Data Communication Network
DAY – 2

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Addressing

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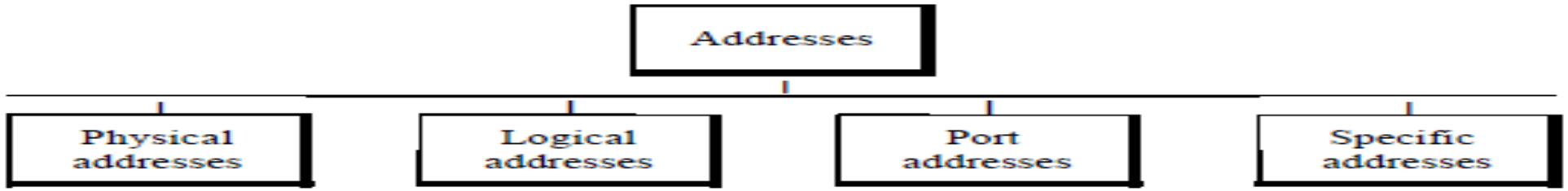


Physical Address/ Link Address

- For example, Ethernet uses a 6-byte (48-bit) physical address that is imprinted on the network interface card (NIC).

Logical Address

- logical address in the Internet is currently a 32-bit address that can uniquely define a host connected to the Internet.

Port Address

- computer A can communicate with computer C by using TELNET. At the same time, computer A communicates with computer B by using the File Transfer Protocol (FTP).

Specific Addresses

- Examples include the e-mail address and any Universal Resource Locator (URL)

MAC Address / Physical Address/ Ethernet Address

- used on data link layer
- used to identify every NIC uniquely
- is burnt into the ROM part of NIC once written the MAC address can not be changed
- also known as read only address
- to find the MAC address of NIC
  - windows: ipconfig /all
  - linux/macOS: ifconfig
- e.g. 78 : 4f : 43 : 90 : 13 : d0
- size: 6 bytes = 8 x 6 = 48 bits
- Group of first three bytes(78 : 4f : 43) represent's manufacturer ID and last 3 bytes (90 : 13 : d0) represents NIC's unique address.
- to find the manufacturer, please visit https://hwaddress.com/

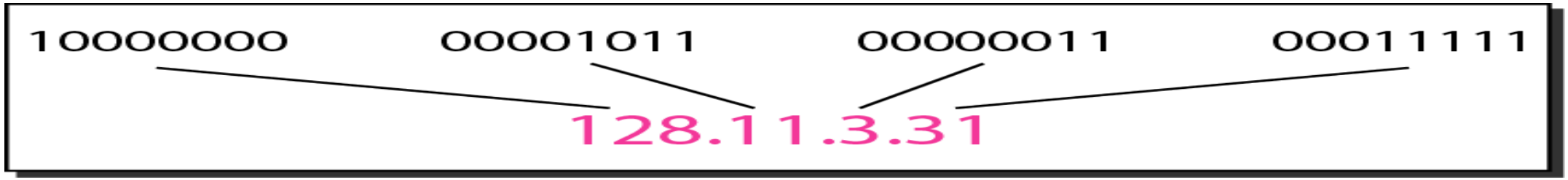
IP Address / Logical Address

- IP address to mean a logical address in the network layer of the TCP/IP protocol suite.
- Identify a machine / device uniquely.
- Size = 4 bytes = 32 bits
- to find the IP address of Machine
  - windows: ipconfig
  - linux/macOS: ifconfig
- IP Versions:
  - IPV4 (32 bits address length)
  - IPV6 (128 bits address length)
- IP addresses are made up of four sets of numbers called **“Octets”.**
- Types
  - Private : used to identify a machine on the LAN and can not be used to connect to internet
  - Public : used to connect to the internet
- e.g.
  - decimal: 192.168.1.6
  - binary : 11000000.10101000.00000001.00000110

IP Addressing Types

- Classful : IP Address is split into 5 classes
- Classless

  - IPv4 uses 32-bit addresses, which means that the address space is 2^{32} or4,294,967,296 (more than 4 billion)
  - **There are two prevalent notations to show an IPv4 address:**
    - binary notation
    - dotted decimal notation



Example

- *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

Example

- *Find the error, if any, in the following IPv4 addresses.*

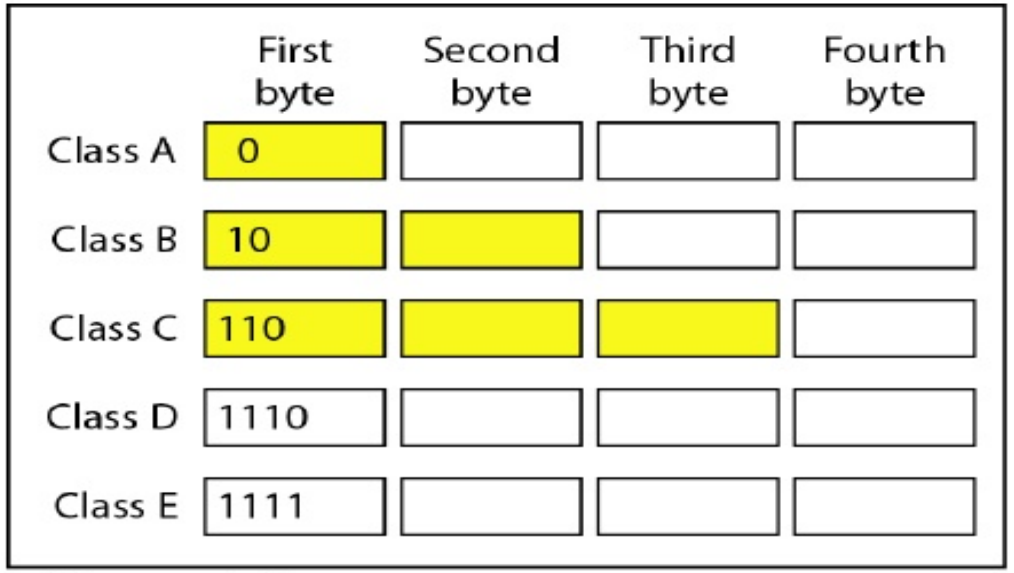
a. 111.56.045.78
b. 221.34.7.8.20
c. 75.45.301.14
d. 11100010.23.14.67

Solution

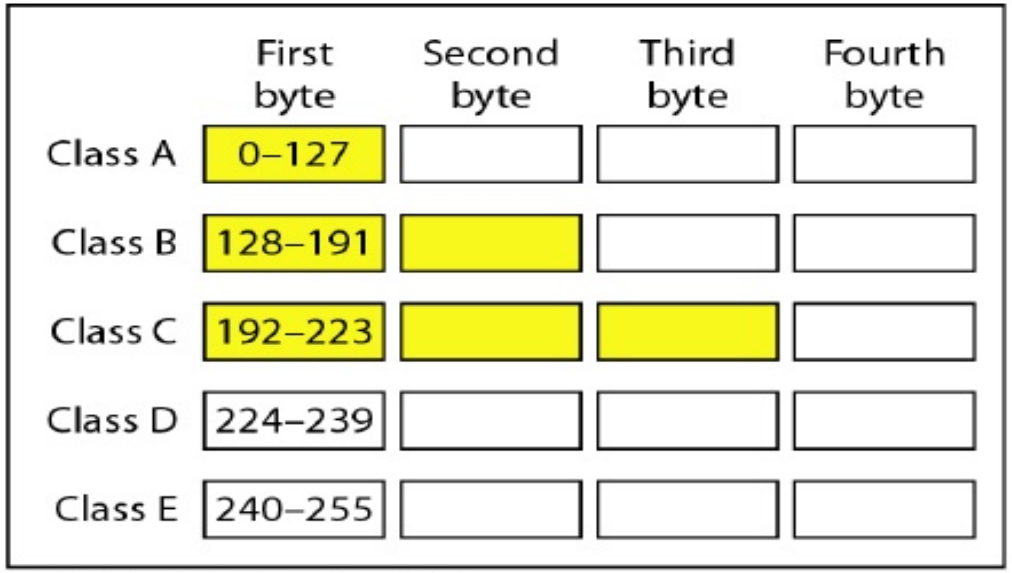
a. There must be no leading zero (045).
b. There can be no more than four numbers.
c. Each number needs to be less than or equal to 255.
d. A mixture of binary notation and dotted-decimal notation is not allowed.

Classful Addressing

- IP is 32 bit means 2^{32} IP Addresses. (more than 4 billion , so many IP Addresses)
- We need to distribute those that's why we have classes.
- In classful addressing, the address space is divided into five classes: A, B, C, D, and E.



a. Binary notation

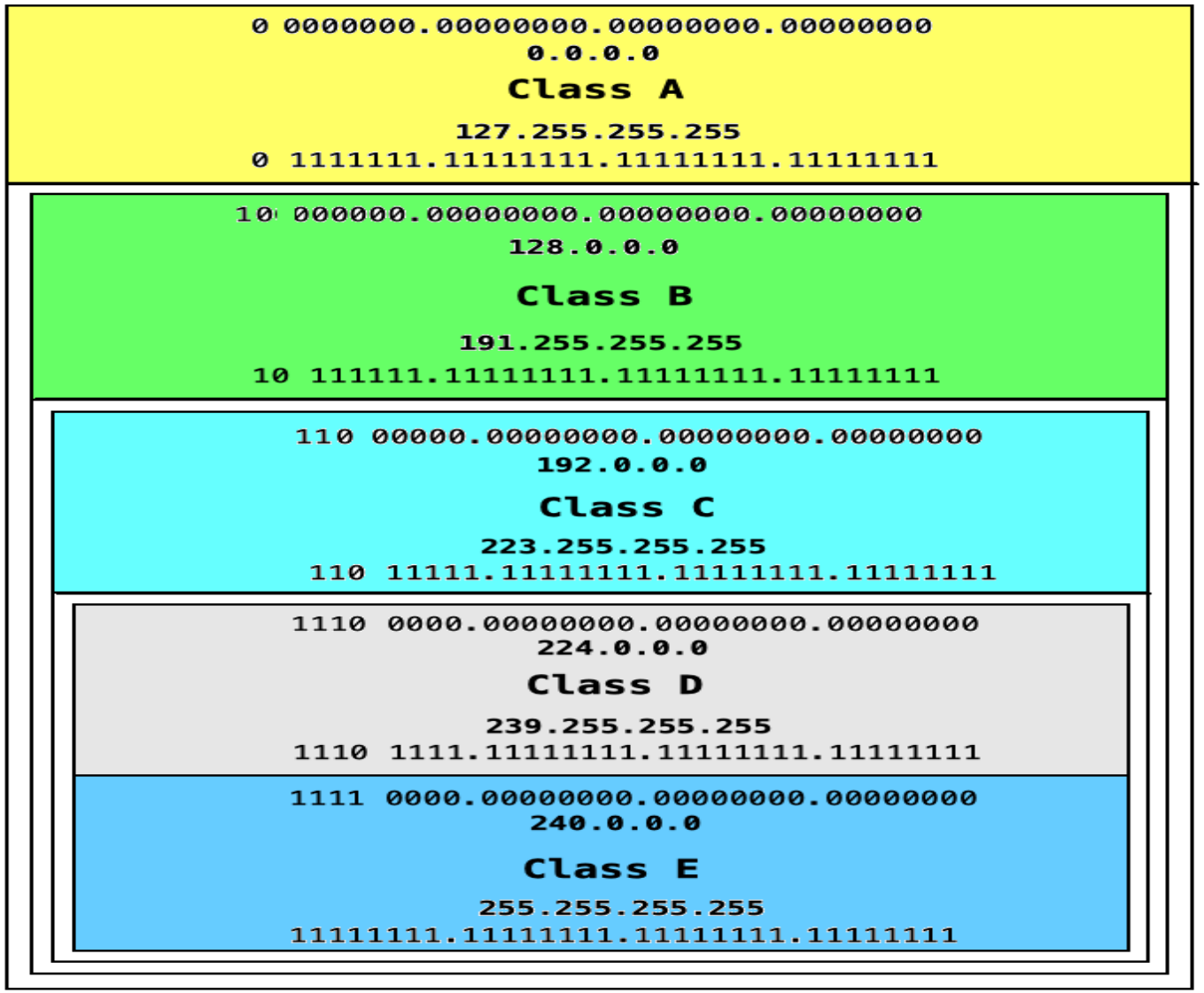


b. Dotted-decimal notation

How range of IP Address is defined

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0		
128	64	32	16	8	4	2	1		Range
0	x	x	x	x	x	x	x	Class A	0-127
1	0	x	x	x	x	x	x	Class B	128-191
1	1	0	x	x	x	x	x	Class C	192-223
1	1	1	0	x	x	x	x	Class D	224-239
1	1	1	1	x	x	x	x	Class E	240-255

IP Classful Addressing



- IP addresses starting with 0
- 0.0.0.0 – 127.255.255.255

- IP addresses starting with 10
- 128.0.0.0 – 191.255.255.255

- IP addresses starting with 110
- 192.0.0.0 – 223.255.255.255

- IP addresses starting with 1110
- 224.0.0.0 – 239.255.255.255

- IP addresses starting with 1111
- 240.0.0.0 – 255.255.255.255

Example

- Find the class of each address.

1. 00000001 00001011 00001011 11101111
2. 11000001 10000011 00011011 11111111
3. 14.23.120.8
4. 252.5.15.111

Example

- Find the class of each address.

1. 00000001 00001011 00001011 11101111
2. 11000001 10000011 00011011 11111111
3. 14.23.120.8
4. 252.5.15.111

Solution

1. The first bit is O. This is a class A address.
2. The first 2 bits are 1; the third bit is O. This is a class C address.
3. The first byte is 14 (between 0 and 127); the class is A.
4. The first byte is 252 (between 240 and 255); the class is E.

Points to be noted

- Any IP Address start with 127, That is : 127.x.x.x means its **a loop back series** that is used for **self testing**.
- E.g. Ping 127.0.0.1 (ping to yourself)
- That is 127.0.0.1 is **Universal IP** ,
- We can not configure **universal IP**. Its by default configured.
- PING (Packet Internet Groper) is a tool used to troubleshoot networking issues .

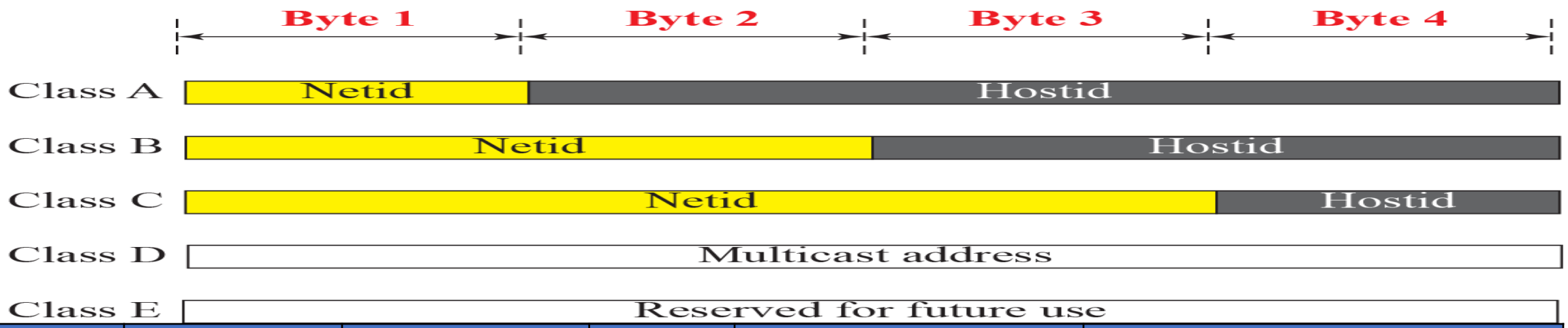
IANA(Inter Associated Number Association) manages private IP's.

Regular Private IP Addresses

Address Class	Reserved Private IP Addresses
Class A	10.0.0.0 - 10.255.255.255
Class B	172.16.0.0 - 172.31.255.255
Class C	192.168.0.0 - 192.168.255.255

Private network will have private IP's means devices that we connect to our router will get private IP addresses provided by IANA.

Netid and hostid of A, B, and C Classes



Class	Network bits	Networks	Host bits	Hosts Per Network	Suitable for
Class A	8	2^8=256	24	2^{24} - 2* =16,777,214 maximum hosts	For large organizations like Apple/Google/MS/Amazon
Class B	16	2^{16}=65536	16	2^{16} - 2* = 65,534 maximum hosts	for medium scaled organizations like Sunbeam
Class C	24	2^{24}=16million	8	2^8 - 2* = 254 maximum hosts	for small organizations/home network

**** Subtracting the network and broadcast address***

Example: What is the type of the given IP address

1. 11.34.56.66
2. 10.46.34.67
3. 156.46.36.46
4. 172.20.34.56
5. 172.45.66.77
6. 192.168.2.5
7. 192.169.34.6

Example (Solution): What is the type of the given IP address

1. 11.34.56.66 : public
2. 10.46.34.67 : private
3. 156.46.36.46 : public
4. 172.20.34.56 : private
5. 172.45.66.77 : public
6. 192.168.2.5 : private
7. 192.169.34.6 : public

Example : which class needs to be used for following number of Devices?

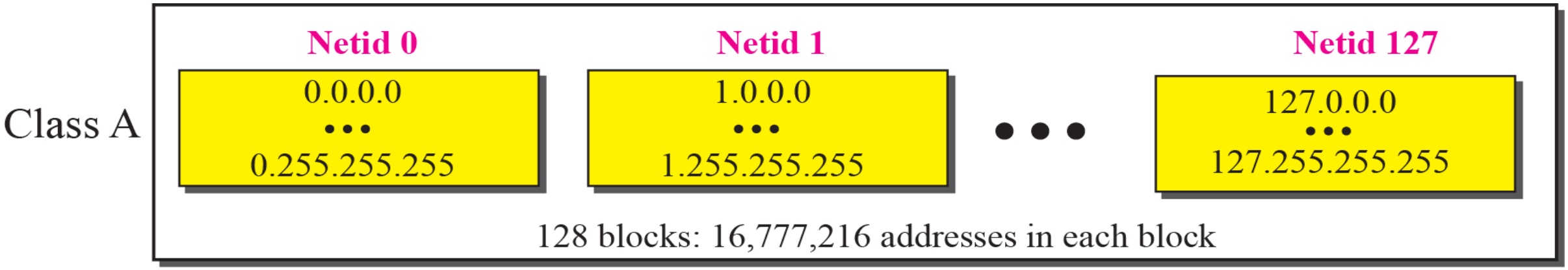
1. 200 devices
2. 3000 devices
3. 50000 devices
4. 200000 devices

Example (Solution) : which class needs to be used for following number of Devices?

1. 200 devices : class C
2. 3000 devices : class B
3. 50000 devices : class B
4. 200000 devices : class A

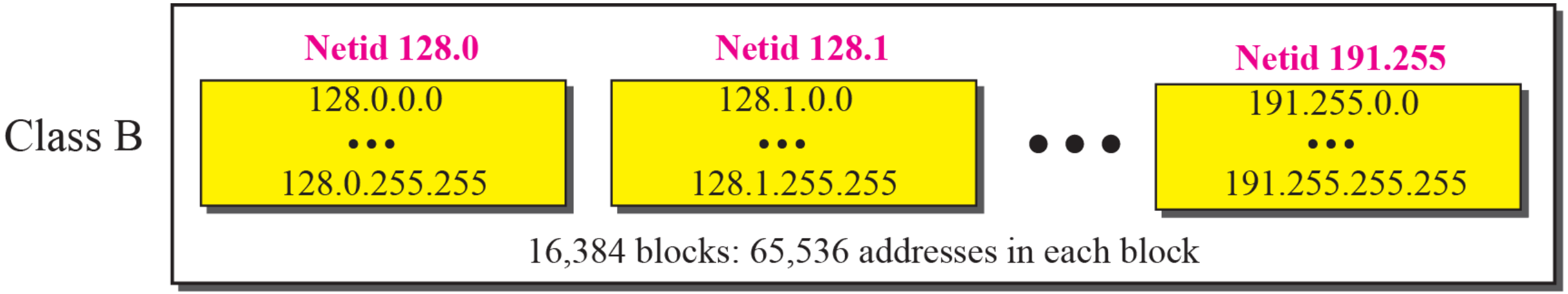
Blocks in Class A

- Only 1 byte in class A defines the netid
- The leftmost bit should be '0' (out of 8 bits one bit leftmost is 0(zero) so remaining bits are 7)
- Class A is divided into 2^7 = 128 blocks
- Each block in class A contains 2^{24-2}=16,777,214 addresses



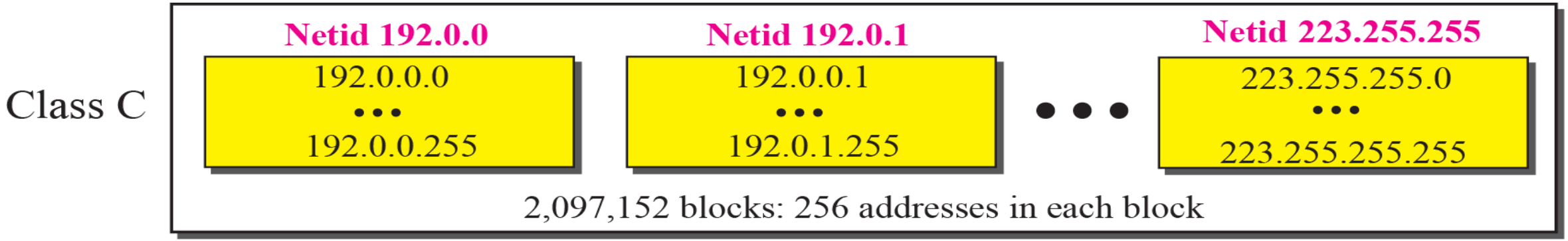
Blocks in Class B

- 2 bytes in class B define the net id
- The two leftmost bits should be ‘10’ (out of 16bits two leftmost bits are 1 and 0 so remaining bits are 14)
- Class B is divided into 2^{14} = 16,384 blocks
- Each block in class B contains 2^{16}= 65,536 addresses



Blocks in Class C

- 3 bytes in class C define the net id.
- The three leftmost bits should be '110' (out of 24 bits three leftmost bits are 110 so remaining bits are 21)
- Class C is divided into 2^{21} = 2,097,152 blocks
- Each block in class C contains 2^{8}= 256 addresses



The Single Block in Class D and E

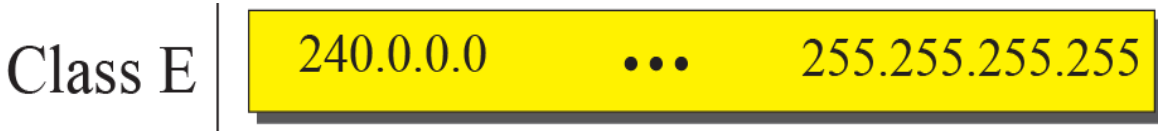
Class D

Class D is designed for multicasting

Used to define one group of hosts on the Internet

Class E

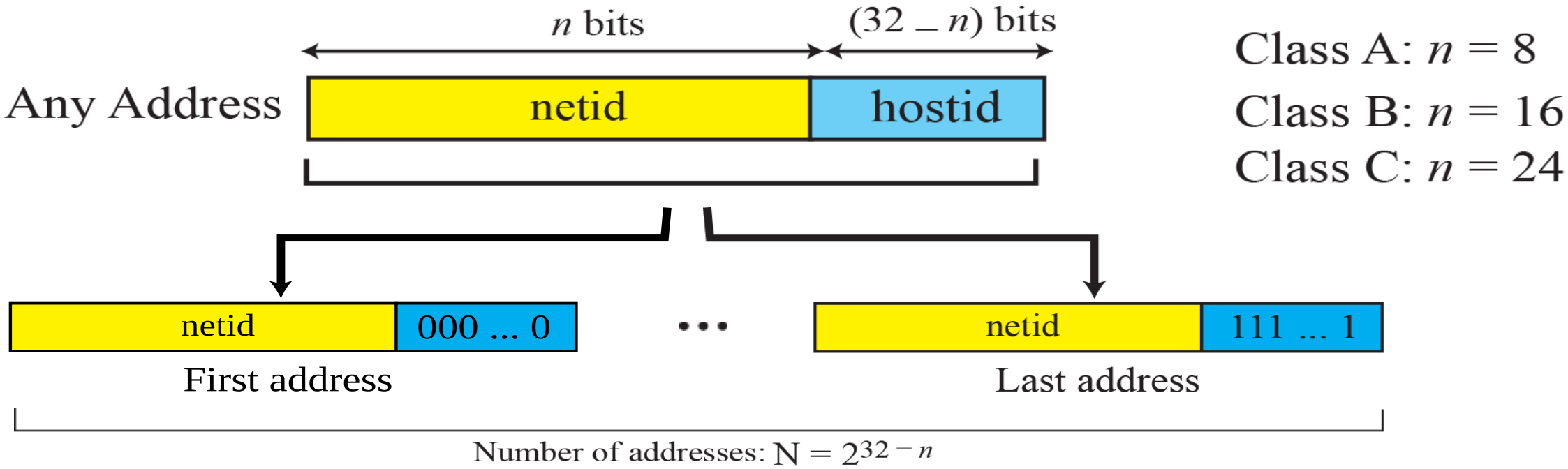
Reserved for future purposes



Information Extraction in Classful Addressing

Information Extraction in Classful Addressing

- The number of addresses
- The first address
- The last address

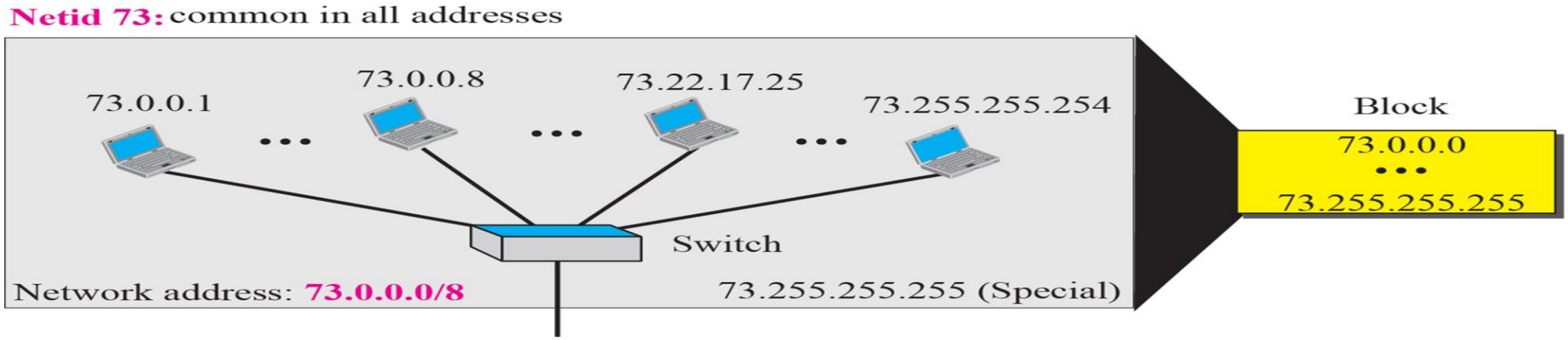


Example

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

If we observe the given address it is of Class A (class A : n=8)

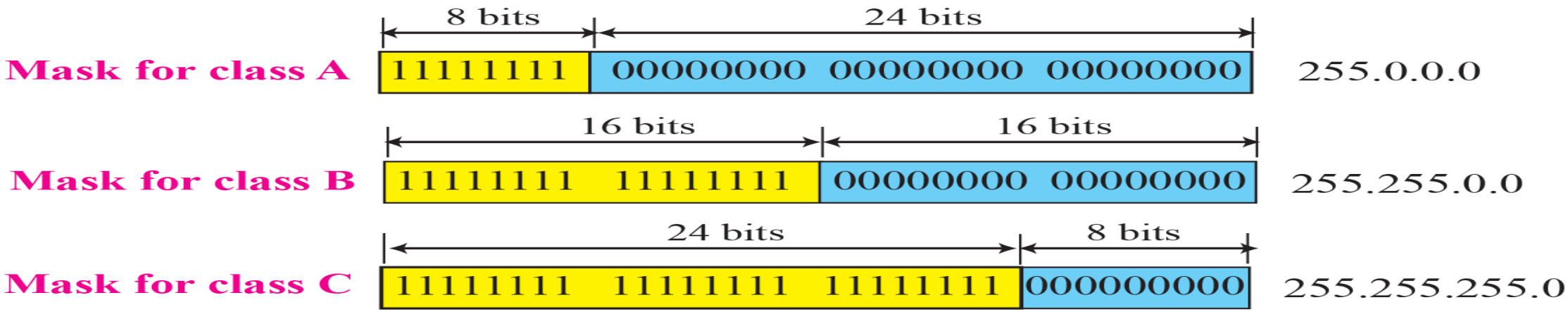
1. The **number of addresses** in this block is
   $N = 2^{32-n} = 2^{24} = 16,777,216$
2. To find the **first address**, we keep the left most 8 bits and set the rightmost 24 bits all to 0s. The first address is 73.0.0.0/8 in which 8 is the value of *n*.
3. To find the **last address**, we keep the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



Finding Network Address

Finding Network Address: Network Mask/ Default Mask/ Subnet Mask

- **IP Address never comes alone , it comes with subnet mask.**
- **Mask :**
  - 32-bit number of contiguous 1's followed by contiguous 0's.
  - Mask Distinguishes which portion of the address identifies the network and which portion of the address identifies the node(host).
- Network Mask is used to extract the network address from the destination address of a packet Called a default mask



Example : Find Network Address

A router receives a packet with the destination address 132.24.67.32. Show how the router finds the network address of the packet.

Solution

Since the class of the address is B (128 to 191) , we assume that the router applies the default mask for class B, 255.255.0.0 to find the network address.

Destination address ->	**132**	**.**	**24**	**.**	**67**	**.**	**32**
Default mask ->	**255**	**.**	**255**	**.**	**0**	**.**	**0**
Network address ->	**132**	**.**	**24**	**.**	**0**	**.**	**0**

Example: Find Network Address

If IP is given as 192.168.1.10 , Find:

1) Class of IP
2) Subnet Mask
3) Network Address
4) Maximum Last Address

Example: Find Network Address Solution

Class C				
IP	192	168	1	10
IP in binary	1100 0000	1010 1000	0000 0001	0000 1010
Subnet Mask	255	255	255	0
Subnet Mask in binary	1111 1111	1111 1111	1111 1111	0000 0000
Network Address	192	168	1	0
Maximum (Last Address)	192	168	1	255

Some Special Addresses

- In classful addressing some addresses were reserved for special purposes.
- Special block
  - All-Zero Address (0.0.0.0)
    - When a host needs to send an IPv4 packet but it does not know its own address
  - All-One Address (255.255.255.255)
    - A host that wants to send a message to every other host can use
  - Loopback Address(127.x.y.z)
    - Used to test the software on a machine
  - Private Address
    - Used either in isolation or in connection with network address translation technique
- Special address in each block
  - Network Address
  - Direct broadcast address

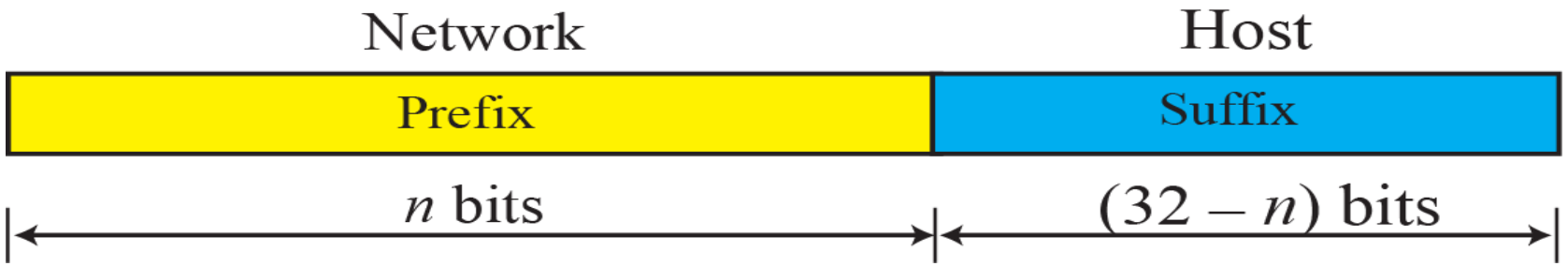
Classless Address

Classless Address & CIDR

- *In classless addressing, the last address in the block does not necessarily end in 255.*
- Also known as variable length subnet mask (vlsm)
- *It uses scheme as CIDR (Classless Inter Domain Routing) notation, the block granted is defined by the first address and the prefix length.*

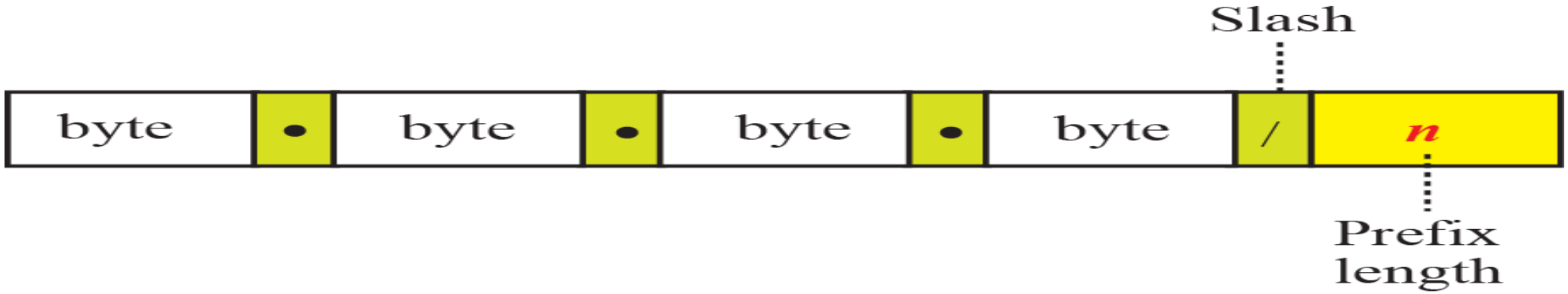
Prefix and Suffix

- Prefix : play the same role as the netid
- Suffix : play the same role as the hostid
- The prefix length in classless addressing can be 1 to 32



Slash Notation

- Notation of address including length of prefix
- In classless addressing, we need to know one of the addresses in the block and the prefix length to define the block



e.g.

255.0.0.0 : 11111111.00000000.00000000.00000000 -> /8
255.255.0.0 : 11111111.11111111.00000000.00000000 -> /16
255.255.255.0 : 11111111.11111111.11111111.00000000 -> /24

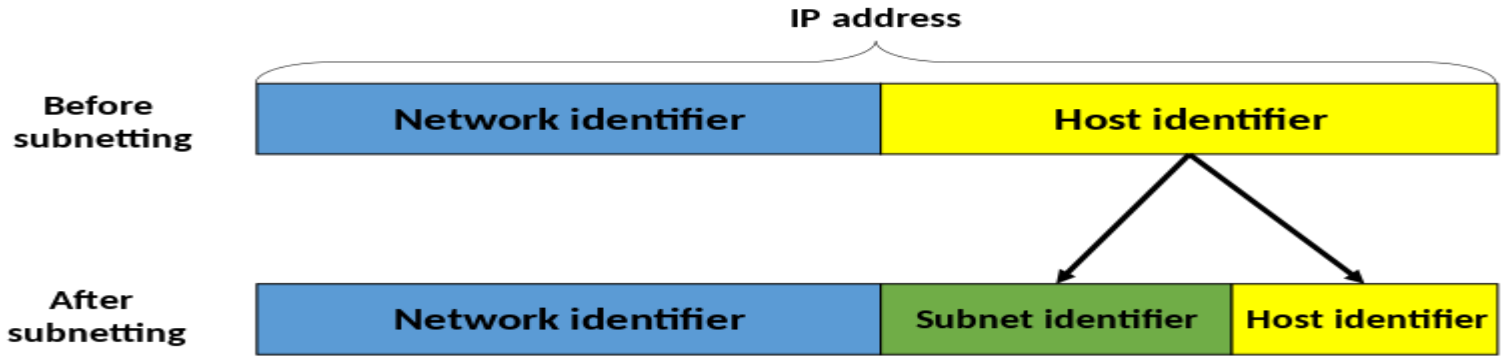
e.g.

/25 : 11111111.11111111.11111111.10000000 -> 255.255.255.128
/29 : 11111111.11111111.11111111.11111000 -> 255.255.255.248

Subnetting / Sub-Networks

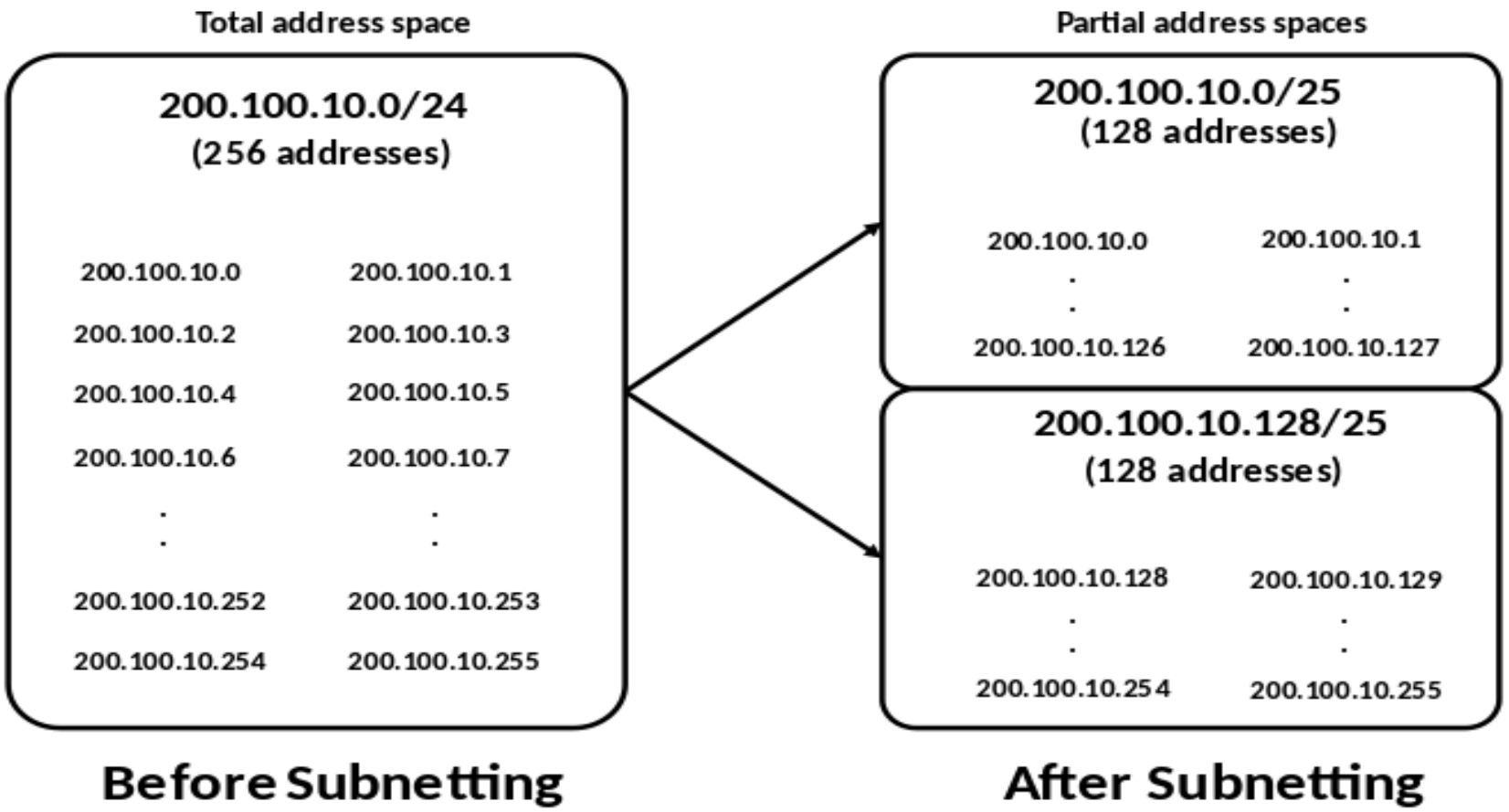
Subnetworks

- To create a subnet address, a network administrator borrows bits from the original host portion and designates them as the subnet field.
- A **subnetwork** or **subnet** is a logical subdivision of an IP network.
- Logical division of an IP address into two fields: the *network number* or *routing prefix* and the *rest field* or *host identifier*.
- When an organization is granted a block of addresses, it can create subnets to meet its needs.
- The prefix length increases to define the subnet prefix length.



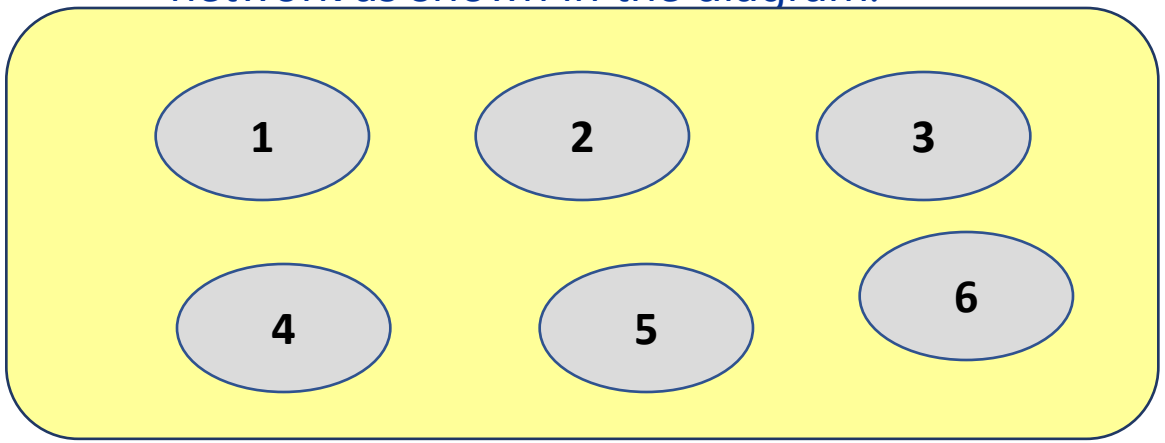
In fixed-length subnetting, the number of subnets is a power of 2.

Subnetting


Total address space
200.100.10.0/24
(256 addresses)
200.100.10.0
200.100.10.1
200.100.10.2
200.100.10.3
200.100.10.4
200.100.10.5
200.100.10.6
200.100.10.7
200.100.10.252
200.100.10.253
200.100.10.254
200.100.10.255
Before Subnetting
Partial address spaces
200.100.10.0/25
(128 addresses)
200.100.10.0
200.100.10.1
200.100.10.126
200.100.10.127
200.100.10.128/25
(128 addresses)
200.100.10.128
200.100.10.129
200.100.10.254
200.100.10.255
After Subnetting

Subnets

- Number of Subnets = 2^n
  - n indicates number of bits
- Number of Hosts=2^n -2 (these number of bits are left for host side)
  - n indicates number of bits
  - -2 means ,2 addresses reserved, one is network id and other is broadcast id
- Consider the scenario :
  - How many bits will be borrowed from host side , If we want to create 6 subnets in a single network as shown in the diagram:



2^0=1 Subnet
2^1=2 Subnets
2^2=4 Subnets
2^3=8 Subnets

It means 3 bits will be borrowed from host side to create 6 sub networks.

Decimal Equivalents of 8-Bit Patterns

Value of an Octet of a Subnet Mask	Binary Equivalent	Number of Binary 1s	Number of Binary 0s
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

What subnet mask can be used in scenario?

1. 100 devices
2. 50 devices
3. 1000 devices
4. 2000 devices

What subnet mask can be used in scenario? (Solution)

1. 100 devices
   - 2^4=16
   - 2^5 :32
   - 2^6 : 64
   - 2^7 : 128
   - 1111 1111. 1111 1111 . 1111 1111. 1000 0000
   - 255 .255. 255. 128
2. 50 devices : 255.255.255.192
   - 2^4=16
   - 2^5 :32
   - 2^6 : 64
   - 1111 1111. 1111 1111 . 1111 1111. 1100 0000
   - 255 .255. 255. 192
3. 1000 devices
   - 2^7 = 128
   - 2^8 = 256
   - 2^9 = 512
   - 2^10 = 1024
   - 11111111.11111111.11111100.00000000
   - 255.255.252.0
4. 2000 devices :
   - 2^11 = 2048
   - 11111111.11111111.11111000.00000000
   - 255.255.248.0

Thank You