

جامعة الحمدانية
كلية التربية
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IPv4 & IPv6

المرحلة الرابعة
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المحاضرة التاسعة

IPv4

- Identifier of each device connected to the Internet : IP Address
- IPv4 Address : 32 bits
 - The address space of IPv4 is 2^{32} or 4,294,967,296
- The IPv4 addresses are unique and universal
 - Two devices on the Internet can never have the same address at same time
- Number in base 2, 16, and 256 .

Binary Notation and Dotted-Decimal Notation

□ Binary notation

01110101

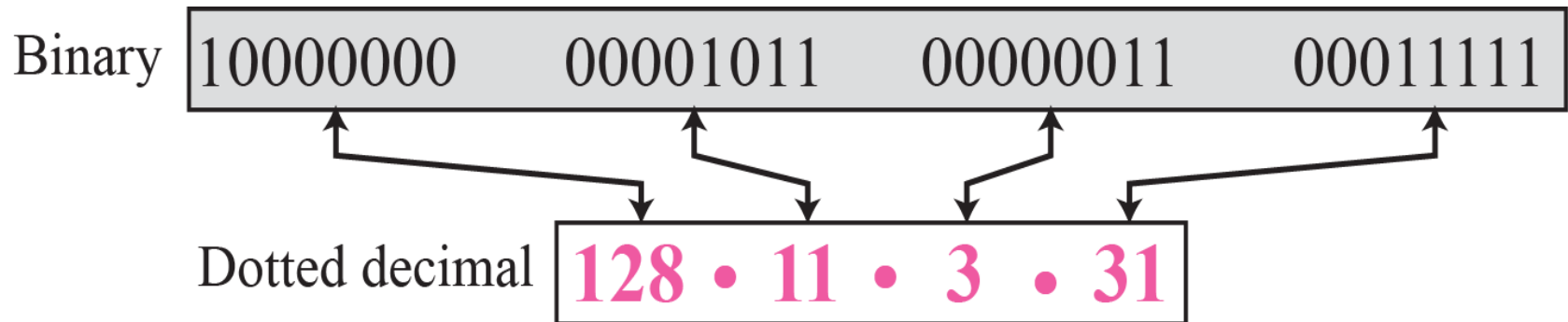
10010101

00011101

11101010

32 bit address, or a 4 octet address or a 4-byte address

□ Decimal point notation



Example 1

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 (see Appendix B) – 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

Example 2

- Find the number of addresses in a range if the first address is 146.102.29.0 and last address is 146.102.32.255.
- Solution
 - We can subtract the first address from the last address in base 256. The result is 0.0.3.255 in this base. To find the number of addresses in the range, we convert this number to base 10 and add 1 to the result

$$\text{Number of addresses} = (0 \times 256^3 + 0 \times 256^2 + 3 \times 256^1 + 255 \times 256^0) + 1 = 1024$$

IP Address Classes

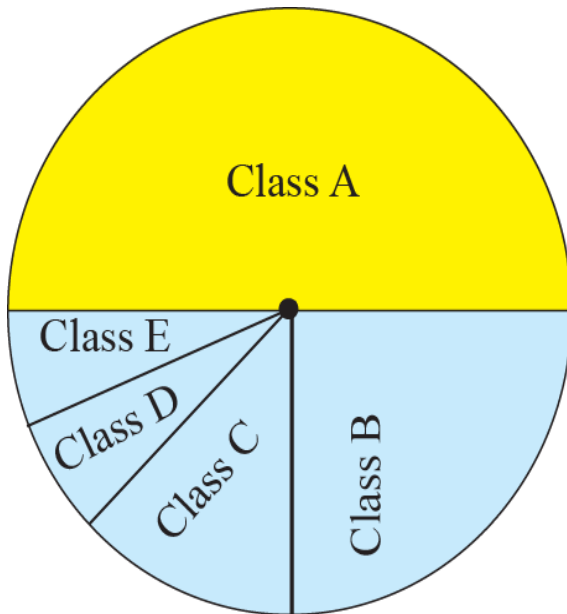
- In order to provide some structure to the way IP addresses are assigned, IP addresses are grouped into classes.
- Each class has a range of IP addresses. The range of IP addresses in each class is determined by the number of bits allocated to the network section of the 32-bit IP address. The number of bits allocated to the network section is represented by a mask written in dotted decimal or with the abbreviation $/n$.
- where n = the numbers of bits in the mask.

The table below lists ranges of IP addresses by class and the masks associated with each class..

Class	Range
A (range/mask in dotted decimal)	0 .0.0.0 to 127.0.0.0/8 (255.0.0.0)
A (range in binary)	0000000.00000000.00000000.00000000 To 01111111.00000000.00000000.00000000
B (range/mask in dotted decimal)	128 .0.0.0 to 191.255.0.0/16 (255.255.0.0)
B (range in binary)	1000000.00000000.00000000.00000000 To 10111111.11111111.00000000.00000000
C (range/mask in dotted decimal)	192 .0.0.0 to 223.255.255.0/24 (255.255.255.0)
C (range in binary)	11000000.00000000.00000000.00000000 To 11011111.11111111.11111111.00000000
D (range/mask in dotted decimal)	224 .0.0.0 to 239.255.255.255/32 (255.255.255.255)
D (range in binary)	11100000.00000000.00000000.00000000 To 11101111.11111111.11111111.11111111
E (range/mask in dotted decimal)	240 .0.0.0 to 255.255.255.255/32 (255.255.255.255)
E (range in binary)	111110000.00000000.00000000.00000000 To 11111111.11111111.11111111.11111111

Occupation of the Address Space

- Five classes



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%

Network and Host Addresses Available for Each Class of IP Address

Class	Network Addresses	Host Addresses
A	128	16,777,214
B	$16,384^3$	65534
C	$2,097,152^4$	254

Example 3

Find the class of each address:

- a. 00000001 00001011 00001011 11101111
- b. 11000001 10000011 00011011 11111111
- c. 10100111 11011011 10001011 01101111
- d. 11110011 10011011 11111011 00001111

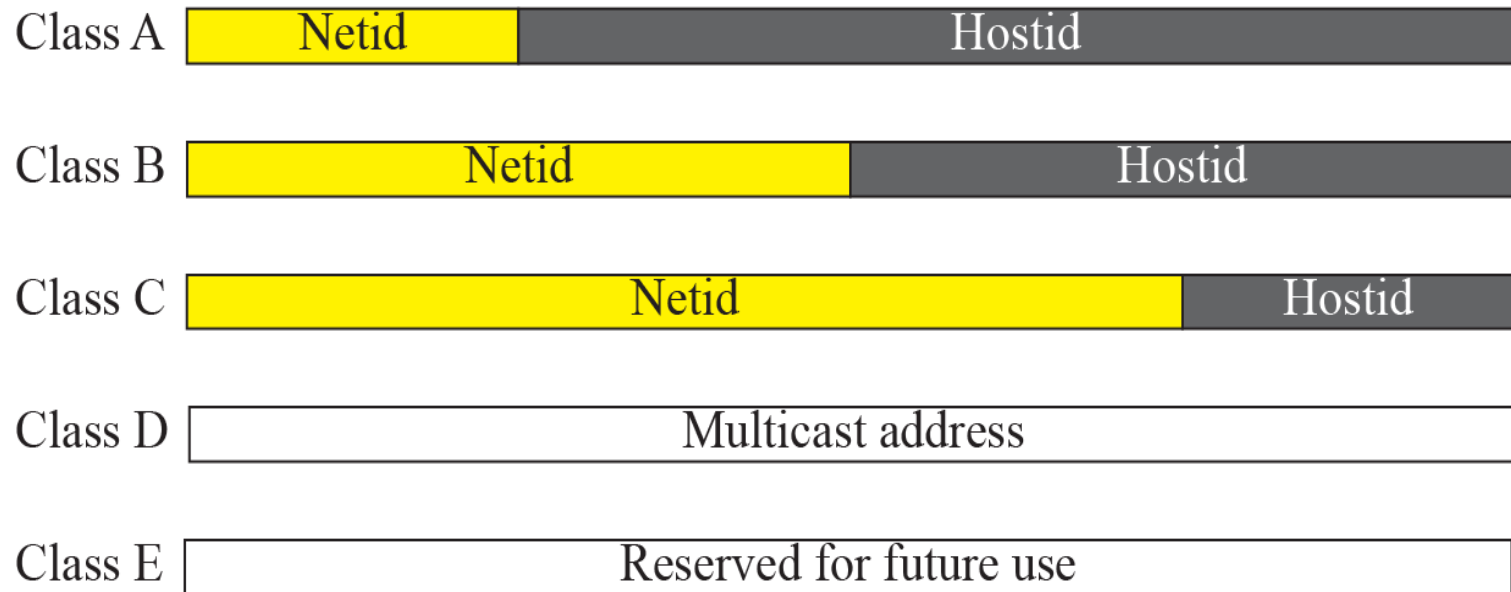
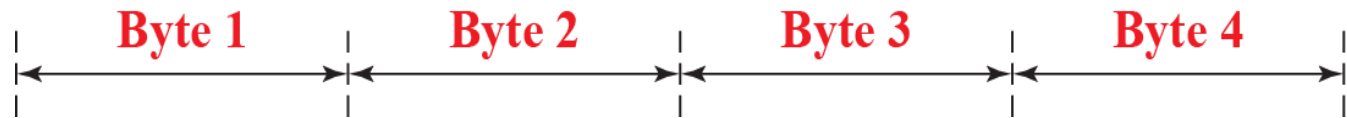
Solution

See the procedure in Figure 5.7

- a. The first bit is 0. This is a class A address.
- b. The first 2 bits are 1; the third bit is 0. This is a class C address.
- c. The first bit is 1; the second bit is 0. This is a class B address.
- d. The first 4 bits are 1s. This is a class E address.

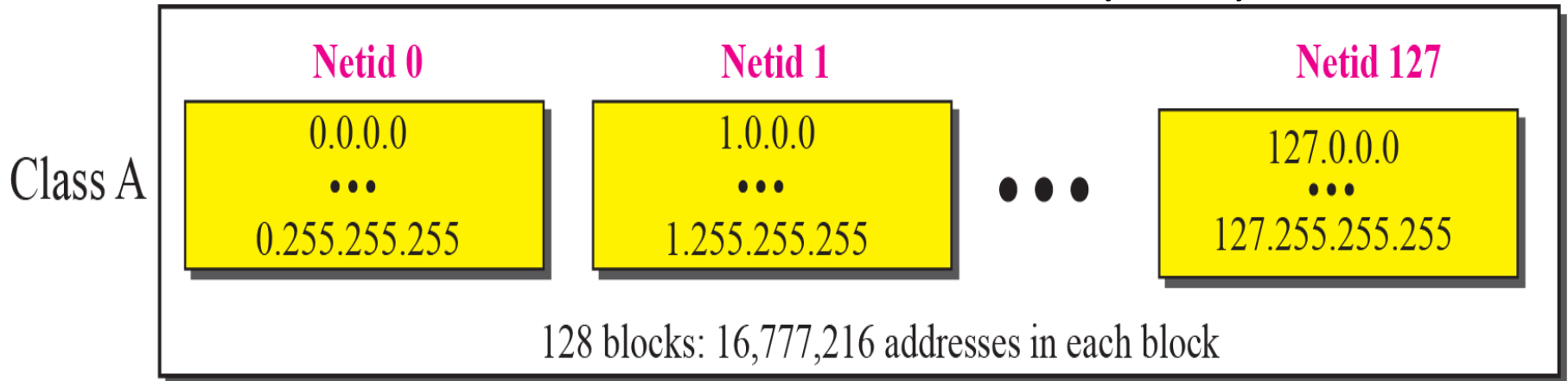
Netid and hostid of A, B, and C Classes

- netid and hostid are of varying lengths, depending on the class of the address



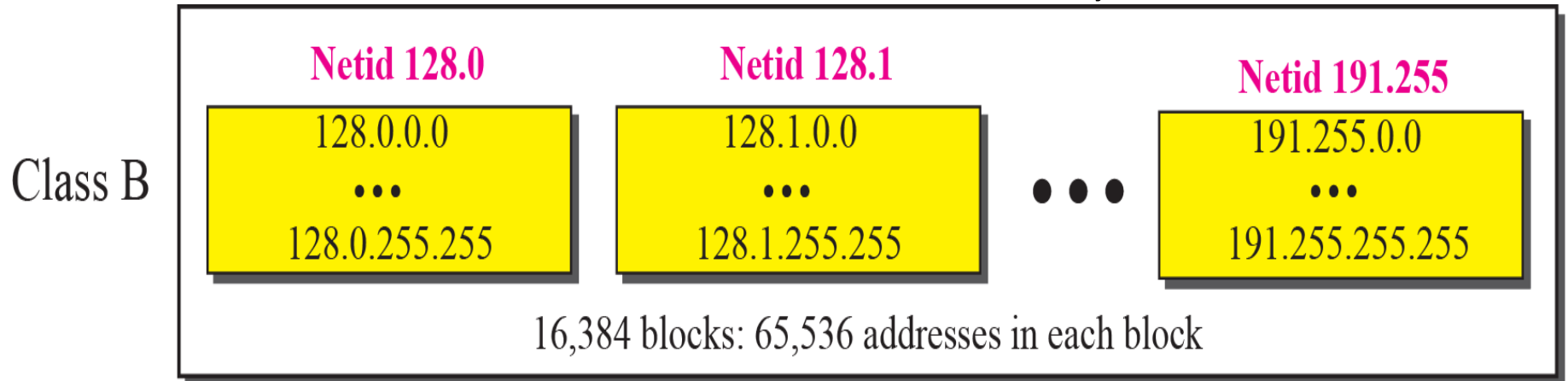
Blocks in Class A

- Only 1 byte in class A defines the netid.
- The leftmost bit should be '0'.
- Class A is divided into $2^7 = 128$ blocks.
- Each block in class A contains 16,777,216



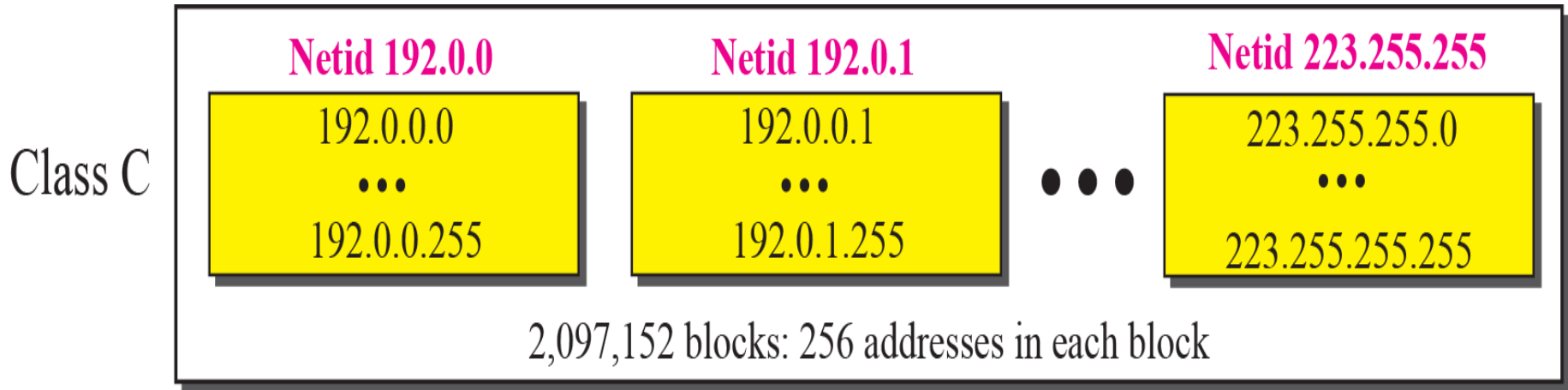
Blocks in Class B

- 2 bytes in class B define the class
- The two leftmost bits should be '10'
- Class B is divided into $2^{14} = 16,384$ blocks
- Each block in class B contains 65,536



Blocks in Class C

- 3 bytes in class C define the class
- The three leftmost bits should be '110'
- Class C is divided into $2^{21} = 2,097,152$ blocks
- Each block in class C contains 256 addresses



The Single Block in Class D and E

- Class D
 - Class D is designed for multicasting
 - Used to define one group of hosts on the Internet

Class D

224.0.0.0 ... 239.255.255.255

One block: 268,435,456 addresses

- Class E

- Reserved for future purposes

Class E

240.0.0.0 ... 255.255.255.255

One block: 268,435,456 addresses

Example 3

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:-

1. The number of addresses in this block is

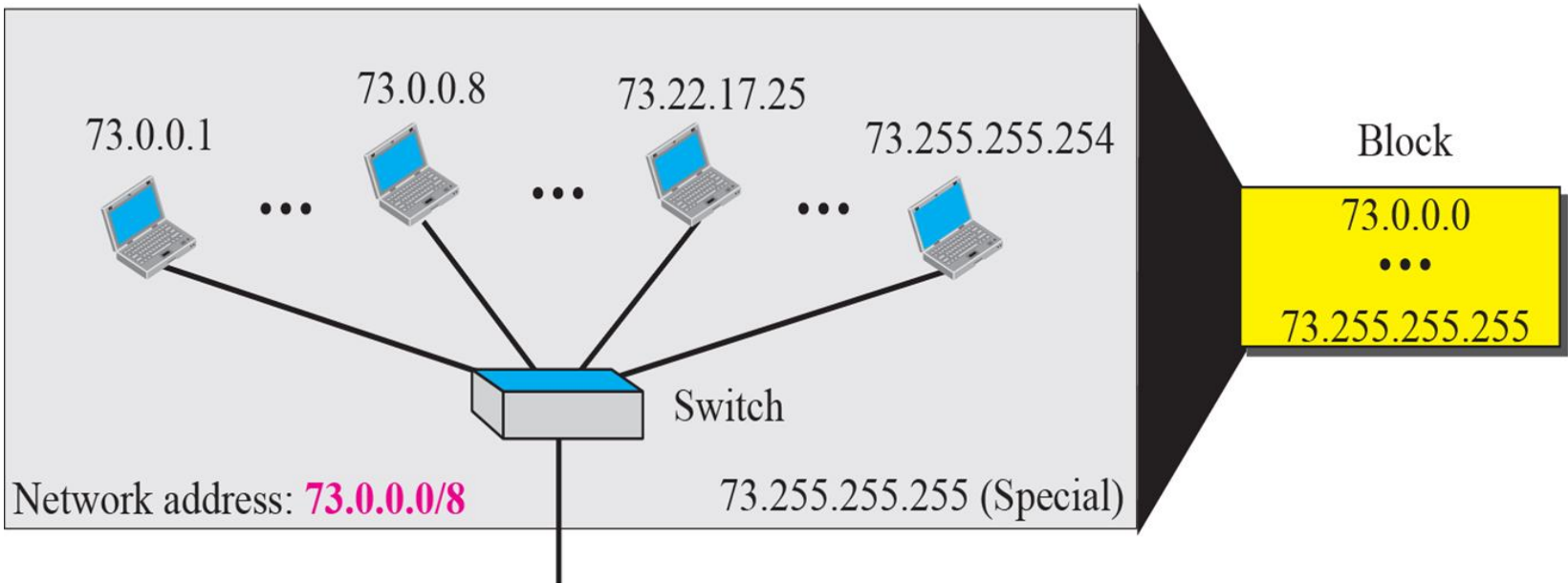
$$N = 2^{32-n} = 2^{24} = 16,777,216$$

2. To find the first address, we keep the left most 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 .

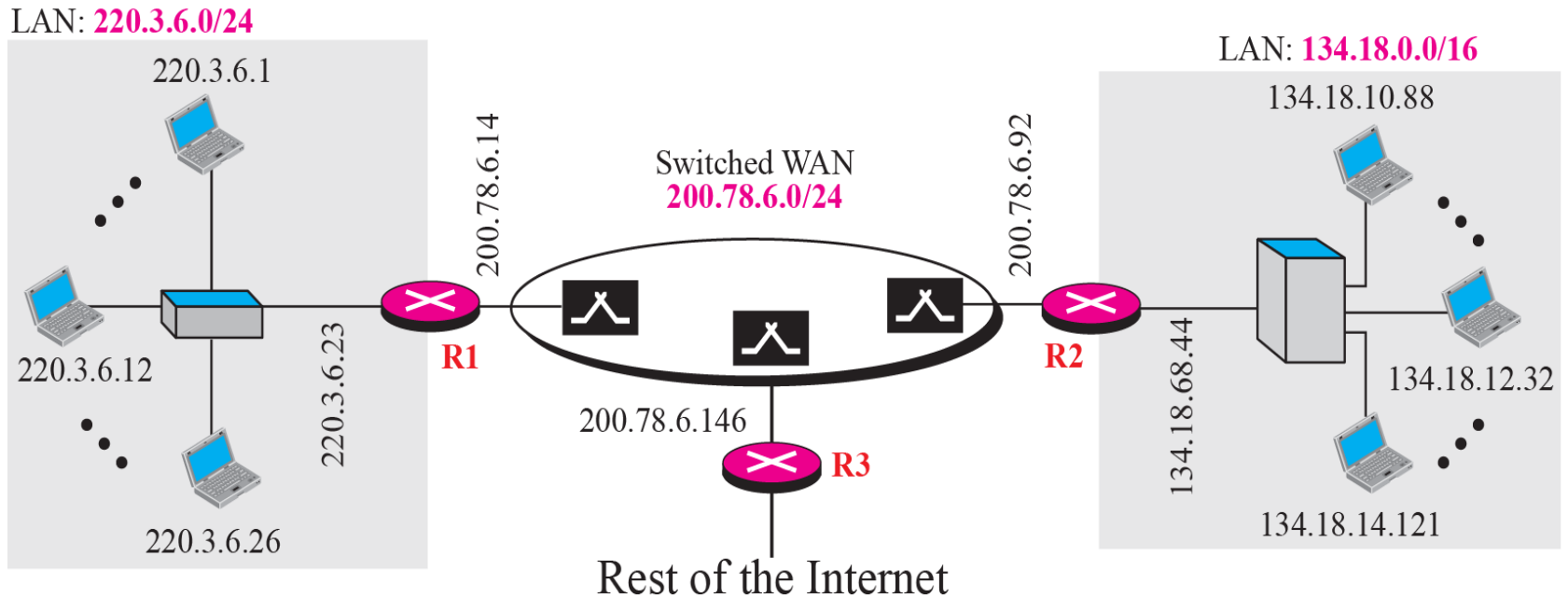
3. To find the last address, we keep the leftmost 8 bits and set the rightmost 24 bits all to 1s. The last address is 73.255.255.255

Solution of Example 3

Netid 73: common in all addresses



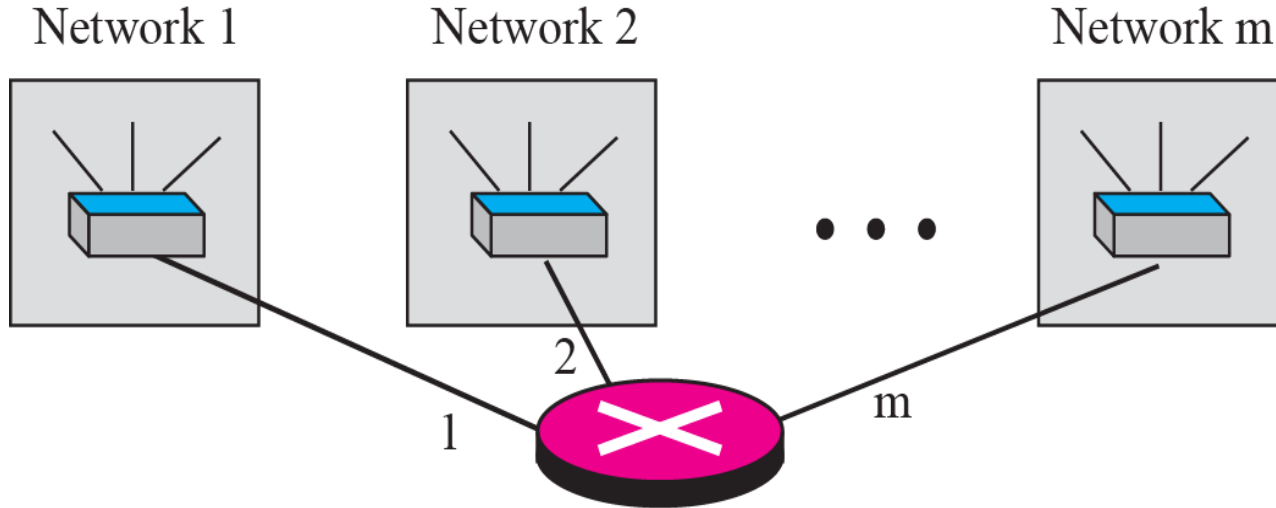
Sample Internet



Network Address

- The first address of block is network address
- Used in routing a packet to its destination network
- The network address is the identifier of a network

Network Address



Routing Process

Destination address

Find Network address

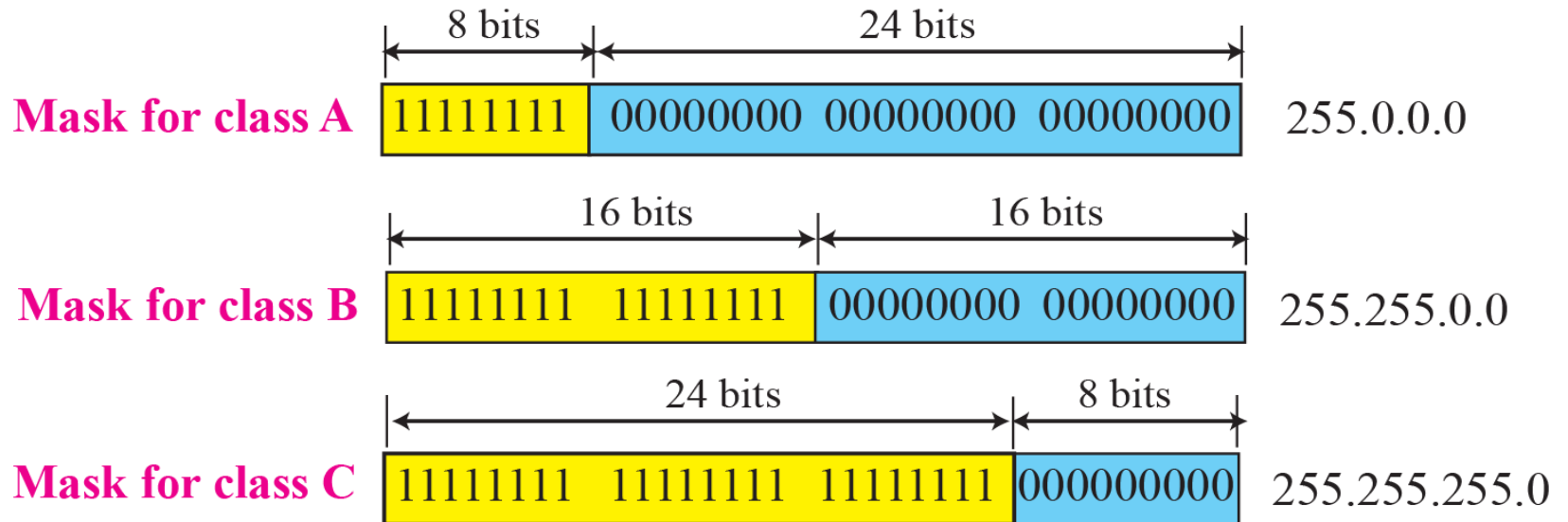
Routing Table

Network address	Interface
$b_1 \cdot c_1 \cdot d_1 \cdot e_1$	1
$b_2 \cdot c_2 \cdot d_2 \cdot e_2$	2
...	...
$b_m \cdot c_m \cdot d_m \cdot e_m$	m

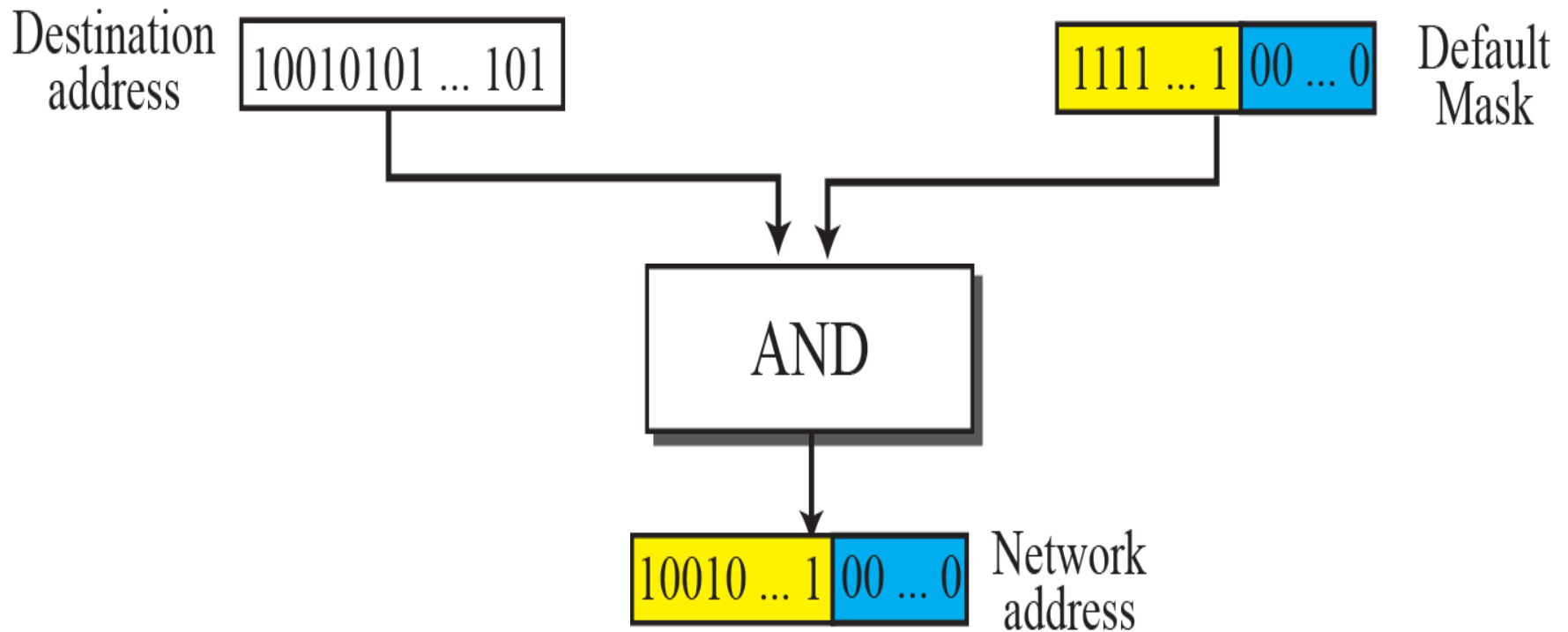
Interface number

Network Mask

- Used to extract the network address from the destination address of a packet
- Called a default mask



Finding a Network Address using the Default Mask



Example 4

A router receives a packet with the destination address 190.24.67.32. Show how the router finds the network address of the packet.

Solution

Since the class of the address is B, we assume that the router applies the default mask for class B, 255.255.0.0 to find the network address.

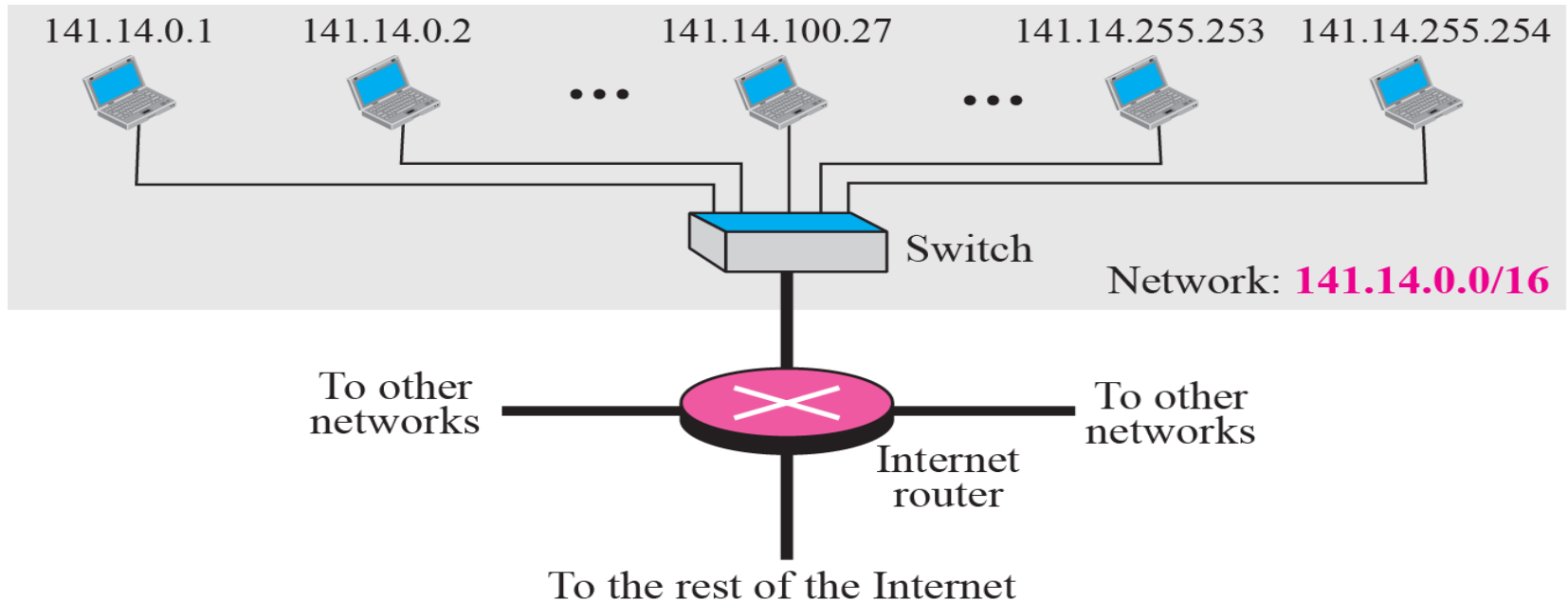
Destination address ->	190	.	24	.	67	.	32
Default mask ->	255	.	255	.	0	.	0
Network address ->	190	.	24	.	0	.	0

Three-Level Addressing : Subnetting

- The organization that was granted a block in class A or B needed to divide its large network into several subnetworks for better security and management.
- In subnetting, a network is divided into several smaller subnetworks with each subnetwork having its own subnetwork address.

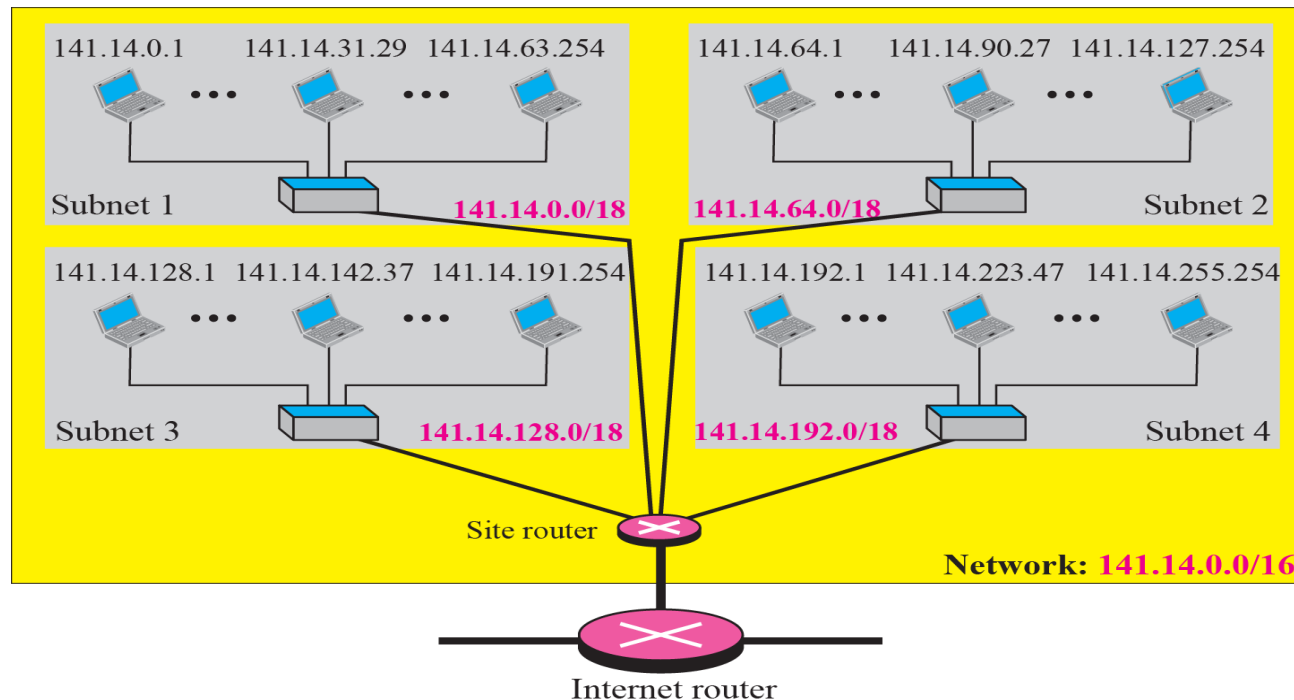
Example 5

- The next figure shows a network using class B addresses before subnetting. We have just one network with almost 2^{16} hosts. The whole network is connected, through one single connection, to one of the routers in the Internet. Note that we have shown /16 to show the length of the netid (class B).

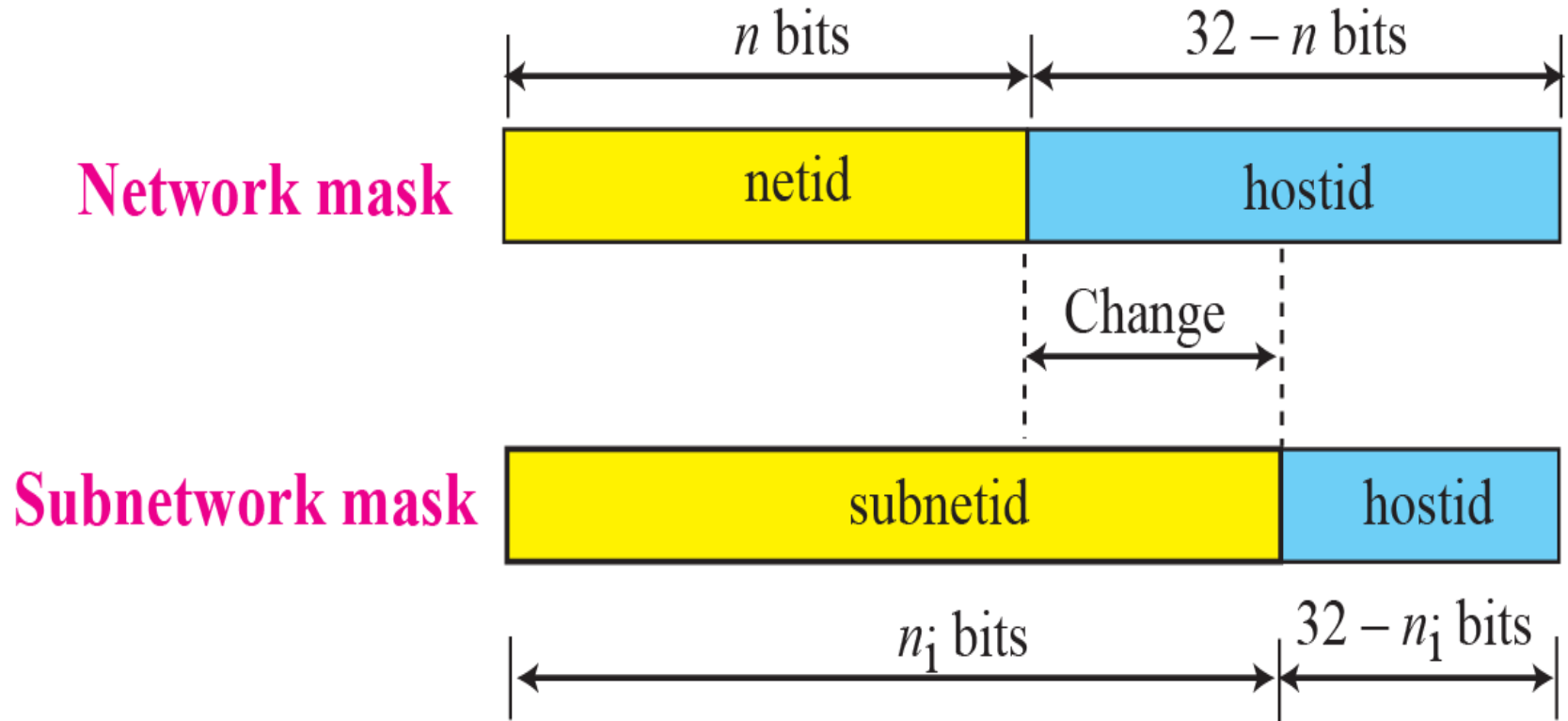


Example 5

- The next figure shows same network in example 4 after subnetting.



Network Mask and Subnet Mask



IPv6 Addressing Rules

- **128 bits (or 16 bytes) long:** four times as long as its predecessor.
- 2^{128} : about 340 billion billion billion billion different addresses
- **Colon hexadecimal notation:**
 - addresses are written using 32 hexadecimal digits.
 - digits are arranged into 8 groups of four to improve the readability.
 - Groups are separated by colons .

2001:0718:1c01:0016:020d:56ff:fe77:52a3

IPv6 Address Notation: Example

128.91.45.157.220.40.0.0.0.0.252.87.212.200.31.255

Binary

```
1000000001011011001011011001110111011100001010000000000000000000
0000000000000000011111100010101111101010011001000000111111111111
```

Dotted
Decimal

128	91	45	157	220	40	0	0	0	0	252	87	212	200	31	255
-----	----	----	-----	-----	----	---	---	---	---	-----	----	-----	-----	----	-----

		0	32	64	96	128					
Hexadecimal											
Straight Hex		805B	2D9D	DC28	0000	0000	FC57	D4C8	1FFF		
Leading-Zero Suppressed		805B	2D9D	DC28	0	0	FC57	D4C8	1FFF		
Zero- Compressed		805B	2D9D	DC28	::		FC57	D4C8	1FFF		
Mixed Notation		805B	2D9D	DC28	::		FC57	212	200	31	255

IPv6 Zero Suppression

- Some types of addresses contain long sequences of zeros.
- To further simplify the representation of IPv6 addresses, a contiguous sequence of 16-bit blocks set to 0 in the colon hexadecimal format can be compressed to “::”, **known as double-colon.**
- For example:
 - FE80:0:0:0:2AA:FF:FE9A:4CA2 → FE80::2AA:FF:FE9A:4CA2.
 - FF02:0:0:0:0:0:0:2 → FF02::2
 - 0:0:0:0:0:0:0:1 → ::1

IPv6 Zero Suppression

- Zero compression can only be used to compress a single contiguous series of 16-bit blocks expressed in colon hexadecimal notation.
- You cannot use zero compression to include part of a 16-bit block.
- For example,
 - cannot express FF02:30:0:0:0:0:0:5 as FF02:3::5
 - correct representation = FF02:30::5.