Data Communication Network
DAY - 2

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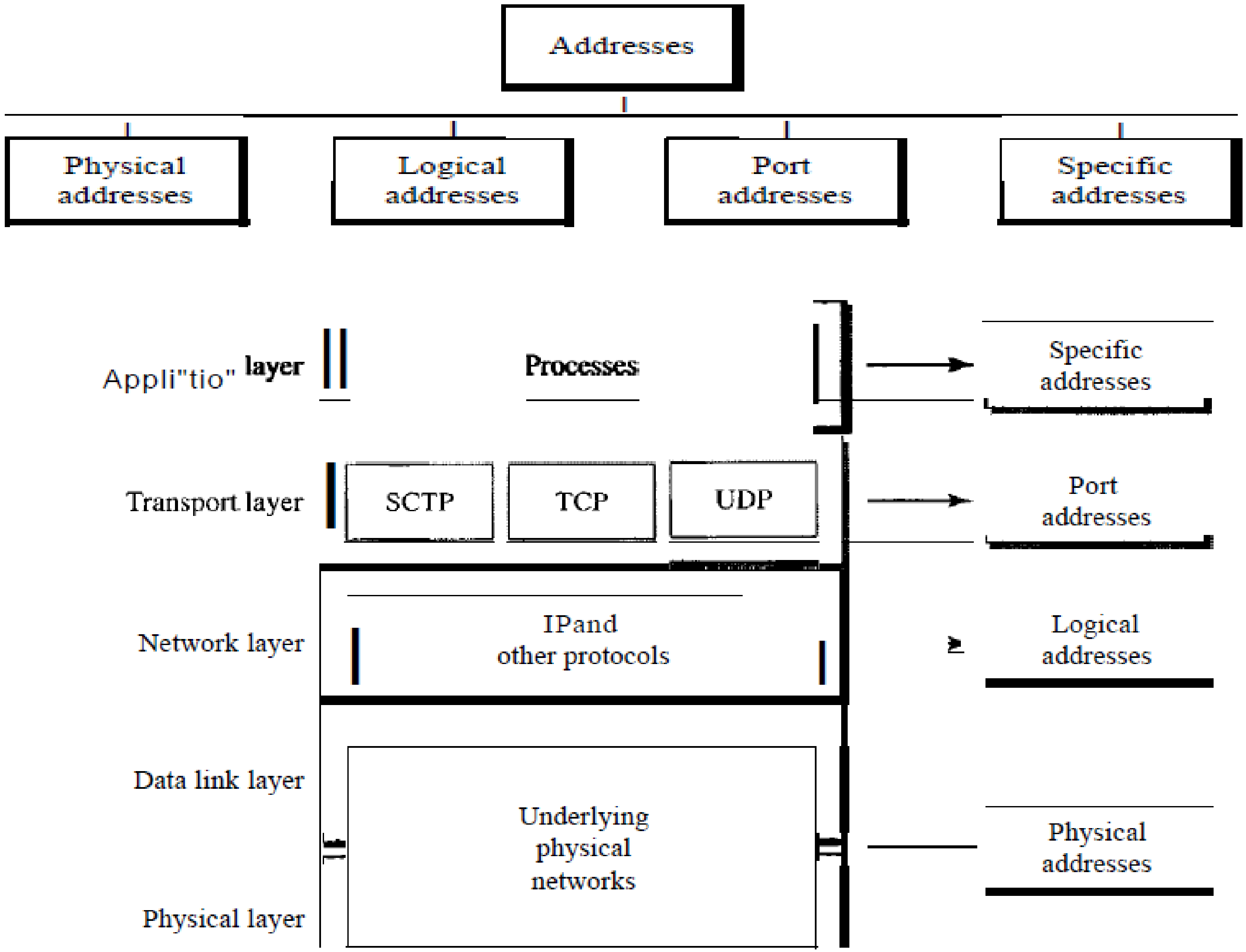
DCN DAY-2 Contents

- Addressing
- IP Addressing
- Information Extraction in Classful Addressing
- Finding Network Address
- Special Addresses
- Classless Addresses
- Subnet / Sub-Network
- Creating Sub-Networks

Addressing

Addressing


Addresses
Physical addresses
Logical addresses
Port addresses
Specific addresses
Appli"tio" layer
Processes
Transport layer
SCTP
TCP
UDP
Network layer
IPand other protocols
Data link layer
Underlying physical networks
Physical layer
Specific addresses
Port addresses
Logical addresses
Physical addresses

Addressing

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)

IP(Internet Protocol) Addresses

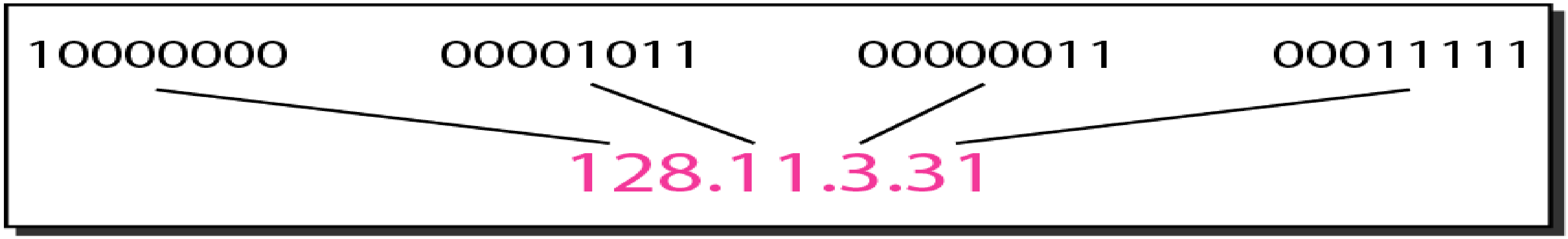
IP Address

- IP address to mean a logical address in the network layer of the TCP/IP protocol suite.
- Internet addresses are 32 bits in length, this gives us a maximum of 2^{32} addresses.
- IPV4 (32 bits address length)
- IPV6 (128 bits address length)
- Defines the connection of a device (for example, a computer or a router) to the Internet.
- IP addresses are made up of four sets of numbers called **"Octets".**

Static IP	Temporary IP
• Static IP addresses are found only on servers and remain the same. • A **Domain Name Server** assigns a "human readable" web address to each static IP address to make it more user friendly.	• Temporary IP addresses are found only on PC's are constantly changing each time it is logged on. • Temporary IP addresses are assigned by an ISP (Internet Service Provider) each time it is logged on to the Internet.

IPV4 Address Space& Notations

- If a protocol uses *N bits to define* an address, the address space is 2^N *because each bit can have two different values (0 or 1)* and *N bits can have* 2^N *values*.
- 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

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.

	Octet 1	Octet 2	Octet 3	Octet 4
Class A	0........			
Class B	10......			
Class C	110.....			
Class D	1110....			
Class E	1111....			

Binary notation

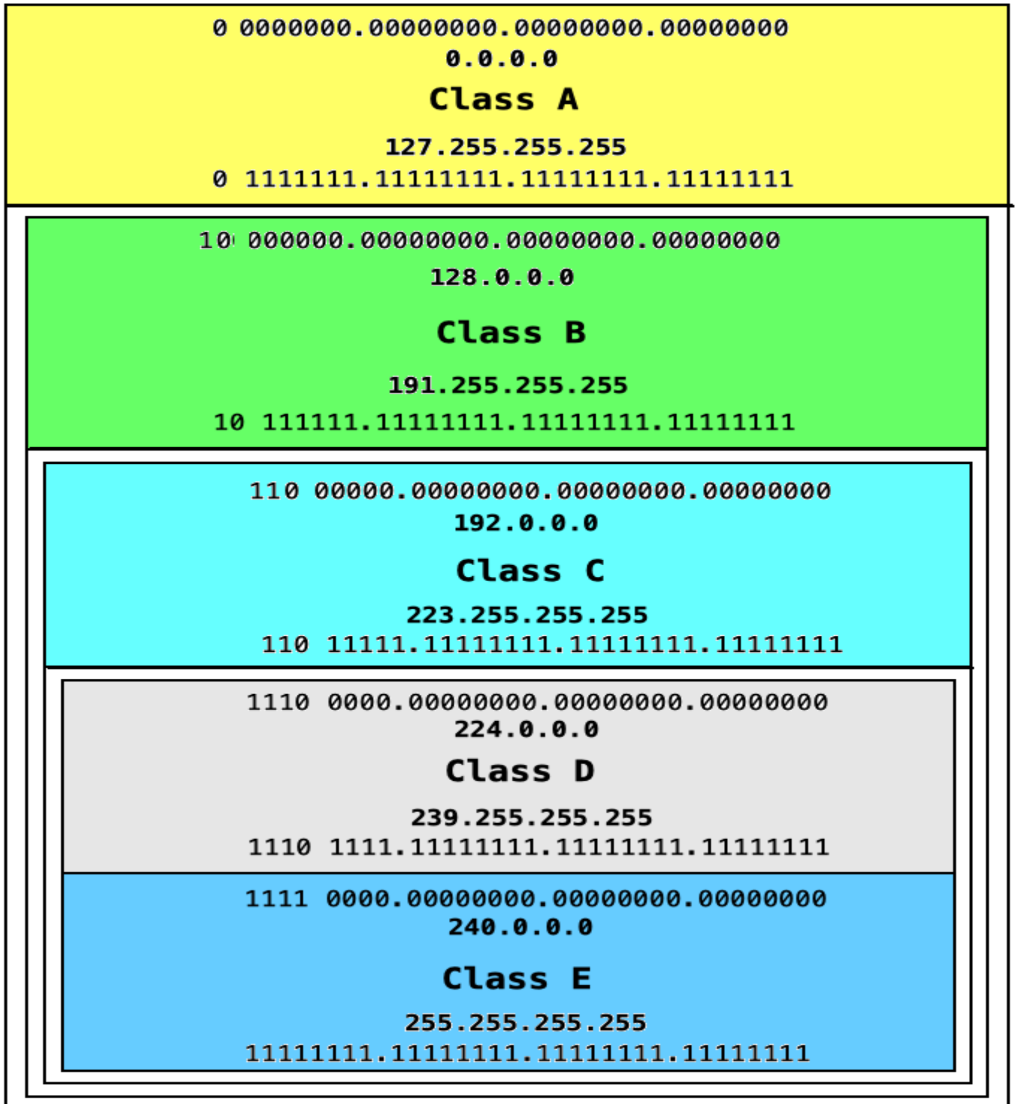
	Byte 1	Byte 2	Byte 3	Byte 4
Class A	0–127			
Class B	128–191			
Class C	192–223			
Class D	224–299			
Class E	240–255			

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

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 .

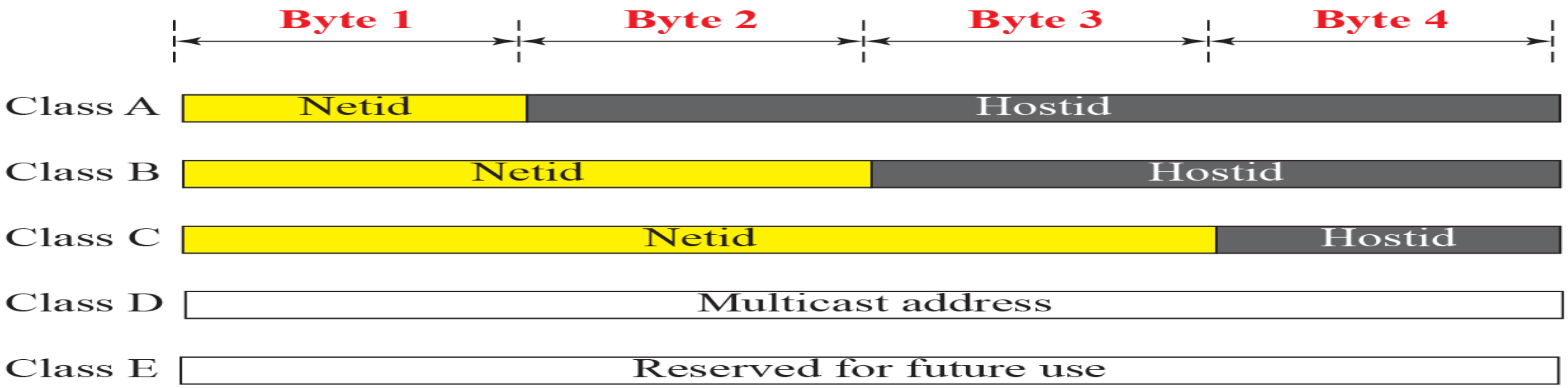
IANA(Inter Associated Number Association) manages private IP's.

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

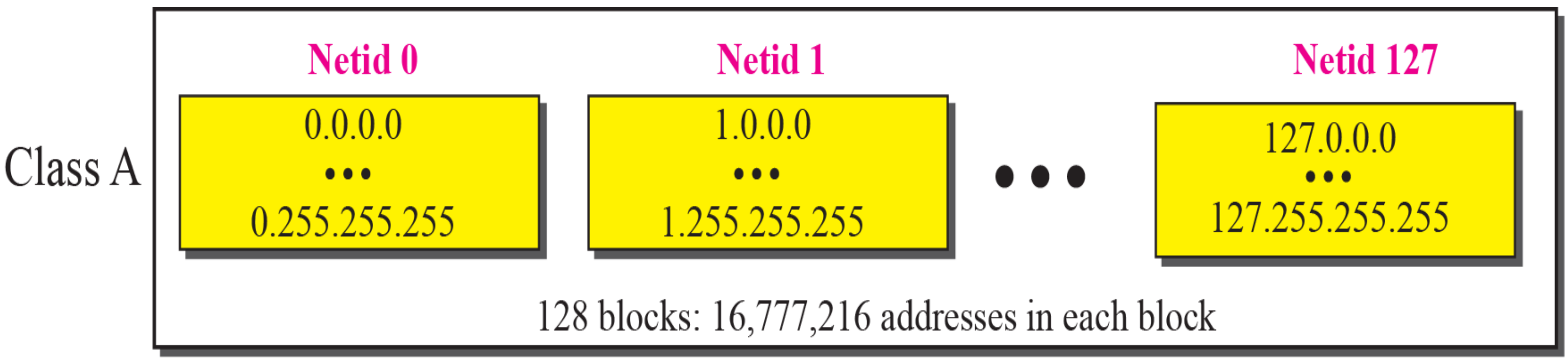
*** Subtracting the network and broadcast address***

Decimal Equivalents of 8-Bit Patterns

128	64	32	16	8	4	2	1	
1	0	0	0	0	0	0	0	= 128
1	1	0	0	0	0	0	0	= 192
1	1	1	0	0	0	0	0	= 224
1	1	1	1	0	0	0	0	= 240
1	1	1	1	1	0	0	0	= 248
1	1	1	1	1	1	0	0	= 252
1	1	1	1	1	1	1	0	= 254
1	1	1	1	1	1	1	1	= 255

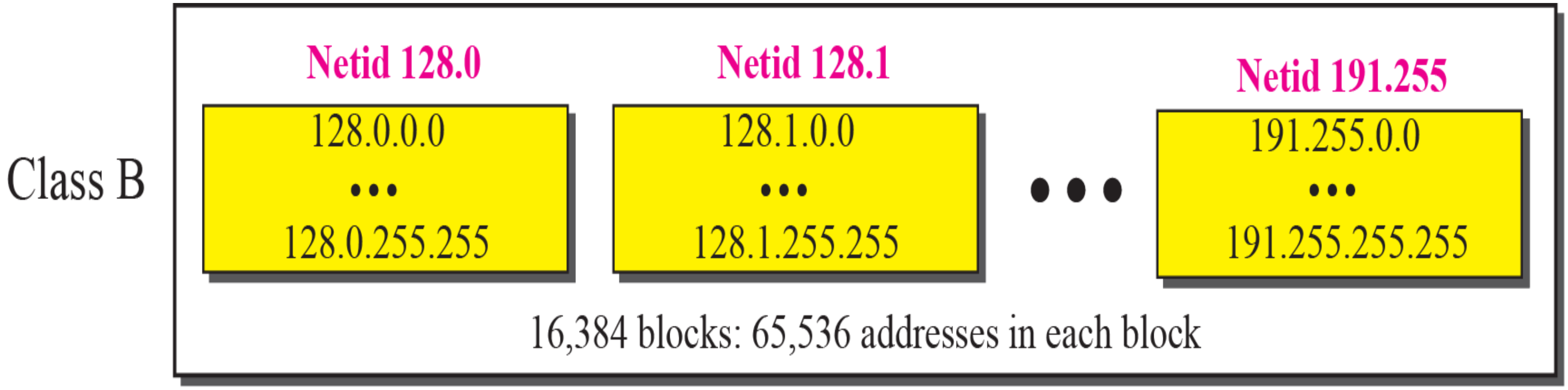
Blocks in Class A

- 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



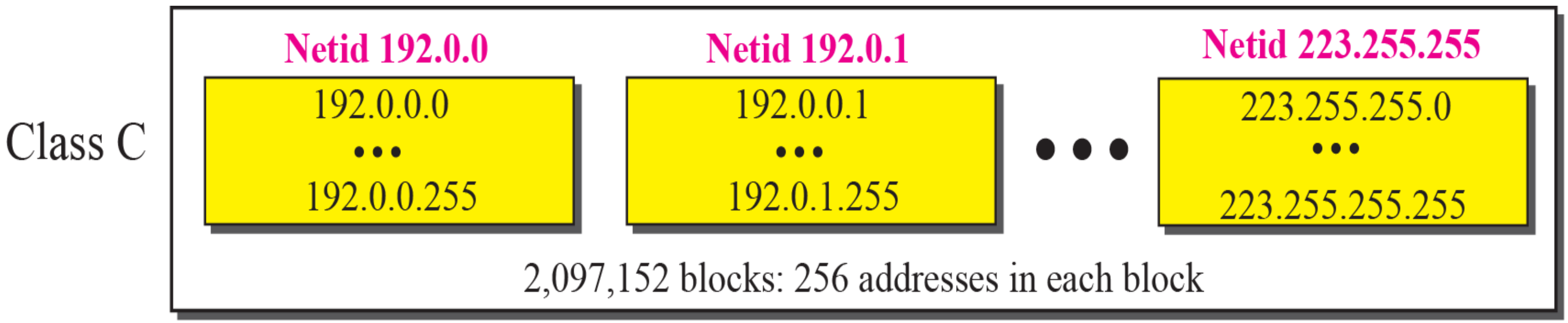
Blocks in Class B

- 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



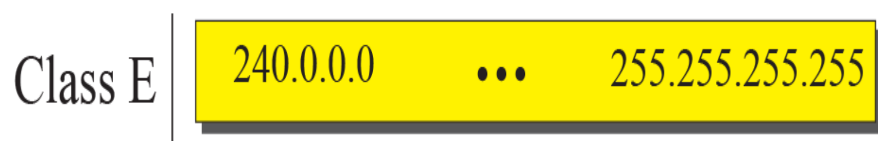
The Single Block in Class D and E

Class D

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

Class E

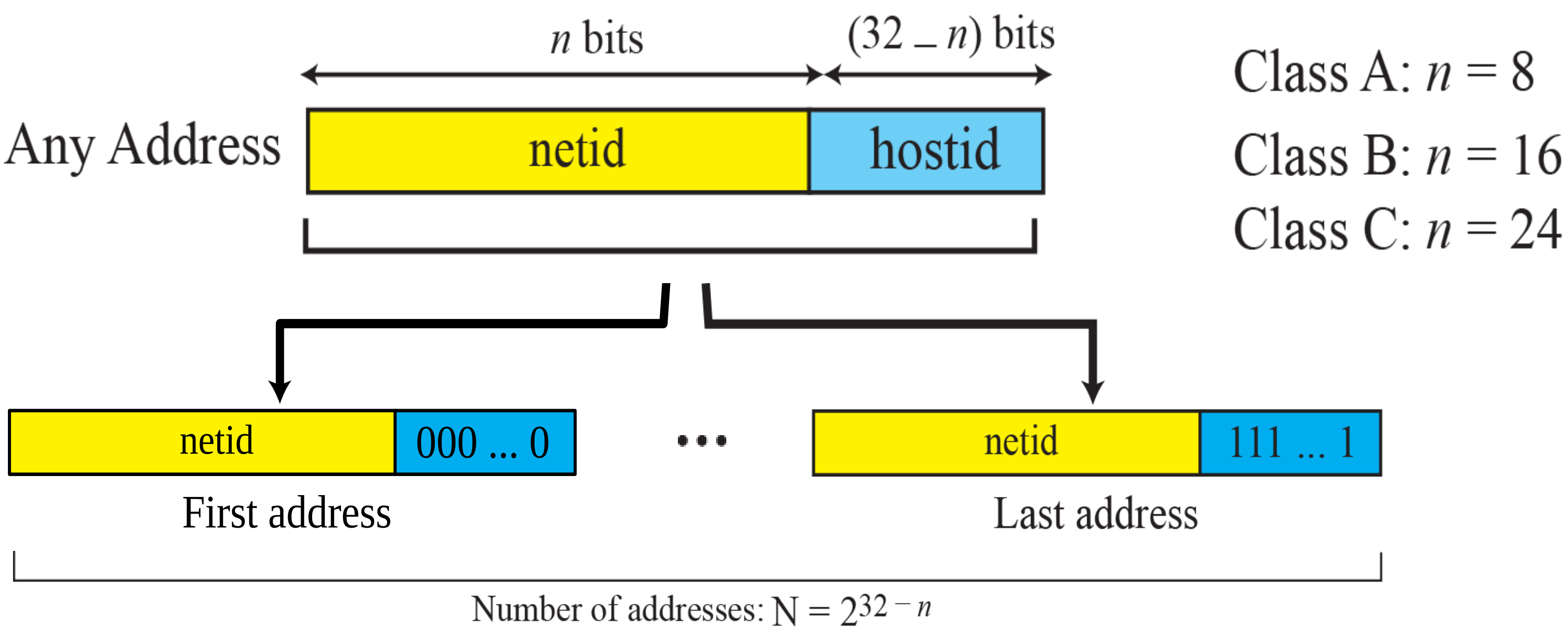
Reserved for future purposes



Information Extraction in Classful Addressing

Information Extraction in Classful Addressing

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

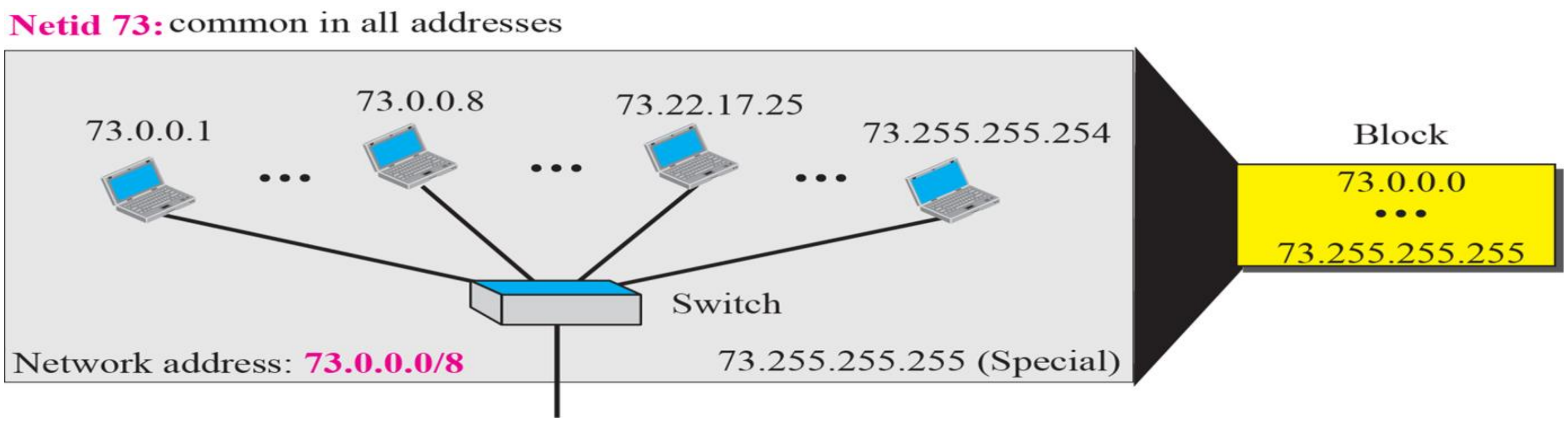


Example

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)

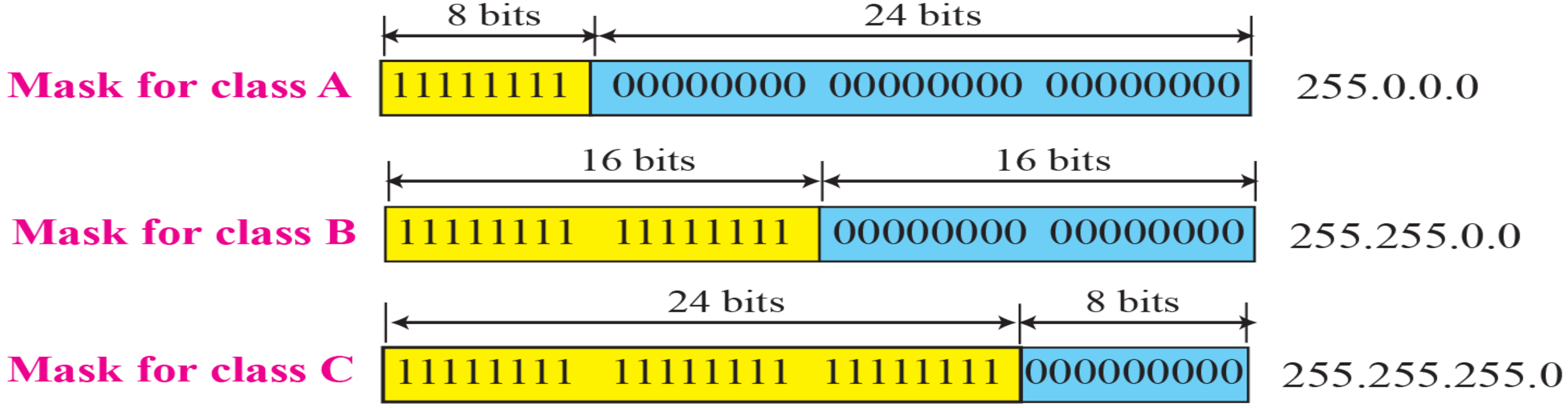
1. The **number of addresses** in this block is
   $N = 2^{32-n} = 2^{24} = 16{,}777{,}216$
2. To find the **first address**, we keep the left most 8 bits and set the rightmost 24 bits all to 0s. The first address is 73.0.0.0/8 in which 8 is the value of *n*.
3. To find the **last address**, we keep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

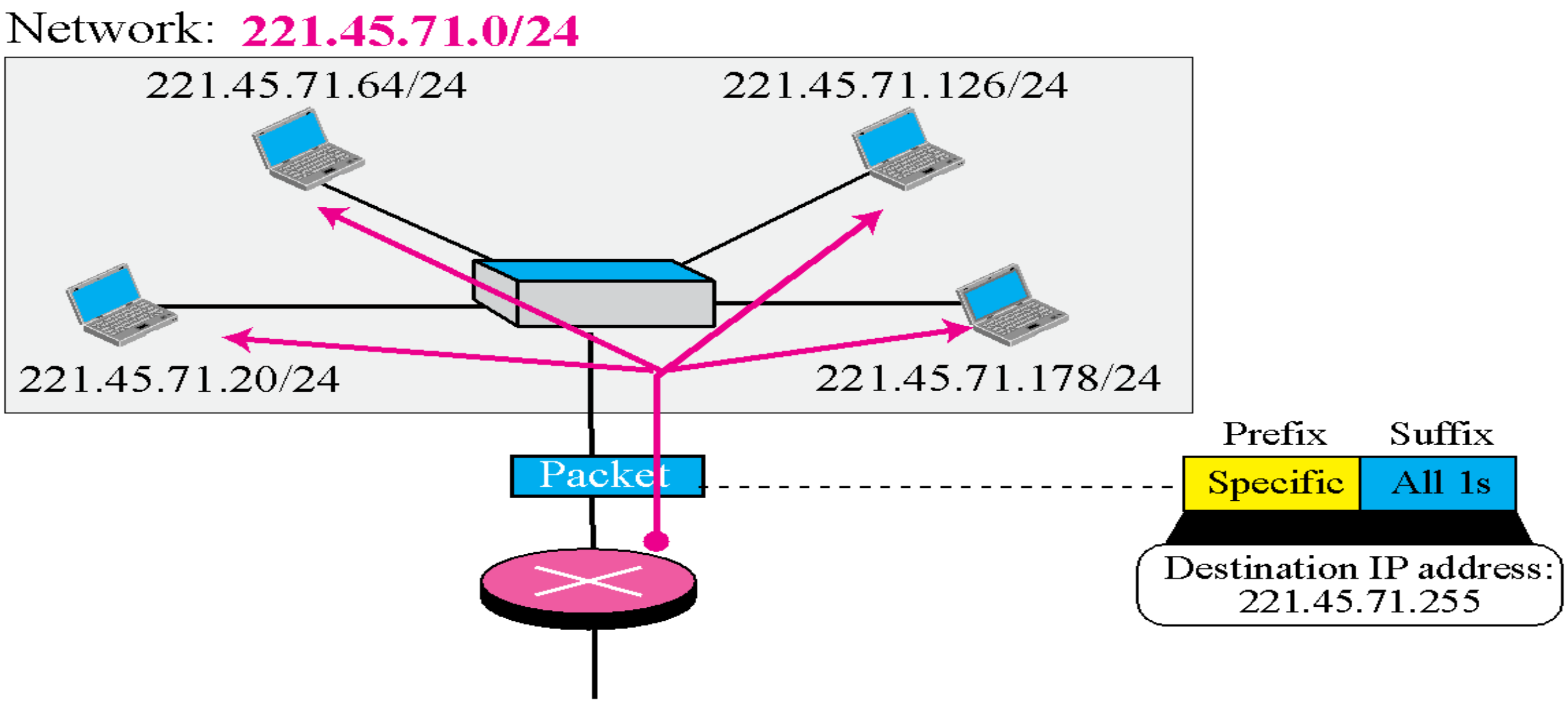
Class C				
IP	192	168	1	10
IP in binary	1100 0000	1010 1000	0000 0001	0000 1010
Subnet Mask	255	255	255	0
Subnet Mask in binary	1111 1111	1111 1111	1111 1111	0000 0000
Network Address	192	168	1	0
Maximum (Last Address)	192	168	1	255

Special Addresses

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

Special Address in any network :
Network Address and Broadcast Address



Network Address (First Address : 221.45.71.0)

The first address in a block is normally not assigned to any device; it is used as the network address that represents the organization to the rest of the world.

Direct broadcast address (Last Address : 221.45.71.255)

The last address in a block is used for broadcasting to all devices under the network.

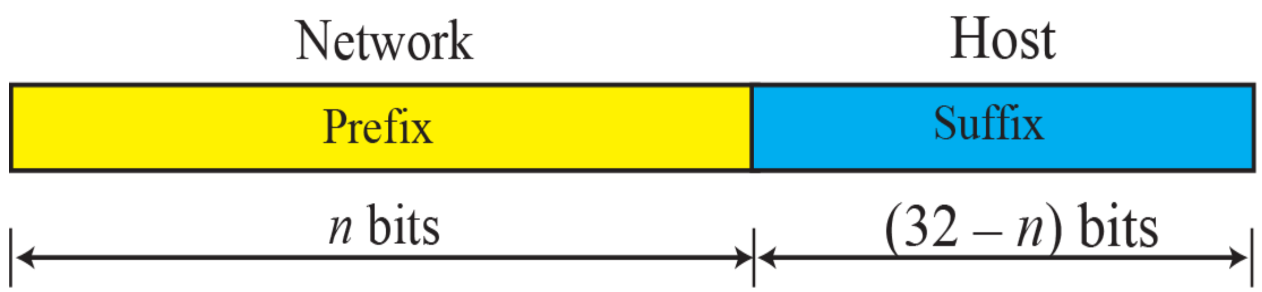
Classless Address

Classless Address & CIDR

- *In classless addressing, the last address in the block does not necessarily end in 255.*
- *In CIDR (Classless Inter Domain Routing) notation, the block granted is defined by the first address and the prefix length.*

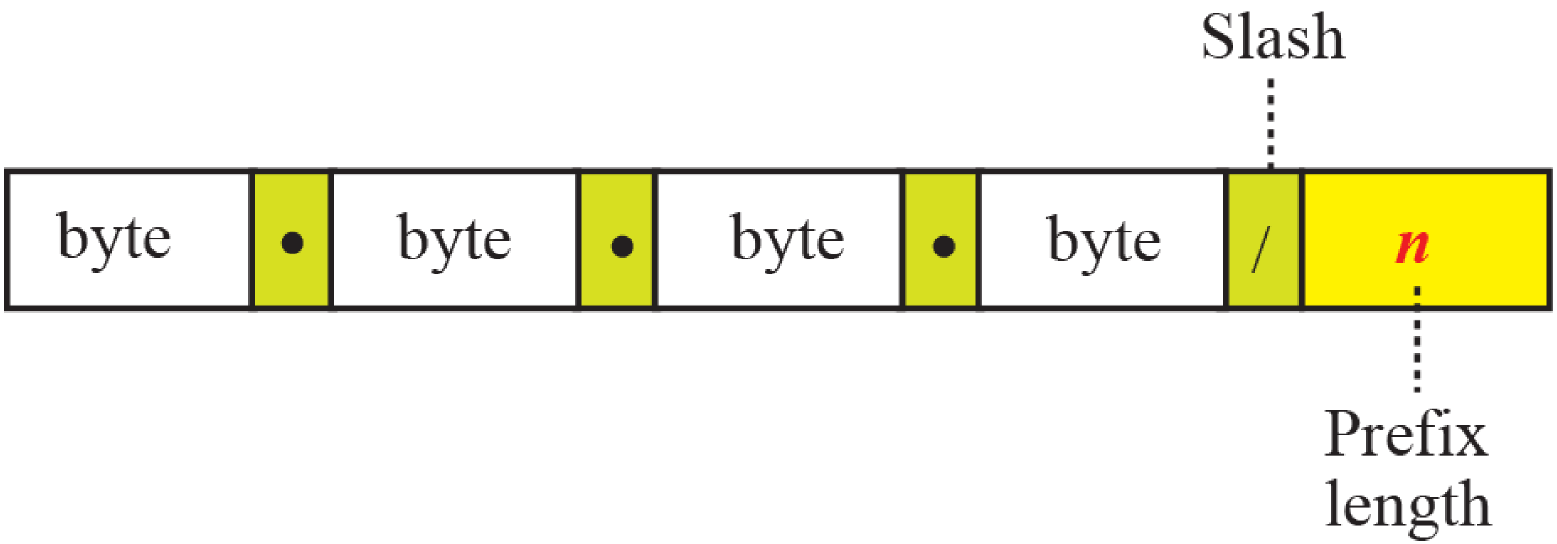
Prefix and Suffix

- 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

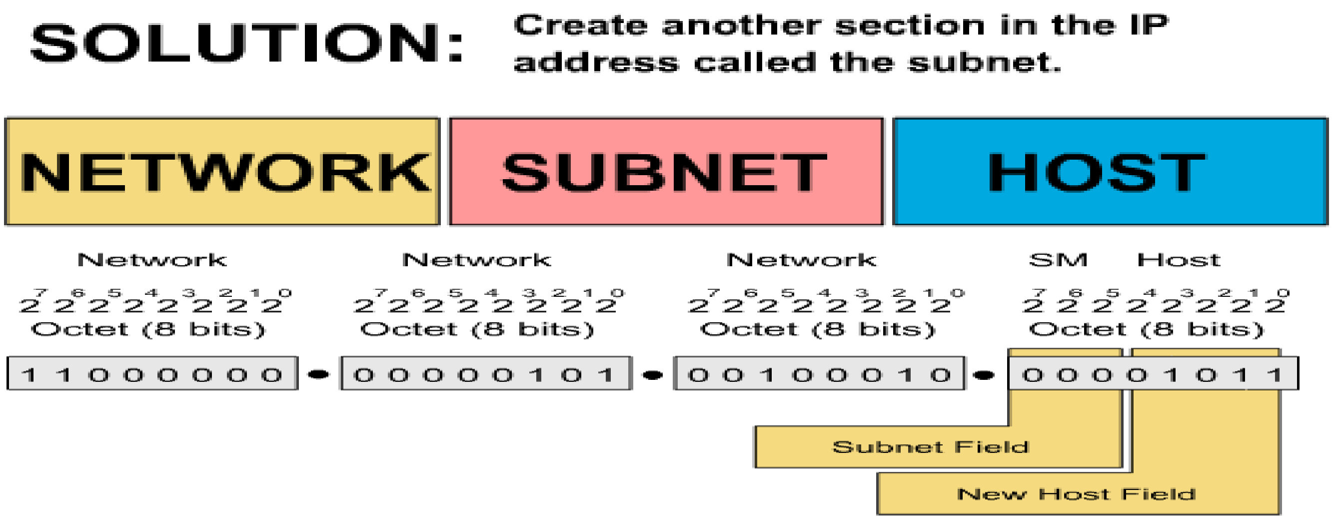
- Notation of address including length of prefix
- In classless addressing, we need to know one of the addresses in the block and the prefix length to define the block



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.
- 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.

Format of classless addressing address

- An address in classless addressing usually has this format

x.y.z.t/n

The **n** after the slash defines the number of bits that are the same in every address in the block. So if n is 20, it means the twenty leftmost bits are identical in each address.

Prefix and Prefix Length

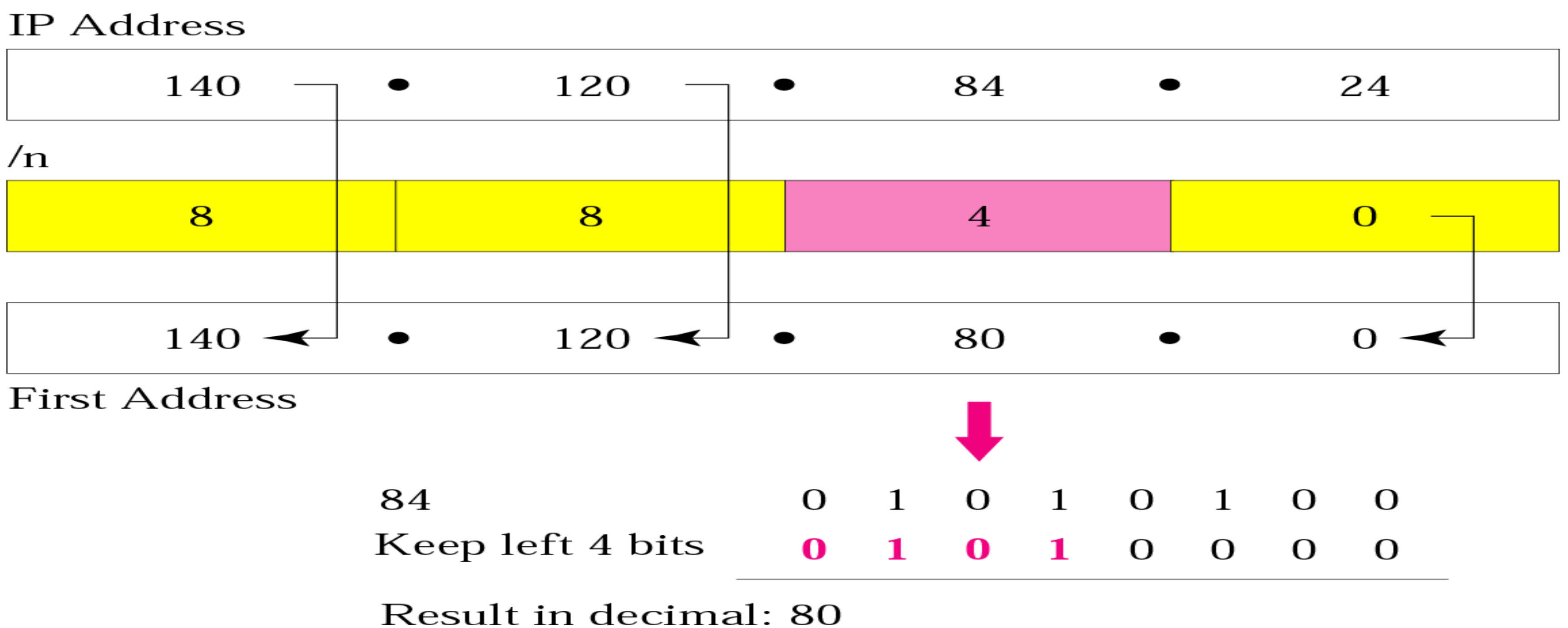
Two terms often used in classless addressing

Prefix – another name for the common part of the address range (netid)

Prefix length – the length of the prefix

Example 1 : Finding First Address

- *What is the first address in the block if one of the addresses is 140.120.84.24/20?*
- *The first, second, and fourth bytes are easy; for the third byte we keep the bits corresponding to the number of 1s in that group. The first address is 140.120.80.0/20.*



Example 2 : Finding First Address

- *What is the first address in the block if one of the addresses is **167.199.170.82/27**?*
- *Solution*
  The prefix length is 27, which means that we must keep the first 27 bits as is and change the remaining bits (5) to 0s. The following shows the process:

Address in binary: *10100111 11000111 10101010 01010010*

Keep the left 27 bits: *10100111 11000111 10101010 01000000*

Result in CIDR notation: *167.199.170.64/27*

Example: Find Number of Addresses

- *Find the number of addresses in the block if one of the addresses is* ***140.120.84.24/20.***
- The prefix length is 20.
- The number of addresses in the block is 2^{32-20} or 2^{12} or 4096.

Example 1: Finding last Address

- *Find the last address in the block if one of the addresses is* ***140.120.84.24/20***
- ***Solution***
- In the previous examples that the first address is 140.120.80.0/20 and the number of addresses is 4096. To find the last address, we need to add 4095 (4096 − 1) to the first address.

*To keep the format in **dotted-decimal notation**, we need to **represent 4095 in base 256** and do the calculation in base 256.*

*We write **4095 as 15.255.** (256 divides into 4095 15 times with a remainder of 255.)*

We then add the first address to this number (in base 255) to obtain the last address as shown below:

```
               140 . 120 .  80 .   0
                            15  .  255
               ------------------------
Last Address   140 . 120 .  95 .  255
```

Example 1 Cont…
Alternate Method 1 to find last address (CIDR / in case of class less addresses)

- Do not want to perform base 256 arithmetic?
- We can do it in binary.
  - .80.0 in binary is 0101 0000.0000 0000
  - 4095 in binary is 0000 1111 1111 1111
- Add the two values:
  - 01011111.11111111
  - This is .95.255

Example 1 Cont…
Another Method 2 To Find last Address (CIDR notation)

- *Find the last address in the block if one of the addresses is 140.120.84.24/20.*
- ***Solution***
  The mask has twenty 1s and twelve 0s. The complement of the mask has twenty 0s and twelve 1s. In other words, the mask complement is

00000000 00000000 00001111 11111111

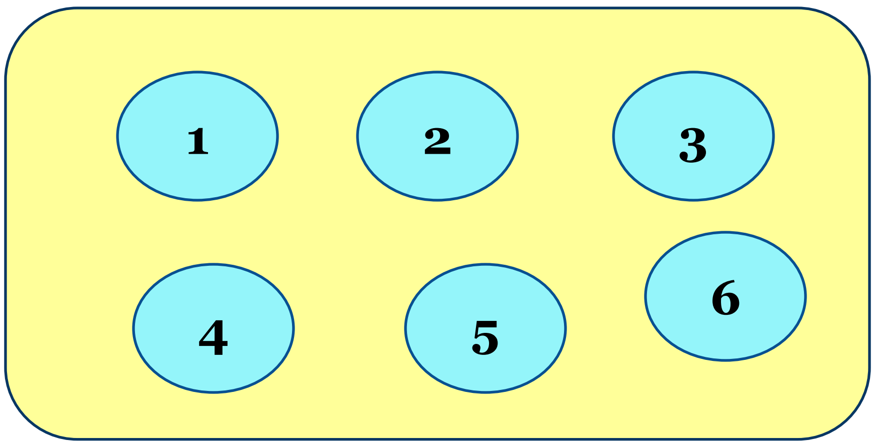
```
140 . 120 . 80 .   0
  0  .   0   . 15 . 255
---------------------------
140 . 120 . 95 . 255
```

The last address is 140.120.95.255/20.

Creating Subnets

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.

How to create subnets

- Determine the number of required network IDs:
  - One for each subnet
  - One for each wide area network connection
- Determine the number of required host IDs per subnet:
  - One for each TCP/IP host
  - One for each router interface
- Based on the above requirements, create the following:
  - One subnet mask for your entire network
  - A unique subnet ID for each physical segment
  - A range of host IDs for each subnet

1. Example of Creating Subnets

- An organization is granted the block 130.34.12.64/26 . The organization needs 4 subnets.
  - What is the subnet prefix length?
  - What are the subnet addresses and the range of addresses for each subnet?
- ***Solution***
  We need 4 subnets, which means we need to add two more 1s ($\log_2 4 = 2$) to the site prefix.
- *The subnet prefix is then /28.*
- *The site has $2^{32-26} = 64$ addresses.*
- *Each subnet has $2^{32-28} = 16$ addresses.*

Example of Creating Subnets Cont….

Finding first address and last address in the first subnet

- *The first address in the first subnet is* ***130.34.12.64/28****.*

Note that the first address of the first subnet is the first address of the block.

- *Since the site has $2^{32-26} = 64$ addresses.*
- *Each subnet has $2^{32-28} = 16$ addresses.*
- *The last address of the subnet can be found by adding 15 (16 −1) to the first address. The last address is* ***130.34.12.79/28.***

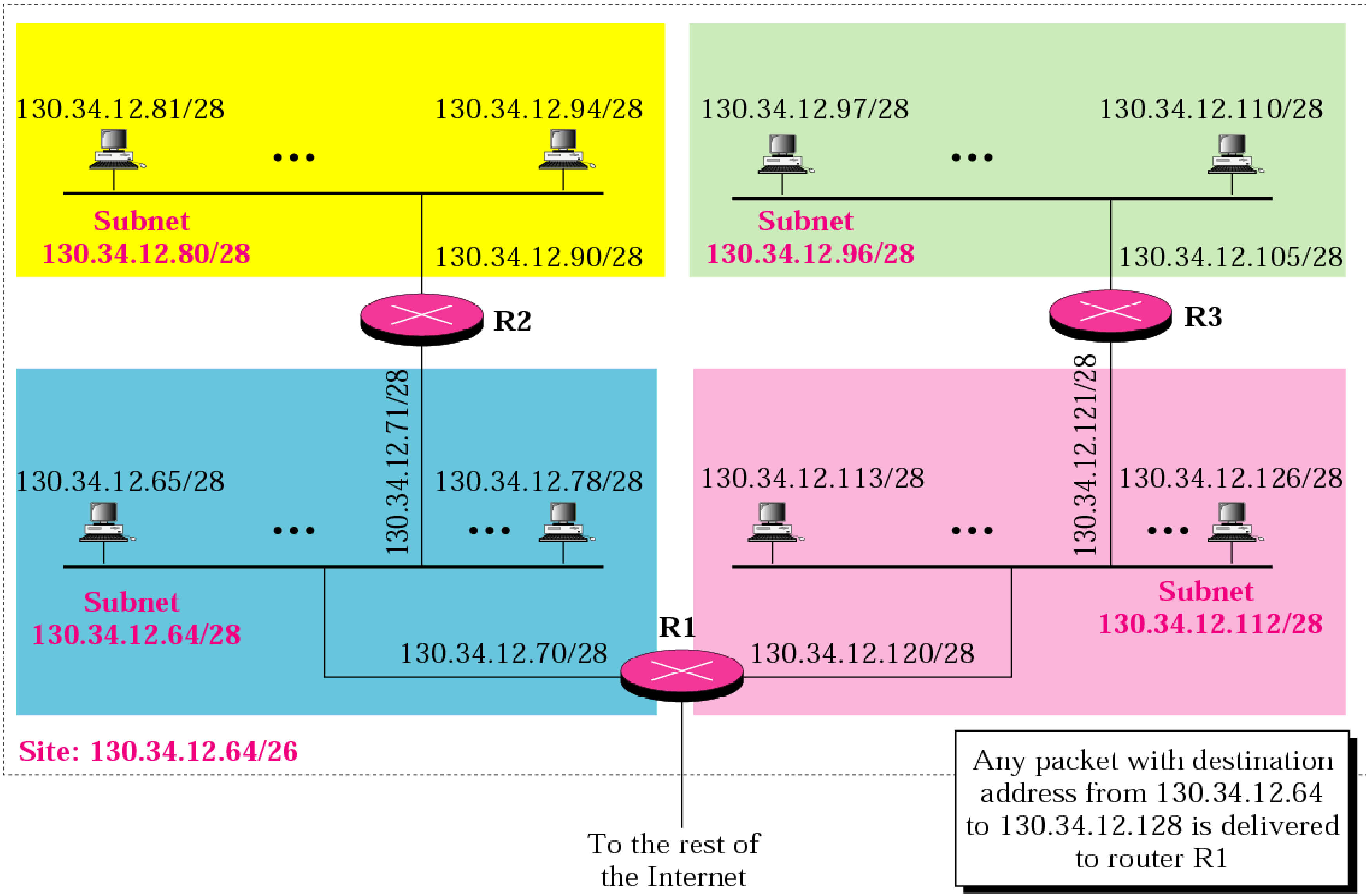
Example of Creating Subnets Cont….

Finding first address and last address in the remaining subnets

*2.The **first address in the second subnet is 130.34.12.80/28**; it is found by adding 1 to the last address of the previous subnet. Again **adding 15** to the first address, we obtain the **last address, 130.34.12.95/28.***

*3. Similarly, we find the **first address of the third subnet to be 130.34.12.96/28** and the **last to be 130.34.12.111/28**.*

*4. Similarly, we find the **first address of the fourth subnet to be 130.34.12.112/28** and **the last to be 130.34.12.127/28.***


130.34.12.81/28
130.34.12.94/28
Subnet
130.34.12.80/28
130.34.12.90/28
130.34.12.97/28
130.34.12.110/28
Subnet
130.34.12.96/28
130.34.12.105/28
R2
R3
130.34.12.71/28
130.34.12.121/28
130.34.12.65/28
130.34.12.78/28
130.34.12.113/28
130.34.12.126/28
Subnet
130.34.12.64/28
Subnet
130.34.12.112/28
R1
130.34.12.70/28
130.34.12.120/28
Site: 130.34.12.64/26
To the rest of
the Internet
Any packet with destination
address from 130.34.12.64
to 130.34.12.128 is delivered
to router R1

Example

One of the address in a block is 167.199.170.82/27. To find the number of addresses in the network, the first address, and the last address.

Solution

The value of *n* is 27. The network mask has twenty-seven 1s and five 0s. It is 255.255.255.240.

a. The number of addresses in the network is $2^{32-n} = 2^5 = 32$

b. We use the AND operation to find the first address. The first address is 167.199.170.64/27

c. To find the last address, we first find the complement of the network mask and the OR it with the given address : the last address is 167.199.170.95/27

Address in Binary	**10100111**	**11000111**	**10101010**	**01010010**
Network mask	**11111111**	**11111111**	**11111111**	**11100000.**
First address	**10100111**	**11000111**	**10101010**	**01000000**

Address in Binary	**10100111**	**11000111**	**10101010**	**01010010**
Network mask	**0000000**	**00000000**	**00000000**	**00011111**
Last address	**10100111**	**11000111**	**10101010**	**01011111**

Subnetting a Class Address

- How many subnets does the chosen subnet mask produce?
- How many valid hosts per subnet are available?
- What are the valid subnets?
- What's the broadcast address of each subnet?
- What are the valid hosts in each subnet?

Example: Class C 255.255.255.128 (/25) Network 192.168.10.0

- How many subnets does the chosen subnet mask produce?
  - Since 128 is 1 bit on (10000000), the answer would be 2^1= 2.
- How many valid hosts per subnet are available?
  - We have 7 host bits off (10000000), so the equation would be 2^7– 2 = 126 hosts.
- What are the valid subnets?
  - 256 – 128 = 128. Remember, we'll start at zero and count in our block size, so our subnets are 0, 128.
- What's the broadcast address of each subnet?
  - The number right before the value of the next subnet is all host bits turned on and equals the broadcast address. For the zero subnet, the next subnet is 128, so the broadcast of the 0 subnet is 127.
- What are the valid hosts in each subnet?
  - These are the numbers between the subnet and broadcast address

Example: Class C 255.255.255.224 (/27) Network 192.168.10.0

- How many subnets does the chosen subnet mask produce?
  - 224 is 11100000, so our equation would be $2^3 = 8$.
- How many valid hosts per subnet are available?
  - We have 5 host bits off (11100000), so the equation would be $2^5 - 2 = 30$ hosts.
- What are the valid subnets?
  - 256 – 224 = 32. We just start at zero and count to the subnet mask value in blocks (increments) of 32: 0, 32, 64, 96, 128, 160, 192, and 224.
- What's the broadcast address of each subnet?
  - The number right before the value of the next subnet is all host bits turned on and equals the broadcast address. For the zero subnet, the next subnet is 32, so the broadcast of the 0 subnet is 223.
- What are the valid hosts in each subnet?
  - These are the numbers between the subnet and broadcast address

Subnet Address	0	32	....	192	224
First Host	1	33		193	225
Last Host	30	62		222	254
Broadcast Address	31	63		223	255

Logical Network Implementation

Subnet Address	0	32	…………	192	224
First Host	1	33		193	225
Last Host	30	62		222	254
Broadcast Address	31	63		223	255

Example: Class B 255.255.128.0 (/17) Network 172.16.0.0

- How many subnets does the chosen subnet mask produce?
  - Since 128 is 1 bit on (10000000), the answer would be $2^1 = 2$
- How many valid hosts per subnet are available?
  - $2^{15} - 2 = 32{,}766$ (7 bits in the third octet, and 8 in the fourth)
- What are the valid subnets?
  - 256 – 128 = 128. Remember, we'll start at zero and count in our block size, so our subnets are 0, 128.
- What's the broadcast address of each subnet?
  - The number right before the value of the next subnet is all host bits turned on and equals the broadcast address. For the zero subnet, the next subnet is 128, so the broadcast of the 0 subnet is 127.
- What are the valid hosts in each subnet?
  - These are the numbers between the subnet and broadcast address

Subnet	0.0	128.0
First Host	0.1	128.1
Last Host	127.254	255.254
Broadcast	127.255	255.255

Example: Class B
255.255.240.0 (/20)
Network 172.16.0.0

- Subnets? $2^4 = 16$.
- Hosts? $2^{12} - 2 = 4094$.
- Valid subnets? 256 – 240 = 0, 16, 32, 48, etc., up to 240.
- Broadcast address for each subnet?
- Valid hosts?

Subnet	0.0	16.0	………..	240.0
First Host	0.1	16.1		240.1
Last Host	15.254	31.254		255.254
Broadcast	15.255	31.255		255.255

Thank You