COMP9332
Network Routing & Switching

IPv4 Addressing

http://www.cse.unsw.edu.au/~cs9332/

Lecture overview

- Key concepts
  - Classful addressing
  - Network mask
  - Subnetting
  - Supernetting
  - Classless addressing
  - Private addressing and Network Address Translation (NAT)

Reference: Forouzan

IP addressing basics

- The Internet is used to "move" data from host to host
- All devices connected to the Internet must have a globally *unique* IP address
  - No two devices can have the same public IP address
  - This address can be permanent or temporary
- IPv4 addresses are 32 bits (= 4 octets) long
  - This gives 2^32 ~ 4.29 billion addresses

Notation

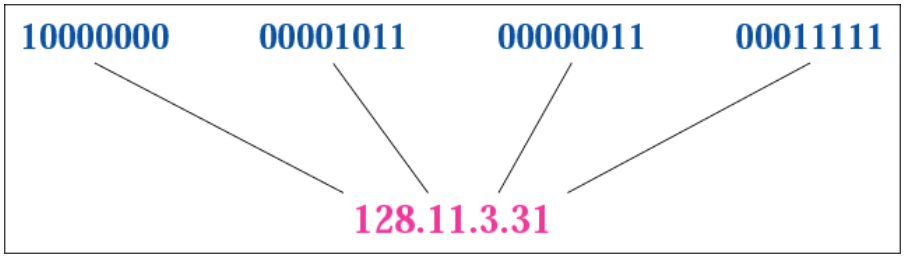
- IPv4 addresses can be written using the following notation
  - Binary
  - Dotted Decimal
  - Hexadecimal

Binary Notation

01110101 10010101 00011101 11101010

Figure 4-1

Dotted-decimal notation



Hexadecimal Notation

0111 0101 1001 0101 0001 1101 1110 1010

75 95 1D EA

0x75951DEA

Exercises

- Exercise 1:
  Change the following IP address from binary notation to dotted-decimal notation.
  10000001 00001011 00001011 11101111
- Exercise 2:
  Change the following IP address from dotted-decimal notation to binary notation.
  111.56.45.78

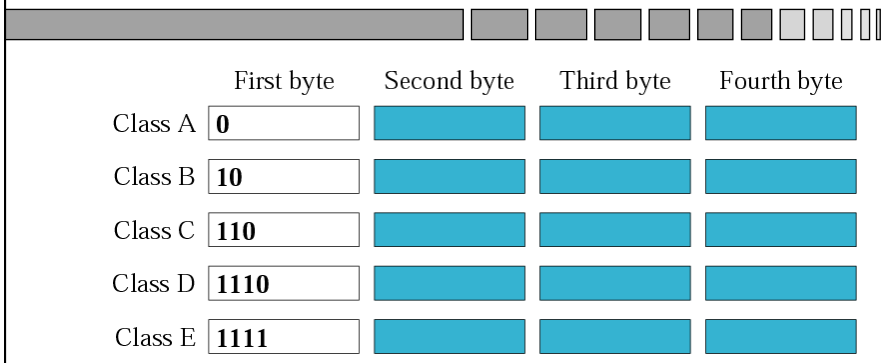
Solutions

- Exercise 1:
  129.11.11.239
- Exercise 2:
  01101111 00111000 00101101 01001110.

Classful addressing

- IP addresses were divided into 5 classes: A,B,C,D and E
  - This is the original scheme known as classful addressing
  - From mid-90's, classless addressing is introduced
  - However, classful addressing is still used

Finding the class in binary notation



Example: Any address whose first bit is 0 belongs to class A.
Any address whose first 2 bits are 10 belongs to class B etc.

Exercises

1. Find the class of these IP addresses:
   a) 11000001 10000011 00011011 11111111
   b) 10000001 10000011 00011011 11111111
2. How many class B addresses are there altogether?
3. What is the range of class B addresses? Answer this by giving the first and last class B addresses in dotted decimal notation.

Solution

1. a) First 3 bits are 110 -> Class C.
   b) First 2 bits are 10 -> Class B.
2. Class B addresses: the first two bits are 10 then followed by 30 bits of 1/0
   -> 2^30 addresses

3. The first and last class B addresses in binary are:

10000000 00000000 00000000 00000000
10111111 11111111 11111111 11111111

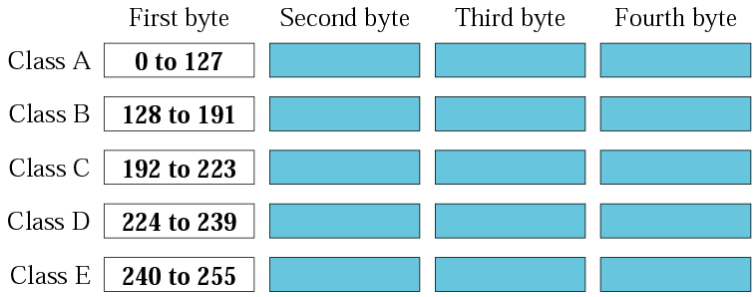
In dotted decimal notation, they are:

128.0.0.0 and 191.255.255.255

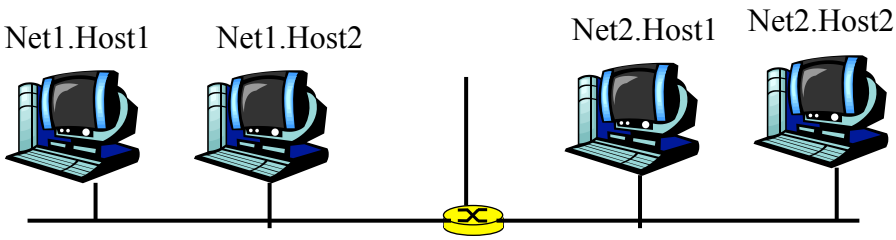
Finding the class in dotted decimal notation

- Given an IP address in dotted decimal notation, we can identify its class by looking at the first byte.
- Example: The first byte of a class C address is of the form 110x xxxx where x is either 0 or 1, which means that it ranges from 1100 0000 (192) to 1101 1111 (223)

Finding the class in decimal notation



IP addresses are hierarchical



Routing table:

Net1:	Interface1
Net2:	Interface2

CSE Routing is based on network address.

17

Netid and hostid

- IP addresses in classes A,B and C are divided into netid and hostid
  - Netid: Identifying the network
  - Hostid: Identifying a host within the network
- Hosts within a network
  - Have the same netid
  - But different hostid

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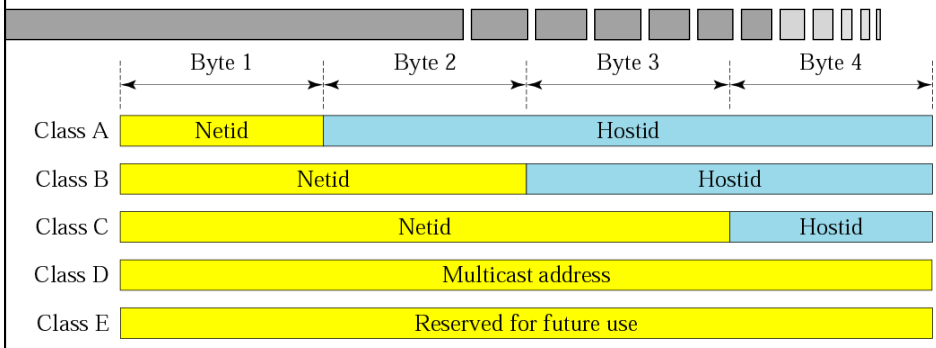
18

Netid and hostid



Classes and blocks

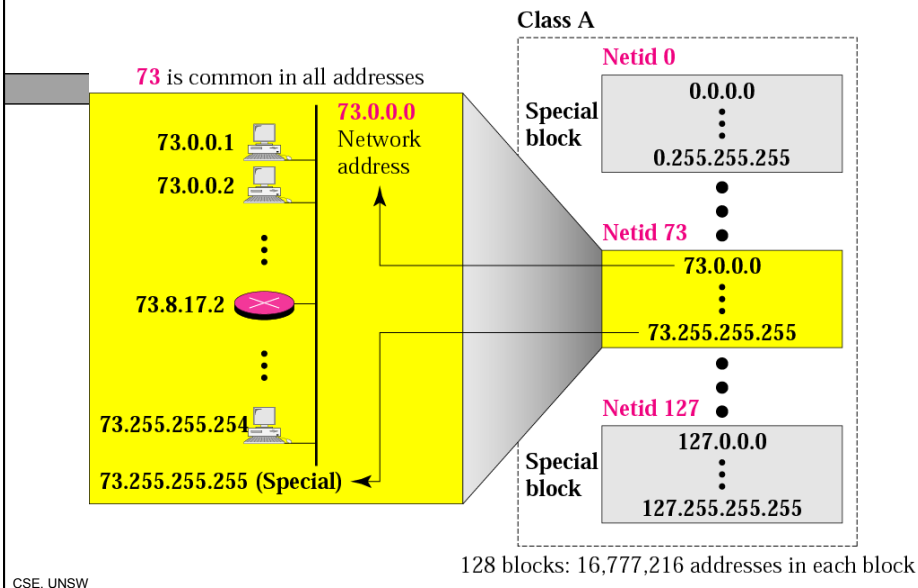
All addresses within a block have the same netid.
For the class A block with netid = 0, the addresses in the block are:

netid	hostid			
00000000	00000000	00000000	00000000	0.0.0.0
00000000	00000000	00000000	00000001	0.0.0.1
00000000	00000000	00000000	00000010	0.0.0.2
• • •				
00000000	11111111	11111111	11111111	0.255.255.255

Classes and blocks

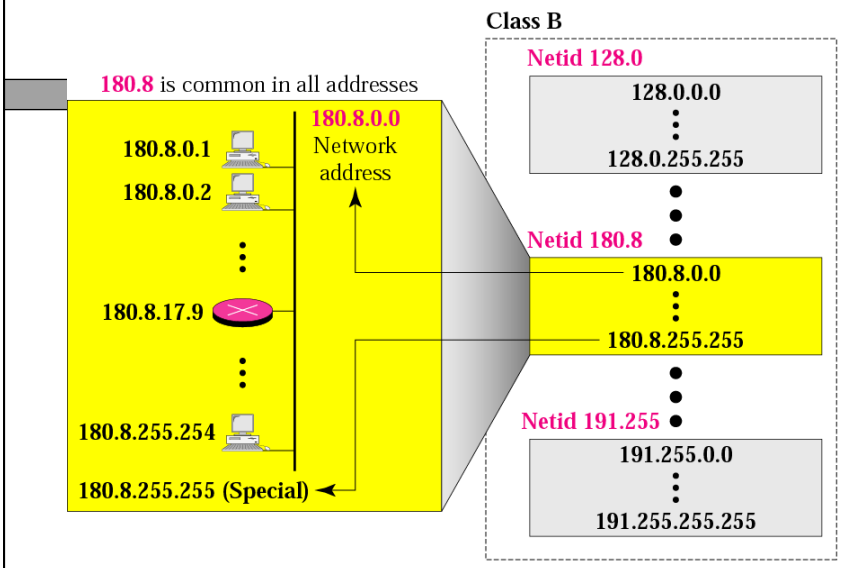
- Class A is divided into 128 blocks
  - Each block has a different netid
  - 1st block: 0.0.0.0 to 0.255.255.255 (netid = 0)
  - 2nd block: 1.0.0.0 to 1.255.255.255 (netid = 1)
  - Last block: 127.0.0.0 to 127.255.255.255 (netid = 127)
- *Network address*: the first address of the block

Blocks in class A



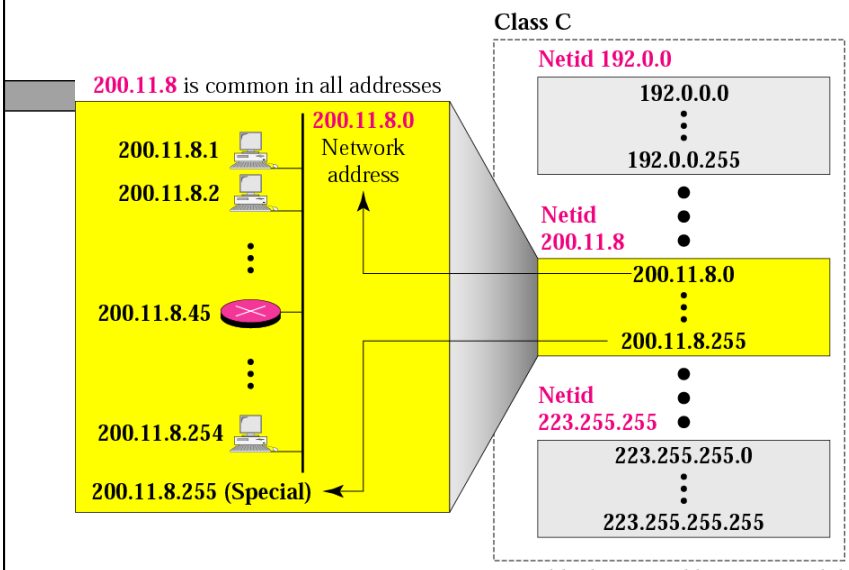
128 blocks: 16,777,216 addresses in each block

Blocks in class B



16,384 blocks: 65,536 addresses in each block

Blocks in class C



2,097,152 blocks: 256 addresses in each block

Use of addresses

- Classes A, B and C addresses can be assigned to hosts, router ports etc
  - They are also known as unicast addresses
- Class D addresses are for multicast
  - Multicast: One sender, multiple recipients
- Class E addresses are reserved for special purposes

Network addresses

- The network address is the first address in the block
- The network address defines the network to the rest of the Internet
  - Routers route packets based on network address
- Given the network address, we can find the class of the address and the range of the address in the block

Exercise

- Given the network address 132.21.0.0, find the class, the block, and the range of the addresses.

Solution

- Solution:
  - The class is B because the first byte is between 128 and 191.
  - The block has a netid of 132.21.
  - The addresses range from 132.21.0.0 to 132.21.255.255.

Finding netid from IP address

- Given an IP address, we can identify the network address by
  - Finding which class it belongs to and then obtain the netid part
  - E.g. Given 134.45.78.2
    - » This is class B. The netid is the first 2 bytes. The network address is 134.45.0.0
- An alternative is to use network mask

Network mask

- Let & denote the bitwise AND operation
  - Example: 1100 & 1010 = 1000
- A network mask is
  - 32 bit binary number
  - Often written in dotted decimal notation
  - Is chosen such that the following relation holds

Network address =
IP address & Network mask

Network mask (cont'd)

- The network mask is different for each class
  - Class A
    - » 11111111 00000000 00000000 00000000 or 255.0.0.0
  - Class B
    - » 11111111 11111111 00000000 00000000 or 255.255.0.0
  - Class C
    - » 11111111 11111111 11111111 00000000 or 255.255.255.0
- Essentially:
  - '1' indicates that the bit is a netid bit
  - '0' indicates that the bit is a hostid bit

Example

- A host has IP address 129.11.11.239 and network mask 255.255.0.0, find the network to which this host belongs.
- Method 1:

10000001 00001011 00001011 11101111
& 11111111 11111111 00000000 00000000
= 10000001 00001011 00000000 00000000
= 129.11.0.0

Example (cont'd)

- Let X denote a byte, then
  - X & 0 = 0 and X & 255 = X
- Method 2:

  129. 11. 11. 239

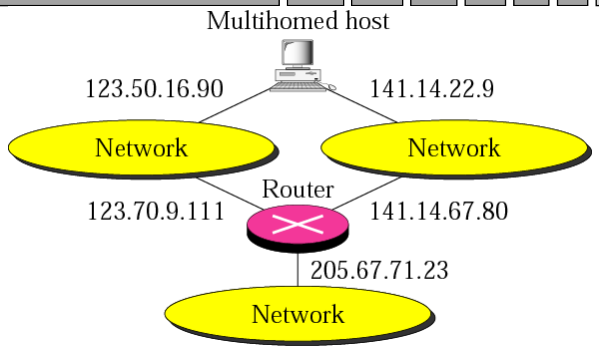
& 255. 255. 0. 0

= 129. 11. 0. 0

Why network mask?

- A host is specified by two attributes
  - An IP address
  - A network mask
- We can find the netid from these two attributes without finding which class the address belongs to
  - This makes it easier to program
  - You'll see the importance of network mask later when we study subnetting and classless addressing

Multihomed devices

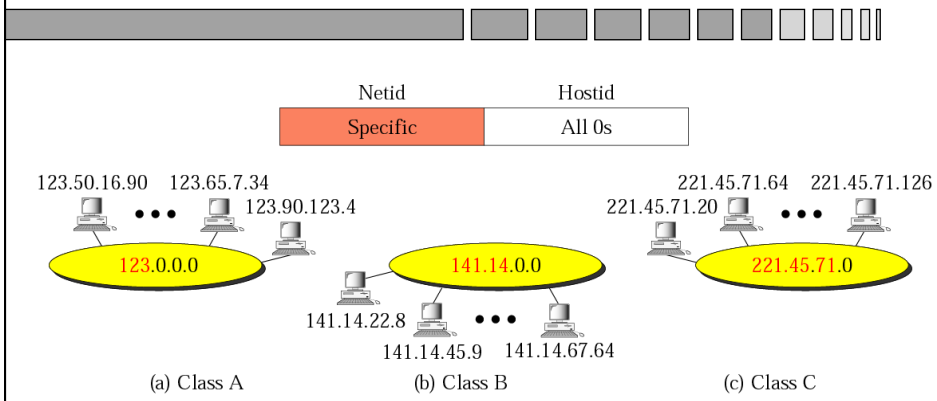


Strictly speaking, IP addresses are assigned to network interfaces.

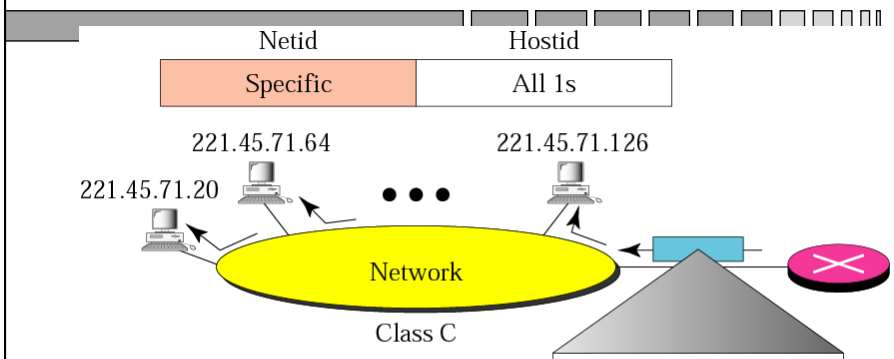
Special IP addresses

- Some IP addresses have been assigned special meaning
- They are not meant to be assigned to individual hosts

Network addresses



Example of 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.

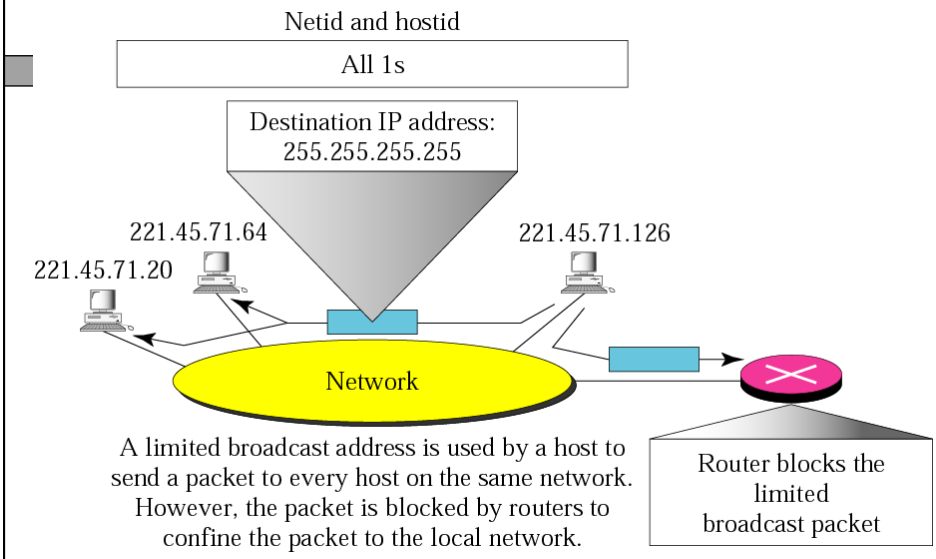
Destination IP address: 221.45.71.255

Hostid: 255

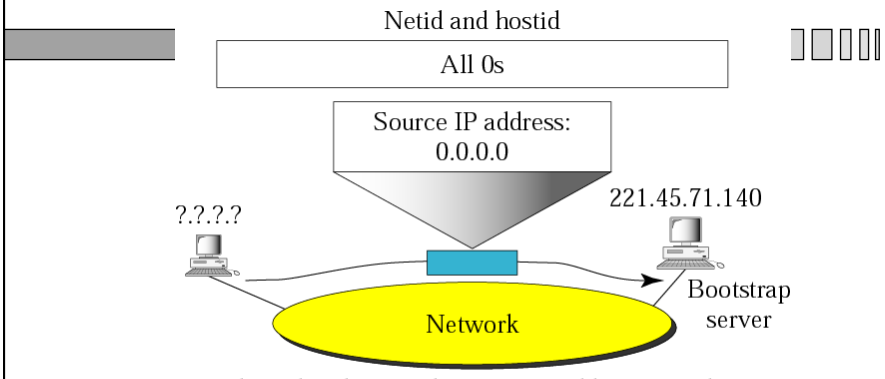
Assignable IP addresses

- These IP addresses cannot be assigned to individual hosts
  - Netid + All-zero-hostid
  - Netid + All-one-hostid
- Example, although each Class C network, has 256 different hostid's, the number of assignable addresses is only 254

Example of limited broadcast address



Example of *this* host on *this* address



A host that does not know its IP address uses the IP address 0.0.0.0 as the source address and 255.255.255.255 as the destination address to send a message to a bootstrap server.

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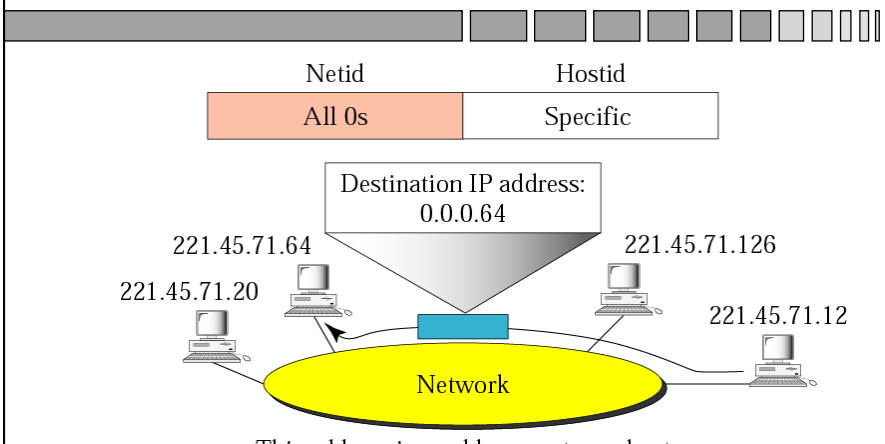
To find out more: BOOTP and DHCP protocols (Chap 17)

41

Example of 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.

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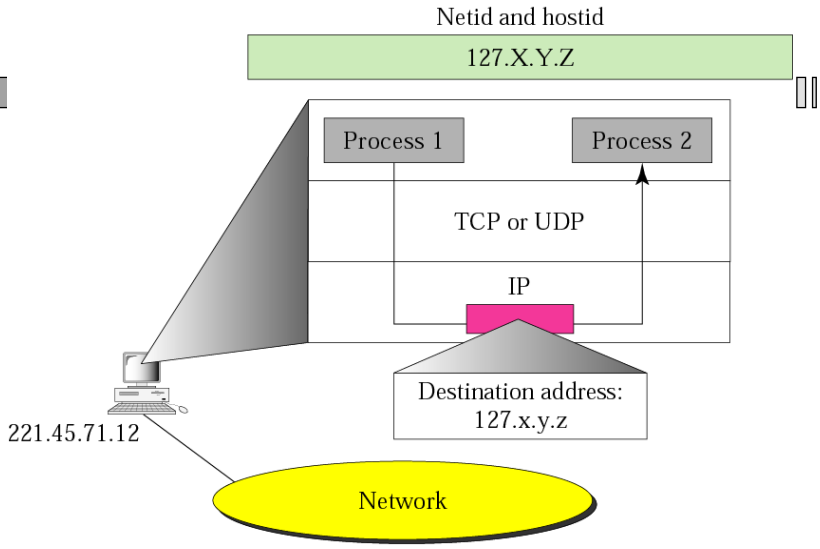
42

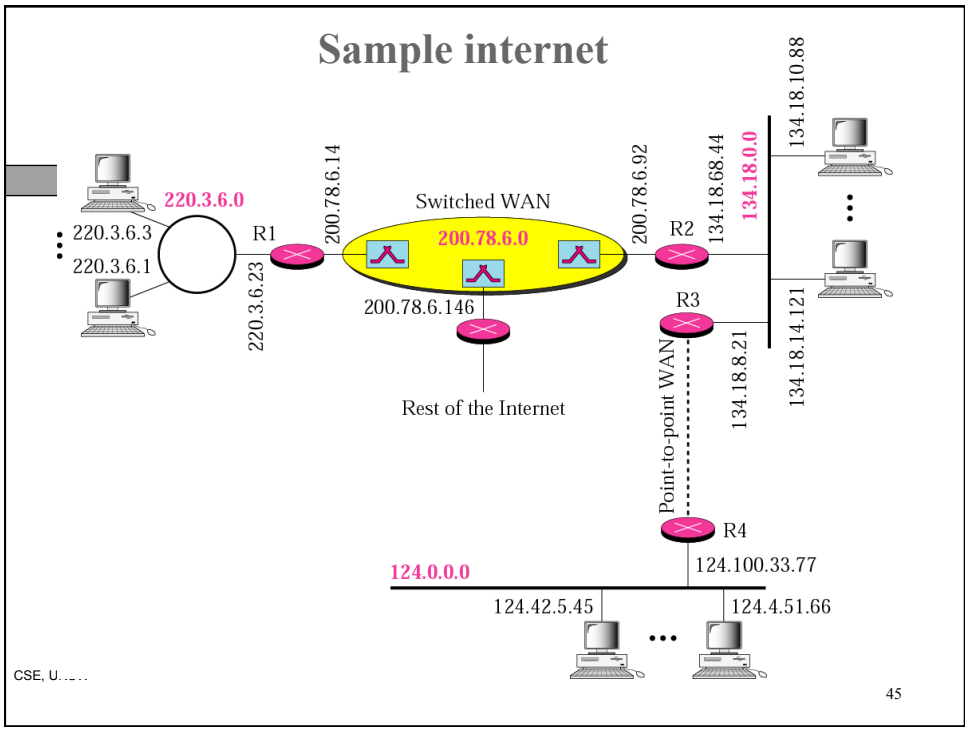
Example of loopback address



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

Private addresses

- Some IP addresses are reserved to be used as private addresses
- A host can use private address if it is not directly connected to the Internet
  - To connect to the Internet, Network Address Translation is required
- The following netids are designated as private
  - 10, 172.16-172.31, 192.168.0-192.168.255



Sample Internet - commentary

- The Internet is organised into networks
- Routers interconnect these networks into the Internet
- All hosts within the same network have the same netid