Lecture 8

Internet (continued)

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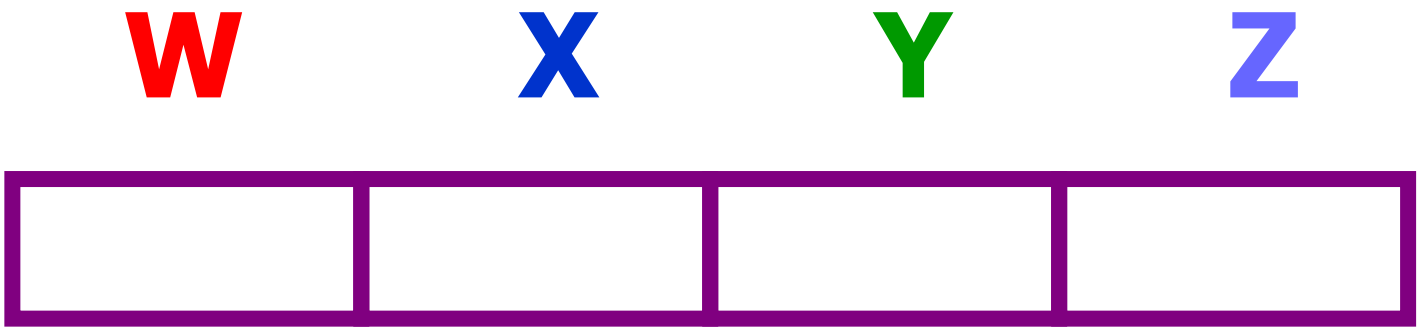
Addresses

- IP Address field consists of 4 bytes = 32 bits



- Decimal values range from :

0 . 0 . 0 . 0 ==> 255 . 255 . 255 . 255

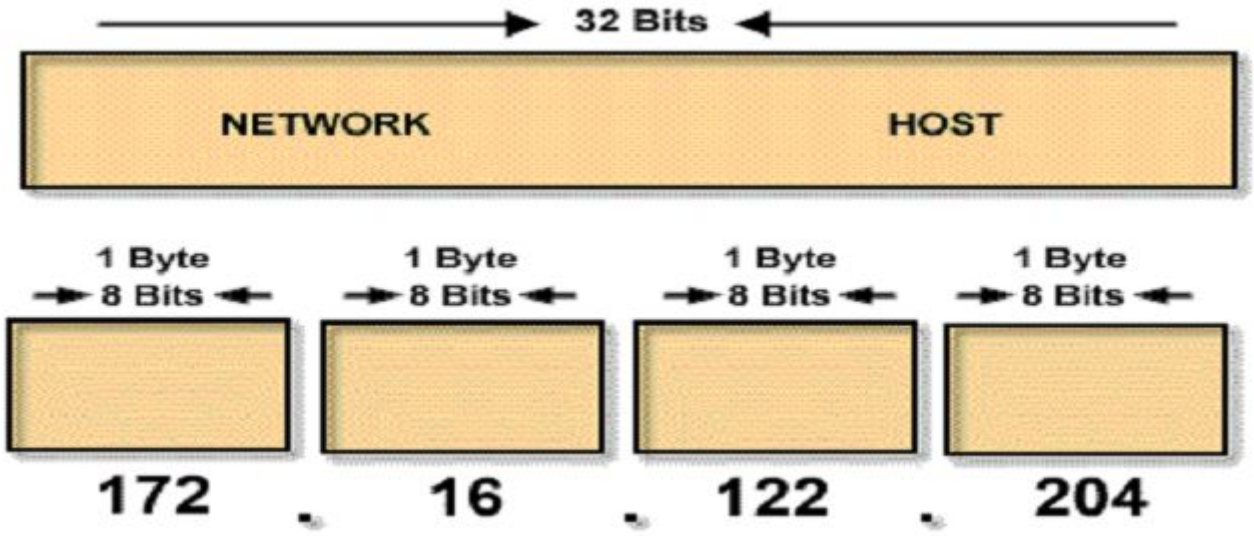
Above notation is called Decimal Dotted Notation (DDN)

Addresses (continued)

- For the Internet, IP Address field has been divided into two parts :

Subnetwork ID and Host ID

Example :



Addresses (continued)

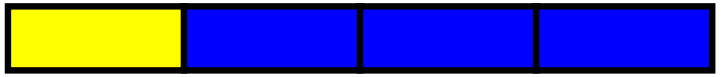
- Addressing of the Internet evolved through 3 stages :

Class-based Addressing
Subnetting
Classless InterDomain Routing (CIDR)

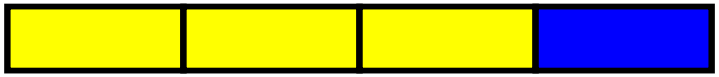
- Class-based Addressing

  * Bits of IP address are assigned to Subnetwork ID/Host ID in units of “bytes” :

small # of bytes for Subnetwork ID
large # of bytes for Host ID
==> Many Hosts (i.e. large NWs)



large # of bytes for Subnetwork ID
small # of bytes for Host ID
==> Few Hosts (i.e. small NWs)



- Class-based Addressing (continued)

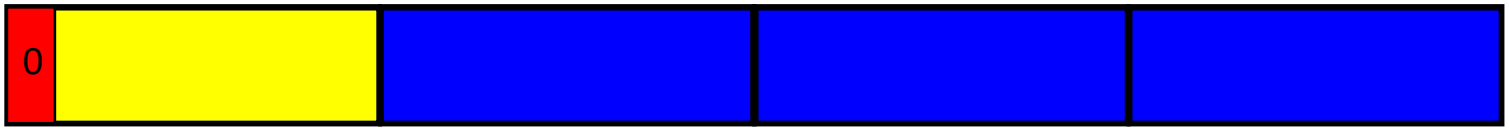
* FOUR classes have been identified :
A , B , C , D (for normal use) + 5th class E (for Research)

* Class A :

(1-126).xxx.xxx.xxx

Fixed #. xxx.xxx.xxx

# of NW's = 126 (Small)
# of Hosts = 16 x 10^6 (Large)



Example

15.xxx.xxx.xxx

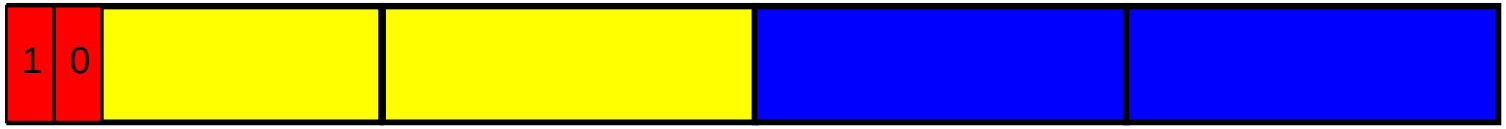
- Class-based Addressing (continued)

* Class B :

(128-191).xxx.xxx.xxx

Fixed #. Fixed #.xxx.xxx

# of NW's = 16,000 (Medium)
# of Hosts = 64,000 (Medium)



Example

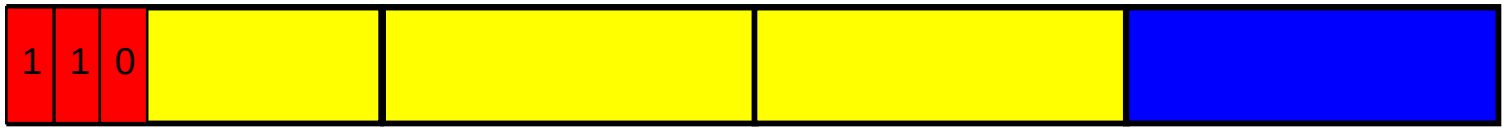
163.121.xxx.xxx

* Class C :

(192-223).xxx.xxx.xxx

Fixed #. Fixed #.Fixed #.xxx

# of NW's = 2 x 10^6 (Large)
# of Hosts = 256 (Small)



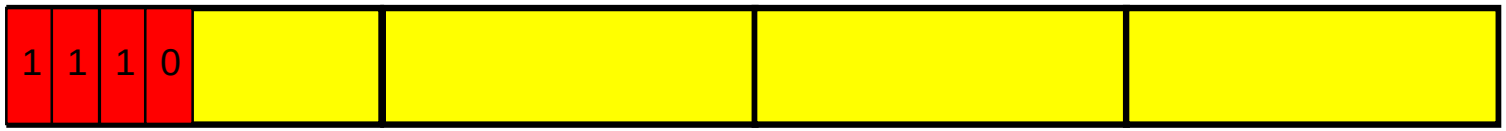
Example

206.103.30.xxx

- Class-based Addressing (continued)
  * Class D (Multicast):

(224-239).xxx.xxx.xxx

Fixed #. Fixed #.Fixed #.Fixed # *# of NW's = 256 x 10^6*



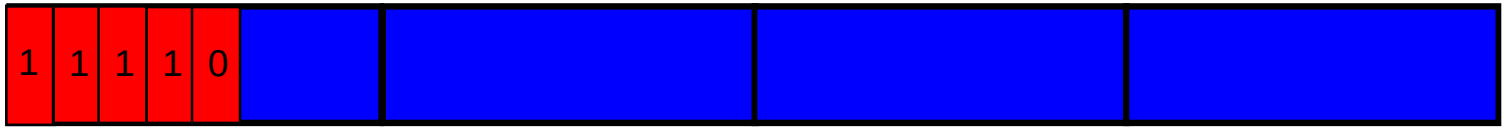
Example

231.57.148.220

* Class E (Research):

(240-247).xxx.xxx.xxx

xxx.xxx.xxx.xxx *# of Hosts = 128 x 10^6*

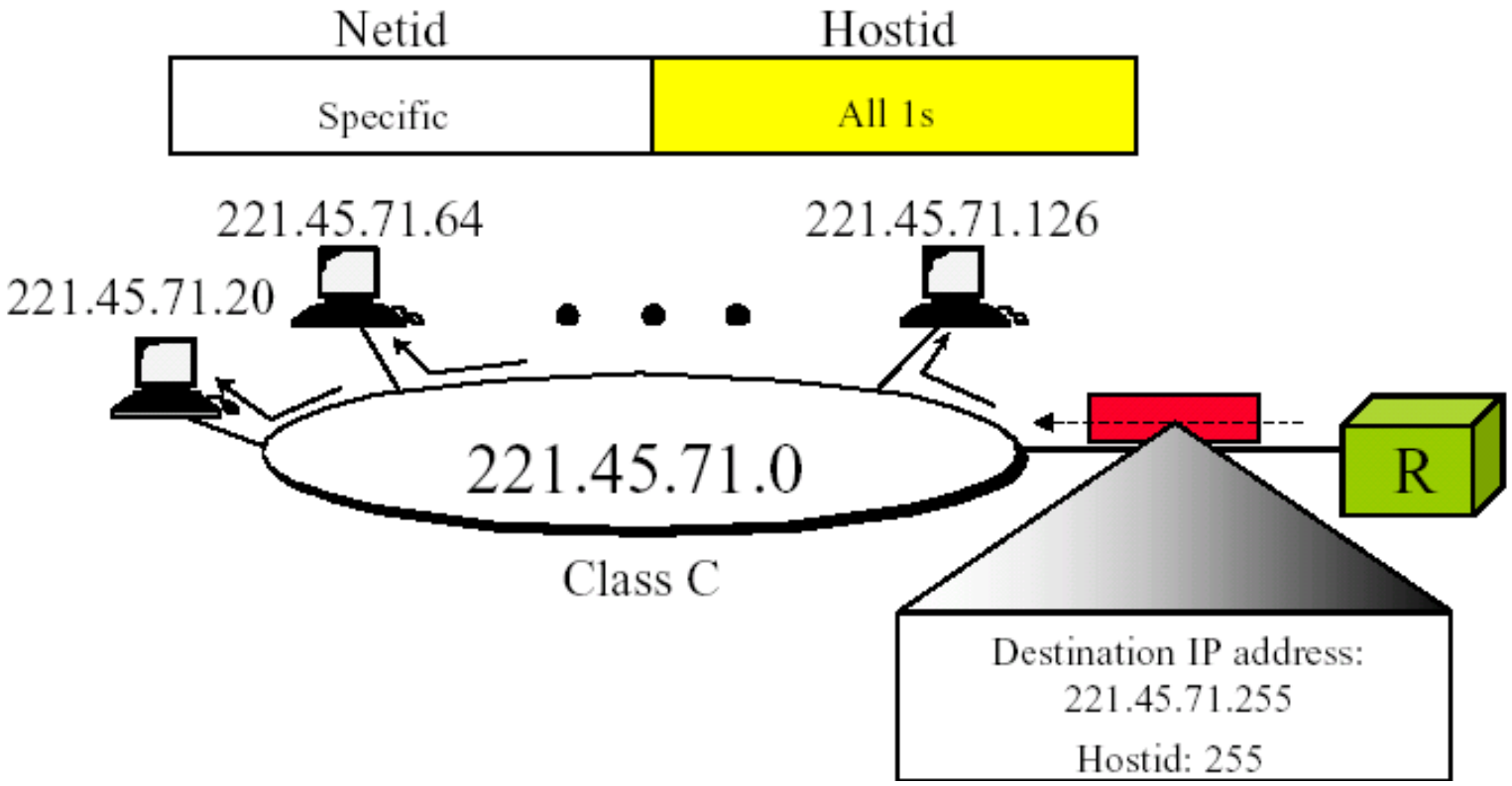


Example

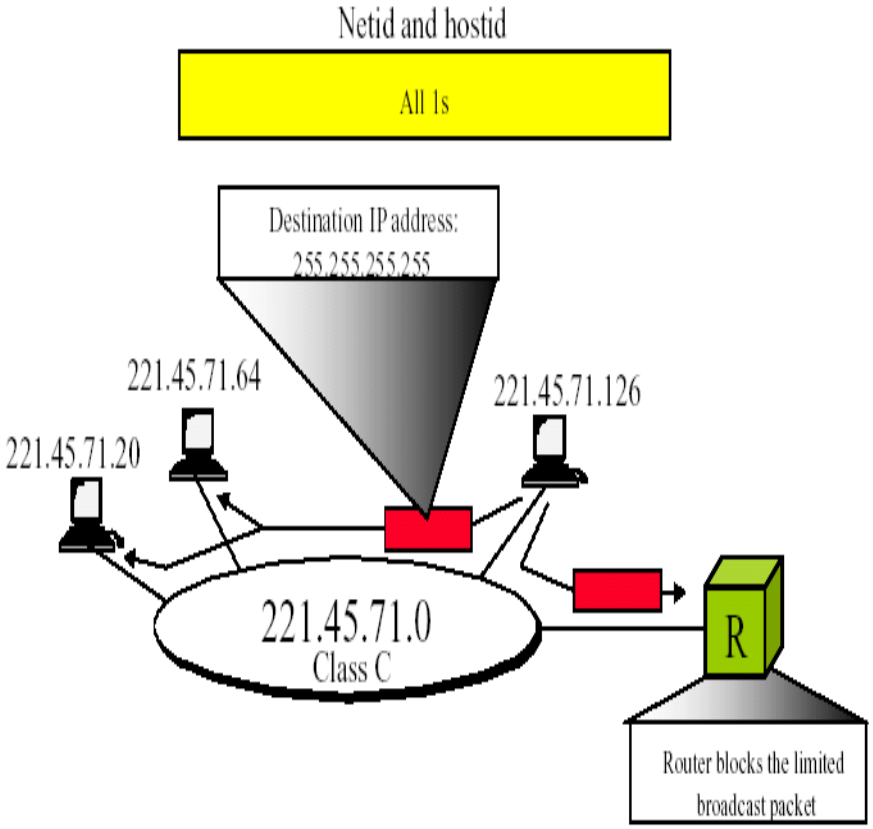
245.103.30.168

- Class-based Addressing (continued)

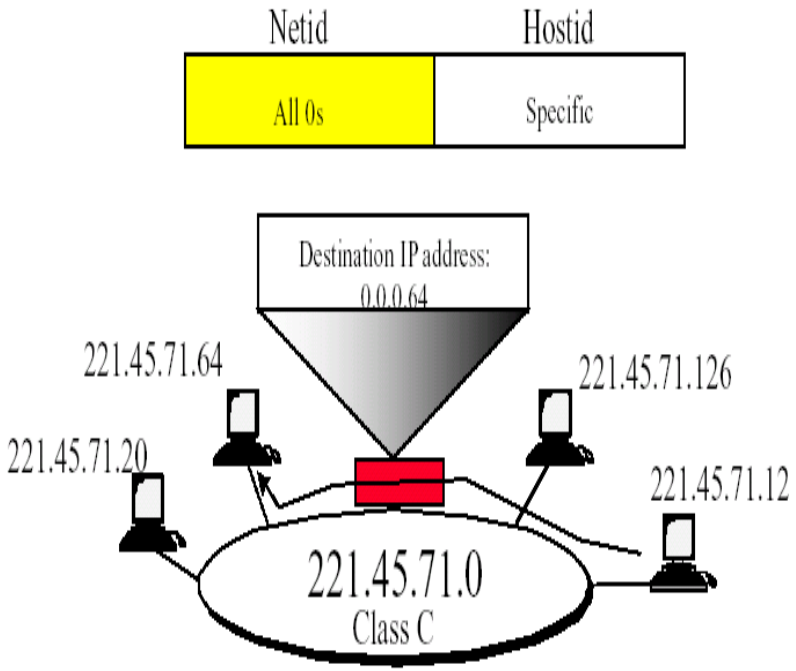
* Broadcasting scenarios in Class-based addressing :
  Direct Broadcast address



Limited broadcast address



Specific host on “this” network



Addresses (continued)

- Class Subnetting

* Motivation for subnetting :
  # of members (Hosts) in “actual” classes does not match with the actual needs of organizations/users + no more free Classes (!!!).
  Solution : Use subnetting
  Example :
    Suppose want to have 5 NWs each with 2000 nodes (Hosts).
    Class-based approach : get 5 Class B’s
    Subnetting approach : get 1 Class B & divide it into subnets

* Subnets are subdivisions of a Class A, B, or C network.
  They take on the properties of a network in many ways:
    - Members of ***one subnet*** have the same numeric value in the subnet parts of the addresses.
    - Members of ***one subnet*** cannot be separated by a router.
    - Members of ***a second subnet*** must be separated from the first subnet by a router.

* Subnetting is not visible to the outside world.

- Class Subnetting (continued)
  * Implementing Subnetting
    Example :
      Consider the class 128.32.xxx.xxx <== Class B
      Can utilize the last 16 bits - xxx.xxx - to create subnets
      Achieved by ***<u>using some (or all) of the bits in the 3rd byte</u>*** as subnet identifier. Thus

      128 . 32 . xxx .xxx =
      10000000.00100000.xxxxxxxx.xxxxxxxx (before Subnetting)

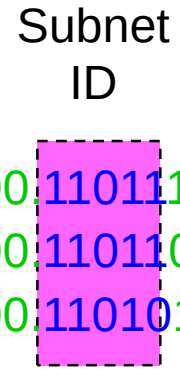
      Host ID

→ 10000000.00100000.11011xxx.xxxxxxxx (after Subnetting)

      Subnet ID Host ID

- Class Subnetting (continued)

Remarks:



R1 – For the three IP addresses :

IP#1 128.32.223.15 = 10000000.00100000.11011111.00001111

IP#2 128.32.217.15 = 10000000.00100000.11011001.00001111

IP#3 128.32.215.15 = 10000000.00100000.11010111.00001111

One has :

a) TWO subnets

128.32.216.0 = 10000000.00100000.11011000.00000000

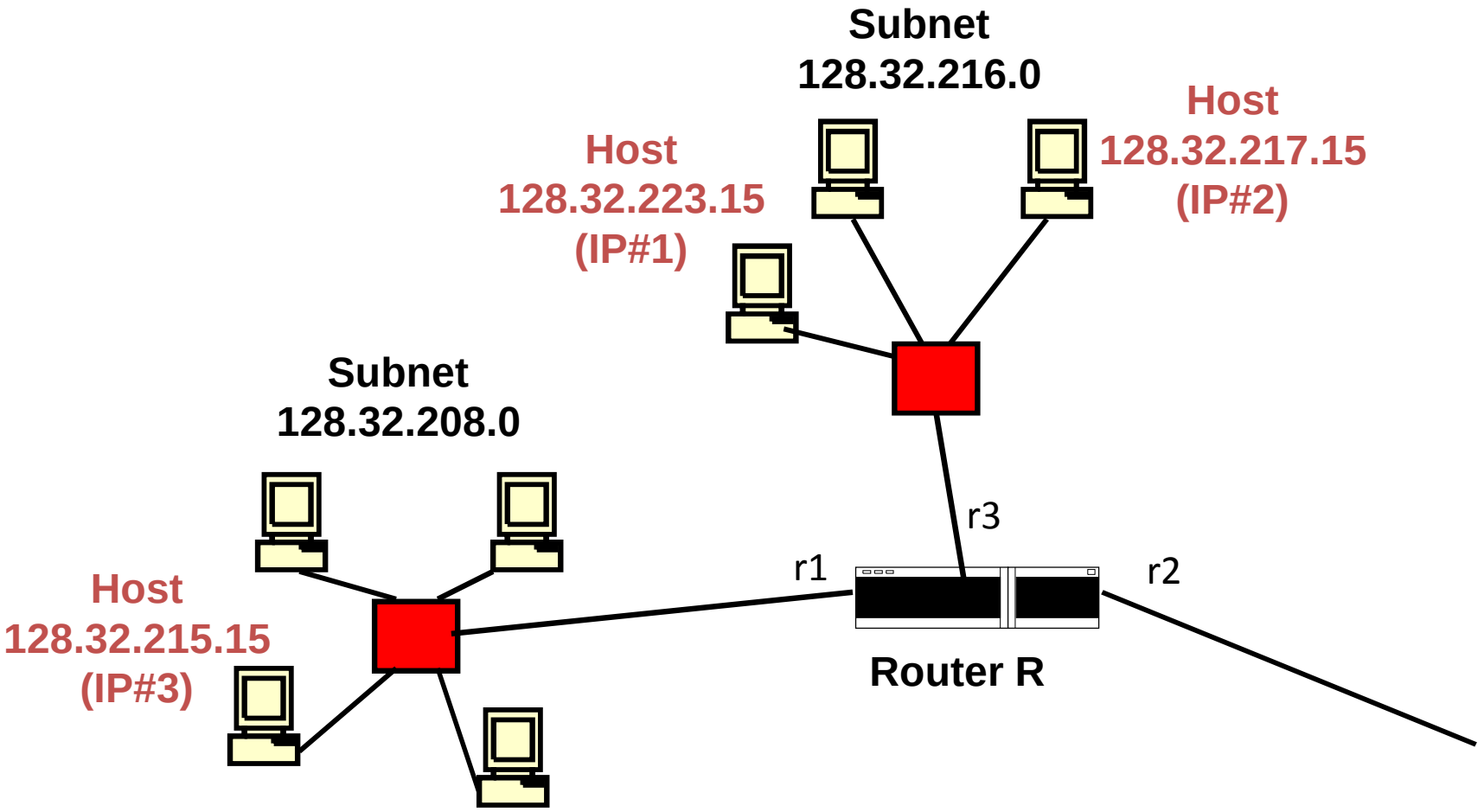
& 128.32.208.0 = 10000000.00100000.11010000.00000000

b) TWO addresses in the 1st Subnet (IP#1, IP#2)

c) ONE address in the 2nd Subnet (IP#3)

- Class Subnetting (continued)

R2 - Since IP#1 &IP#3 are not in the same Subnet, Host with IP#1 can access Host with IP#3 only through a router.



- Class Subnetting (continued)
  * Subnet Mask
    Is used to :
    - Enable a Host (which is a member of a Subnet) to know the range of bits assigned for the Network/Subnet ID (Important for the Host to decide whether or not to forward a pkt. to its gateway router).

Network ID of 128.32.223.15
= 128.32.0.0 (Class B) Without using a Mask

Network/Subnet ID of 128.32.223.15
= 128.32.216.0 (Subnetted Class B) With a Mask

To get the Network/Subnet ID of 128.32.223.15, we *hide the bits used for the Host ID* from the entire IP address :

10000000.00100000.11011111.00001111
= 128.32.216.0

Bits to be hidden

- Class Subnetting (continued)

Procedure for hiding bits of Host ID :

10000000.00100000.11011111.00001111

ANDed by :

11111111.11111111.11111000.00000000 (Mask)

gives :

10000000.00100000.11011000.00000000

= 128.32.216.0

The Mask has the value (in DDN) of : 255.255.248.0

Hence, when using class subnetting one should specify :

IP address + Subnet Mask

in order to to be able to identify the Network/Subnet ID part of the IP address.

Subnetting Examples

Address	130.4.100.1	1000 0010 0000 0100 0110 0100 0000 0001
Mask	255.255.255.128	1111 1111 1111 1111 1111 1111 1000 0000
Result	130.4.100.0	1000 0010 0000 0100 0110 0100 0000 0000

Address	199.1.1.4	1100 0111 0000 0001 0000 0001 0000 0100
Mask	255.255.255.224	1111 1111 1111 1111 1111 1111 1110 0000
Result	199.1.1.0	1100 0111 0000 0001 0000 0001 0000 0000

Address	172.100.201.2	1010 1100 0110 0100 1100 1001 0000 0010
Mask	255.255.254.0	1111 1111 1111 1111 1111 1110 0000 0000
Result	172.100.200.0	1010 1100 0110 0100 1100 1000 0000 0000

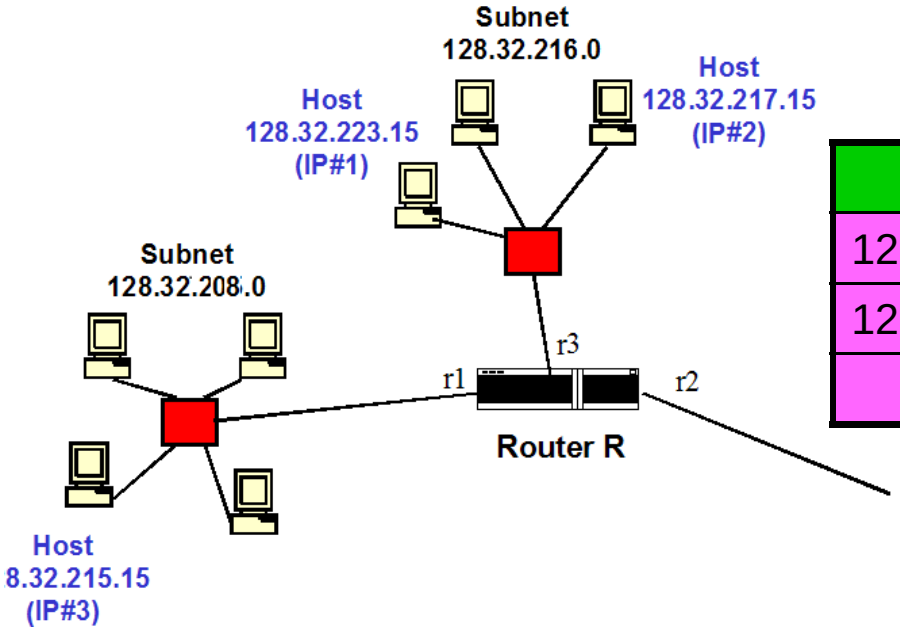
Address	17.9.44.70	0001 0001 0000 1001 0010 1100 0100 0110
Mask	255.255.255.192	1111 1111 1111 1111 1111 1111 1100 0000
Result	17.9.44.64	0001 0001 0000 1001 0010 1100 0100 0000

the broadcast address

Address	8.1.4.5	0000 1000 0000 0001 0000 0100 0000 0101
Mask	255.255.0.0	1111 1111 1111 1111 **0000 0000 0000 0000**
Subnet	8.1.0.0	0000 1000 0000 0001 0000 0000 0000 0000
Broadcast	8.1.255.255	0000 1000 0000 0001 **1111 1111 1111 1111**

Address	130.4.100.1	1000 0010 0000 0100 0110 0100 0000 0001
Mask	255.255.255.128	1111 1111 1111 1111 1111 1111 1000 0000
Subnet	130.4.100.0	1000 0010 0000 0100 0110 0100 0000 0000
Broadcast	130.4.100.127	1000 0010 0000 0100 0110 0100 **0111 1111**

- Class Subnetting (continued)
  * Subnet Mask
    Is used *also* to :
    - Enable a router to match the Network/Subnet ID of an incoming IP address with one of the Network/Subnet ID's it has in its routing table, thereby deciding which port a pkt. should be forwarded to.



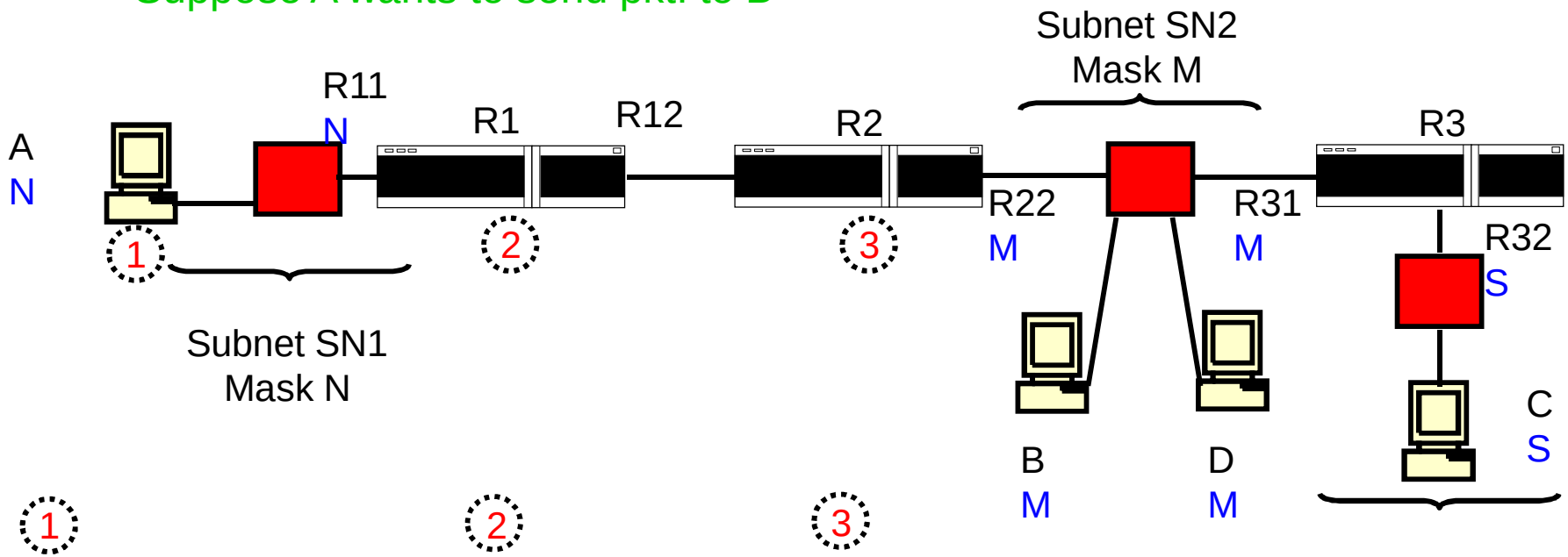
Routing Table for Router R

Subnet ID	Subnet Mask	Next Hop
128.32.216.0	255.255.248.0	r3
128.32.208.0	255.255.248.0	r1
Others		r2

- Class Subnetting (continued)
  * Illustration of routing using Subnet Mask

Let : Host 1 has (IP address A, Subnet SN1, Subnet Mask N)
Host 2 has (IP address B, Subnet SN2, Subnet Mask M)
Router R1 connects to SN1 and Router R2
Router R2 connects to R1 and SN2
Router R3 connects to SN2 and SN3

Suppose A wants to send pkt. to B



1 — A AND N Not = B AND N
➔ A, B in diff subnets
➔ send to R1

2 — R1 sends to R2 based on NW address & routing table

3 — R22 AND M = B AND M
➔ R22, B in same subnet
➔ Perform ARP

Addresses (continued)

- Classless InterDomain Routing (CIDR)
  * Motivation for CIDR :
    a) Need to aggregate several subnets (say of Class C) into one Supernet, in order to reduce # of ports in a router and # of entries in its routing table.

Example 1 :

Suppose have TWO Class C networks :

192.168.2.0/24 = 11000000.10101000.00000010.xxxxxxxx

192.168.3.0/24 = 11000000.10101000.00000011.xxxxxxxx

24 bits

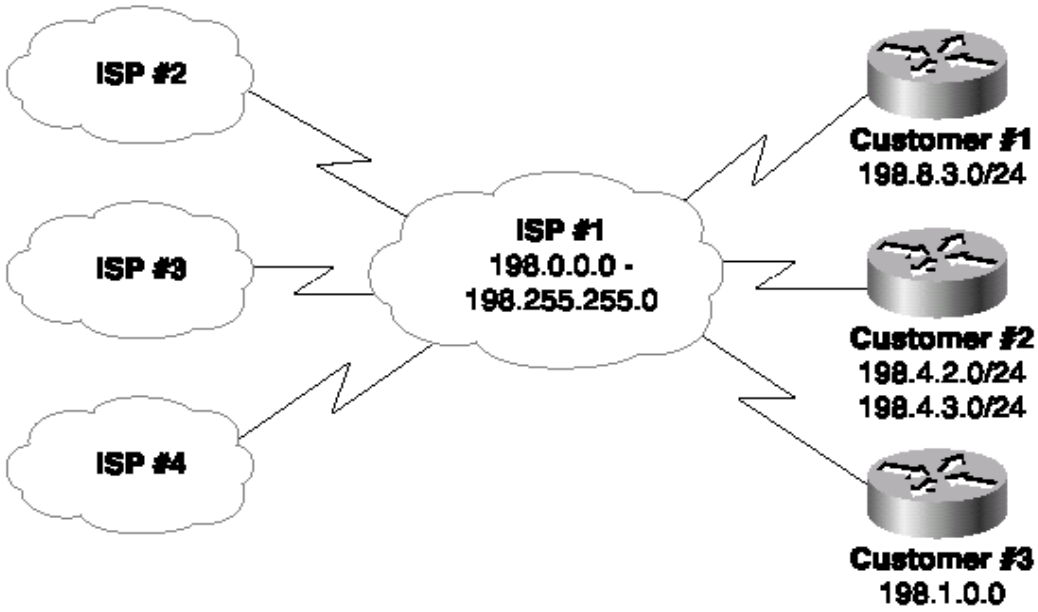
Using Supernetting, these two classes are aggregated into ONE Supernet with ID :

192.168.2.0/23 = 11000000.10101000.0000001x.xxxxxxxx

23 bits

- Classless InterDomain Routing (CIDR) (continued)

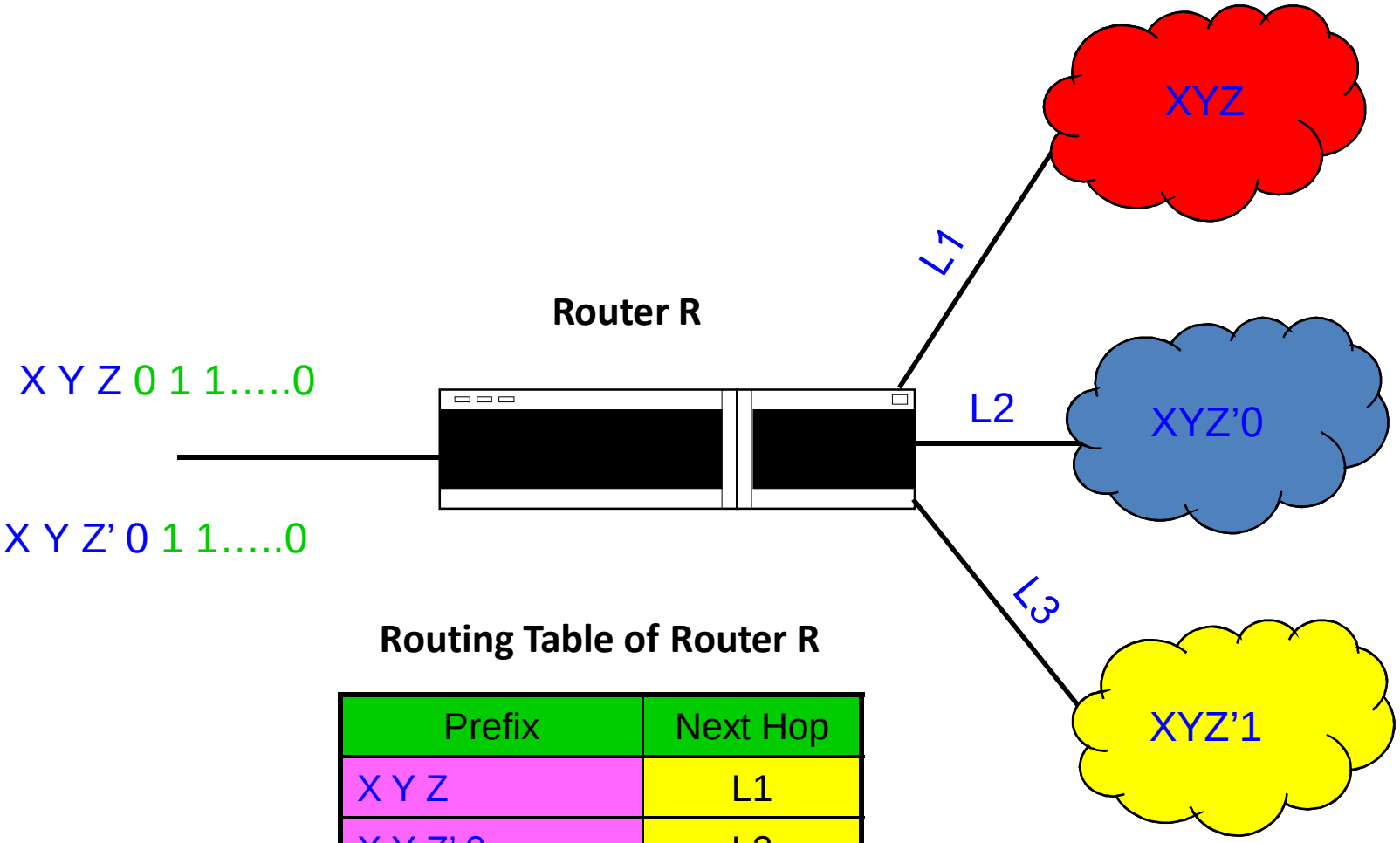
Example 2 :



* Without Supernetting, ISP#2, ISP#3, and ISP#4 should have different router ports and separate entries in the routing table for each Class C subnetwork belonging to ISP#1 (~ 216 Subnetworks)

* With Supernetting, all Class C subnetworks of ISP#1 are aggregated into one Supernet of ID : 198.0.0.0/8 (= 1 Subnetwork).

- Classless InterDomain Routing (CIDR) (continued)
  * Motivation for CIDR :
  b) Need to make full utilization of the entire range of IP addresses.
  Achieved by defining a "prefix" that characterizes a range of IP addresses, and using another "prefix" to characterize another range of IP addresses, such that deleting one bit (or more) from one prefix does not yield another prefix.
  Example :
  Addresses
  X Y Z x x x x x x
  X Y Z' 0 x x x x x
  X Y Z' 1 x x x x x
  belong to THREE different domains with prefixes :
  X Y Z
  X Y Z' 0
  X Y Z' 1
  Remark :
  Each domain will be connected to a different router port.



Routing Table of Router R

Prefix	Next Hop
X Y Z	L1
X Y Z' 0	L2
X Y Z' 1	L3