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Discover Your Future

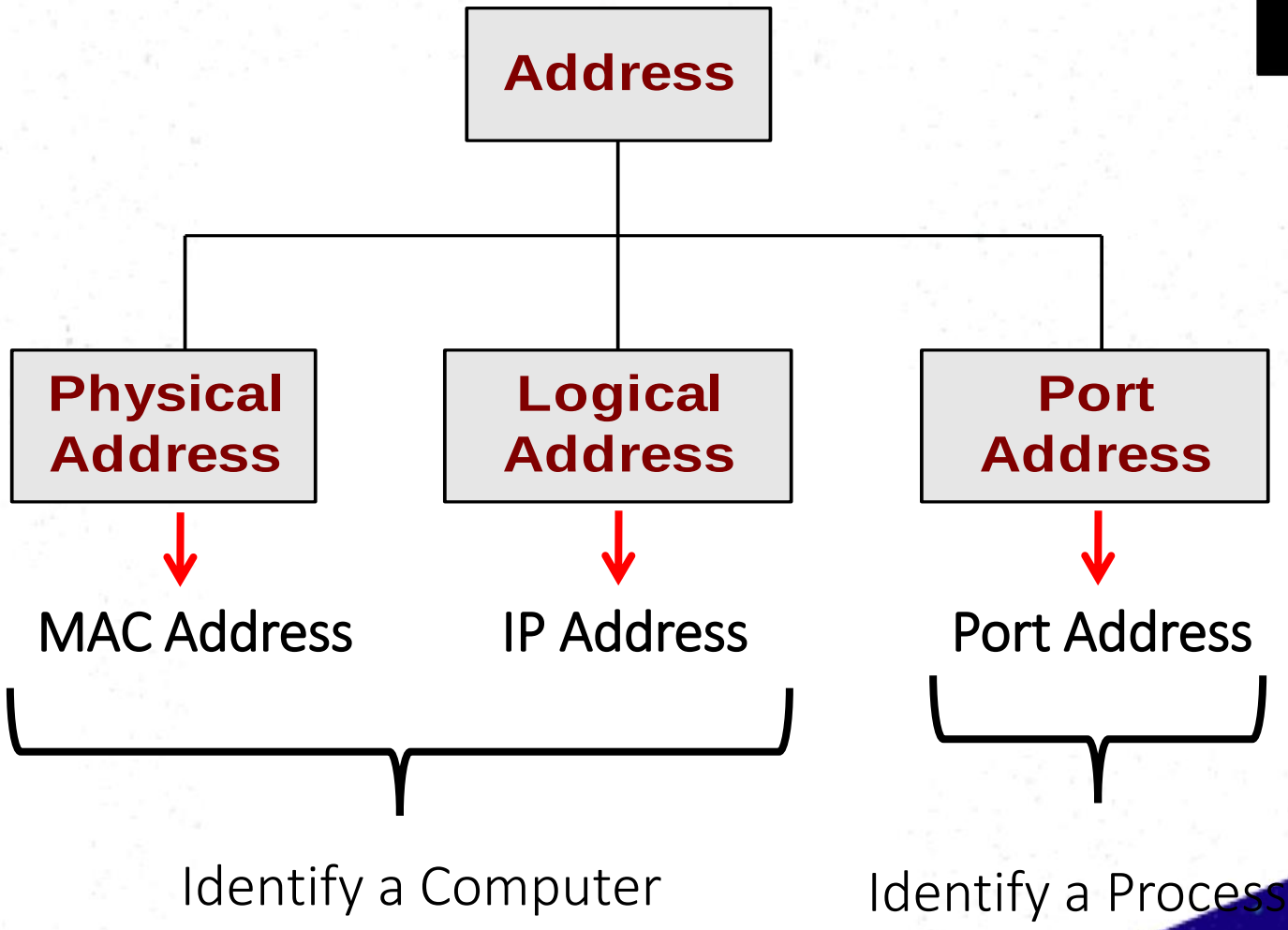
IT2050 - COMPUTER NETWORKS

Lecture 2

IP Addressing

SLIIT FACULTY OF COMPUTING

Addressing with TCP/IP



Physical Address

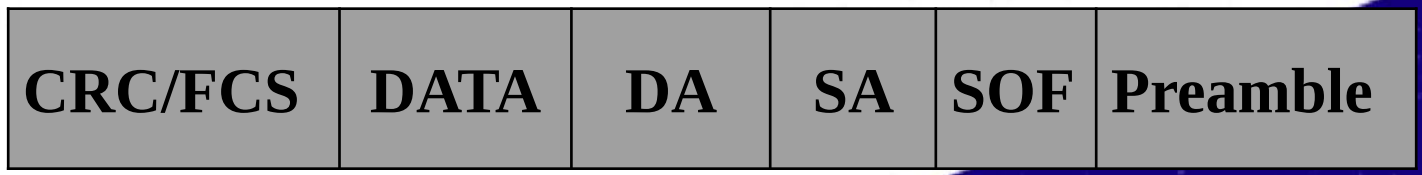
- Stored in the Network Interface Card (NIC)
- A hardware setting set by the manufacturer of NIC .
- Unchangeable

  Ex :- *MAC address*
- For Ethernet, the MAC address is a 48 bit or 12 Hex number

  Ex : 5A:B3:87:F1:93:7C

  5A-B3-87-F1-93-7C
- MAC address operates in the Data Link Layer (Layer 2)

Ethernet Frame



Logical Address

- Address scheme depends on the used protocol
- Widely used protocol is TCP/IP

  Ex :- IP Address

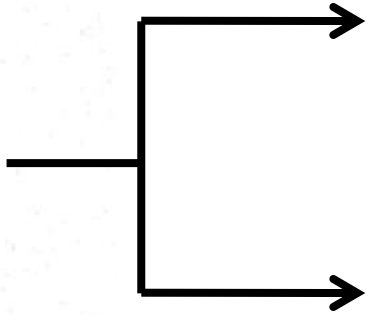
  192.168.16.53

  10.39.40.3
- Logical address operates at the Network Layer (Layer 3)

IP Address

- Uniquely identifies devices

- IP Addresses



IP Version 4 (IPV4)
32 bit scheme

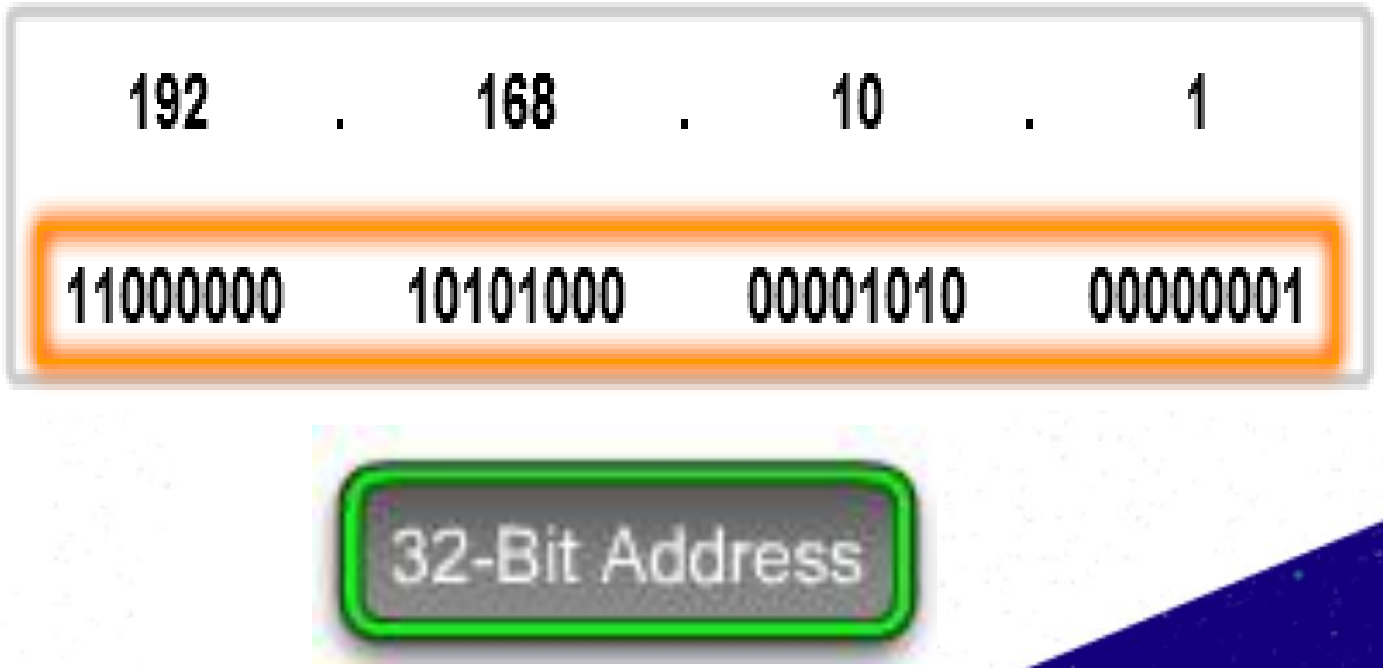
IP Version 6 (IPV6) (IPng)
128 bit scheme

IP Version 4 (IPV4)

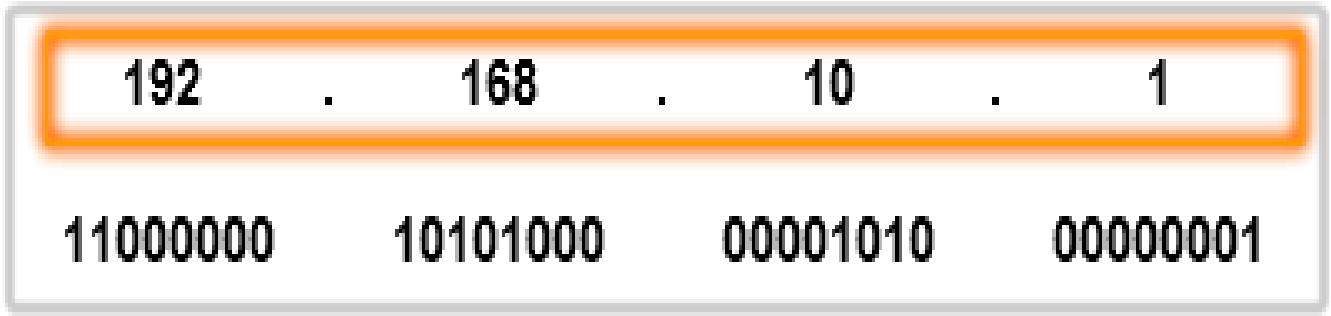
- The 32 bits are represented in following manner.

  Byte 1. Byte 2. Byte 3. Byte 4

  (1 byte = 8 bits)



IP Version 4 (IPV4) cont.



IP Version 4 (IPV4) cont.

- The minimum value of a byte

  00000000 = 0

- The maximum value of a byte

  11111111 = 255

- The minimum IP Address

  0.0.0.0

- The maximum IP Address

  255.255.255.255

Network ID and Host ID

- IP Addresses ➔ Network ID + Host ID

Classes of IP addresses

Class	Net ID	Host ID
A	1 Byte	3 Bytes
B	2 Bytes	2 Bytes
C	3 Bytes	1 Byte

IPv4 Address Classes

Class A	Network	Host		
Octet	1	2	3	4

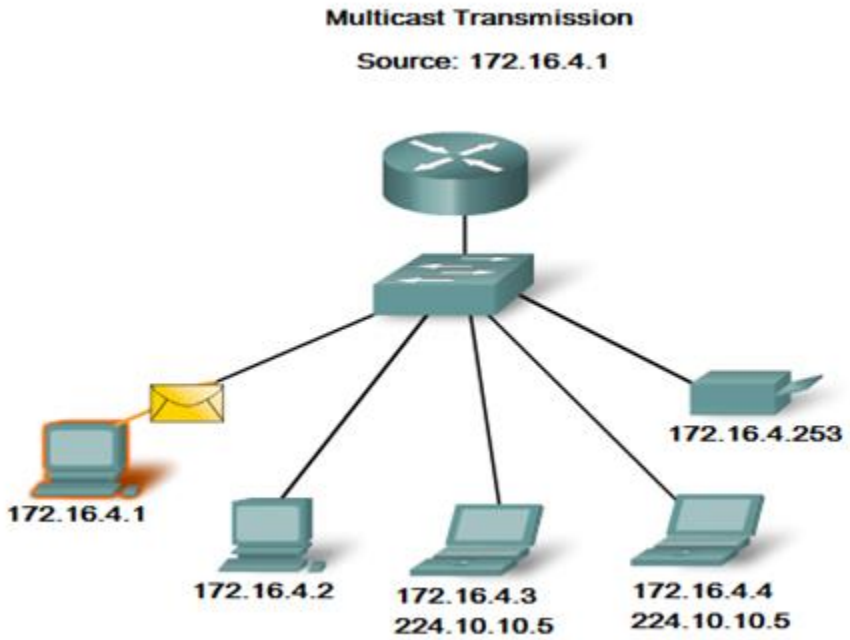
Class B	Network		Host	
Octet	1	2	3	4

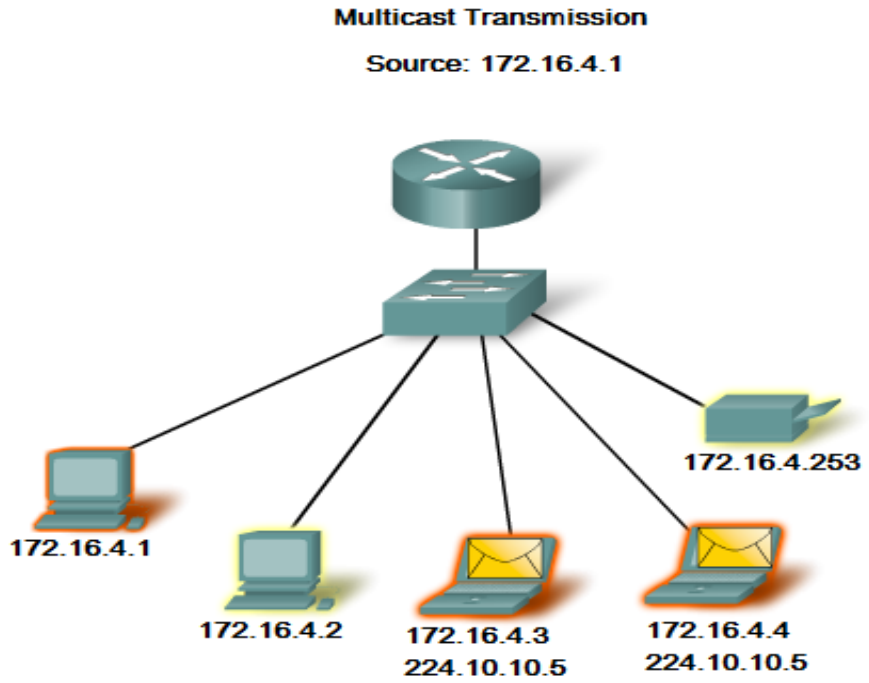
Class C	Network			Host
Octet	1	2	3	4

Class D	Host			
Octet	1	2	3	4

Classes of IP addresses cont.

- Class D is introduced for Multicasting





- Class E is reserved

Classes of IP addresses cont.

Class D Addresses

- A Class D address begins with binary 1110 in the first octet.
- First octet range 224 to 239.
- Class D address can be used to represent a group of hosts called a host group, or multicast group.

Class E Addresses

- First octet of an IP address begins with 1111
- Class E addresses are reserved for experimental purposes and should not be used for addressing hosts or multicast groups.

Class A byte 1

Class B byte 1

Class C byte 1

Class	Minimum Network ID	Maximum Networks ID
A	0 0000000 0	0 1111111 127
B	10 000000.00000000 128.0	10 111111.11111111 191.255
C	110 00000.00000000.00000000 192.0.0	110 11111.11111111.11111111 223.255.255

- Class A – 2^7
- Class B – 2^14
- Class C – 2^21

Address Class	First Octet Range	Number of Possible Networks	Number of Hosts per Network
Class A	0 to 127	128	16,777,214
Class B	128 to 191	16,348	65,534
Class C	192 to 223	2,097,152	254

Network Address and Broadcast Address

- For the Network Address, the Host ID part of the IP Address will be considered as All 0s
- For the Broadcast Address, the Host ID part of the IP Address will be considered as All 1

Ex : 103.58.35.1

This is a Class A address

Net ID is = 103

Host ID is = 58.35.1

Network Address ➔ 103.0.0.0

Broadcast Address ➔ 103.255.255.255

198 . 8 . 0 . 1

1100 0110 . 0000 1000 . 0000 0000 . 0000 0001

Class C

Network ID : 3 bytes (24 bits)

Host ID : 1 byte (8 bits)

- Both in Network ID and Host ID all 0s and all 1s are reserved for special purposes.

  The actual maximum no. of Hosts per Network

  $=2^8 - 2 = 254$

- Network Address :

  1100 0110 . 0000 1000 . 0000 0000 . 0000 0000 (198.8.0.0)

- Broadcast Address :

  1100 0110 . 0000 1000 . 0000 0000 . 1111 1111 (198.8.0.255)

Classful Addressing - Subnet Mask

Class	*Mask in binary*	*Mask in dotted-decimal*
A	11111111 00000000 00000000 00000000	255.0.0.0
B	11111111 11111111 00000000 00000000	255.255.0.0
C	11111111 11111111 11111111 00000000	255.255.255.0

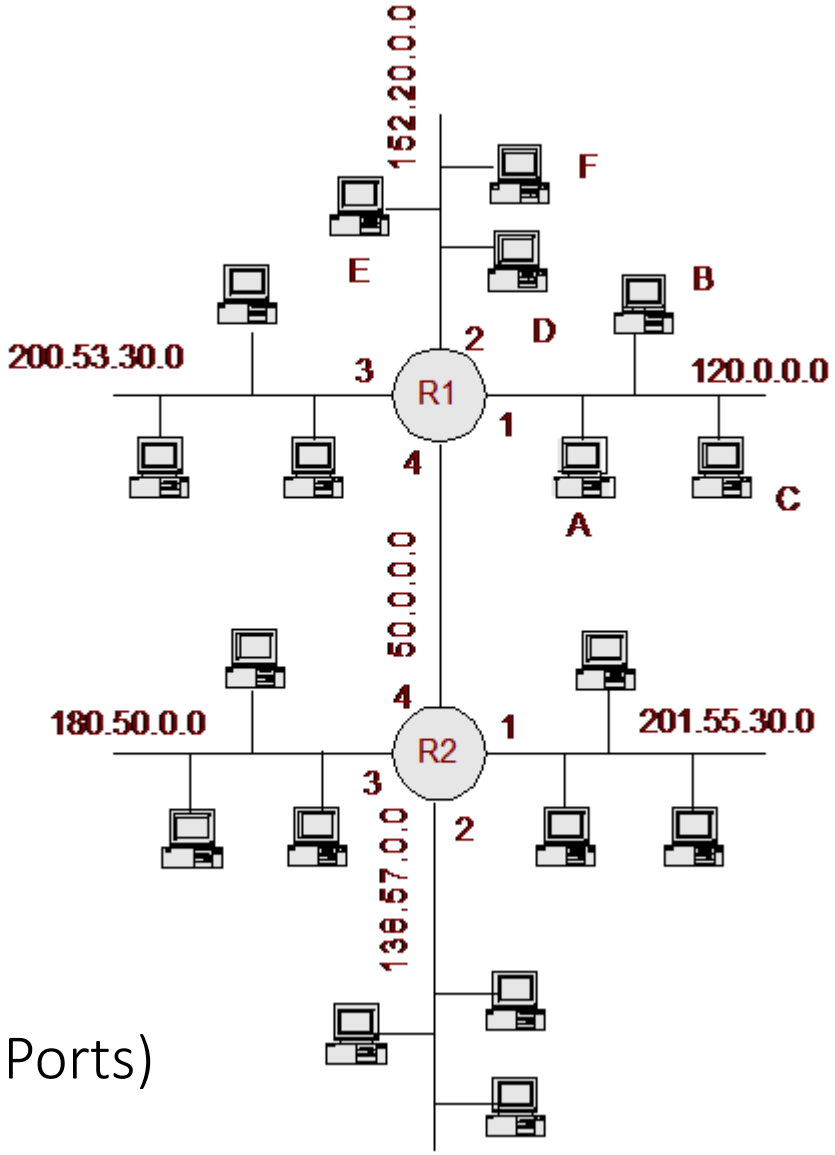
Net ID part : All 1's
Host ID part : All 0's

Exercise

IP Address	Class	Subnet Mask	Actual No.of hosts	Network Address	Broadcast Address
140.35.45.55					
50.60.70.5					
201.35.40.201					
125.38.55.185					
193.201.55.105					
127.53.35.10					

IP address of a Router

Host/Port	IP Address
A	120.0.0.1
B	120.0.0.2
C	120.0.0.3
Port 1 R1	120.0.0.50
D	150.20.0.1
E	150.20.0.2
F	150.20.0.3
Port 2 R1	150.20.0.50
Port 3 R1	200.53.30.50
Port 4 R1	50.0.0.1
Port 4 R2	50.0.0.2
Port 1 R2	201.55.30.50
Port 2 R2	138.57.0.50
Port 3 R2	180.50.0.50

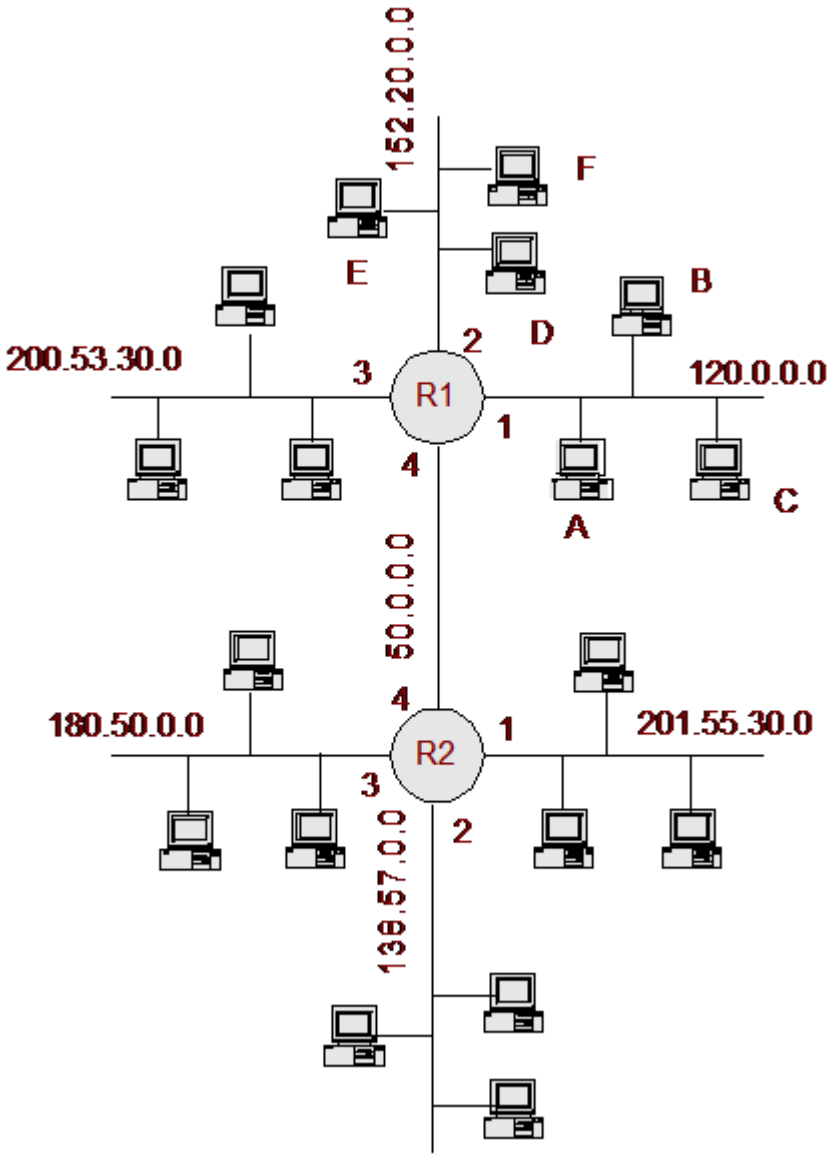


- A router has many ports. (LAN and WAN Ports)
- An IP address is assigned to each port.

Default Gateway IP Address

Network Address	Gateway IP Address
120.0.0.0	120.0.0.50
152.20.0.0	152.20.0.50
200.53.30.0	200.53.30.50
201.55.30.0	201.55.30.50
138.57.0.0	138.57.0.50
180.50.0.0	180.50.0.50

The IP address of router port which is connected to a particular LAN is called the “Gateway IP Address” of the LAN



Public IP Addresses

- **A public IP address is any valid address that can be accessed over the Internet**

- The Internet is a Public Computer Network which is spread all over the world.
- Allocations of IP addresses are controlled by the Internet Assigned Number Authority (IANA) which responsible for the IP address ranges **allocation** to different countries.
- CINTEC assigns different range of IP address to different Internet Service Providers (ISPs)
- The ISPs allocate IP addresses to their customers
- Sri Lanka Telecom(SLT) provides allocates 8 IP addresses for each 64 kb/s leased line.

Private IP Addresses

- **A private IP address is address assigned to a device on a private LAN that is accessible only within the LAN.**

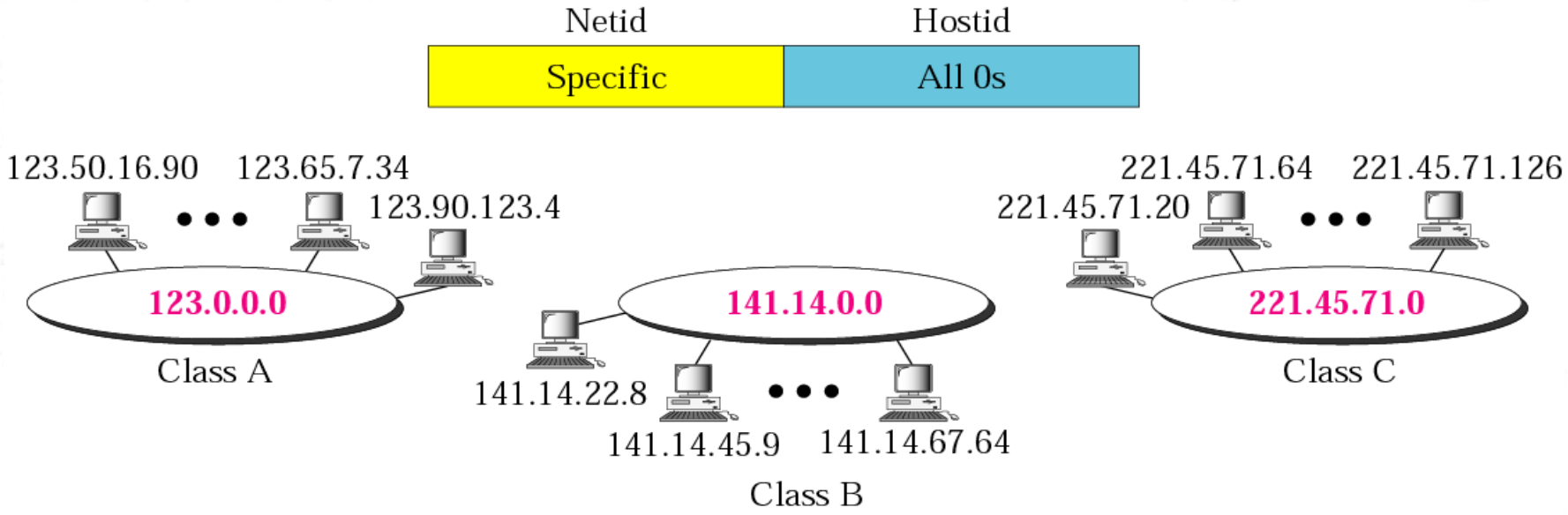
- A network which is not connected to Internet can use any IP address range without obtaining any permission
- It is not advisable to use any IP address since the network may connect to Internet in the future
- To avoid such problems, IANA has reserved some IP address ranges for private use

Class	Private Network Address	No.of Networks
A	10.0.0.0	1
B	172.16.0.0 to 172.31.0.0	16
C	192.168.0.0 to 192.168.255.0	256

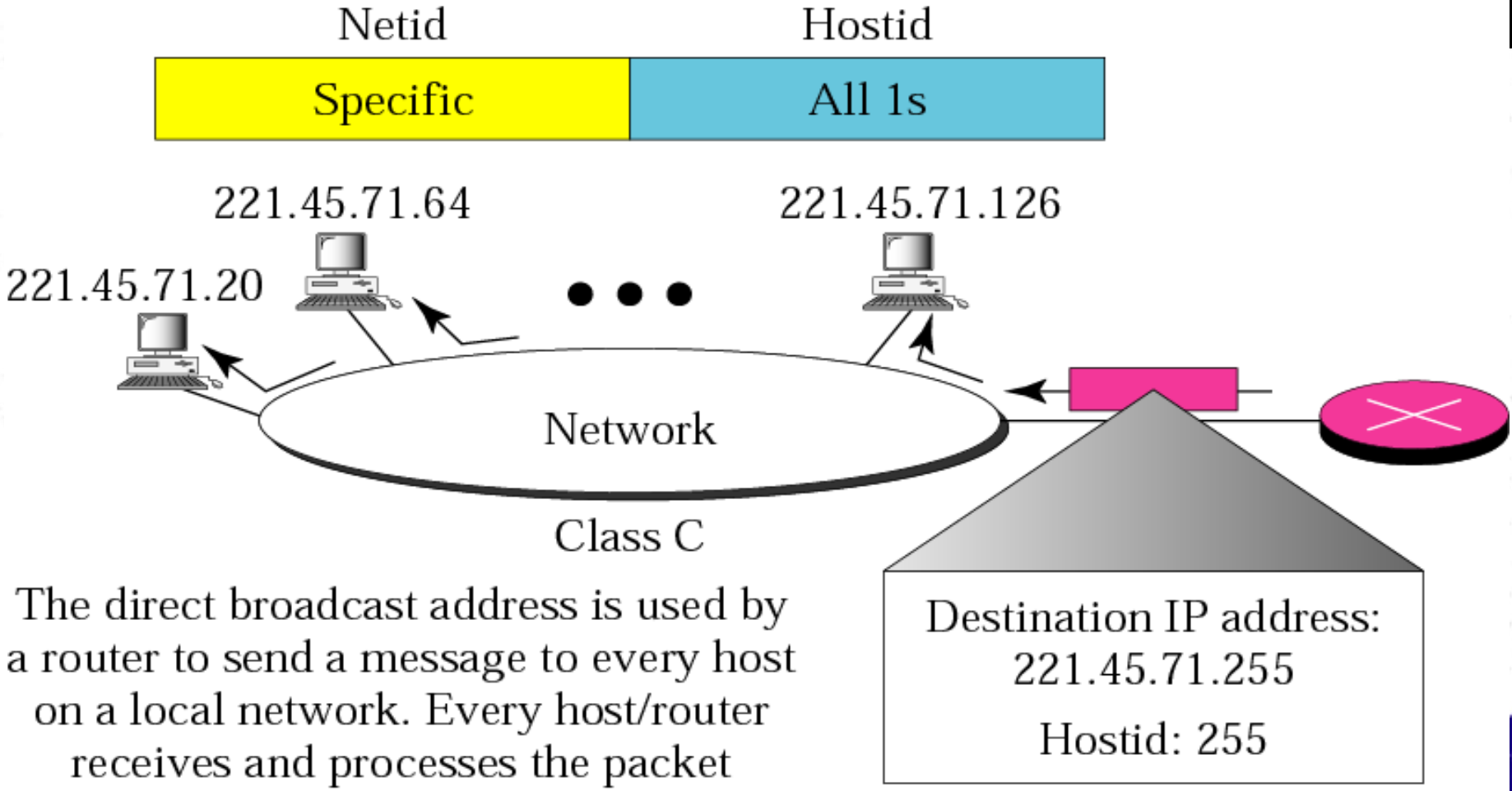
IP special addresses

	Net ID	Host ID	Remarks
Network Address	Specific	All 0's	None
Direct Broadcast Address	Specific	All 1's	Destination Address
Limited Broadcast Address	All 1's	All 1's	Destination Address
This Host on this Network	All 0's	All 0's	Source Address
Specific host on this network	All 0's	Specific	Destination Address
Loopback Address	127	Any	Destination Address

Network Address

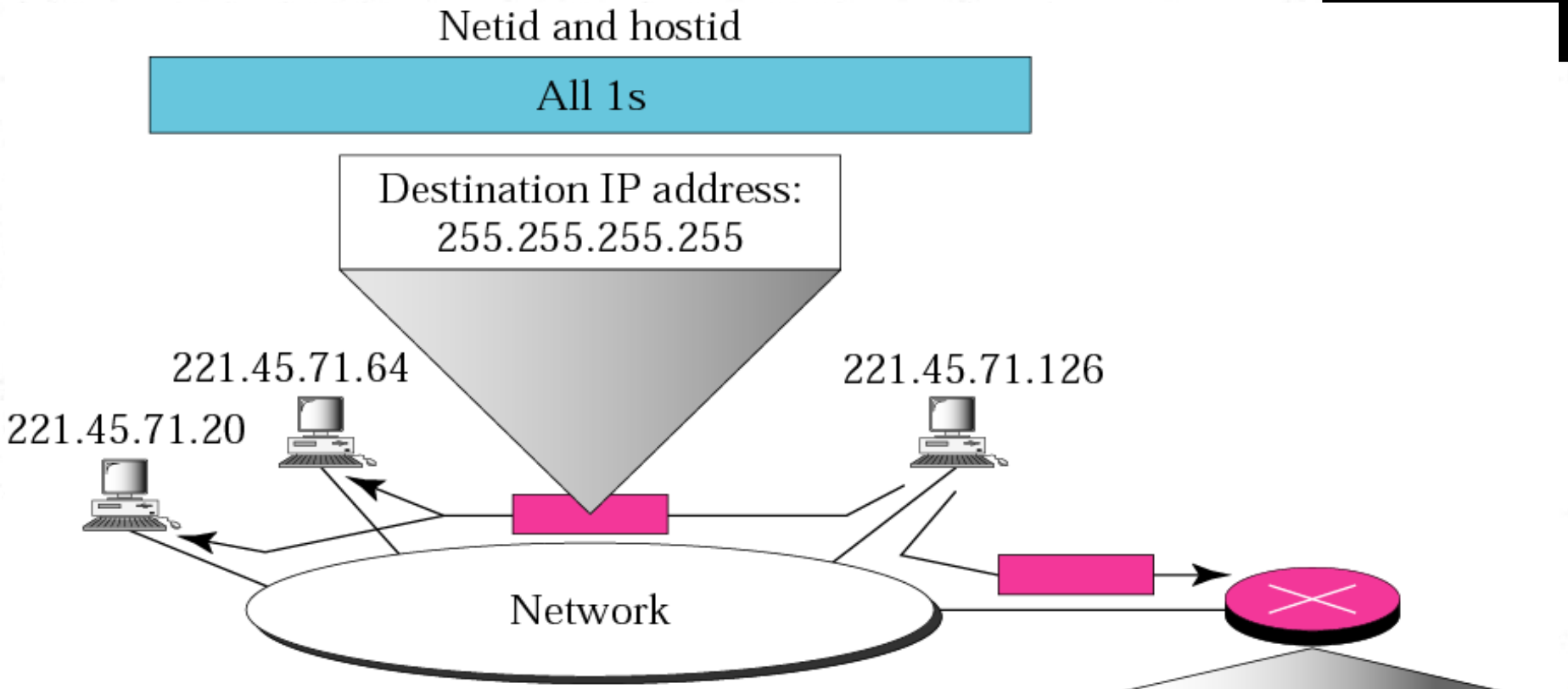


Direct Broadcast Address



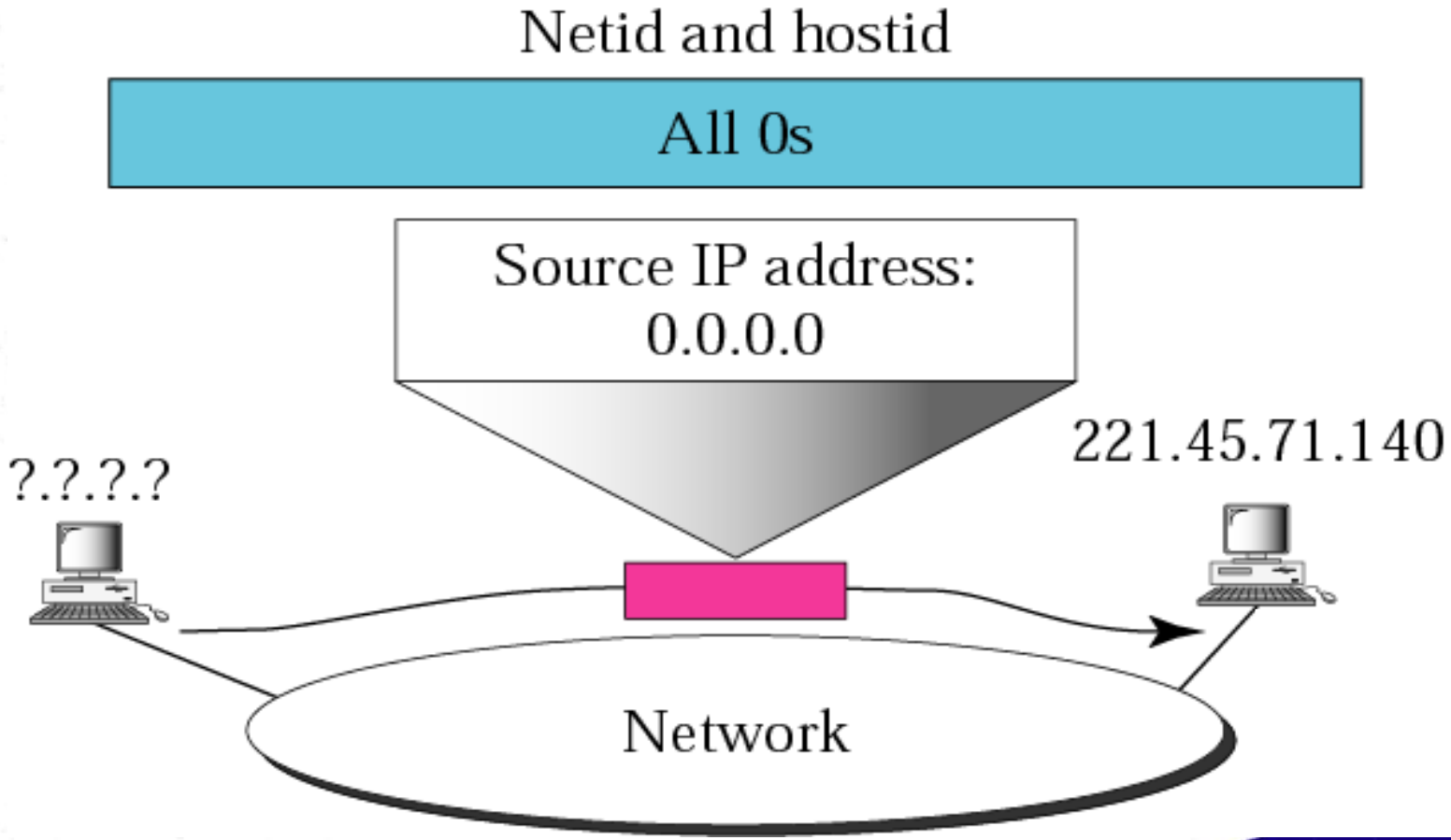
The direct broadcast address is used by a router to send a message to every host on a local network. Every host/router receives and processes the packet with a direct broadcast address.

Limited Broadcast Address

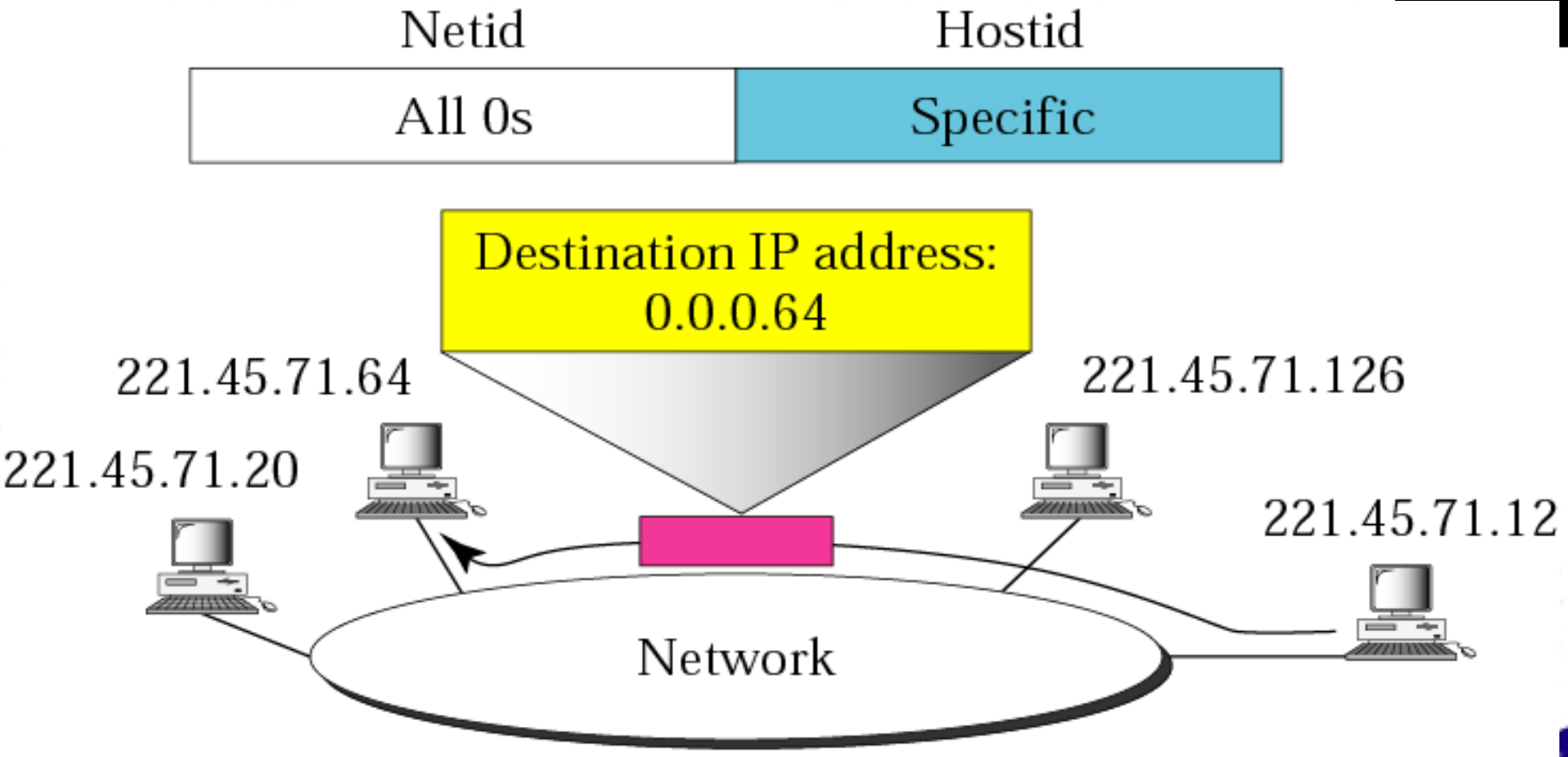


A limited broadcast address is used by a host to send a packet to every host on the same network. However, the packet is blocked by routers to confine the packet to the local network.

This host on this network

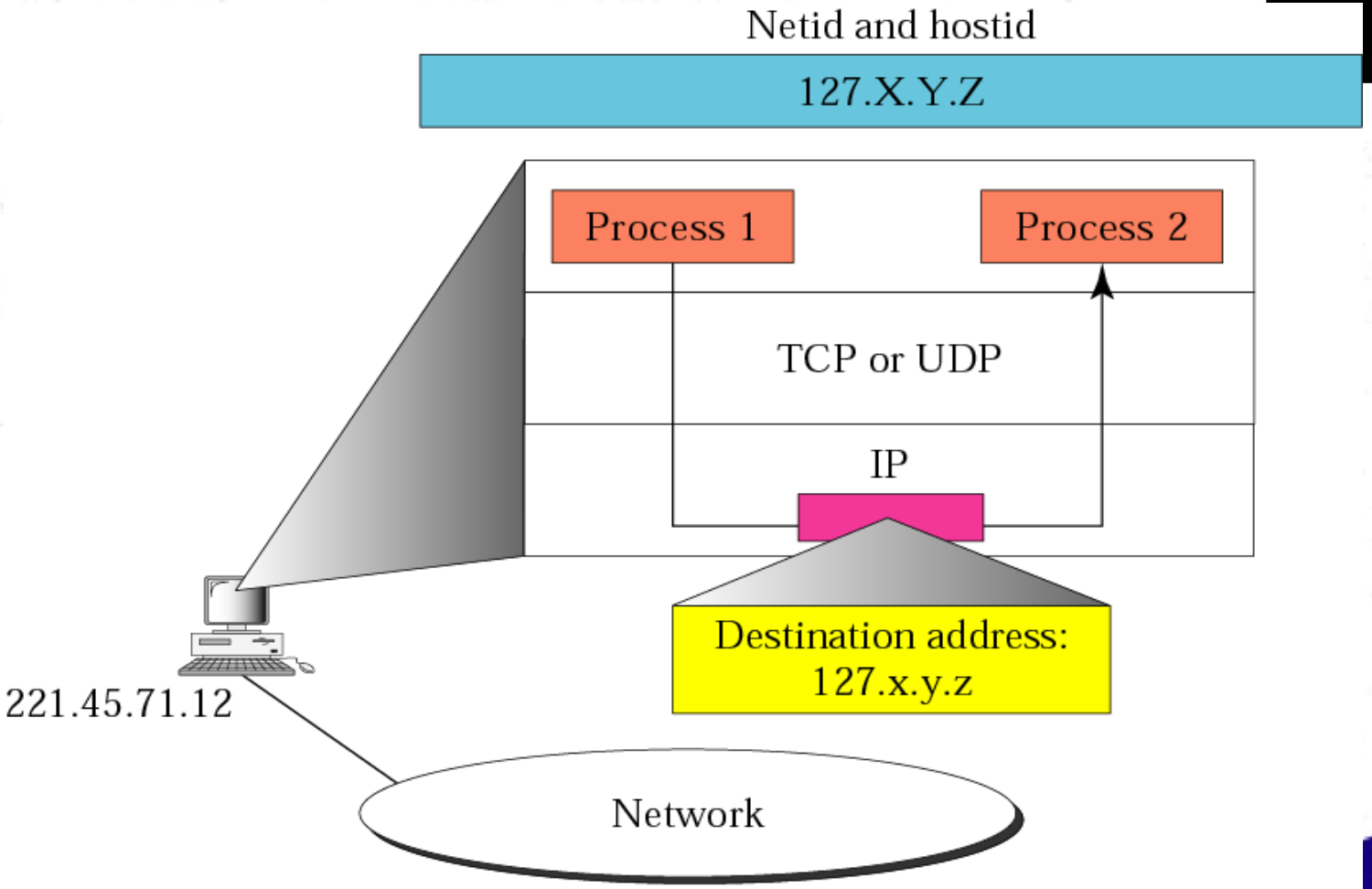


Specific host on this network



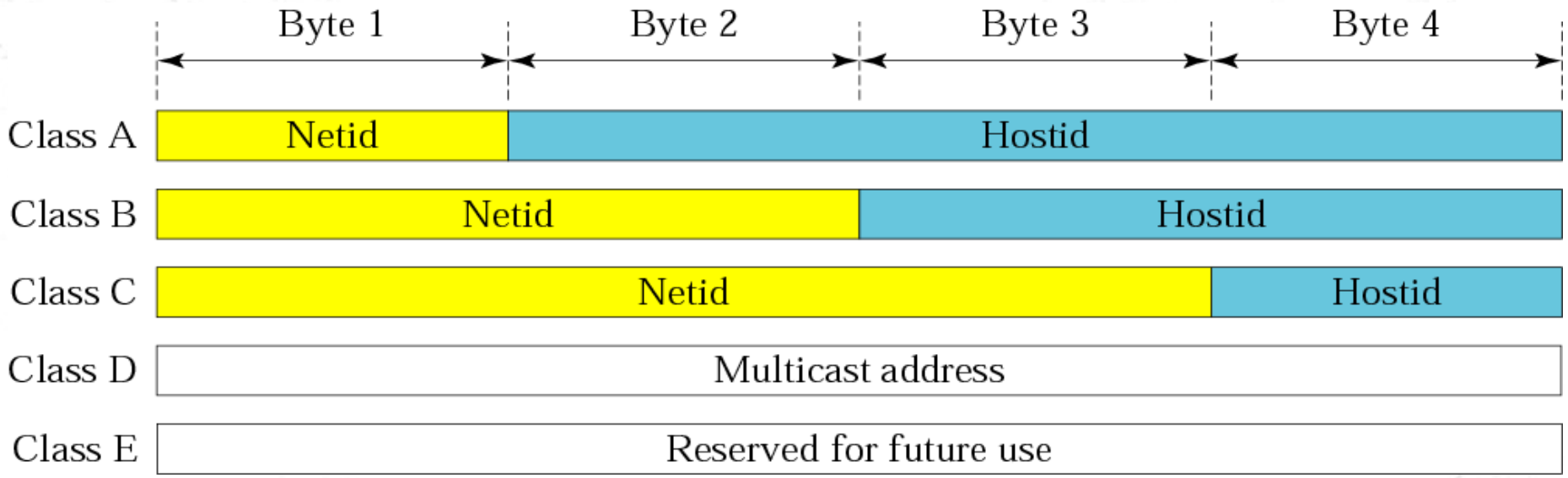
This address is used by a router or host
to send a message to a specific host on the same network.

Loopback address

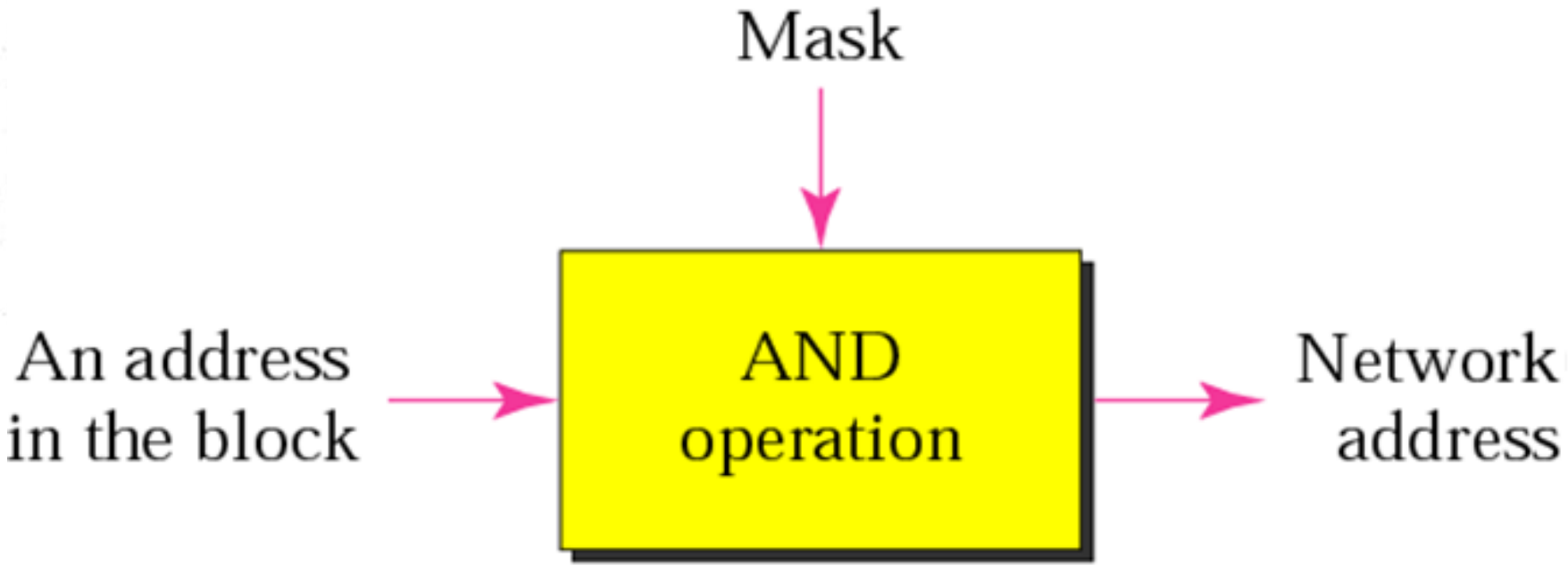


A packet with a loopback address will not reach the network.

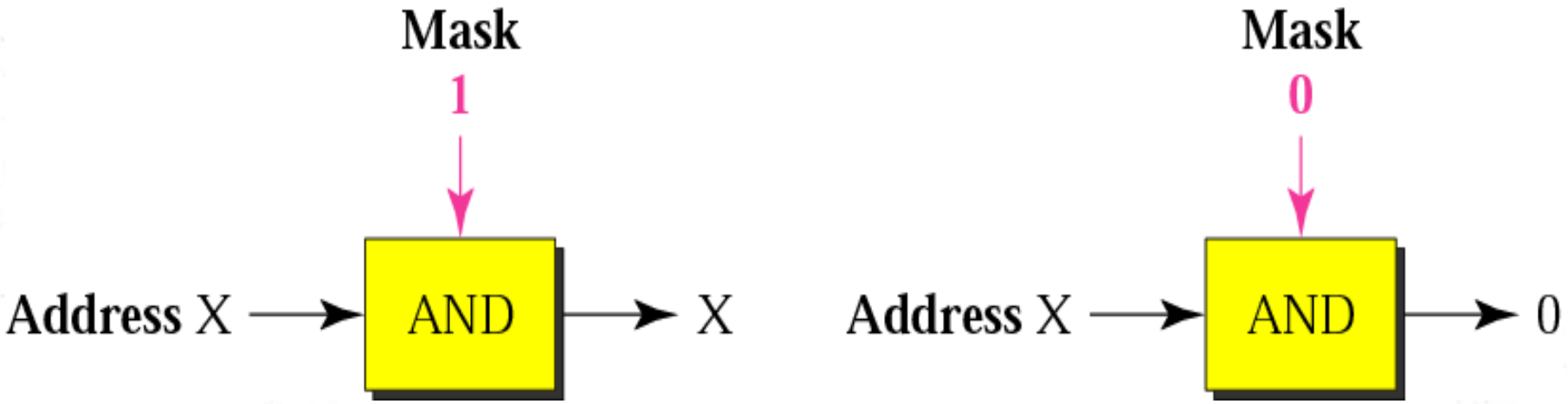
Classful Addressing



Masking Concept



AND Operation



Subnetting – Classless Addressing

- Suppose you are given a network address 150.100.0.0 /16 for your network.

  10010110.01100100.00000000.00000000

- You have the computers of Finance, Production and Administration Sections. In order to enhance the efficiency of network you want divide this into three networks. But you cannot get another two network addresses. This requirement can be satisfied from the same network address by using the subnet concept.

- Now the IP address is divided into three parts.

  Net ID Subnet ID Host ID

Classless Addressing cont

- The original Net ID bits not changed.
- Part of Host ID is allocated for “Subnet ID”.
- Most significant bits allocated as Subnet ID.

XXXX XXXX. XXXX XXXX.. XXXX XXXX. XXXX XXXX

Net ID Subnet ID Host ID

Classless Addressing cont.

- subnets can be written as

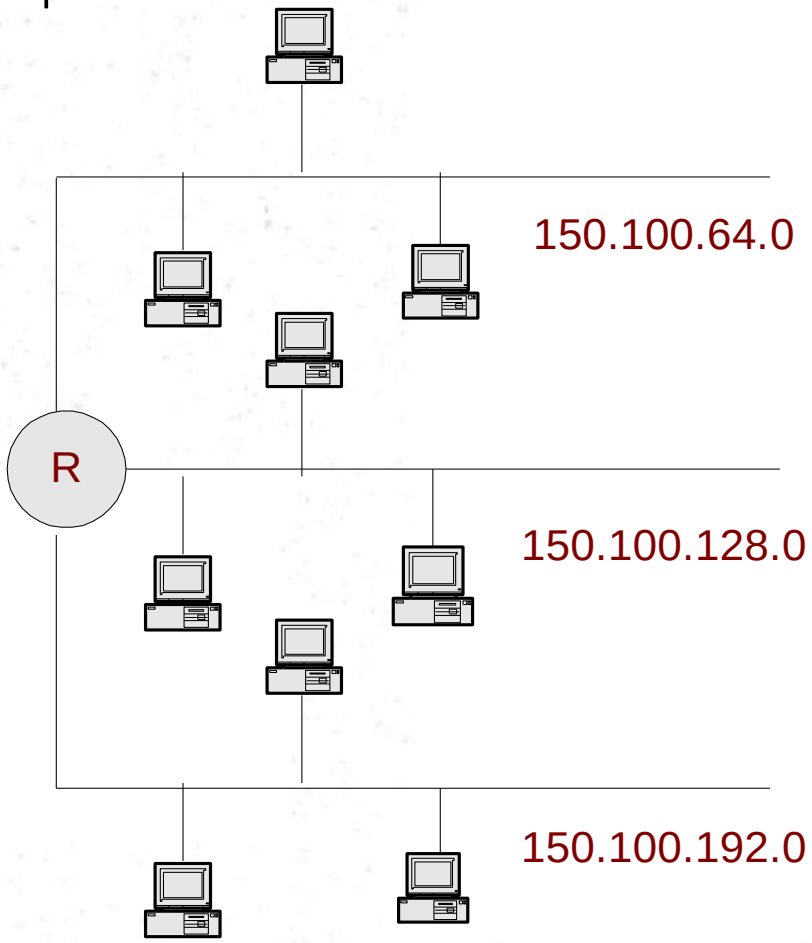
Subnet 0	10010110.01100100.00000000.00000000
Subnet 1	10010110.01100100.01000000.00000000
Subnet 2	10010110.01100100.10000000.00000000
Subnet 3	10010110.01100100.11000000.00000000

- In dotted decimal, it can be written as,

Subnet 0 address	150.100.0.0 /18
Subnet 1 address	150.100.64.0 /18
Subnet 2 address	150.100.128.0 /18
Subnet 3 address	150.100.192.0 /18

Classless Addressing cont.

For the above example the Finance, Production and Administratio
can be put to three subnets as follows.



Consider the hosts in subnet 150.100.64.0

The IP addresses can be given as
150.100.64.1
150.100.64.2
150.100.64.3
150.100.64.4 etc.

Classless Addressing cont.

- In classless addressing the number of bits for network address cannot be decided.
- Indicated with a “/” symbol.
- The IP address is written as,

  150.100.64.1 /18

  150.100.64.2 /18

  150.100.64.3 /18

  the subnet mask will be,

  11111111.11111111.11000000.00000000

  255.255.192.0

- Write the possible 12 subnet addresses of 150.72.0.0 / 16 network.

- **150.72.0.0 / 20**
- **150.72.16.0 / 20**
- **150.72.32.0 / 20**
- **150.72.48.0 / 20**
- **150.72.64.0 / 20**
- **150.72.80.0 / 20**
- **150.72.96.0 / 20**
- **150.72.112.0 / 20**
- **150.72.128.0 / 20**
- **150.72.144.0 / 20**
- **150.72.160.0 / 20**
- **150.72.176.0 / 20**

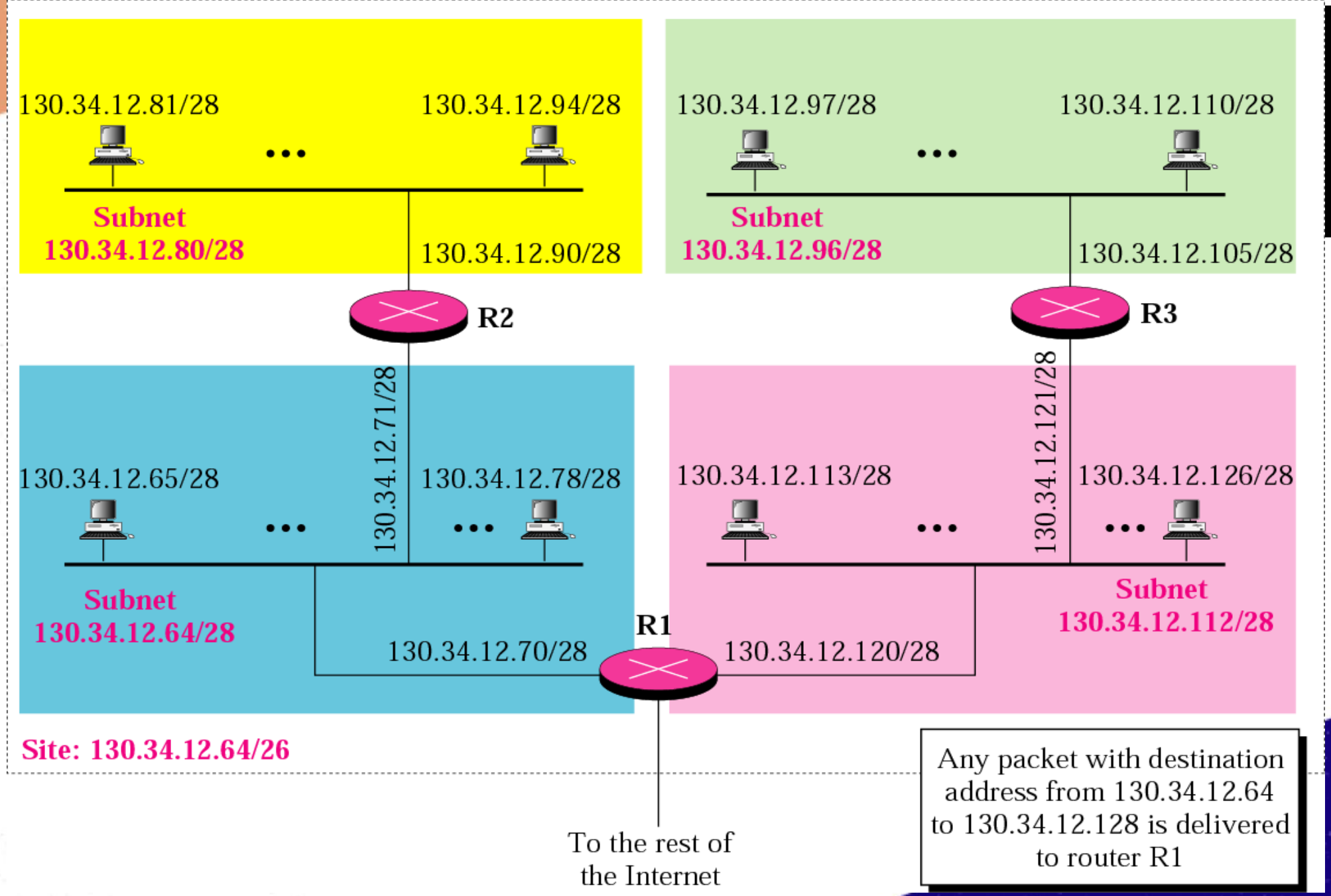
VLSM

Variable Length Sub-netting

- ***An organization is granted the block 130.34.12.64/26. The organization needs 4 subnets. What is the subnet prefix length?***

Solution

We need 4 subnets, which means we need to add two more bits ($log_2\ 4 = 2$) to the site prefix. The subnet prefix is then /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

VLSM

- Variable Length subnet Masking
- The number of devices are not equal in all the subnets
- Prefixes vary for separate subnets

- **Class-full routing**
  - **Only allows for one subnet mask for all networks**

- **VLSM & Classless routing**
  - **The process of subnetting a subnet**
  - **More than one subnet mask can be used**
  - **More efficient use of IP addresses as compared to classfull IP addressing**

- *An organization is granted a block of addresses with the beginning address 14.24.74.0/24. There are 2^{32-24}= 256 addresses in this block. The organization needs to have 11 subnets as shown below:*

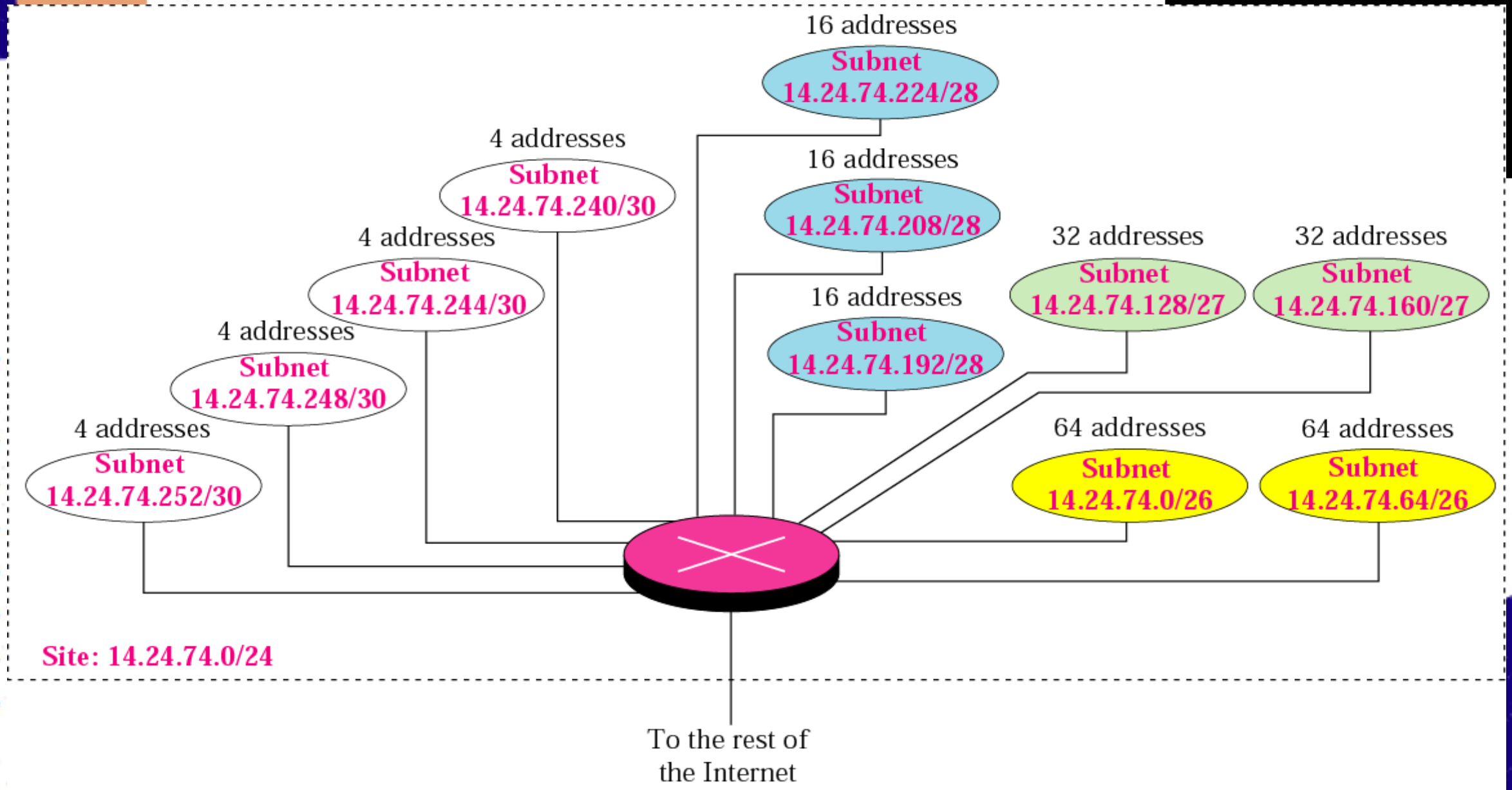
    a. 2 subnets, each with 64 ip addresses.[62 usable ip addresses]

    b. 2 subnets, each with 32 ip addresses.[30 usable ip addresses]

    c. 3 subnets, each with 16 addresses.[14 usable ip addresses]

    d. 4 subnets, each with 4 addresses.[2 usable ip addresses]

- *Design the subnets*


16 addresses
Subnet
14.24.74.224/28
4 addresses
Subnet
14.24.74.240/30
16 addresses
Subnet
14.24.74.208/28
4 addresses
Subnet
14.24.74.244/30
32 addresses
Subnet
14.24.74.128/27
32 addresses
Subnet
14.24.74.160/27
4 addresses
Subnet
14.24.74.248/30
16 addresses
Subnet
14.24.74.192/28
4 addresses
Subnet
14.24.74.252/30
64 addresses
Subnet
14.24.74.0/26
64 addresses
Subnet
14.24.74.64/26
Site: 14.24.74.0/24
To the rest of
the Internet

VLSM Example using /30 subnets

207.21.24.0/24 network subnetted into eight /27 (255.255.255.224) subn

- **This network has seven /27 subnets with 30 hosts each *AND* eight /30 subnets with 2 hosts each.**
- **/30 subnets are very useful for serial networks.**

Subnet 0	207.21.24.0 /27
Subnet 1	207.21.24.32 /27
Subnet 2	207.21.24.64 /27
Subnet 3	207.21.24.96 /27
Subnet 4	207.21.24.128 /27
Subnet 5	207.21.24.160 /27
Subnet 6	207.21.24.192 /27
Subnet 7	207.21.24.224 /27

Sub-subnet 0	207.21.24.192 /30
Sub-subnet 1	207.21.24.196 /30
Sub-subnet 2	207.21.24.200 /30
Sub-subnet 3	207.21.24.204 /30
Sub-subnet 4	207.21.24.208 /30
Sub-subnet 5	207.21.24.212 /30
Sub-subnet 6	207.21.24.216 /30
Sub-subnet 7	207.21.24.220 /30

207.21.24.192/27 subnet, subnetted into eight /30 (255.255.255.252) subnets

Subnet 0	207.21.24.0 /27
Subnet 1	207.21.24.32 /27
Subnet 2	207.21.24.64 /27
Subnet 3	207.21.24.96 /27
Subnet 4	207.21.24.128 /27
Subnet 5	207.21.24.160 /27
Subnet 6	207.21.24.192 /27
Subnet 7	207.21.24.224 /27

Sub-subnet 0	207.21.24.192 /30
Sub-subnet 1	207.21.24.196 /30
Sub-subnet 2	207.21.24.200 /30
Sub-subnet 3	207.21.24.204 /30
Sub-subnet 4	207.21.24.208 /30
Sub-subnet 5	207.21.24.212 /30
Sub-subnet 6	207.21.24.216 /30
Sub-subnet 7	207.21.24.220 /30

207.21.24.192/27 207.21.24. 11000000

			/30	Hosts	Bcast	2 Hosts
0	207.21.24.192/30	207.21.24.	110 00000	01	10	11 .193 & .194
1	207.21.24.196/30	207.21.24.	110 00100	01	10	11 .197 & .198
2	207.21.24.200/30	207.21.24.	110 01000	01	10	11 .201 & .202
3	207.21.24.204/30	207.21.24.	110 01100	01	10	11 .205 & .206
4	207.21.24.208/30	207.21.24.	110 10000	01	10	11 .209 & .210
5	207.21.24.212/30	207.21.24.	110 10100	01	10	11 .213 & .214
6	207.21.24.216/30	207.21.24.	110 11000	01	10	11 .217 & .218
7	207.21.24.220/30	207.21.24.	110 11100	01	10	11 .221 & .222

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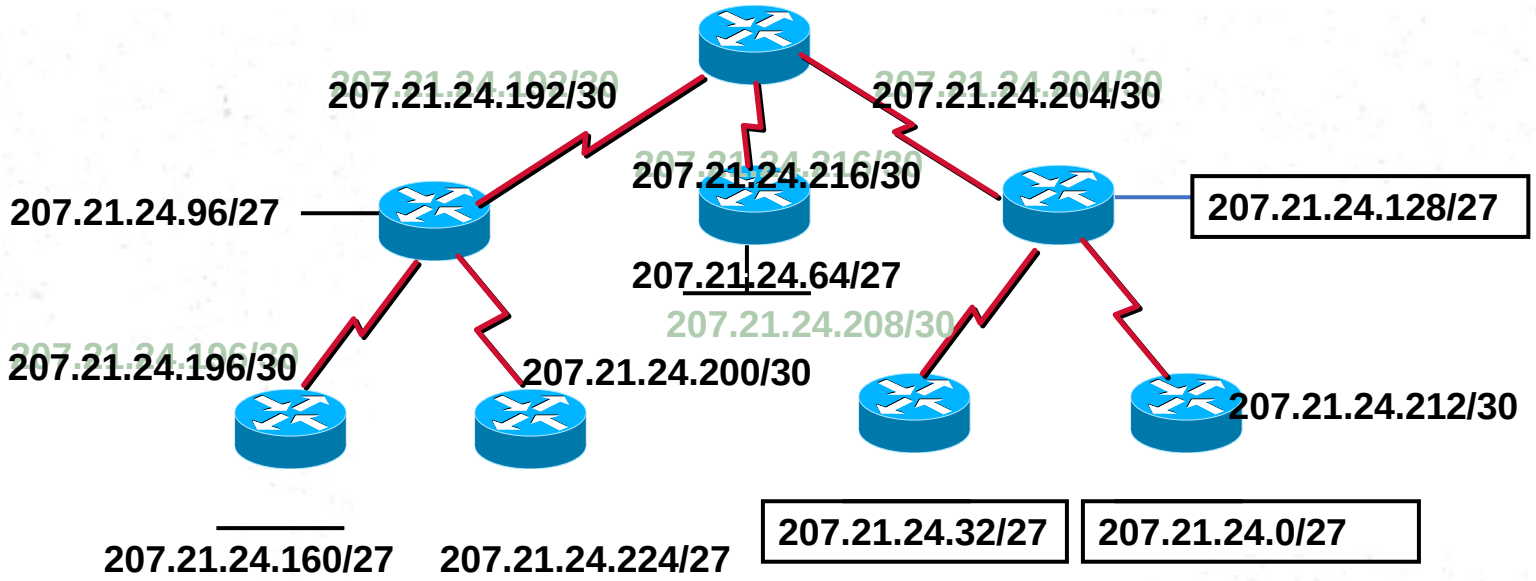
graziani@cabrillo.ed

Subnet 0	207.21.24.0 /27
Subnet 1	207.21.24.32 /27
Subnet 2	207.21.24.64 /27
Subnet 3	207.21.24.96 /27
Subnet 4	207.21.24.128 /27
Subnet 5	207.21.24.160 /27
Subnet 6	207.21.24.192 /27
Subnet 7	207.21.24.224 /27

Sub-subnet 0	207.21.24.192 /30
Sub-subnet 1	207.21.24.196 /30
Sub-subnet 2	207.21.24.200 /30
Sub-subnet 3	207.21.24.204 /30
Sub-subnet 4	207.21.24.208 /30
Sub-subnet 5	207.21.24.212 /30
Sub-subnet 6	207.21.24.216 /30
Sub-subnet 7	207.21.24.220 /30



- This network has seven /27 subnets with 30 hosts each *AND* seven /30 subnets with 2 hosts each (one left over).
- /30 subnets with 2 hosts per subnet do not waste host addresses on serial networks .

VLSM and the Routing Table

```
Routing Table without VLSM
RouterX#show ip route
     207.21.24.0/27 is subnetted, 4 subnets
C       207.21.24.192 is directly connected, Serial0
C       207.21.24.196 is directly connected, Serial1
C       207.21.24.200 is directly connected, Serial2
C       207.21.24.204 is directly connected, FastEthernet0
```

Displays one subnet mask for all child routes. Classful mask is assumed for the parent route.

Each child routes displays its own subnet mask. Classful mask is included for the parent route.

```
Routing Table with VLSM
RouterX#show ip route
     207.21.24.0/24 is variably subnetted, 4 subnets, 2 masks
C       207.21.24.192 /30 is directly connected, Serial0
C       207.21.24.196 /30 is directly connected, Serial1
C       207.21.24.200 /30 is directly connected, Serial2
C       207.21.24.96  /27 is directly connected, FastEthernet0
```

- Parent Route shows classful mask instead of subnet mask of the child routes.
- Each Child Routes includes its subnet mask.