Course 3:
IP V4 and IP V6

Day-1

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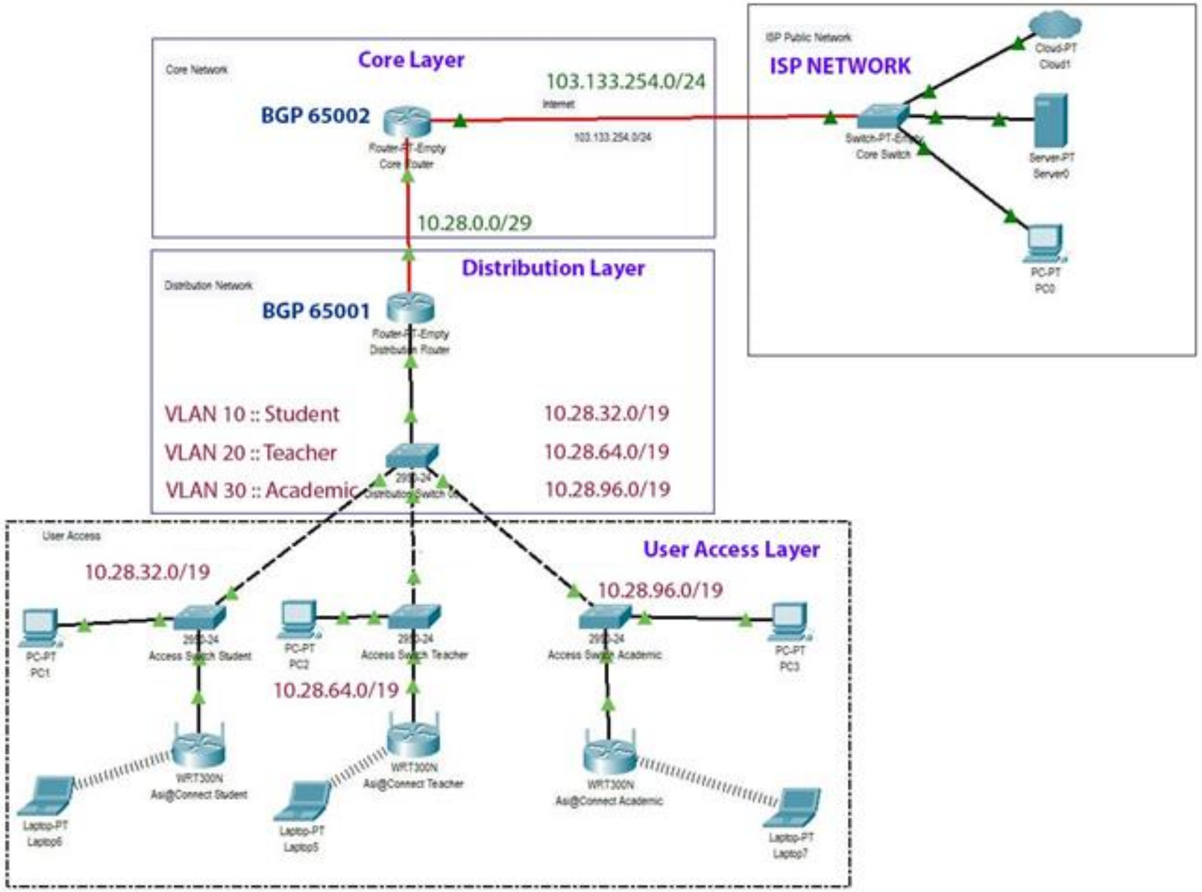
Course Content : Day-1

Campus Network IP Address



Addressing Table 1:

Device/Endpoints	IP Address	Subnet Mask	Default Gateway	Network
ISP Public Network			103.133.254.1	103.133.254.0/24
Public DNS/HTTP Server	103.133.254.2	255.255.255.0	103.133.254.1	103.133.254.0/24
Remote PC	103.133.254.4	255.255.255.0	103.133.254.1	103.133.254.0/24
Core Router:				
Interface 1	103.133.254.1	255.255.255.0		103.133.254.0/24
Interface 2	10.28.0.1	255.255.255.248		10.28.0.0/29
Dist Router:				
Interface 1	10.28.0.2	255.255.255.248		10.28.0.0/29
Interface 2:				
Sub-interface 10	10.28.32.1	255.255.224.0		10.28.32.0/19
Sub-interface 20	10.28.64.1	255.255.224.0		10.28.64.0/19
Sub-interface 30	10.28.96.1	255.255.224.0		10.28.96.0/19

Addressing Table 2 (VLANs):

VLAN-ID & Name	DHCP Pool		Default Gateway	Network
	DHCP From	DHCP To		
VLAN-10 Student	10.28.32.2	10.28.63.254	10.28.32.1	10.28.32.0/19
VLAN-10 Student	10.28.64.2	10.28.95.254	10.28.64.1	10.28.64.0/19
VLAN-10 Student	10.28.96.2	10.28.127.254	10.28.96.1	10.28.96.0/19

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OSI Model (7)/ TCP IP Layer (5)

7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

- Provides connectivity between end hosts on *different* networks (ie. outside of the LAN).
- Provides logical addressing (IP addresses).
- Provides path selection between source and destination.
- Routers operate at Layer 3.

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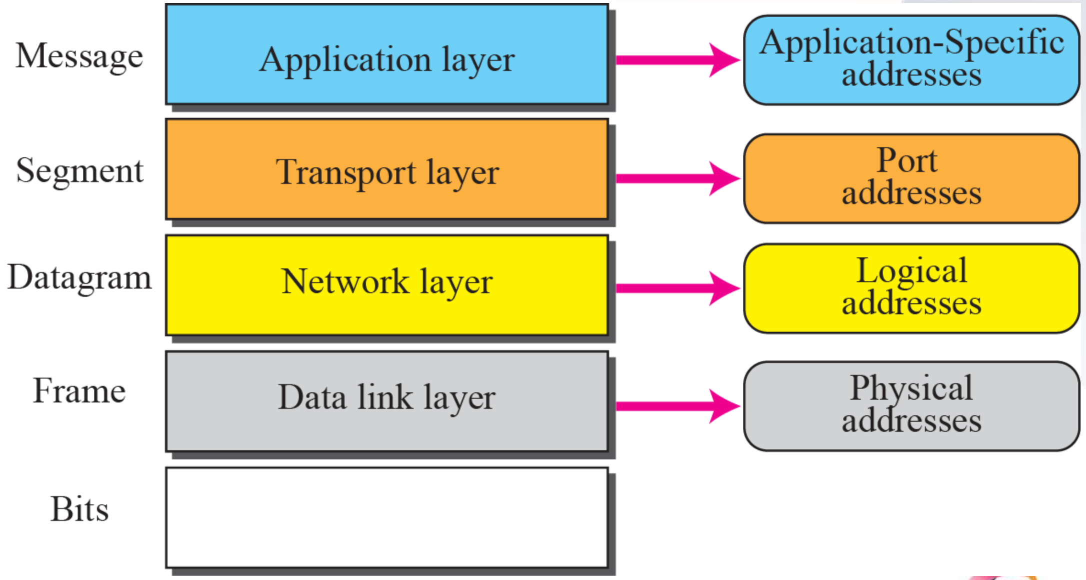
Addressing

Four levels of addresses are used in an internet employing the TCP/IP protocols: physical address, logical address, port address, and application-specific address. Each address is related to a one layer in the TCP/IP architecture, as shown in Figure.

- ✓ Physical Addresses
- ✓ Logical Addresses
- ✓ Port Addresses
- ✓ Application-Specific Addresses



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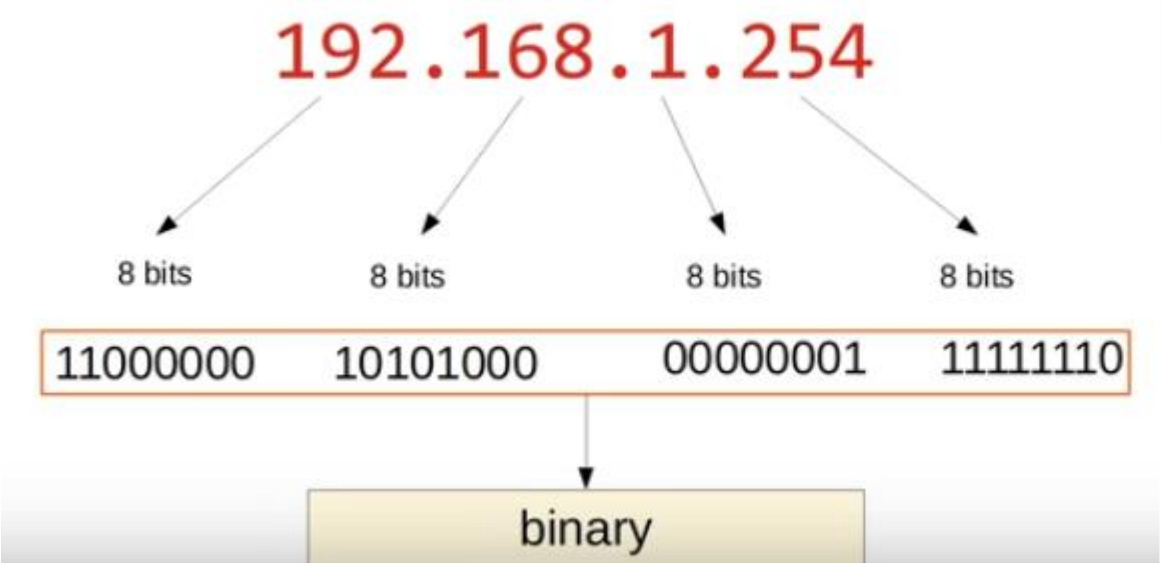
IP Addresses/ Logical Addressing

The identifier used in the IP layer of the TCP/IP protocol suite to identify each device connected to the Internet is called the Internet address or IP address.

An IP address is the address of the interface/NIC.

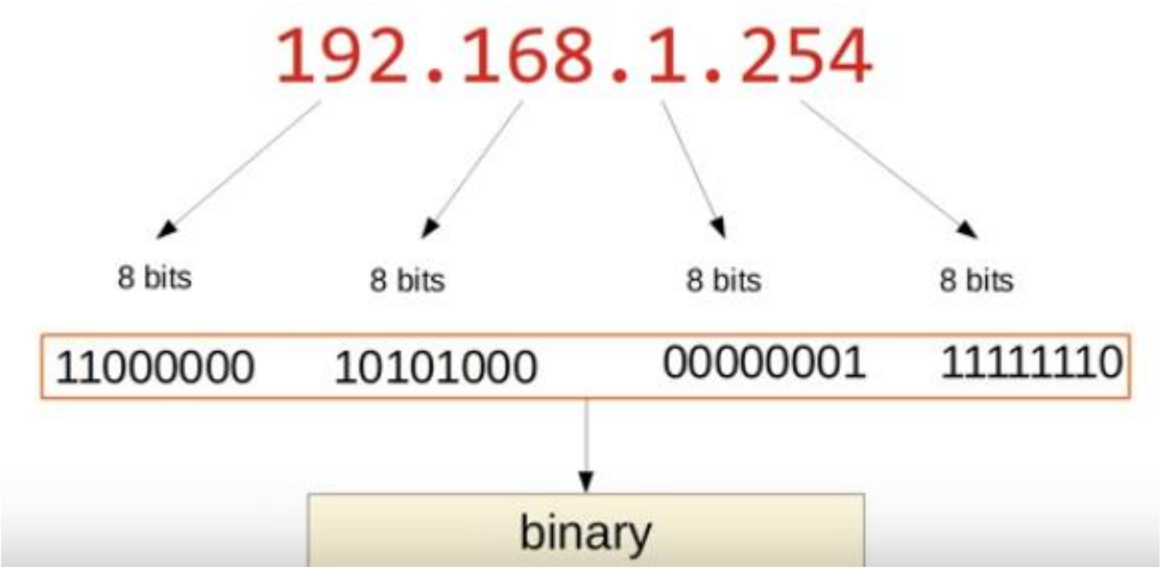


Types of IP Addresses/ Logical Addressing

Internet connected networks use two types of IP Addressing

– IPv4 – legacy Internet protocol

– IPv6 – new Internet protocol



IPv4 Address Representation

2001:0DB8:0000:1111:0000:0000:0000:0200
FE80:0000:0000:0000:0123:4567:89AB:CDEF

IPv6 Address Representation

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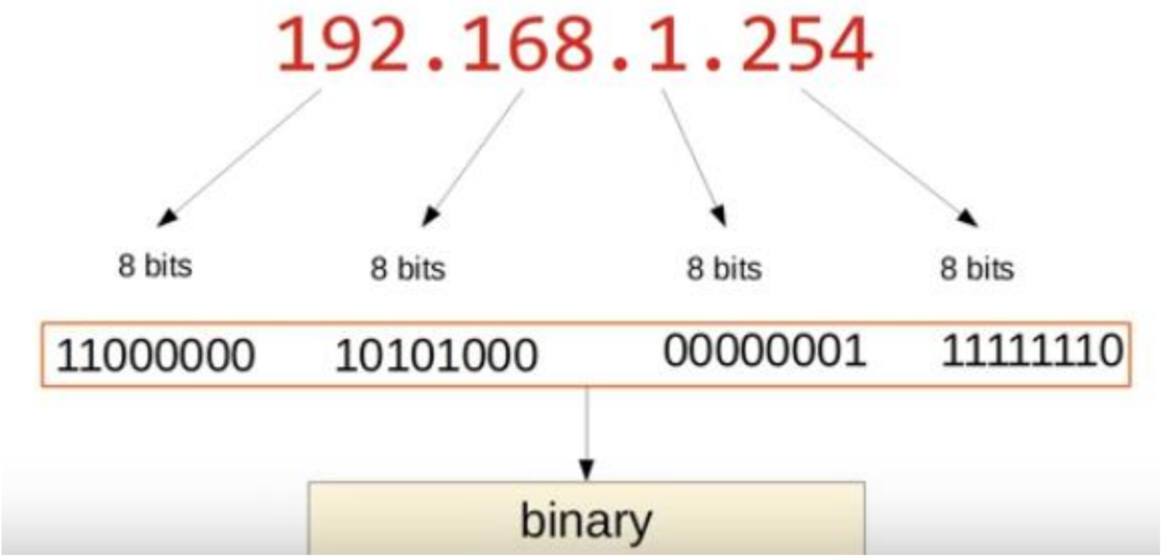
IPv4 Addresses

An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet

An IPv4 address consists of four bytes (32 bits). These bytes are also known as octets.

--- . --- . --- . ---



Address Space

A protocol like IPv4 that defines addresses has an address space.

The address space of IPv4 is 2^{32} or 4,294,967,296.

0.0.0.0 through **255.255.255.255**

00000000 00000000 00000000 00000000

.

.

11111111 11111111 11111111 11111111

Total of 32 bits

2 power 32 (2^{32}) 4 billion addresses

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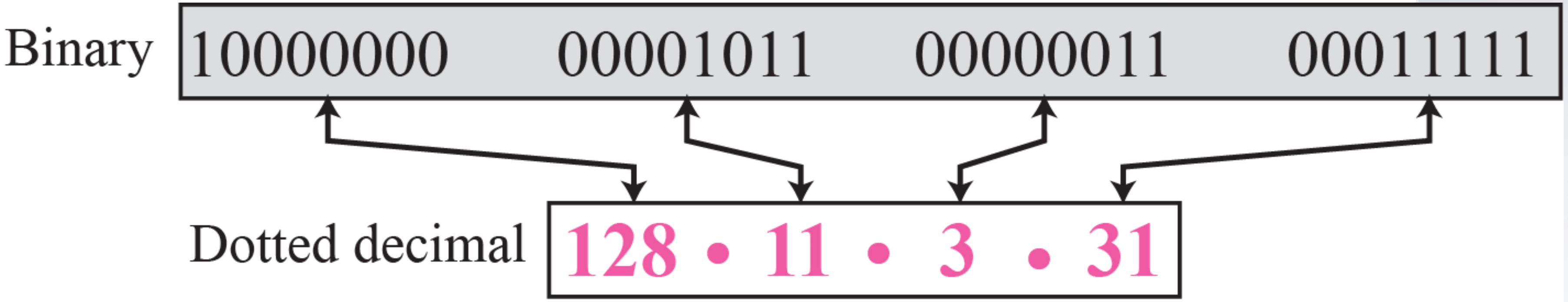
IP address Notation

a) Binary Notation: Base 2

01110101 10010101 00011101 11101010

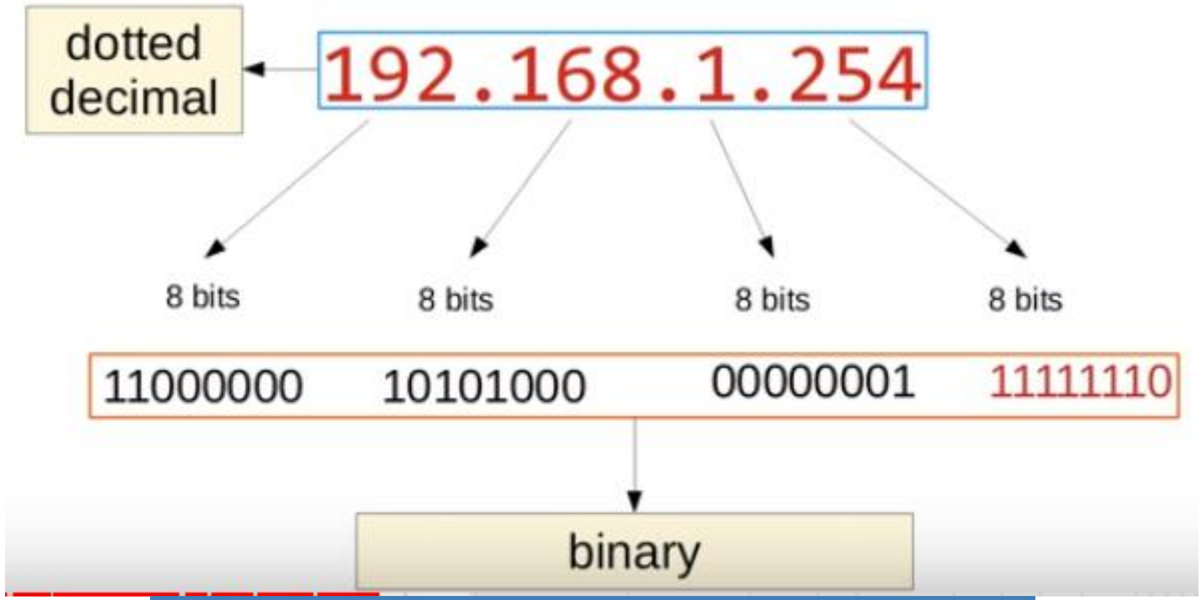
b) Dotted-Decimal Notation: Base 256

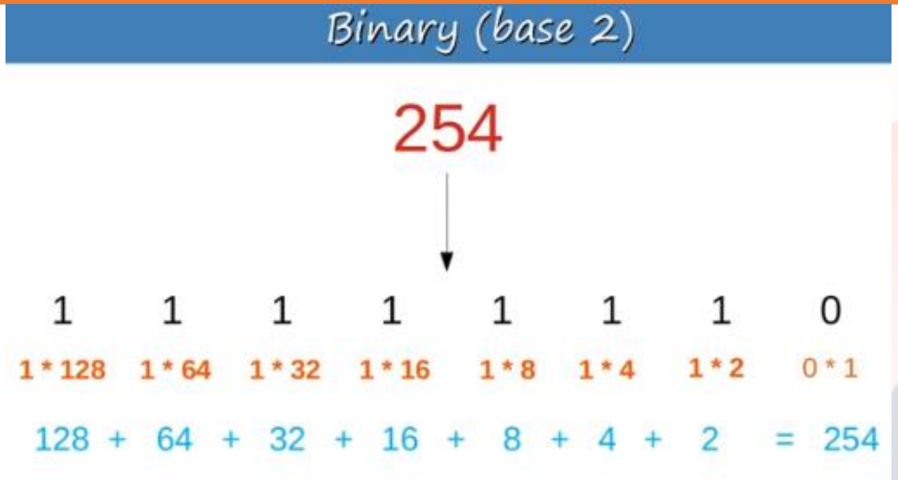


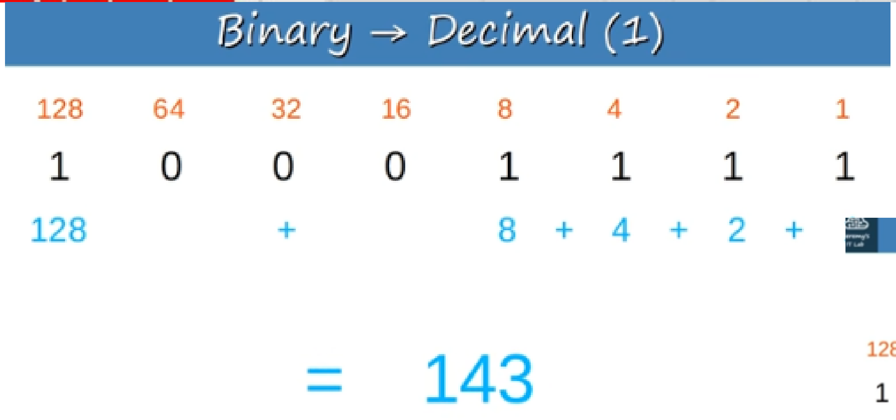
c) Hexadecimal Notation: Base 16

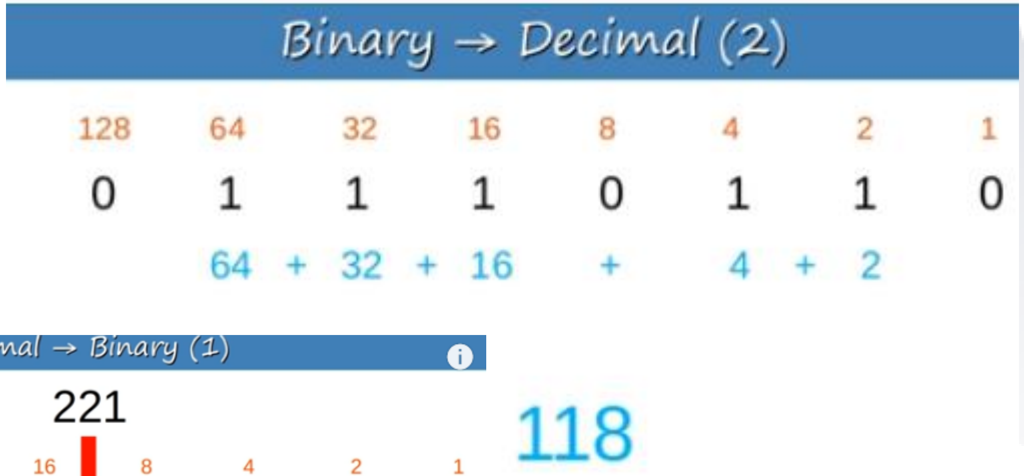
$0X810B0BEF$ or $810B0BEF_{16}$

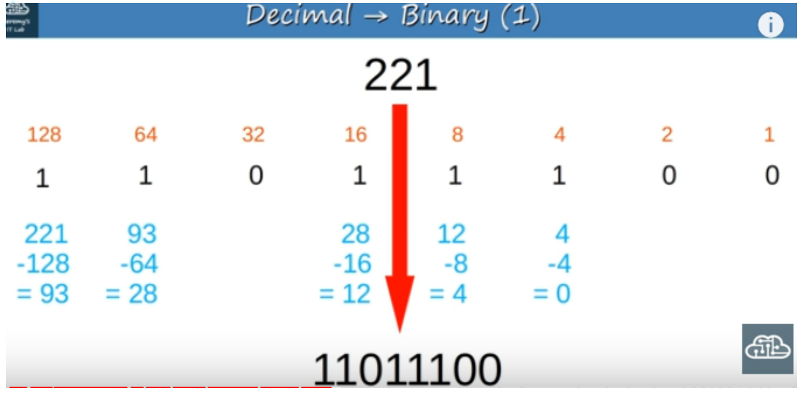
Address Notation











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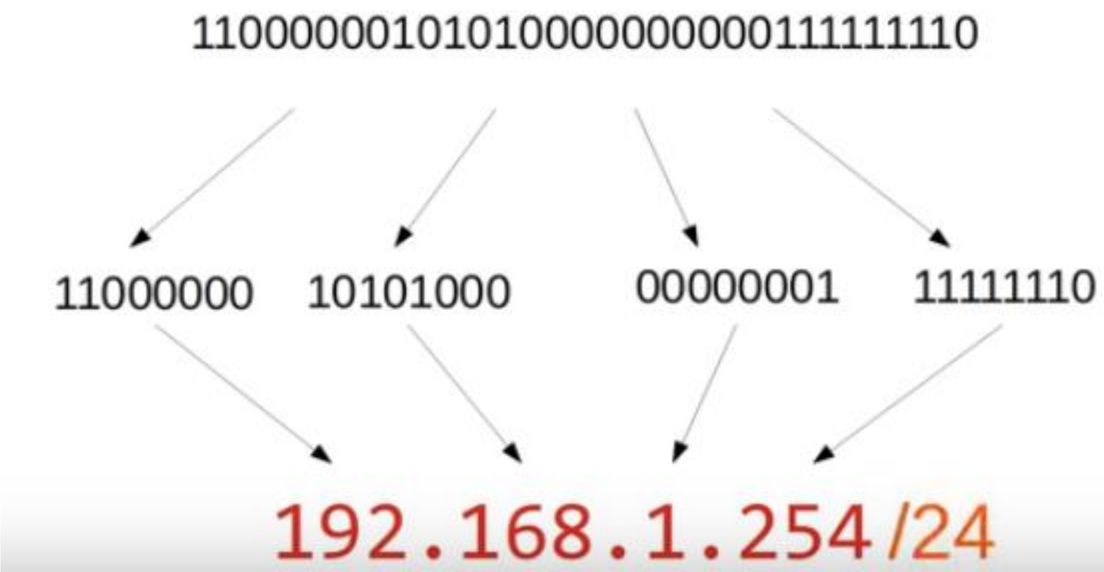
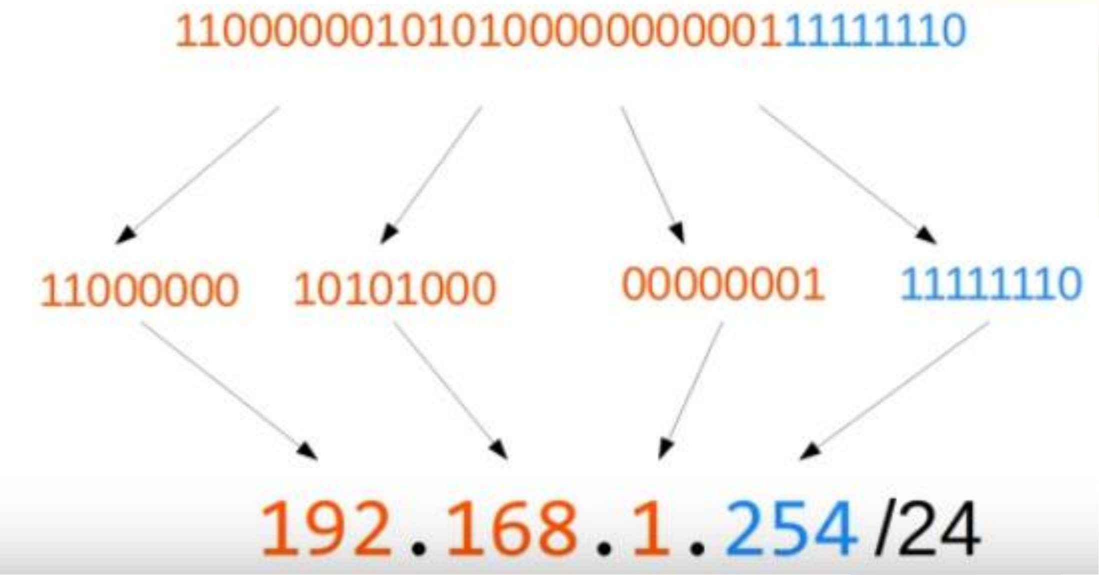
Address Notation





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IPv4 Addresses

Change the following IPv4 addresses from binary notation to dotted-decimal notation.

a. 10000001 00001011 00001011 11101111
b. 11000001 10000011 00011011 11111111
c. 11100111 11011011 10001011 01101111
d. 11111001 10011011 11111011 00001111

Solution

We replace each group of 8 bits with its equivalent decimal number and add dots for separation:

a. 129.11.11.239
b. 193.131.27.255
c. 231.219.139.111
d. 249.155.251.15

IPv4 Addresses

Change the following IPv4 addresses from dotted-decimal notation to binary notation.

a. 111.56.45.78
b. 221.34.7.82
c. *241.8.56.12*
d. *75.45.34.78*

Solution

We replace each decimal number with its binary equivalent:

a. 01101111 00111000 00101101 01001110
b. 11011101 00100010 00000111 01010010
c. 11110001 00001000 00111000 00001100
d. 01001011 00101101 00100010 01001110

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IPv4 Addresses

Find the error, if any, in the following IPv4 addresses:

a. 111.56.045.78
b. 221.34.7.8.20
c. 75.45.301.14
d. 11100010.23.14.67

Solution

a. There should be no leading zeroes (045).
b. We may not have more than 4 bytes in an IPv4 address.
c. Each byte should be less than or equal to 255.
d. A mixture of binary notation and dotted-decimal notation.

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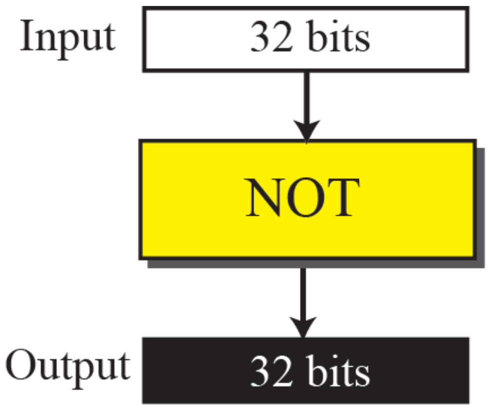
Logical Operation of IPv4 Addresses

Bitwise NOT operation



NOT operation

Input	Output
0	1
1	0

Operation for each bit

The following shows how we can apply the NOT operation on a 32-bit number in binary.

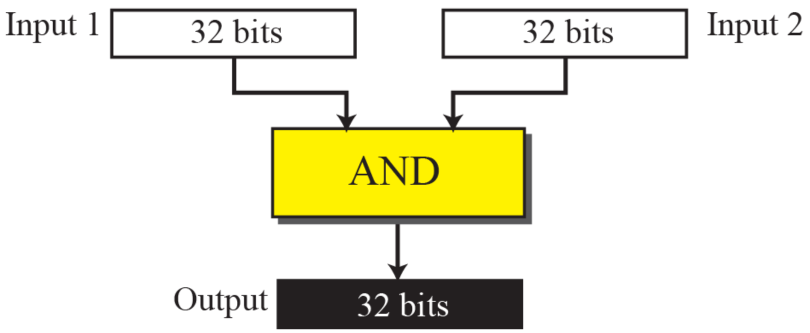
Original number:	00010001	01111001	00001110	00100011
Complement:	11101110	10000110	11110001	11011100

We can use the same operation using the dotted-decimal representation and the short cut.

Original number:	17 .	121 .	14 .	35
Complement:	238 .	134 .	241 .	220

Logical Operation of IPv4 Addresses

Bitwise AND operation



AND

Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

Operation for each bit

First number:	00010001	01111001	00001110	00100011
Second number:	11111111	11111111	10001100	00000000
Result	00010001	01111001	00001100	00000000

We can use the same operation using the dotted-decimal representation and the short cut.

First number:	17	.	121	.	14	.	35
Second number:	255	.	255	.	140	.	0
Result:	17	.	121	.	12	.	0

We have applied the first short cut on the first, second, and the fourth byte; we have applied the second short cut on the third byte. We have written 14 and 140 as the sum of terms and selected the smaller term in each pair as shown below.

Powers	2^7		2^6		2^5		2^4		2^3		2^2		2^1		2^0
Byte (14)	0	+	0	+	0	+	0	+	8	+	4	+	2	+	0
Byte (140)	128	+	0	+	0	+	0	+	8	+	4	+	0	+	0
Result (12)	0	+	0	+	0	+	0	+	8	+	4	+	0	+	0

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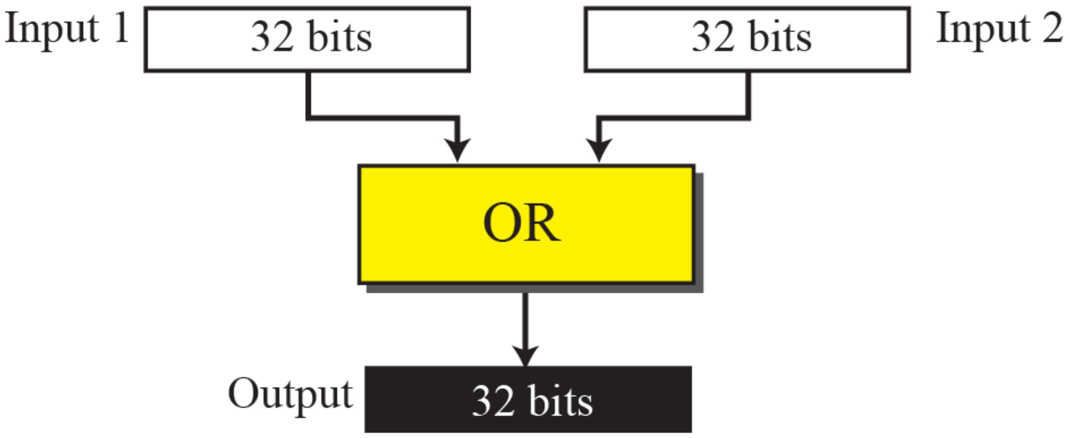
Logical Operation of IPv4 Addresses



OR

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

Operation for each bit

The following shows how we can apply the OR operation on two 32-bit numbers in binary.

First number:	00010001	01111001	00001110	00100011
Second number:	11111111	11111111	10001100	00000000
Result	11111111	11111111	10001110	00100011

We can use the same operation using the dotted-decimal representation and the short cut.

First number:	17	.	121	.	14	.	35
Second number:	255	.	255	.	140	.	0
Result:	255	.	255	.	142	.	35

We have used the first short cut for the first and second bytes and the second short cut for the third byte.

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Types of IPV4 Address

CLASSFUL ADDRESSING

IP addresses, when started a few decades ago, used the concept of classes. This architecture is called classful addressing.

CLASSLESS ADDRESSING

In the mid-1990s, a new architecture, called classless addressing, was introduced that supersedes the original architecture.

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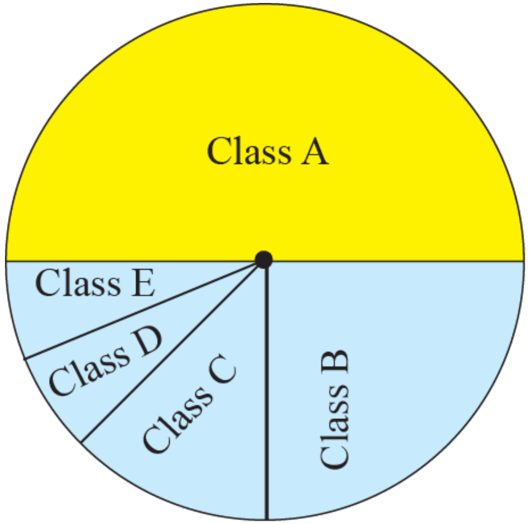
CLASSFUL ADDRESSING

- In classful addressing, the IP address space is divided into five classes: A, B, C, D, and E.
- Each class occupies some part of the whole address space.



Occupation of address space

Class A: 2^{31} = 2,147,483,648 addresses, 50%

Class B: 2^{30} = 1,073,741,824 addresses, 25%

Class C: 2^{29} = 536,870,912 addresses, 12.5%

Class D: 2^{28} = 268,435,456 addresses, 6.25%

Class E: 2^{28} = 268,435,456 addresses, 6.25%

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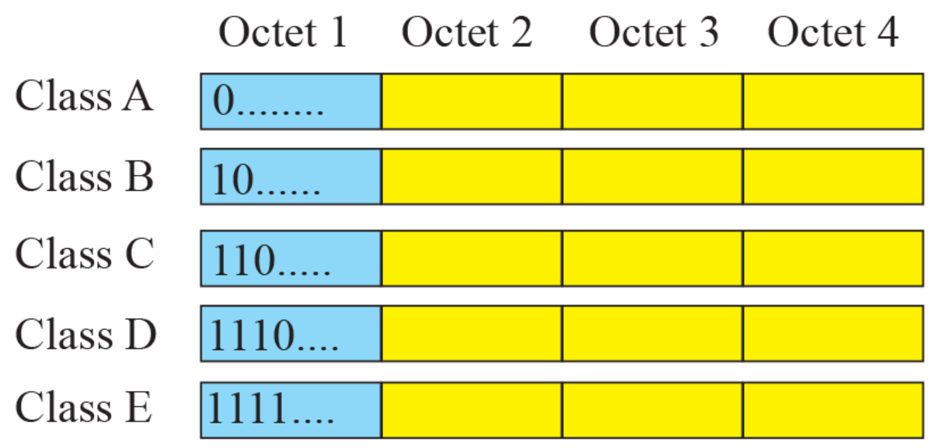
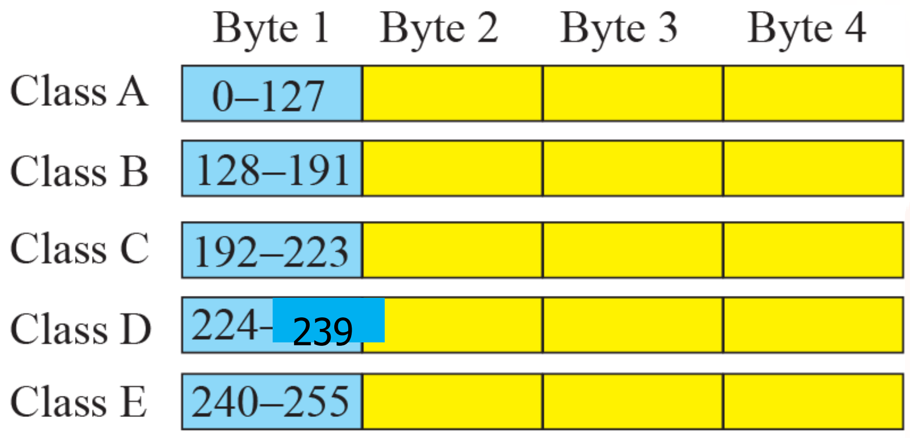
CLASSFUL ADDRESSING

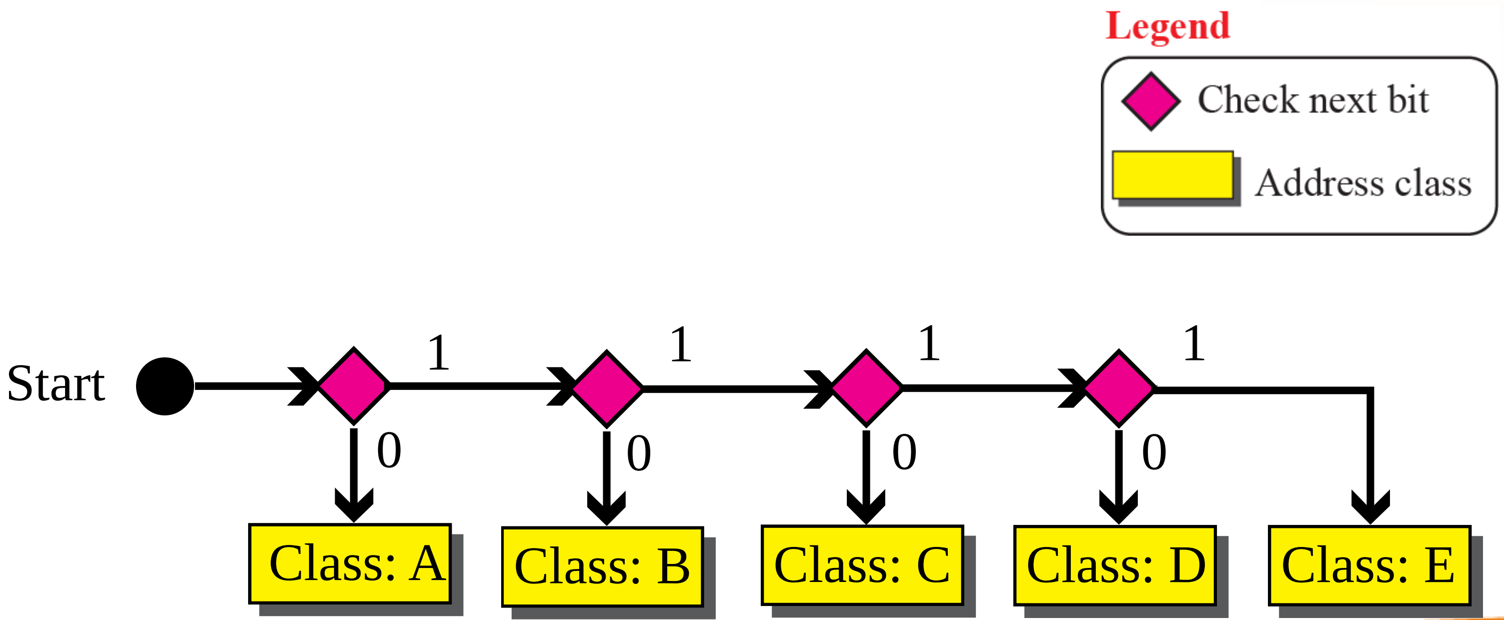
Finding the class of address



Binary notation



Dotted-decimal notation



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Classful Addressing

Find the class of each address:

a. 227.12.14.87

b. 193.14.56.22

c. 14.23.120.8

d. 252.5.15.111

Solution

a. The first byte is 227 (between 224 and 239); the class is D.

b. The first byte is 193 (between 192 and 223); the class is C.

c. The first byte is 14 (between 0 and 127); the class is A.

d. The first byte is 252 (between 240 and 255); the class is E.

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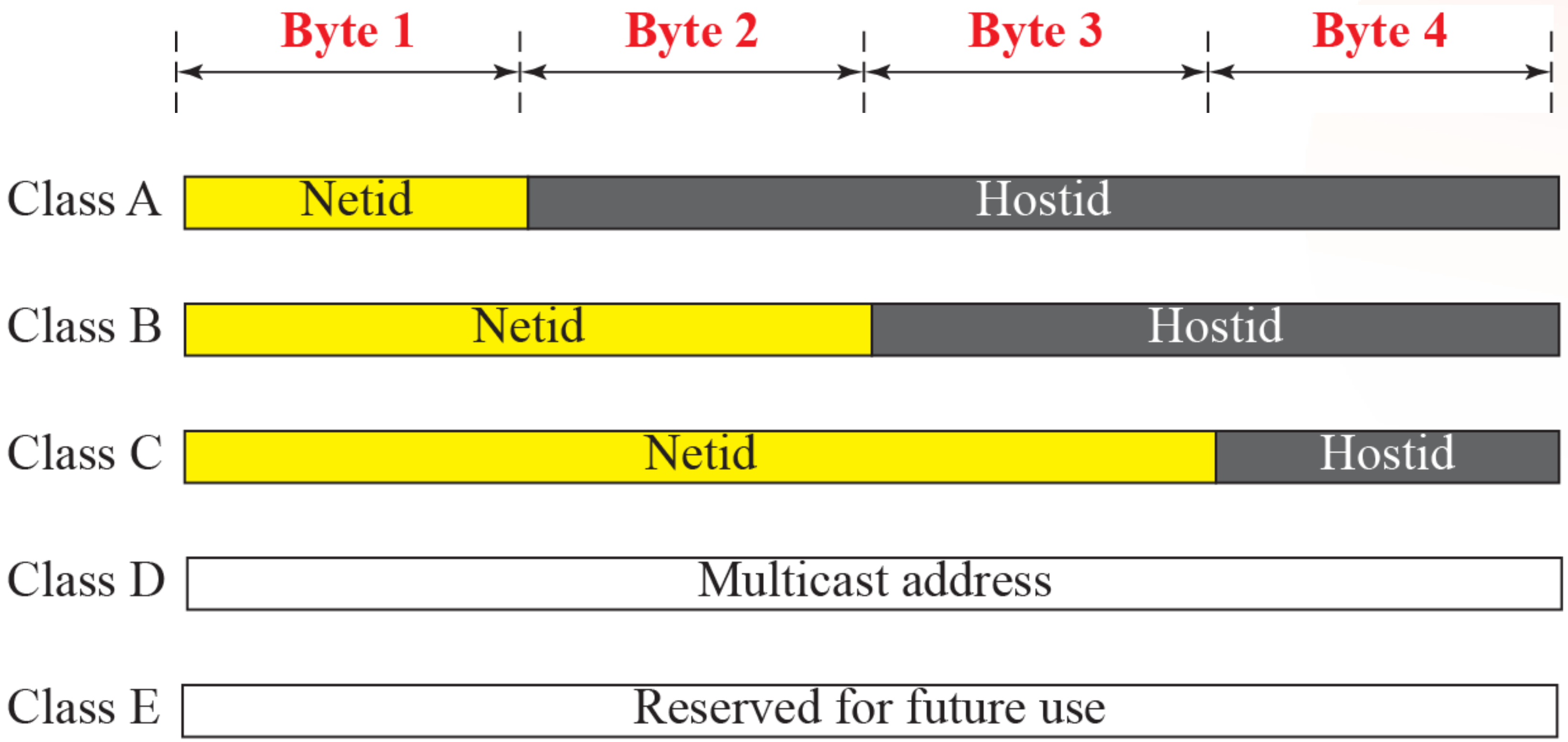
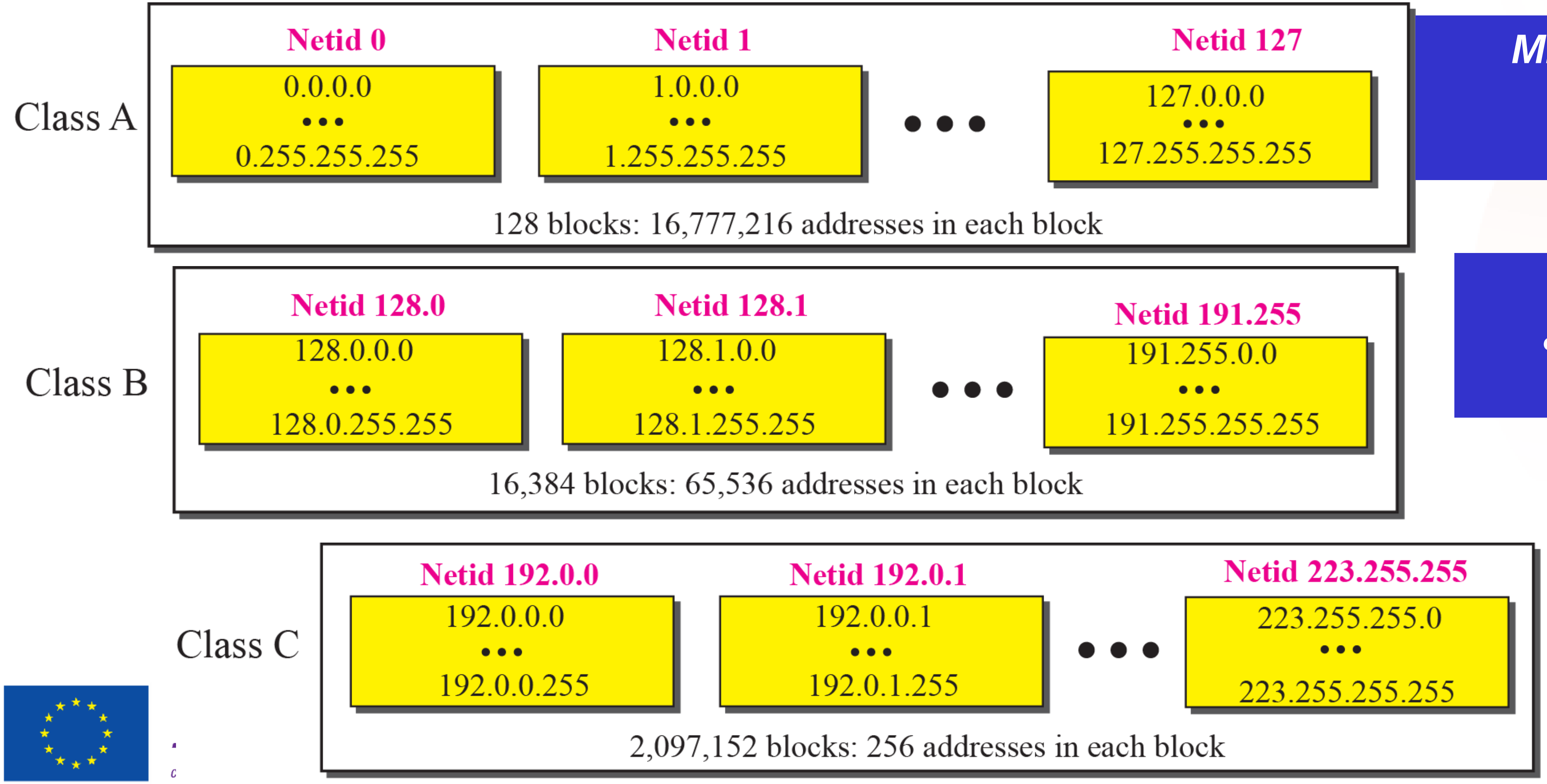
Classful Addressing

Netid and Hostid



Classful Addressing

Classes and Blocks



Millions of class A addresses are wasted.

Many class B addresses are wasted.

Not so many organizations are so small to have a class C block.

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Classful Addressing

Classes and Blocks

Class D

224.0.0.0 ••• 239.255.255.255

One block: 268,435,456 addresses

Class D addresses are made of one block, used for multicasting.

Class E

240.0.0.0 ••• 255.255.255.255

One block: 268,435,456 addresses

The only block of class E addresses was reserved for future purposes.

The range of addresses allocated to an organization in classful addressing was a block of addresses in Class A, B, or C.

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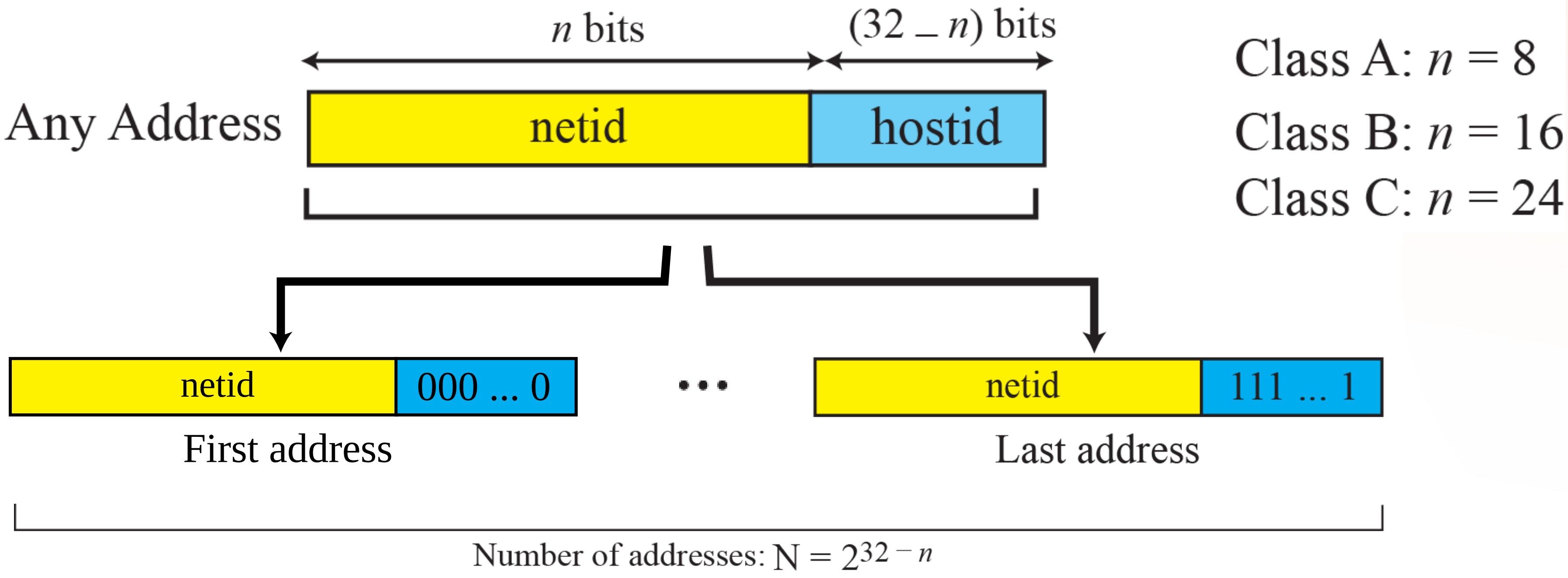
Classful Addressing

Two-Level Addressing



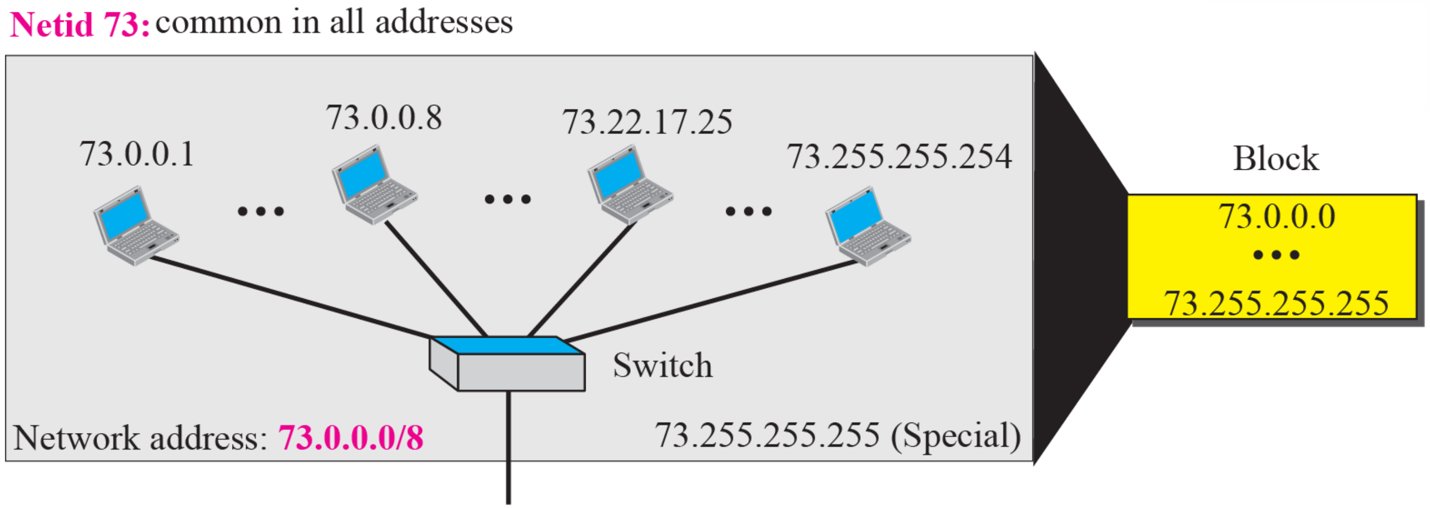
Classful Addressing

An address in a block is given as 73.22.17.25. Find the number of addresses in the block, the first address, and the last address.

Solution

Figure shows a possible configuration of the network that uses this block.

1. The number of addresses in this block is $N = 2^{32-n} =$ 16,777,216.
2. To find the first address, we keep the leftmost 8 bits and set the rightmost 24 bits all to 0s. The first address is 73.0.0.0/8, in which 8 is the value of *n*.
3. To find the last address, we keep the leftmost 8 bits and set the rightmost 24 bits all to 1s. The last address is 73.255.255.255.



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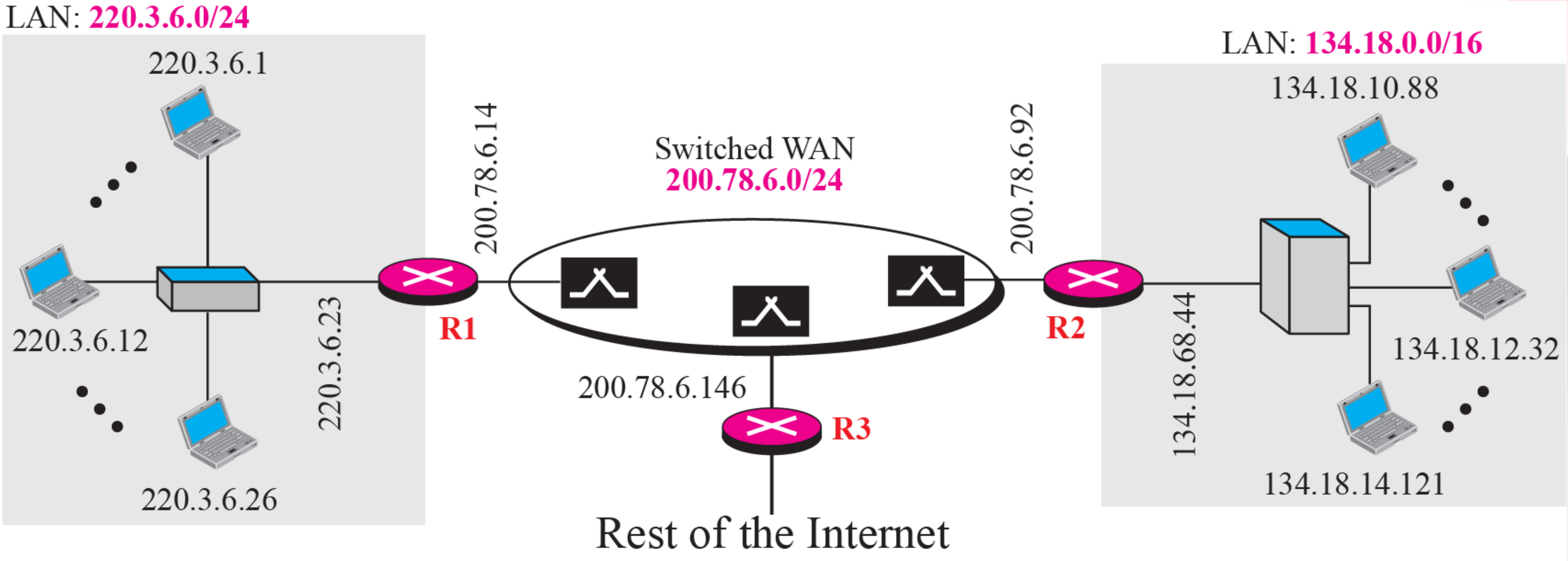
Classful Addressing (*Sample Internet*)



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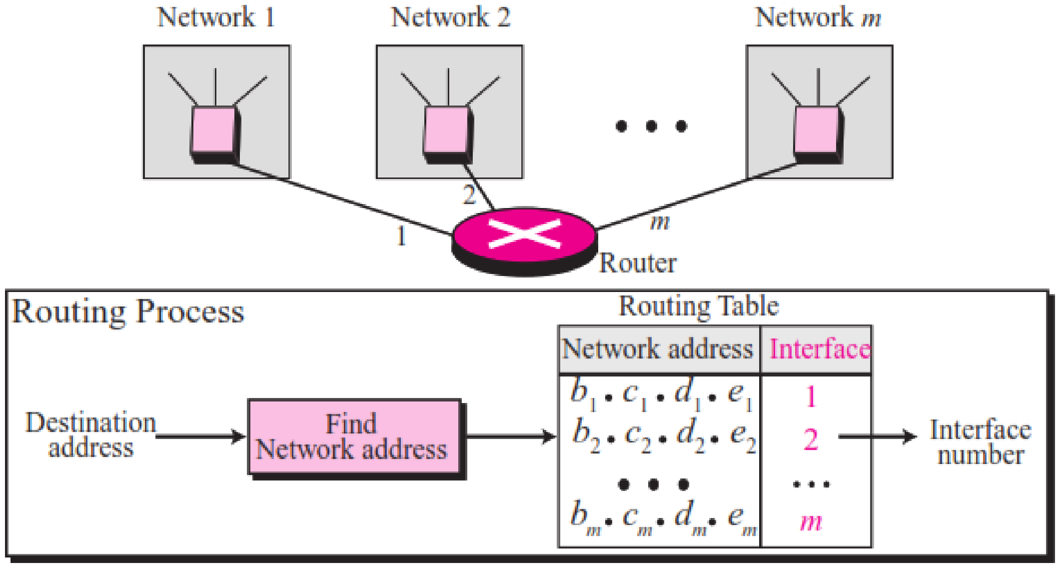
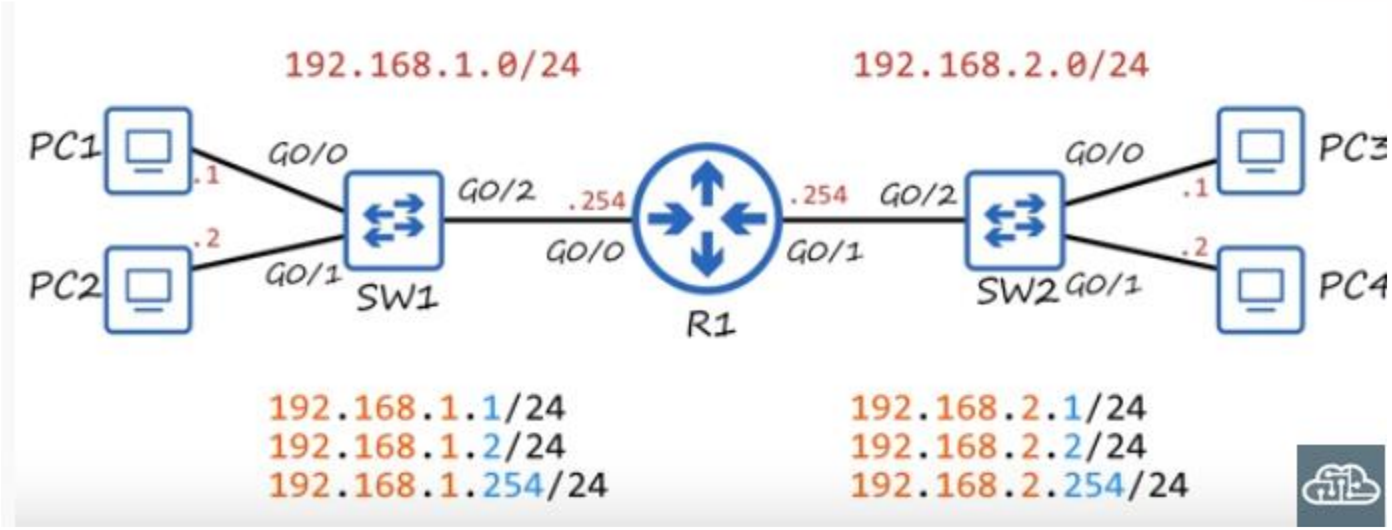
Network Address

The network address is the identifier of a network.





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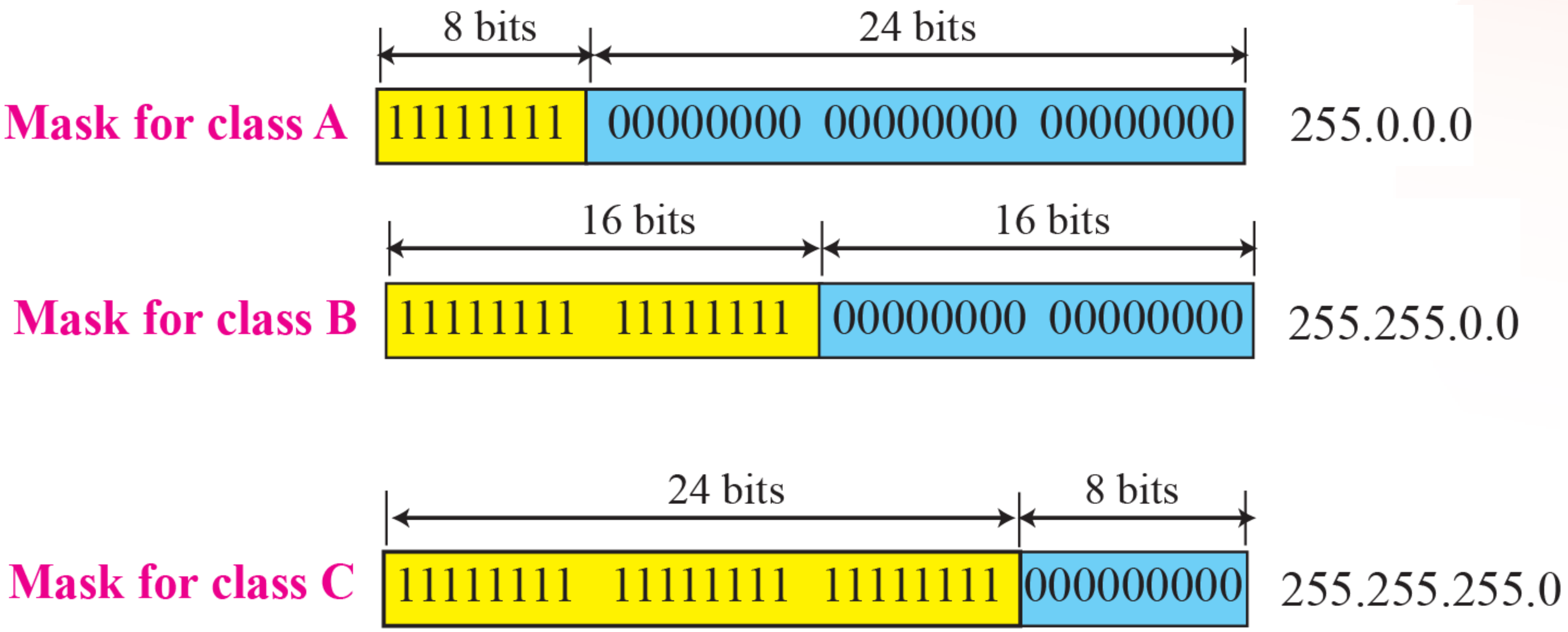
Network mask (Default Mask)

- **It is called a subnet mask because it is used to identify network address of an IP address by perfoming a bitwise AND operation on the netmask.**
- **A Subnet mask is a 32-bit number that masks an IP address, and divides the IP address into network address and host address.**



Classful Addressing

A router receives a packet with the destination address 201.24.67.32. Show how the router finds the network address of the packet.

Solution

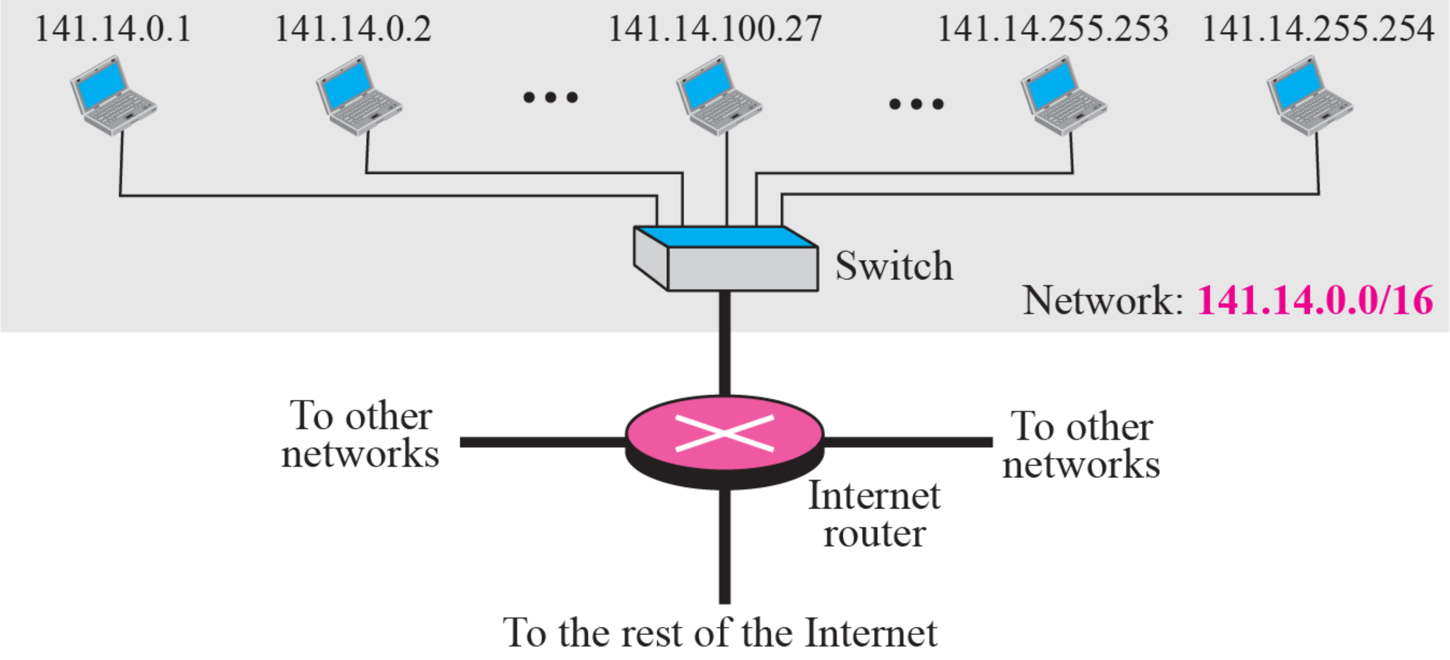
Since the class of the address is C, we assume that the router applies the default mask for class C, 255.255.255.0 to find the network address.

Destination address	→	201	.	24	.	67	.	32
Default mask	→	255	.	255	.	0	.	0
Network address	→	201	.	24	.	0	.	0

Classful Addressing

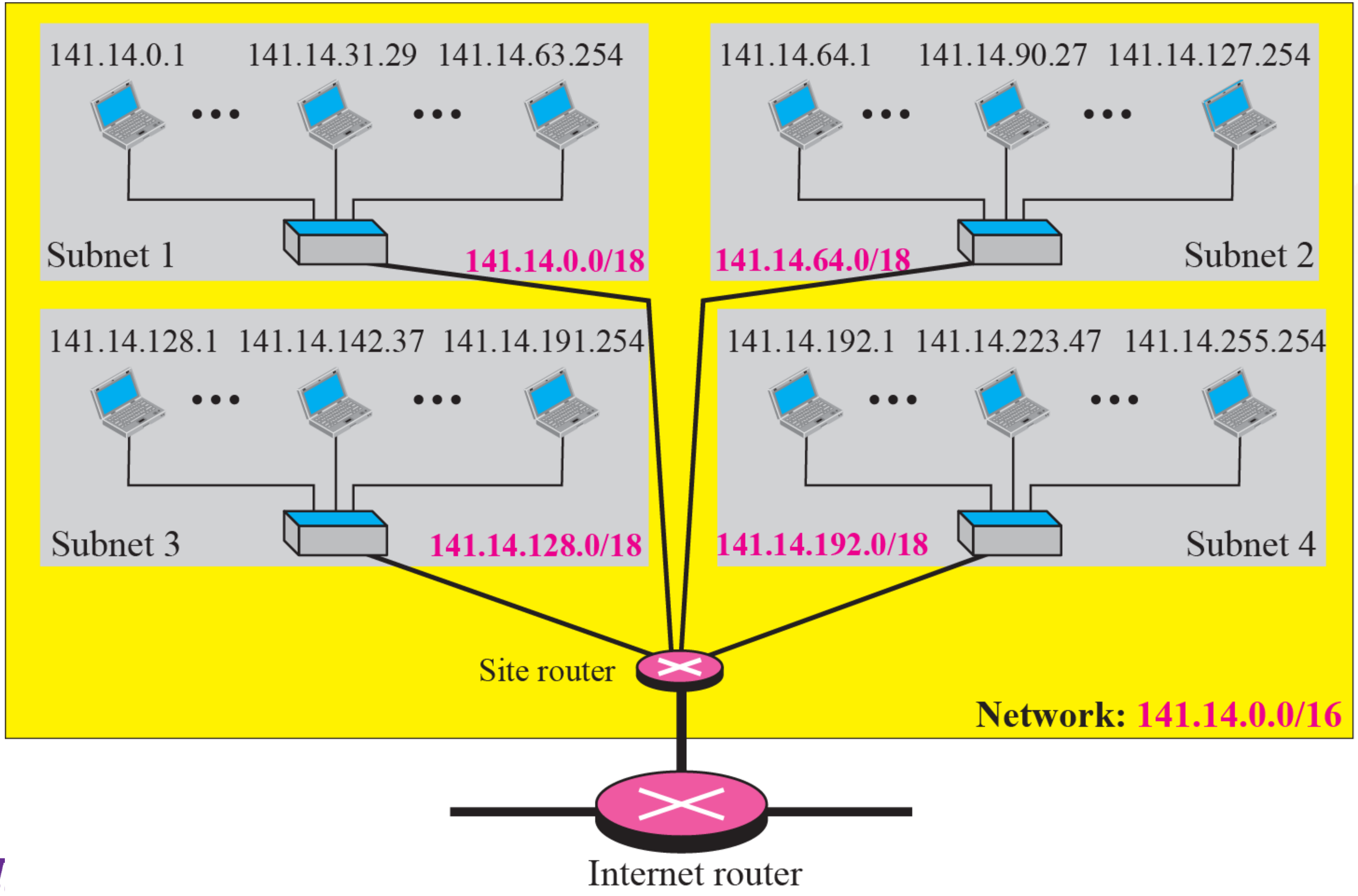
Three-Level Addressing: Subnetting

- The idea of splitting a block to smaller blocks is referred to as subnetting.
- In subnetting, a network is divided into several smaller subnetworks (subnets) with each subnetwork having its own subnetwork address.



A network using class B addresses before subnetting.

Classful Addressing



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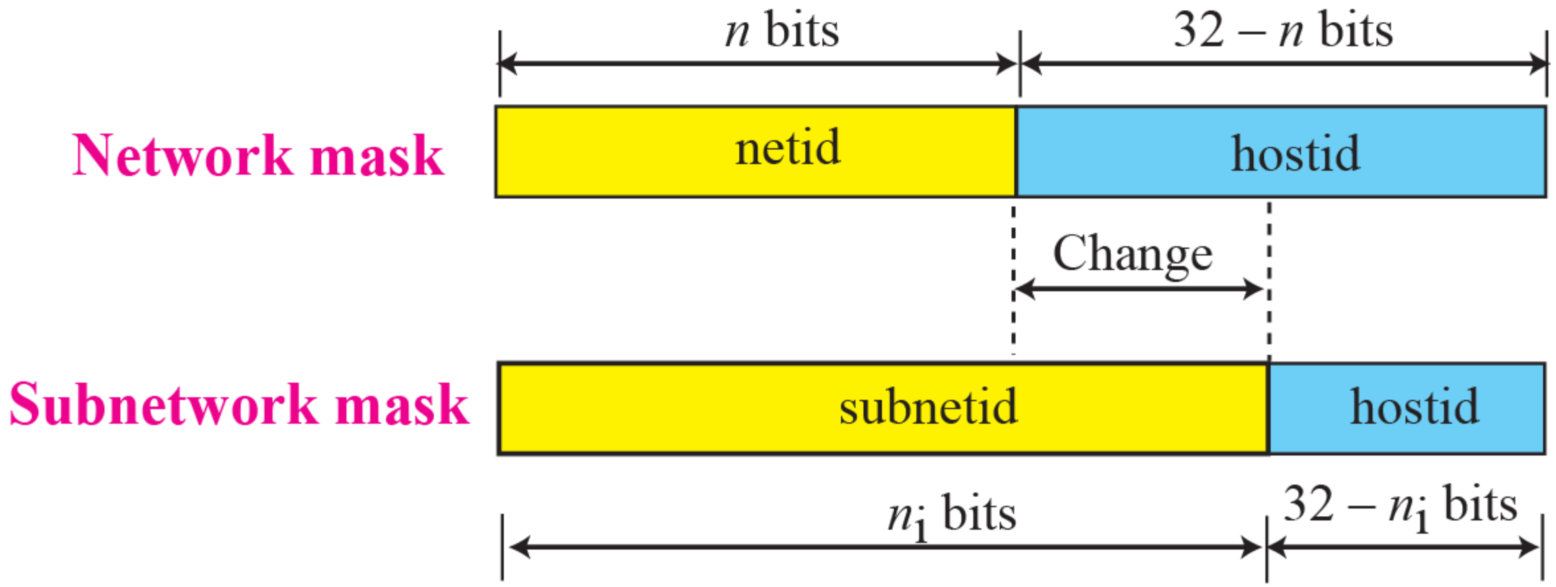
Classful Addressing

- The network mask is used when a network is not subnetted.
- When we divide a network to several subnetworks, we need to create a subnetwork mask (or subnet mask) for each subnetwork.
- A subnetwork has subnetid and hostid



$$n_{sub} = n + \log_2 s$$

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Classful Addressing

In previous example we divided a class B network into four subnetworks. The value of n = 16 and the value of

$$n_1 = n_2 = n_3 = n_4 = 16 + \log_2 4 = 18.$$

This means that the subnet mask has eighteen 1s and fourteen 0s. In other words, the subnet mask is 255.255.192.0 which is different from the network mask for class B (255.255.0.0).

Classless Addressing

In Previous Example , we show that a network is divided into four subnets. Since one of the addresses in subnet 2 is 141.14.120.77, we can find the subnet address as:

Address	→	141	.	14	.	120	.	77
Mask	→	255	.	255	.	192	.	0
Subnet Address	→	141	.	14	.	64	.	0

The values of the first, second, and fourth bytes are calculated using the first short cut for AND operation. The value of the third byte is calculated using the second short cut for the AND operation.

Address (120)	0	+	64	+	32	+	16	+	8	+	0	+	0	+	0
Mask (192)	128	+	64	+	0	+	0	+	0	+	0	+	0	+	0
Result (64)	0	+	64	+	0	+	0	+	0	+	0	+	0	+	0

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Thank You

It Feels Good When You can Design a Campus Network