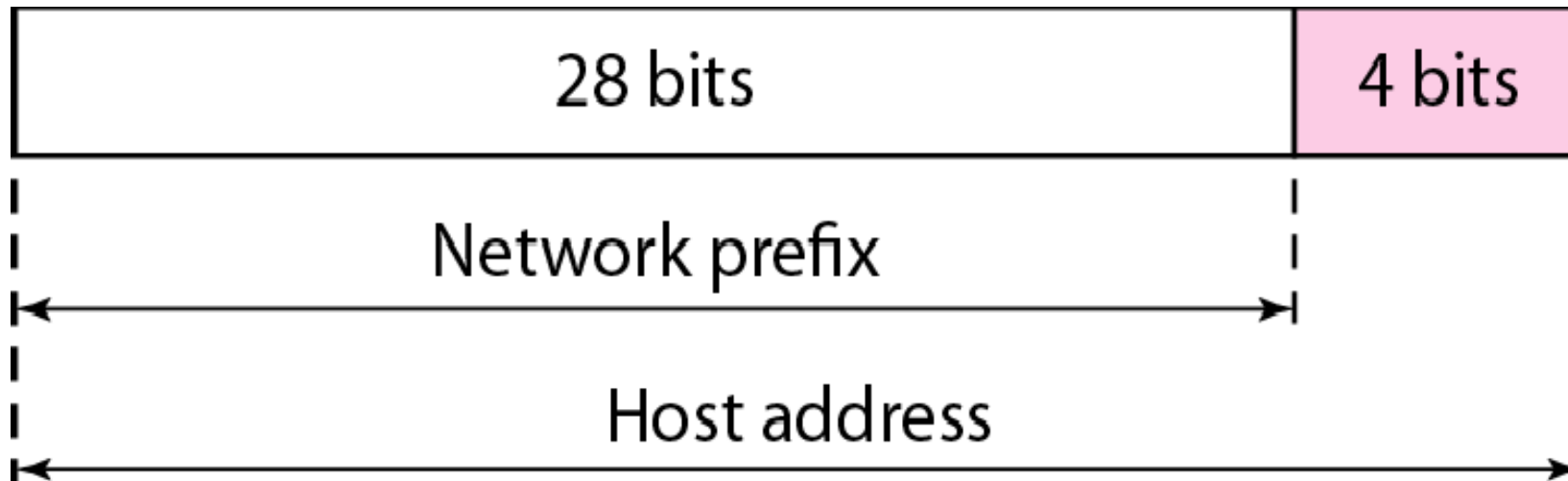
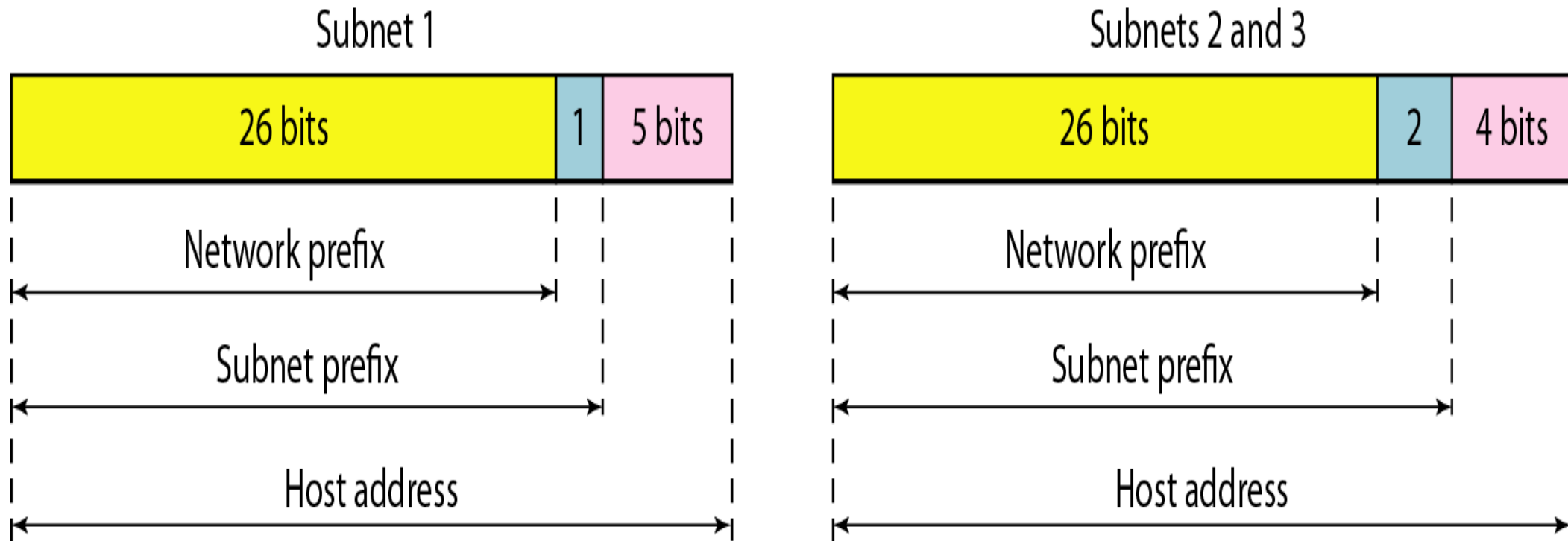


Figure 3 *Three-level hierarchy in an IPv4 address*



Example 1

A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block? last address ? number of addresses ?

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

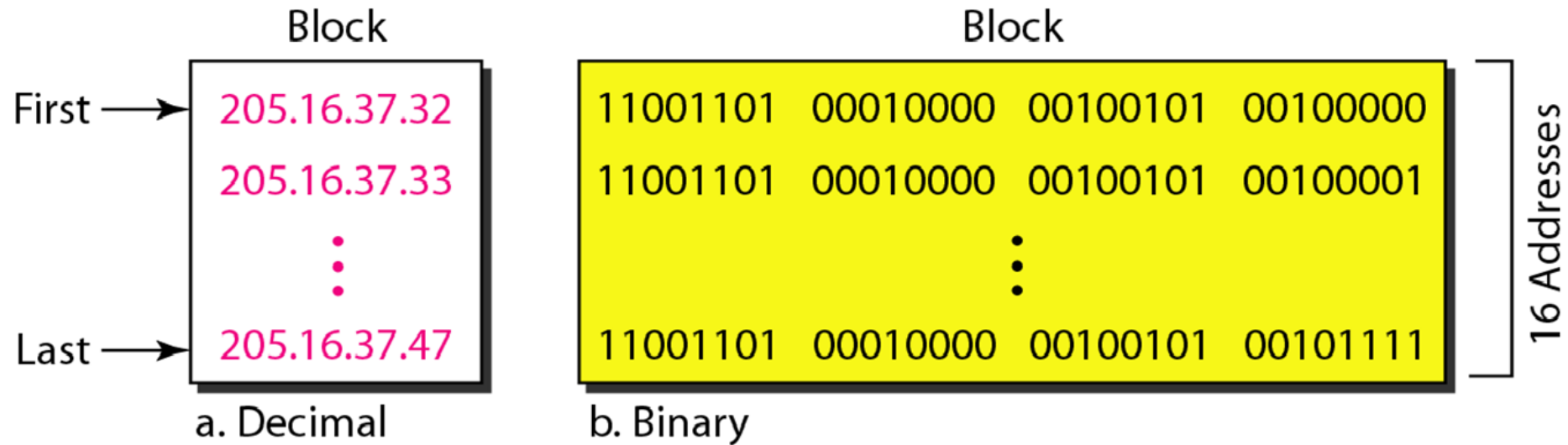
If we set 32–28 rightmost bits to 0, we get

11001101 00010000 00100101 00100000

or **205.16.37.32 first address**

This is actually the block shown in Figure 4.

Figure 4 A block of 16 addresses granted to a small organization



Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32 – 28 rightmost bits to 1, we get

11001101 00010000 00100101 00101111

or **205.16.37.47** last address

This is actually the block shown in Figure 4

The value of n is 28,
(IP length – prefix (number of ones in subnet Mask))
(32–28) = 4 (no of zeros)
 $2^4 = 16$ which means number of addresses .

Or

By using another method

256-240=16 Block Size (Hop)
Number of addresses in each subnet

للحصول على عدد
العناوين الكلي ممكن
استخدام طريقتين
الاولى طرح عدد
الواحدات من طول
العنوان الكلي
للحصول على عدد
الاصفار ثم نطبق
المعادلة أو
بأستخدام الطريقة
القديمة (الثانية)
وهي طرح الحقل
الاخير للماسك من
العدد 256

Example 2

Another way to find the first address, the last address, and the number of addresses is to represent the mask as a 32-bit binary (or 8-digit hexadecimal) number. This is particularly useful when we are writing a program to find these pieces of information. In Example 1 the /28 can be represented as

11111111 11111111 11111111 11110000

(twenty-eight 1s and four 0s).

Find

- a.** The first address
- b.** The last address
- c.** The number of addresses.

Example 2 (continued)

Solution

- a.** The first address can be found by **ANDing** the given addresses with the mask. **ANDing** here is done bit by bit. The result of **ANDing** 2 bits is 1 if both bits are 1s; the result is 0 otherwise.

Address:	11001101	00010000	00100101	00100111
Mask:	11111111	11111111	11111111	11110000
First address:	11001101	00010000	00100101	00100000

للحصول على
العنوان الاول نجري
عملية ضرب
منطقي بين العنوان
والماسك

Subnets

IP address:

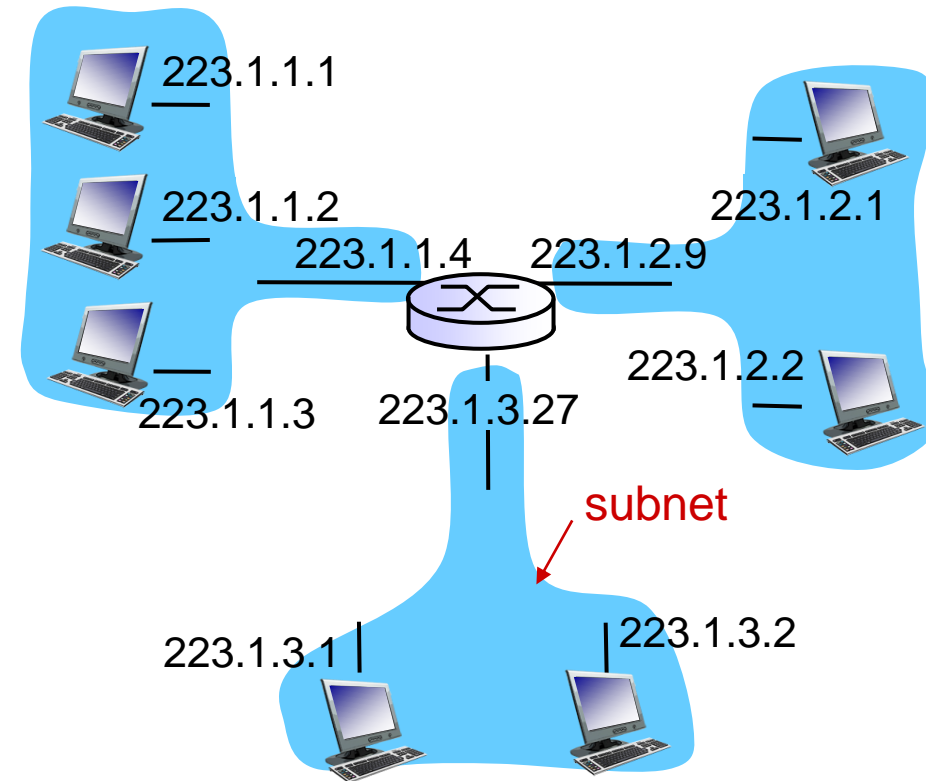
subnet part - high order bits

host part - low order bits

what's a subnet ?

device interfaces with same subnet part of IP address

can physically reach each other *without intervening router*

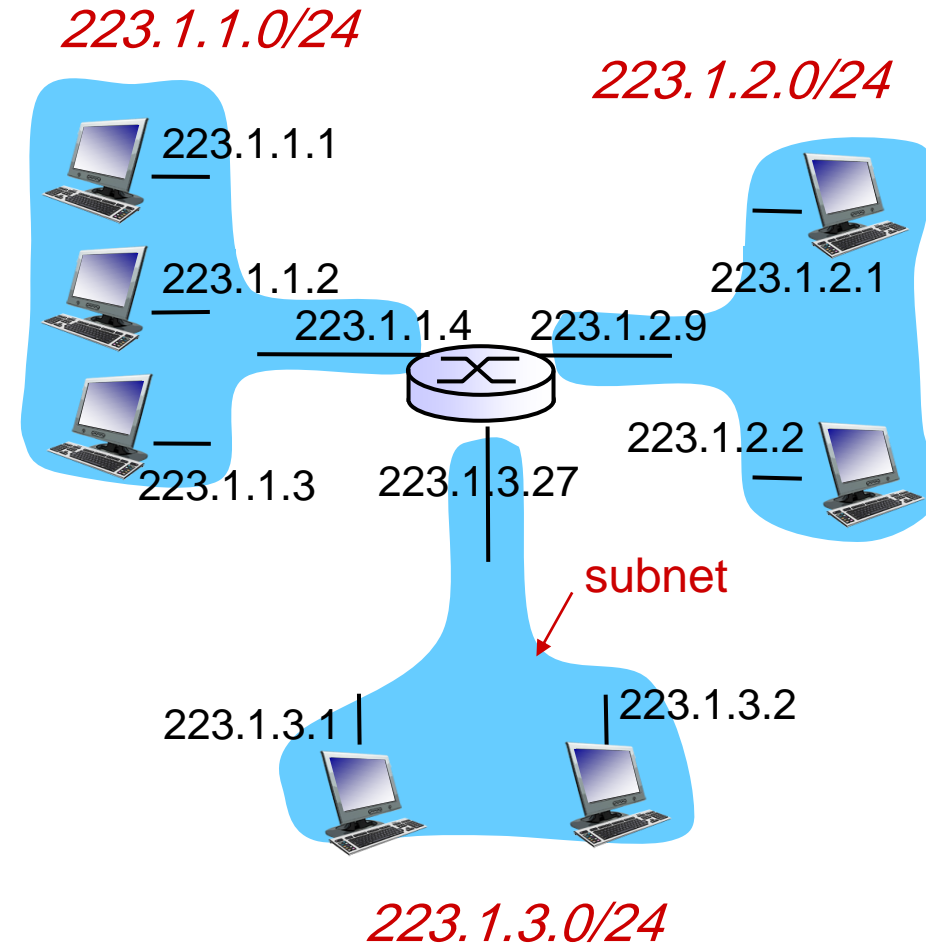


network consisting of 3 subnets

Subnets

recipe

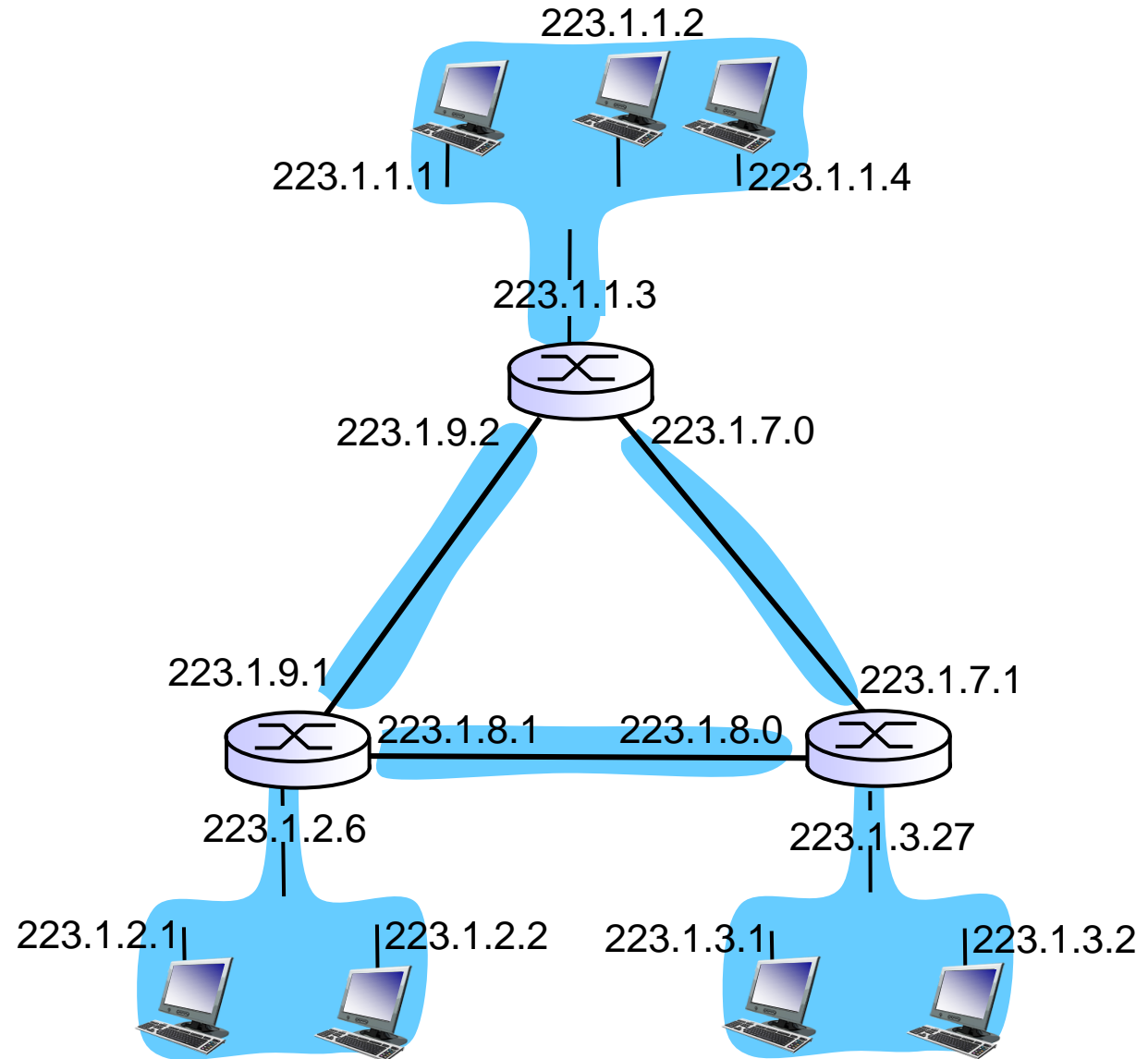
- ❖ to determine the subnets, detach each interface from its host or router, creating islands of isolated networks
- ❖ each isolated network is called a *subnet*



subnet mask: /24

Subnets

how many?



Example 3

What is the subnetwork address if the destination address(IP address) is 129.45.34.56 and the subnet mask is 255.255.240.0?

```
10000001 00101101 00100010 00111000
11111111 11111111 11110000 00000000
10000001 00101101 00100010 00000000
```

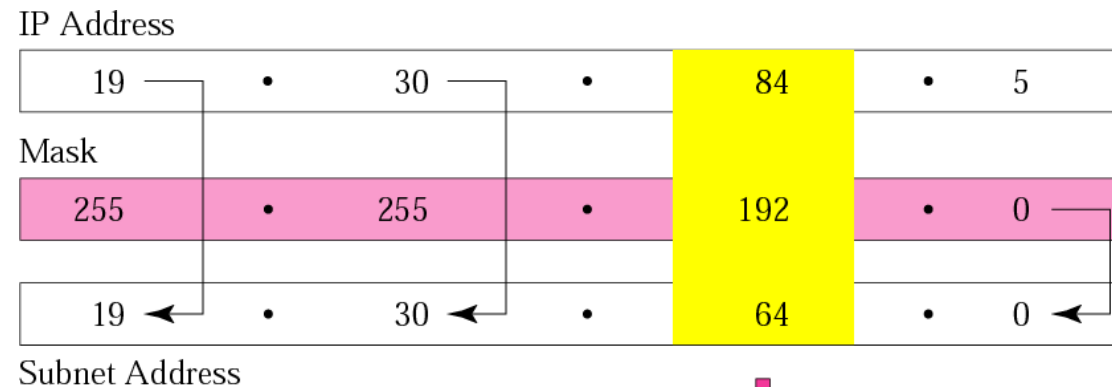
Solution

The subnetwork address is 129.45.32.0

Example 4

What is the subnetwork address if the destination address is 19.30.84.5 and the mask is 255.255.192.0?

Solution



84 0 1 0 1 0 1 0 0
192 1 1 0 0 0 0 0 0

64 0 1 0 0 0 0 0 0

Example 5

A small organization is given a block with the beginning address and the prefix length 205.16.37.24/29 (in slash notation). What is the range of the block?

Solution1

The beginning address is 205.16.37.24. To find the last address we keep the first 29 bits and change the last 3 bits to 1s.

Beginning: 11001111 00010000 00100101 00011000

Ending : 11001111 00010000 00100101 00011111

There are only 8 addresses in this block.

Example 5 / Solution2

Range of the block  Number of addresses in this subnet

Mask 29  248 (11111000)

Subnet Mask 255.255.255.248

$2^5 = 32$ Number of subnets

$(2^3) - 2 = 8 - 2 = 6$ Number of hosts

$256 - 248 = 8$ Block Size (Hop)  Number of addresses in each subnet

The subnet address 205.16.37.24 Beginning

First host 205.16.37.25

Last host 205.16.37.30

Broadcast address 205.16.37.31 Ending

Example 6

- **Host IP Address:** 138.101.114.250
- **Network Mask:** 255.255.0.0 (or /16)
- **Subnet Mask:** 255.255.255.192 (or /26)

Given the following Host IP Address, Network Mask and Subnet mask find the following information:

- Major Network Information
 - Major Network Address
 - Major Network Broadcast Address
 - Range of Hosts if not subnetted
- Subnet Information
 - Subnet Address
 - Range of Host Addresses (first host and last host)
 - Broadcast Address
- Other Subnet Information
 - Total number of subnets
 - Number of hosts per subnet

Solution

Major Network Information

- **Host IP Address:** 138.101.114.250
- **Network Mask:** 255.255.0.0
- **Subnet Mask:** 255.255.255.192

- **Major Network Address:** 138.101.0.0
- **Major Network Broadcast Address:** 138.101.255.255
- **Range of Hosts if not Subnetted:** 138.101.0.1 to 138.101.255.254

Step 1: Convert to Binary

128	64	32	16	8	4	2	1
------------	-----------	-----------	-----------	----------	----------	----------	----------

	138.	101.	114.	250
IP Address	10001010	01100101	01110010	11111010
Mask	11111111	11111111	11111111	11000000
	255.	255.	255.	192

Step 1:

Translate Host IP Address and Subnet Mask into binary notation

Step 2: Find the Subnet Address

	138.	101.	114.	250
IP Address	10001010	01100101	01110010	11111010
Mask	<u>11111111</u>	<u>11111111</u>	<u>11111111</u>	<u>11000000</u>
Network	10001010	01100101	01110010	11000000
	138	101	114	192

Step 2:

Determine the Network (or Subnet) where this Host address lives:

1. Draw a line under the mask
2. Perform a bit-wise AND operation on the IP Address and the Subnet Mask

Note: 1 AND 1 results in a 1, 0 AND anything results in a 0

3. Express the result in Dotted Decimal Notation
4. The result is the **Subnet Address** of this Subnet or “Wire” which is 138.101.114.192

Step 2: Find the Subnet Address

	138.	101.	114.	250
IP Address	10001010	01100101	01110010	11111010
Mask	11111111	11111111	11111111	11000000
Network	10001010	01100101	01110010	11000000
	138	101	114	192

Step 2:

Determine the Network (or Subnet) where this Host address lives:

Quick method:

1. Find the last (right-most) 1 bit in the subnet mask.
2. Copy all of the bits in the IP address to the Network Address
3. Add 0's for the rest of the bits in the Network Address

Step 3: Subnet Range / Host Range

		G.D.		S.D.
IP Address	10001010	01100101	01110010	11 111010
Mask	<u>11111111</u>	<u>11111111</u>	<u>11111111</u>	11 000000
Network	10001010	01100101	01110010	11 <u>000000</u>
			← subnet counting range →	← host → counting range

Step 3:

Determine which bits in the address contain Network (subnet) information and which contain Host information:

- Use the **Network Mask**: 255.255.0.0 and divide (**Great Divide**) the from the rest of the address.
- Use **Subnet Mask**: 255.255.255.192 and divide (**Small Divide**) the subnet from the hosts between the last “1” and the first “0” in the subnet mask.

Step 4: First Host / Last Host

IP Address	10001010	01100101
Mask	<u>11111111</u>	<u>11111111</u>
Network	10001010	01100101

G.D.		S.D.
	01110010	11 111010
	<u>11111111</u>	11 000000
	01110010	11 000000
	← subnet counting range →	← host counting range →
	01110010	11 000001
	114	193
	01110010	11 111110
	114	254
	01110010	11 111111
	114	255

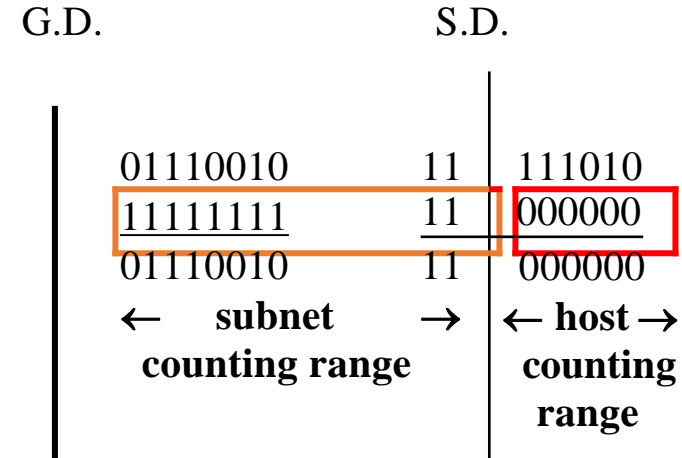
First Host	10001010 138	01100101 101
Last Host	10001010 138	01100101 101
Broadcast	10001010 138	01100101 101

Host Portion

- **Subnet Address:** all 0's
- **First Host:** all 0's and a 1 in rightmost bit
- **Last Host:** all 1's and a 0 in rightmost bit
- **Broadcast:** all 1's

Step 5: Total Number of Subnets

IP Address	10001010	01100101
Mask	<u>11111111</u>	<u>11111111</u>
Network	10001010	01100101



- Total number of subnets
 - Number of subnet bits 10
 - $2^{10} = 1,024$
 - 1,024 total subnets
 - Subtract one “if” all-zeros subnet cannot be used
 - Subtract one “if” all-ones subnet cannot be used

Step 6: Total Number of Hosts per Subnet

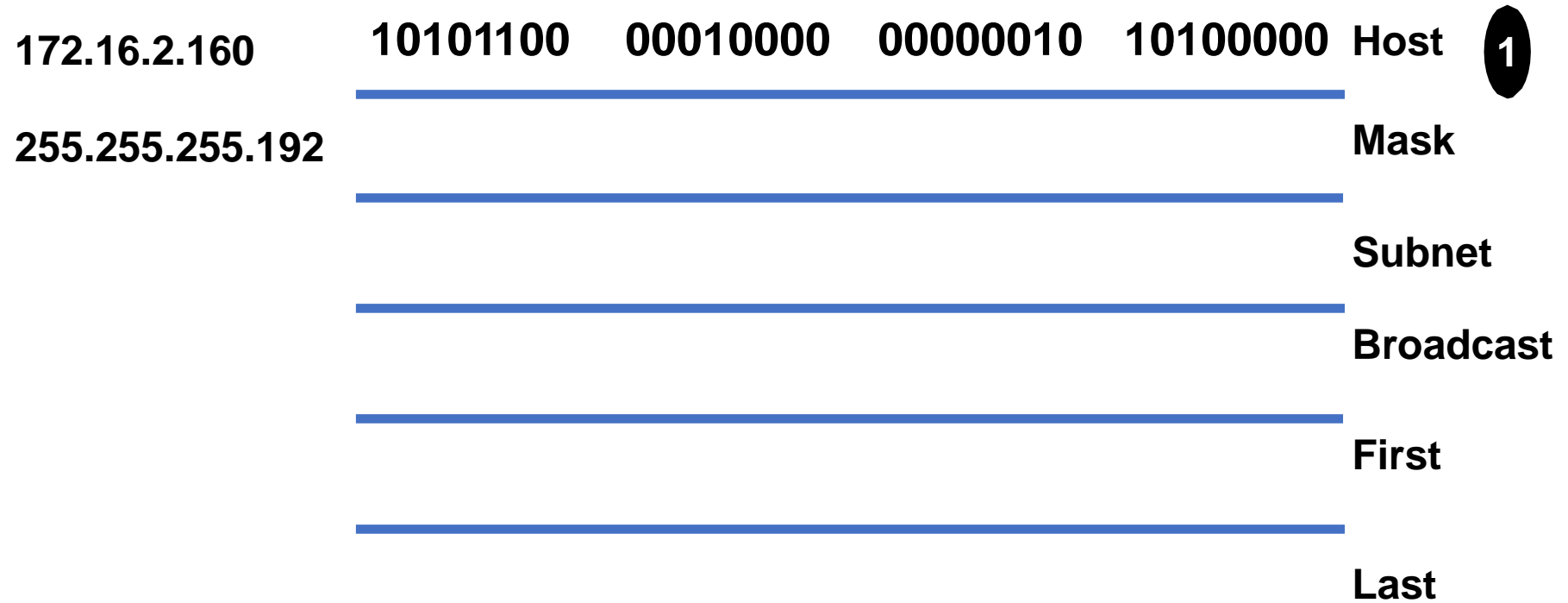
			G.D.		S.D.
IP Address	10001010	01100101		01110010	11 111010
Mask	<u>11111111</u>	<u>11111111</u>		<u>11111111</u>	<u>11</u> <u>000000</u>
Network	10001010	01100101		01110010	11 000000
				← subnet →	← host →
				counting range	counting range

- Total number of hosts per subnet
 - Number of host bits 6
 - $2^6 = 64$
 - 64 host per subnets
 - Subtract one for the subnet address
 - Subtract one for the broadcast address
 - 62 hosts per subnet

Subnet Mask Exercise Answers

Address	Subnet Mask	Class	Subnet
172.16.2.10	255.255.255.0	B	172.16.2.0
10.6.24.20	255.255.240.0	A	10.6.16.0
10.30.36.12	255.255.255.0	A	10.30.36.0

Addressing Summary Example

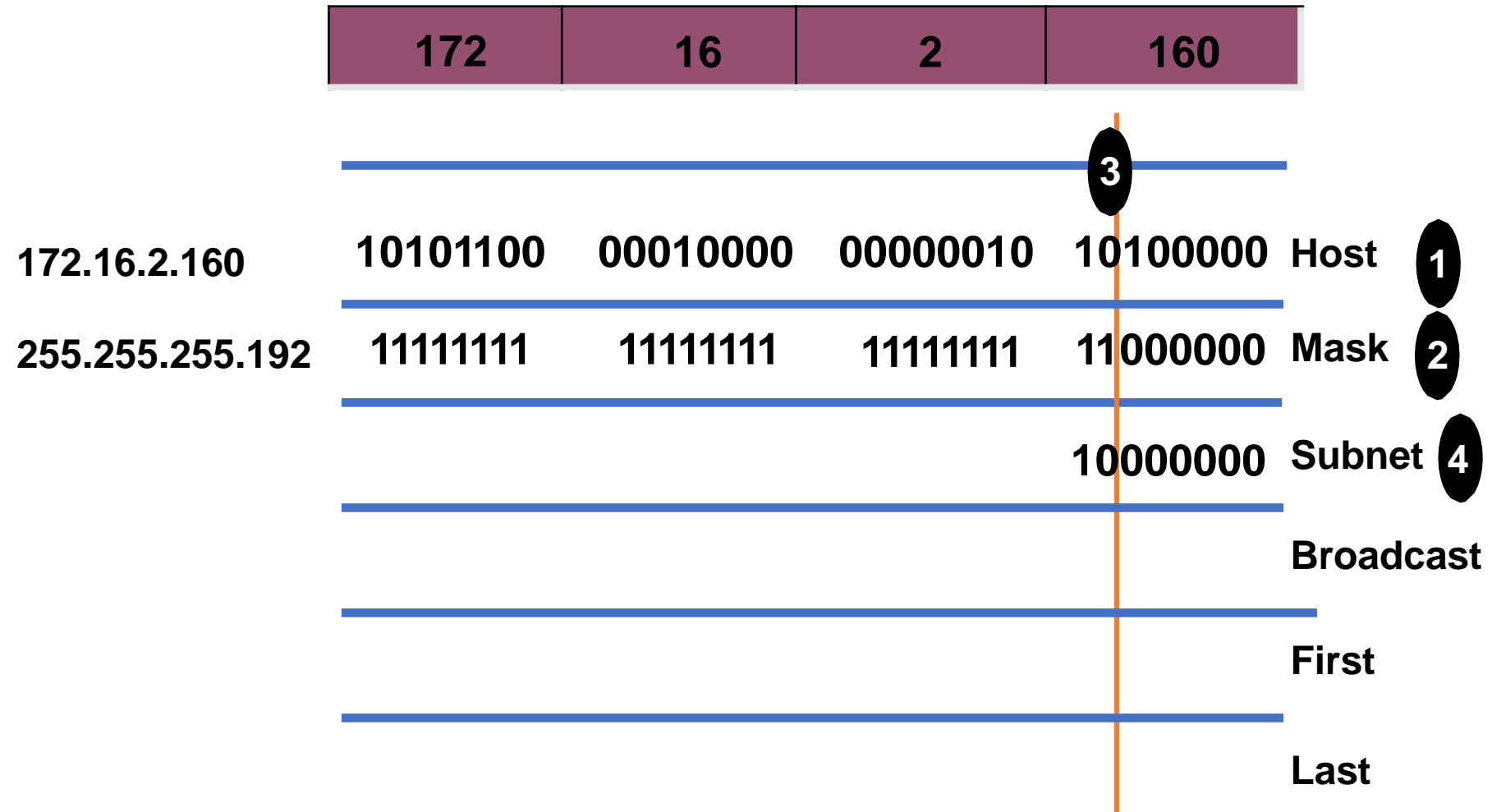


Addressing Summary Example

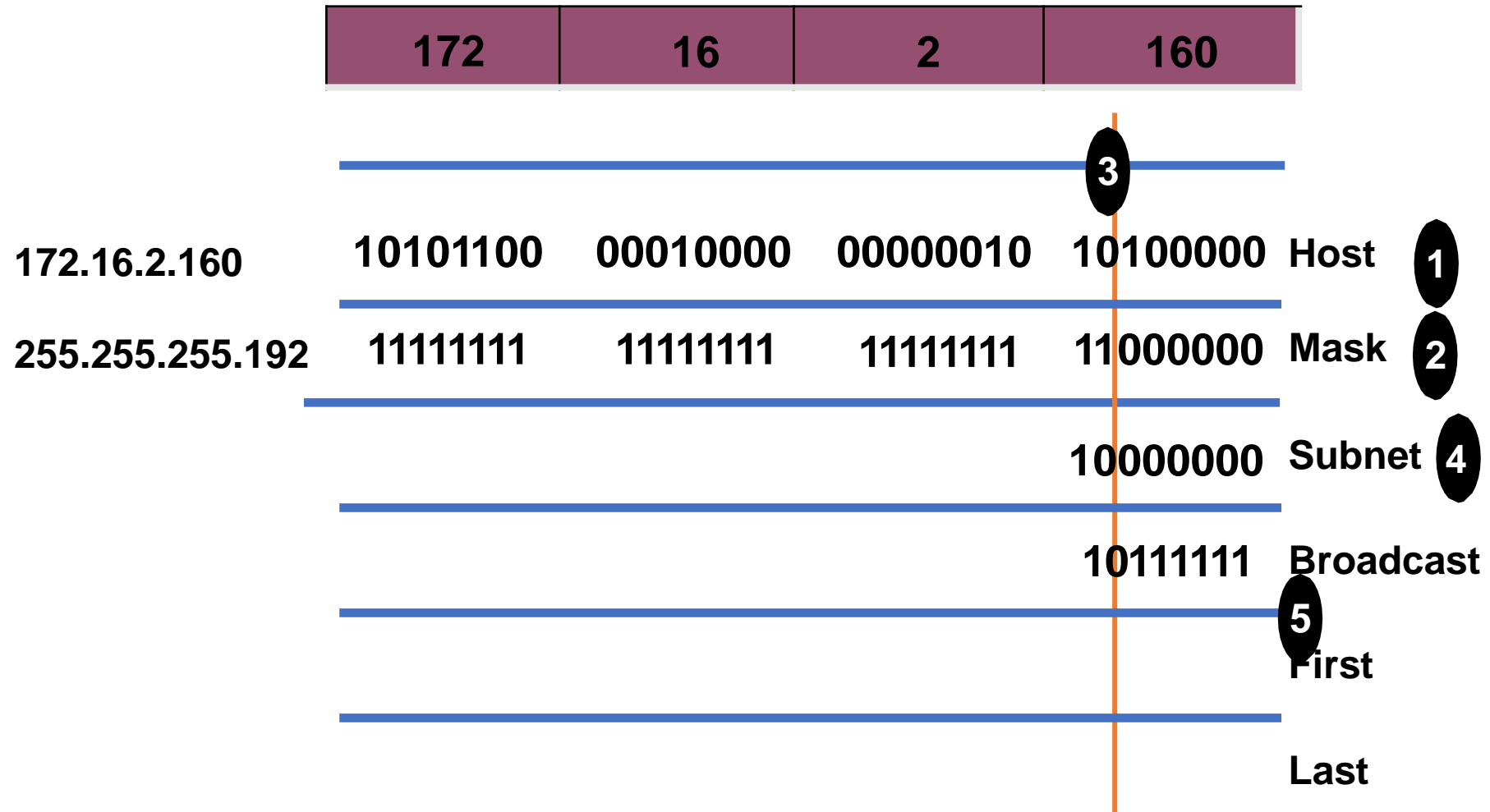
172	16	2	160
-----	----	---	-----

172.16.2.160	10101100	00010000	00000010	10100000	Host	1
255.255.255.192	11111111	11111111	11111111	11000000	Mask	2
					Subnet	
					Broadcast	
					First	
					Last	

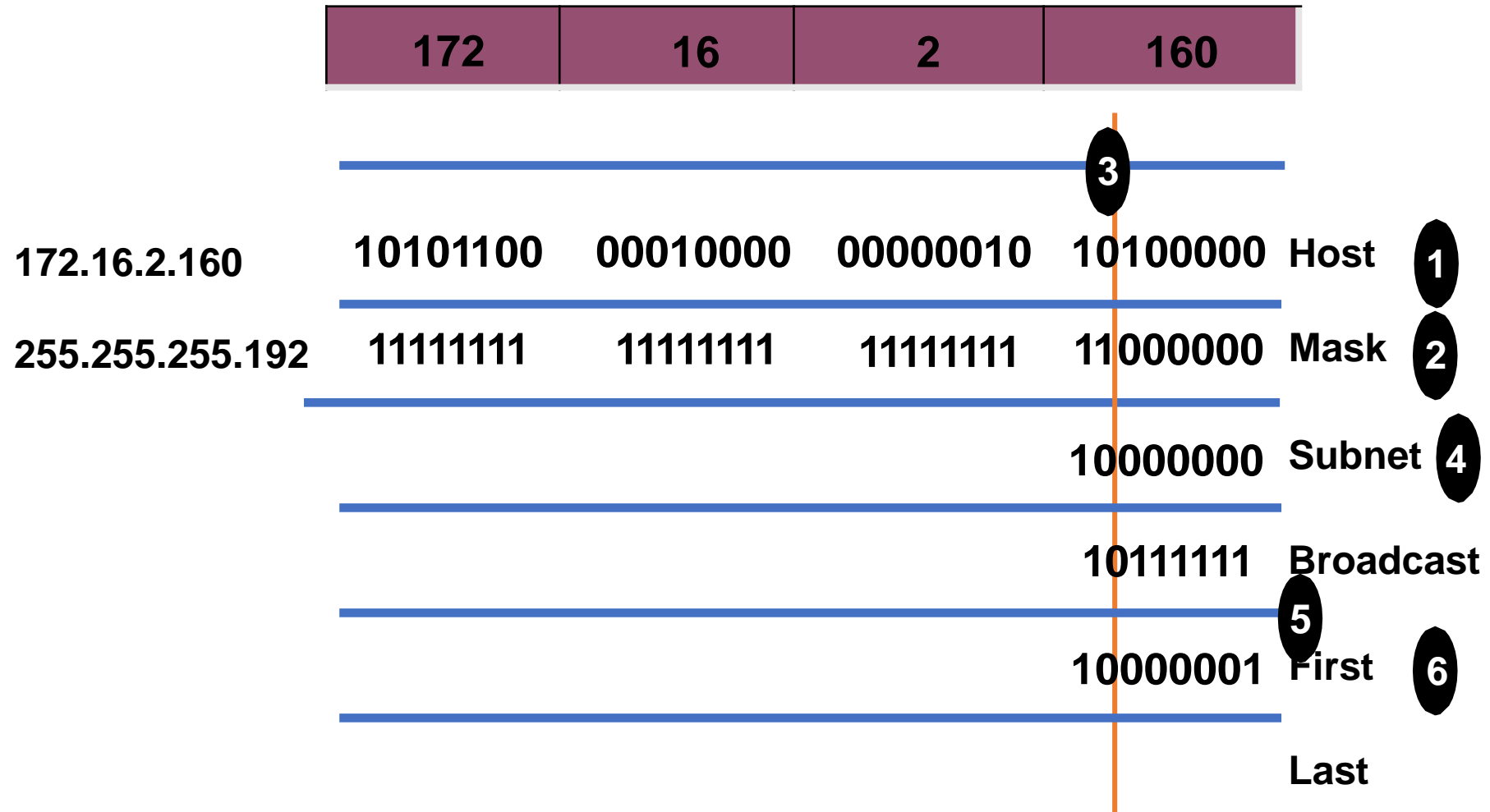
Addressing Summary Example



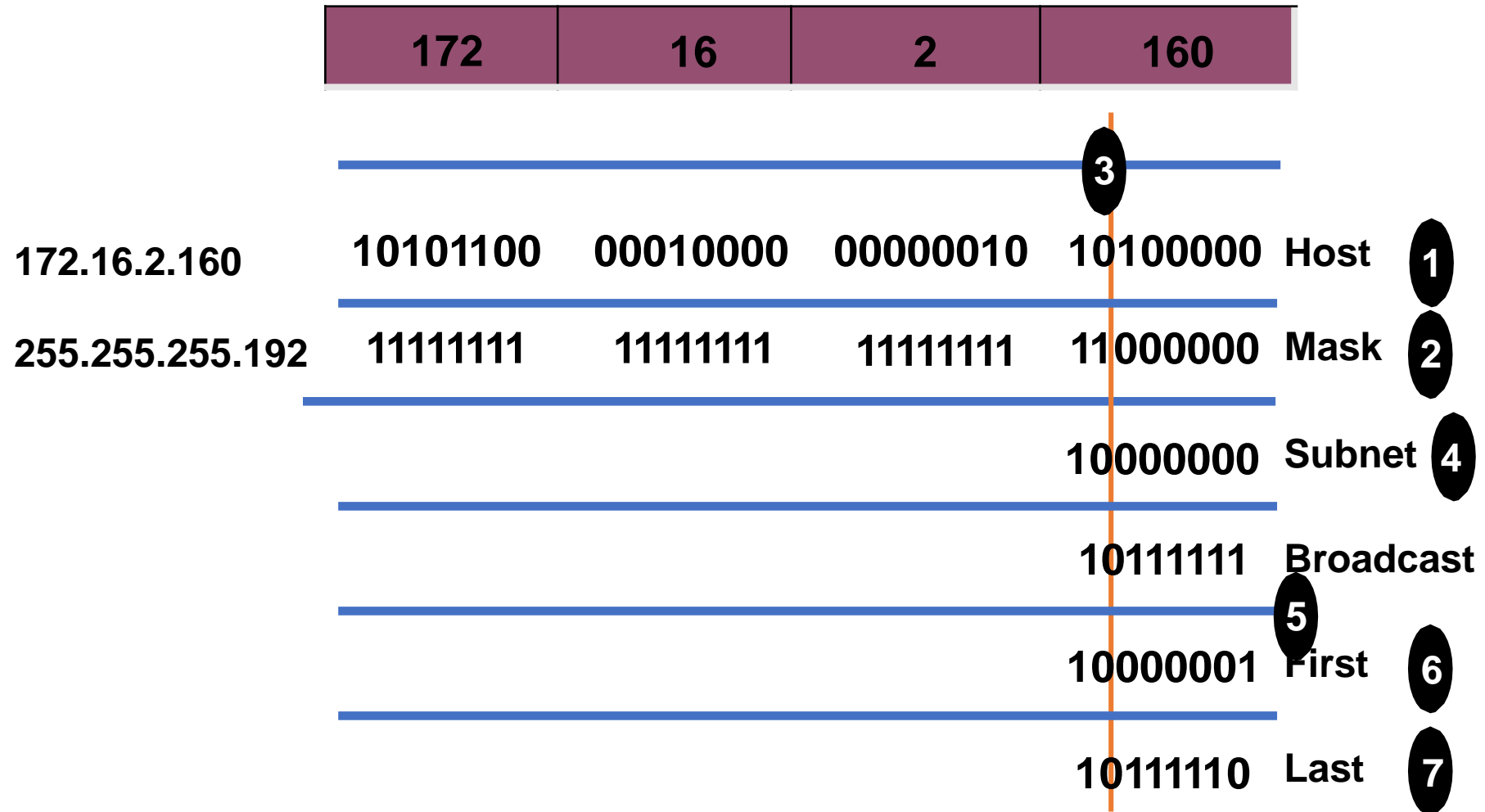
Addressing Summary Example



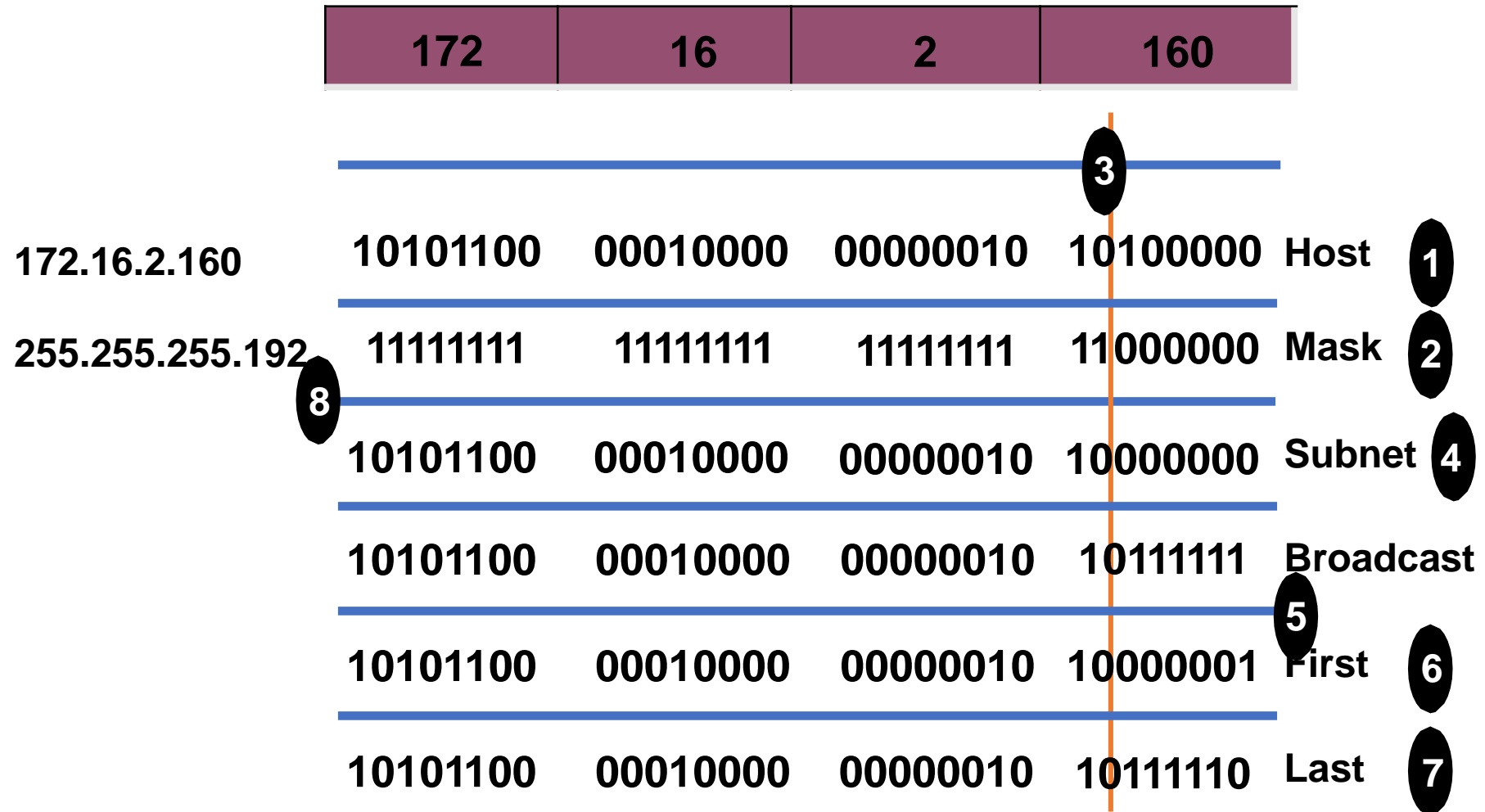
Addressing Summary Example



Addressing Summary Example



Addressing Summary Example



Addressing Summary Example

	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
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

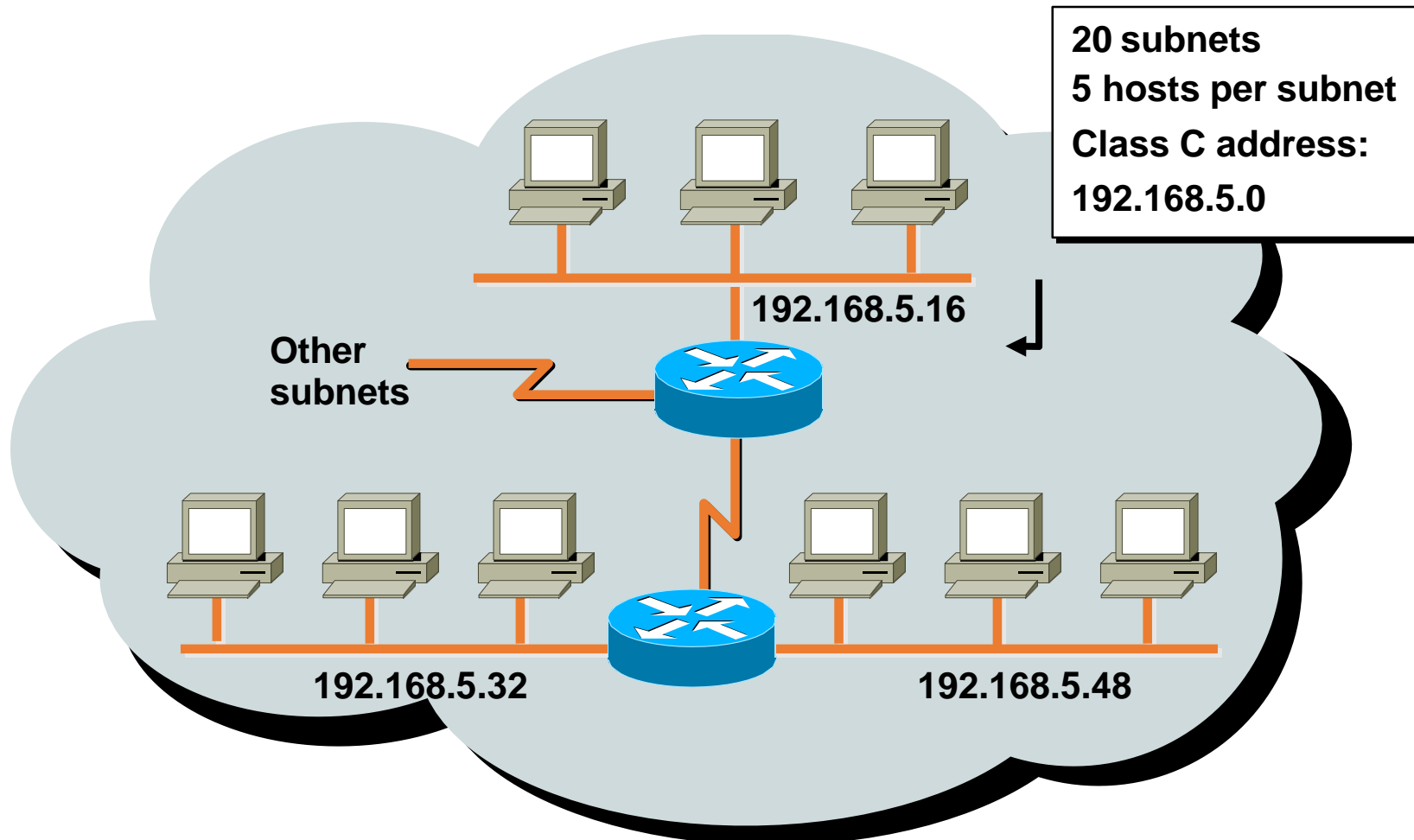
Class B Subnet Example

IP Host Address: 172.16.2.121
Subnet Mask: 255.255.255.0

	Network	Network	Subnet	Host
172.16.2.121:	10101100	00010000	00000010	01111001
255.255.255.0:	11111111	11111111	11111111	00000000
Subnet:	10101100	00010000	00000010	00000000
Broadcast:	10101100	00010000	00000010	11111111

- Subnet Address = 172.16.2.0
- Host Addresses = 172.16.2.1–172.16.2.254
- Broadcast Address = 172.16.2.255
- Eight bits of subnetting

Subnet Planning



Class C Subnet Planning Example

IP Host Address: 192.168.5.121

Subnet Mask: 255.255.255.248

	Network	Network	Network	Subnet	Host
192.168.5.121:	11000000	10101000	00000101	01111001	
255.255.255.248:	11111111	11111111	11111111	11111000	
Subnet:	11000000	10101000	00000101	01111000	
Broadcast:	11000000	10101000	00000101	01111111	

- Subnet Address = 192.168.5.120
- Host Addresses = 192.168.5.121–192.168.5.126
- Broadcast Address = 192.168.5.127
- Five Bits of Subnetting

Broadcast Addresses Exercise Answers

Address	Subnet Mask	Class	Subnet	Broadcast
201.222.10.60	255.255.255.248	C	201.222.10.56	201.222.10.63
15.16.193.6	255.255.248.0	A	15.16.192.0	15.16.199.255
128.16.32.13	255.255.255.252	B	128.16.32.12	128.16.32.15
153.50.6.27	255.255.255.128	B	153.50.6.0	153.50.6.127

Discussion

- Is 99.0.0.0 valid IP address ?
- Is 99.0.255.0 valid IP address ?
- Is 192.100.1.0 valid IP address ?
- Is 192.0.0.255 valid IP address ?
- Is 156.0.0.1 valid IP address ?
- Is 188.0.255.0 valid IP address ?
- Is 188.0.254.255 valid IP address ?

Binary to Decimal Conversion

128	64	32	16	8	4	2	1	255
1	0	0	1	0	0	1	0	<hr/>
0	1	1	1	0	1	1	1	146
1	1	1	1	1	1	1	1	<hr/>
1	1	0	0	0	1	0	1	<hr/>
1	1	1	1	0	1	1	0	<hr/>
0	0	0	1	0	0	1	1	<hr/>
1	0	0	0	0	0	0	1	<hr/>
0	0	1	1	0	0	0	1	<hr/>
0	1	1	1	1	0	0	0	<hr/>
1	1	1	1	0	0	0	0	<hr/>
0	0	1	1	1	0	1	1	<hr/>
0	0	0	0	0	1	1	1	<hr/>

Binary to Decimal Conversion

128	64	32	16	8	4	2	1	255
0	0	0	1	1	0	1	1	_____
1	0	1	0	1	0	1	0	_____
0	1	1	0	1	1	1	1	_____
1	1	1	1	1	0	0	0	_____
0	0	1	0	0	0	0	0	_____
0	1	0	1	0	1	0	1	_____
0	0	1	1	1	1	1	0	_____
0	0	0	0	0	0	1	1	_____
1	1	1	0	1	1	0	1	_____
1	1	0	0	0	0	0	0	_____

Decimal to Binary Conversion

128	64	32	16	8	4	2	1	255
1	1	1	0	1	1	1	1	239
0	0	1	0	0	0	0	0	32
								10
								13
								224
								192
								178
								202
								240

- Subtraction, or with leading bits. If less than 8 remainder zeros will come to left

IP Address Class Identification

IP Address

- 10.250.1.1
- 150.10.15.0
- 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

Class

A

B

IP Address

- 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

Class

Network & Host Identification

Circle the Network Portion of IP Addresses

- 177.100.18.4
- 119.18.45.0
- 209.240.80.78
- 199.155.77.56
- 117.89.56.45
- 215.45.45.0
- 192.200.15.0
- 95.0.21.90
- 33.0.0.0

Circle the Host Portion of IP Addresses

- 10.15.123.50
- 171.2.199.31
- 198.125.87.177
- 223.250.200.222
- 17.45.222.45
- 126.201.54.231
- 191.41.35.112
- 155.25.169.227
- 192.15.155.2

Network & Host Identification

Circle the Network Portion of IP Addresses

- 158.98.80.0
- 217.21.56.0
- 10.250.1.1
- 150.10.15.0
- 192.14.2.0
- 148.17.9.1
- 193.42.1.1
- 126.8.156.0
- 220.200.23.1

Circle the Host Portion of IP Addresses

- 123.102.45.254
- 148.17.9.155
- 100.25.1.1
- 195.0.21.98
- 25.250.135.46
- 171.102.77.77
- 55.250.5.5
- 218.155.230.14
- 10.250.1.1

Default Subnet Masks

- 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 _____

Default Subnet Masks

- 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

- 95.250.91.99

Thank you for listening

Taqwa Altameemi