CSC465 – Computer Networks
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These slides were produced almost entirely from material by Behrouz Forouzan for the text "TCP/IP Protocol Suite (2nd Edition)", McGraw Hill Publisher

**Chapter 4**

# *IP Addresses: Classful Addressing*

## Classful Network Layer Addressing

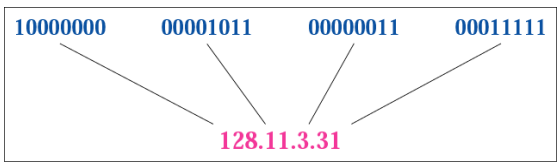
- To allow global communication, each Internet device requires a unique identifier
  - Like unique phone number (country/area/local)
- In the IP layer of TCP/IP, the ID is 32-bits
- Uniquely and universally defines the ***connection*** of a host or router to the Internet
- Classful addressing is one addressing mechanism of IPv4
- Classless addressing to be discussed

## IP Address Space

- $2^{32} = 4{,}294{,}967{,}296$
- Actual number much less due to self-imposed restrictions

Figure 4-1

**Dotted-decimal notation**




## *Hexadecimal Notation*

**0111 0101 1001 0101 0001 1101 1110 1010**

**75 95 1D EA**

**0x75951DEA**

Note

***The binary, decimal, and hexadecimal number systems are reviewed in Appendix B.***

***Example 1***

Change the following IP address from binary notation to dotted-decimal notation.

10000001 00001011 00001011 11101111

***Solution***

***129.11.11.239***

***Example 2***

Change the following IP address from dotted-decimal notation to binary notation.

111.56.45.78

***Solution***

***01101111 00111000 00101101 01001110***

***Example 3***

Find the error, if any, in the following IP address:

111.56.045.78

***Solution***

There are no leading zeroes in dotted-decimal notation (045).

***Example 3 (continued)***

Find the error, if any, in the following IP address:

75.45.301.14

***Solution***

In dotted-decimal notation, each number is less than or equal to 255; 301 is outside this range.

***Example 4***

Change the following IP addresses from binary notation to hexadecimal notation.

10000001 00001011 00001011 11101111

***Solution***

0X810B0BEF or $810B0BEF_{16}$

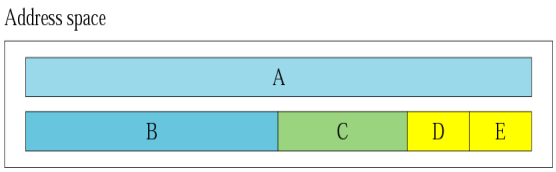
# 4.2

# CLASSFUL ADDRESSING

**Note**

***In classful addressing, the address space is divided into five classes: A, B, C, D, and E.***

## Occupation of the address space




| Class | Addresses | Percentage |
|---|---|---|
| A | $2^{31}$ | 50% |
| B | $2^{30}$ | 25% |
| C | $2^{29}$ | 12.5% |
| D | $2^{28}$ | 6.25% |
| E | $2^{28}$ | 6.25% |

Figure 4-3

## Finding the class in binary notation

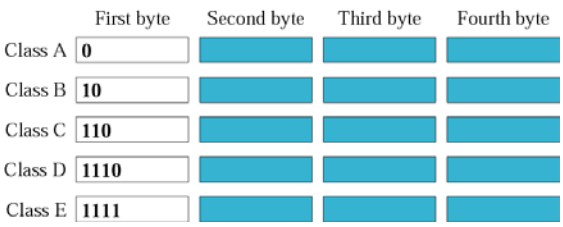
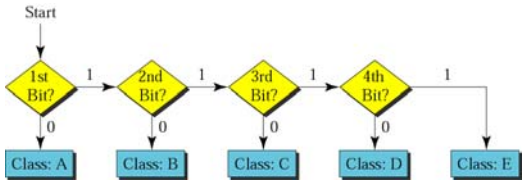



Figure 4-4

## Finding the address class



***Example 5***

How can we prove that we have 2,147,483,648 addresses in class A?

***Solution***

In class A, only 1 bit defines the class. The remaining 31 bits are available for the address. With 31 bits, we can have $2^{31}$ or 2,147,483,648 addresses.

***Example 6***

Find the class of the address:

**0**0000001 00001011 00001011 11101111

***Solution***

The first bit is 0. This is a class A address.

***Example 6 (Continued)***

Find the class of the address:

**11**000001 10000011 00011011 11111111

***Solution***

The first 2 bits are 1; the third bit is 0. This is a class C address.

Figure 4-5

**Finding the class in decimal notation**

| | First byte | Second byte | Third byte | Fourth byte |
|---|---|---|---|---|
| Class A | 0 to 127 | | | |
| Class B | 128 to 191 | | | |
| Class C | 192 to 223 | | | |
| Class D | 224 to 239 | | | |
| Class E | 240 to 255 | | | |

***Example 7***

Find the class of the address:

**227**.12.14.87

***Solution***

The first byte is 227 (between 224 and 239); the class is D.

***Example 7 (Continued)***

Find the class of the address:

**193**.14.56.22

***Solution***

The first byte is 193 (between 192 and 223); the class is C.

***Example 8***

In Example 4 we showed that class A has $2^{31}$ (2,147,483,648) addresses. How can we prove this same fact using dotted-decimal notation?

***Solution***

The addresses in class A range from 0.0.0.0 to 127.255.255.255. We notice that we are dealing with base 256 numbers here.

***Solution (Continued)***

Each byte in the notation has a weight. The weights are as follows:

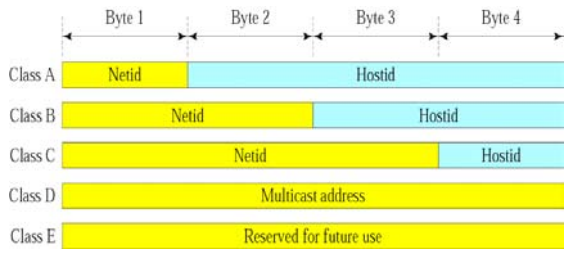
$256^3$ , $256^2$, $256^1$, $256^0$

Last address: $127 \times 256^3 + 255 \times 256^2 + 255 \times 256^1 + 255 \times 256^0 = 2,147,483,647$

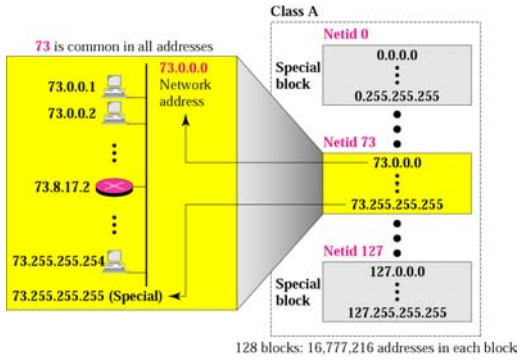
First address: = 0

If we subtract the first from the last and add 1, we get 2,147,483,648.

**Netid and hostid**




**Blocks in class A**



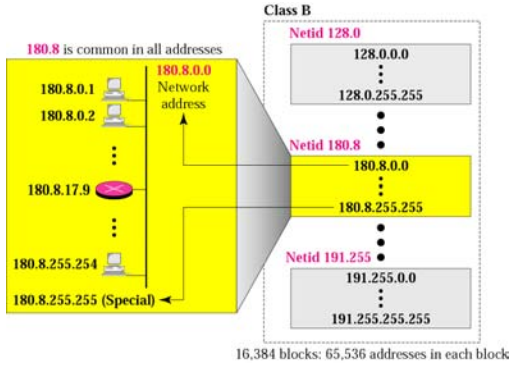

## Some Class A Host Organizations

- 043 Japan Inet
- 044 Amateur Radio Digital Communications
- 045 Interop Show Network
- 046 Bolt Beranek and Newman Inc.
- 047 Bell-Northern Research
- 048 Prudential Securities Inc.
- 051 Deparment of Social Security of UK
- 052 E.I. duPont de Nemours and Co., Inc.
- 054 Merck and Co., Inc.
- 055 Boeing Computer Services
- 056 U.S. Postal Service

Note

***Millions of class A addresses are wasted.***

## Blocks in class B

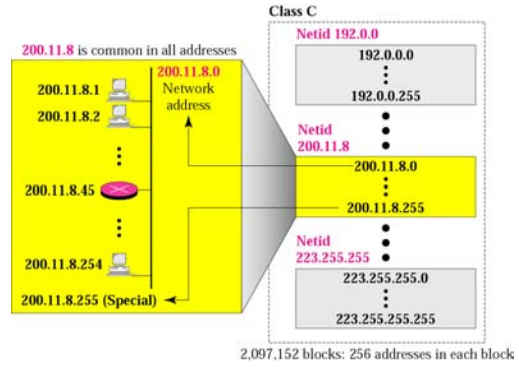



Note

***Many class B addresses are wasted.***

Figure 4-9

## Blocks in class C




Note

***The number of addresses in a class C block is smaller than the needs of most organizations.***

Note

***Class D addresses are used for multicasting; there is only one block in this class.***

Note

***Class E addresses are reserved for special purposes; most of the block is wasted.***

## Network Addresses

The network address is the first address.

The network address defines the network to the rest of the Internet.

Given the network address, we can find the class of the address, the block, and the range of the addresses in the block

Note

***In classful addressing, the network address (the first address in the block) is the one that is assigned to the organization.***

***Example 9***

Given the network address 17.0.0.0, find the class, the block, and the range of the addresses.

***Solution***

The class is A because the first byte is between 0 and 127. The block has a netid of 17. The addresses range from 17.0.0.0 to 17.255.255.255.

***Example 10***

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

***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.

***Example 11***

Given the network address 220.34.76.0, find the class, the block, and the range of the addresses.

***Solution***

The class is C because the first byte is between 192 and 223. The block has a netid of 220.34.76. The addresses range from 220.34.76.0 to 220.34.76.255.

## Determining Network ID

Given IP address it is straightforward to determine the network ID:

1. Determine class
2. Mask out host IDs bits based on class

## Mask

A mask is a 32-bit binary number that gives the first address in the block (the network address) when bitwise ANDed with an address in the block.

Figure 4-10

**Masking concept**


Figure 4-11

**AND operation**


**Note**

***The network address is the beginning address of each block. It can be found by applying the default mask to any of the addresses in the block (including itself). It retains the netid of the block and sets the hostid to zero.***

***Example 12***

Given the address 23.56.7.91 and the default class A mask, find the beginning address (network address).

***Solution***

The default mask is 255.0.0.0, which means that only the first byte is preserved and the other 3 bytes are set to 0s. The network address is 23.0.0.0.

***Example 13***

Given the address 132.6.17.85 and the default class B mask, find the beginning address (network address).

***Solution***

The default mask is 255.255.0.0, which means that the first 2 bytes are preserved and the other 2 bytes are set to 0s. The network address is 132.6.0.0.

***Example 14***

Given the address 201.180.56.5 and the class C default mask, find the beginning address (network address).

***Solution***

The default mask is 255.255.255.0, which means that the first 3 bytes are preserved and the last byte is set to 0. The network address is 201.180.56.0.

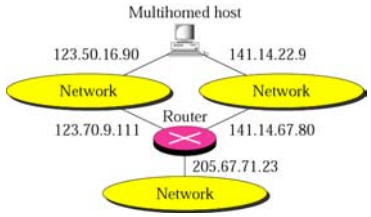
## Multihomed Device

- Internet address defines the node's connection to its network
- A device with multiple network connections must have multiple IP addresses – one for each network
- A computer attached to different networks is termed ***multihomed***
- The different addresses may belong to different classes

## Multihomed Device

- A router must be connected to different networks to route packets
- Hence a router must have > 1 IP address – one for each interface; so is multihomed
- IP address defines the network location of a device, not its identity (Network,HostID)
- A device's IP address must be changed if it is moved to another network

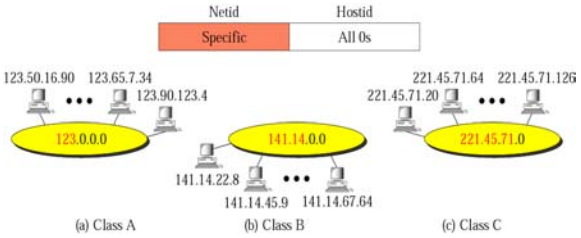
## Multihomed devices



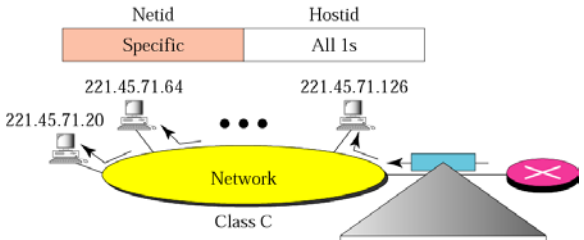

## Special Addresses

| Special Address | Netid | Hostid | Source/Dest |
|---|---|---|---|
| Network Address | Specific | All 0's | None |
| Direct Broadcast | Specific | All 1's | Destination |
| Limited Broadcast | All 1's | All 1's | Destination |
| This host on network | All 0's | All 0's | Source |
| Specific host on this network | All 0's | Specific | Destination |
| Loopback address | 127 | Any | Destination |

## Network addresses



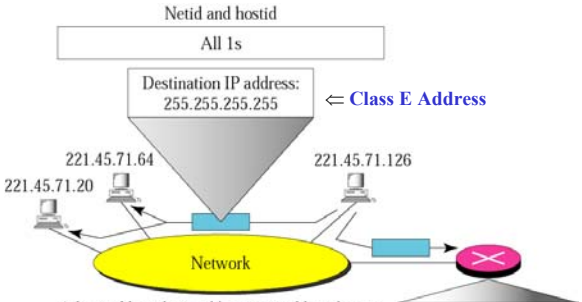
## Direct Broadcast Address




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

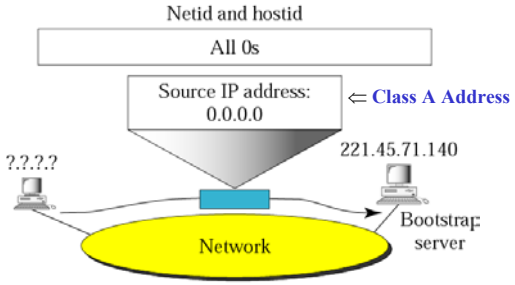
## Limited Broadcast Address




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.

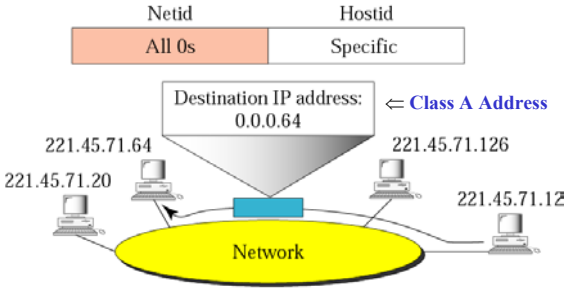
Router blocks the limited broadcast packet

## Example of *this* host on *this* address



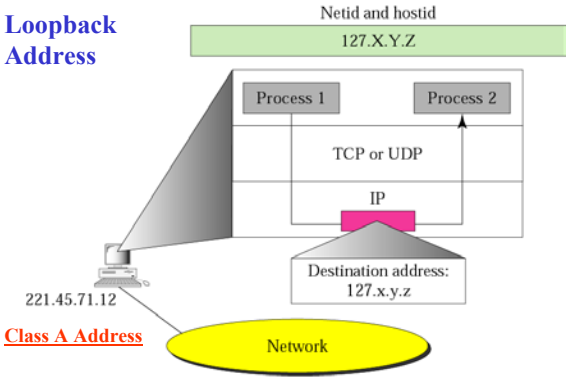

A host that does not know its IP address uses the IP address 0.0.0.0 as the source address and 255.255.255.255 as the destination address to send a message to a bootstrap server.

## 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.

## Loopback Address




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

## Private Addresses

A number of blocks in each class are assigned for private use. They are not recognized globally.

| Class | Netids | Blocks |
|---|---|---|
| A | 10.0.0.0 to 10.255.255.255 | 1 |
| B | 172.16.0.0 to 172.31.255.255 | 16 |
| C | 192.168.0.0 to 192.168.255.255 | 256 |

## Unicast Addresses

- Unicast communication is *one-to-one*.
- All hosts on the internet have at least one unicast address
- Unicast addresses belong to classes A, B & C

## Multicast Addresses

- Multicast communication is *one-to-many*.
- Sent from individual source to multiple destinations
- Class D address
- Entire address defines Group ID
- A system on the Internet may have > 1 Class D multicast addresses in addition to unicast address
- Class D address can only be destination

## Assigned Multicast Addresses

- Internet authorities have designated some multicast addresses to specific groups

| Address | Group |
|---|---|
| 224.0.0.1 | All systems on this subnet |
| 224.0.0.2 | All routers on this subnet |
| 224.0.0.9 | RIP2 Routers |
| 224.0.1.11 | IETF-1-Audio |
| | Many Others… |

**A SAMPLE INTERNET WITH CLASSFUL ADDRESSES**