



**PART IV**  
**CLASSFUL INTERNET ADDRESSES**

## Definitions

- Name
  - Identifies *what* an entity is
  - Often textual (e.g., ASCII)
- Address
  - Identifies *where* an entity is located
  - Often binary and usually compact
  - Sometimes called locator
- Route
  - Identifies *how* to get to the object
  - May be distributed

## **Internet Protocol Address (IP Address)**

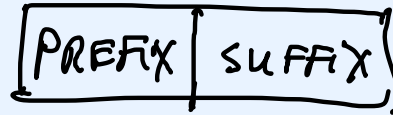
- Analogous to hardware address
- Unique value assigned as unicast address to each host on Internet
- Used by Internet applications

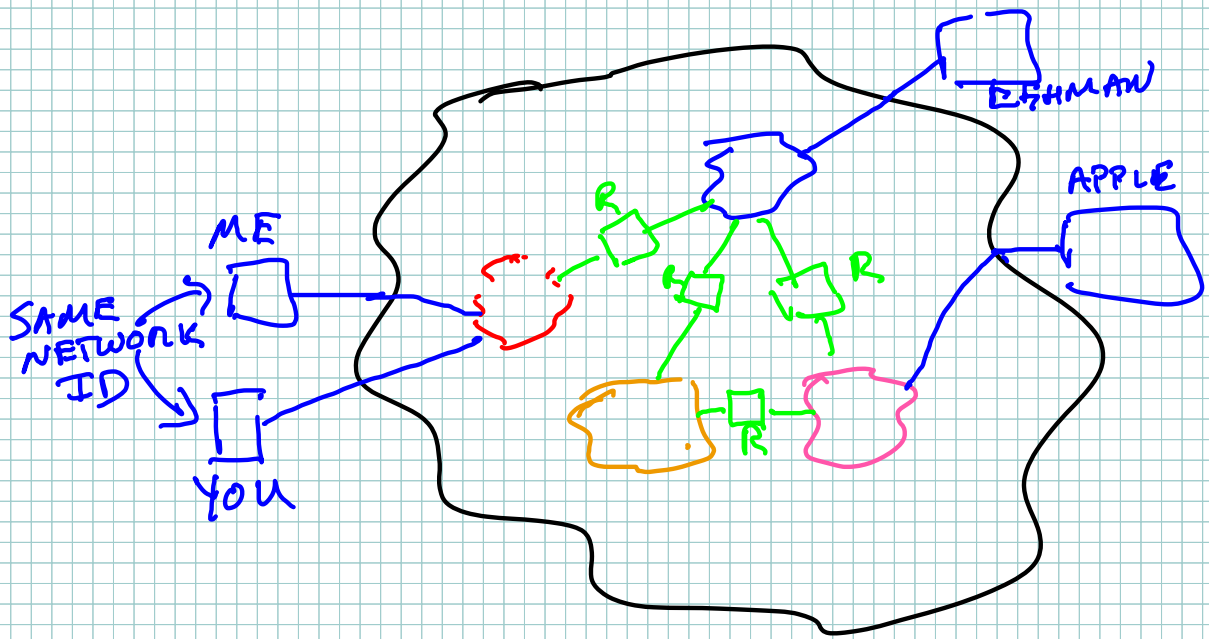
## IP Address Details

- 32-bit binary value
- Unique value assigned to each host in Internet
- Values chosen to make routing efficient

## IP Address Division

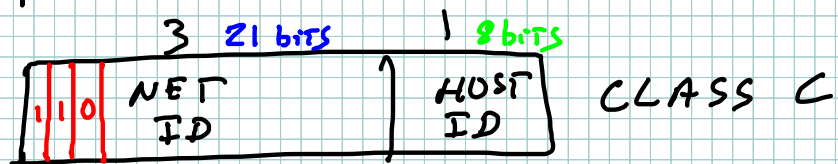
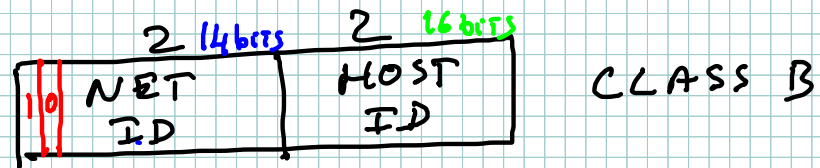
- Address divided into two parts
  - Prefix (network ID) identifies network to which host attaches
  - Suffix (host ID) identifies host on that network





## Classful Addressing

- Original IP scheme
- Explains many design decisions
- New schemes are backward compatible







7B 3C 2E 4F  
0111 1011

0011 1100  
0010 1110  
0100 1111

- a) CLASS A
- b) NETID = 7B
- c) HOSTID = 3C2E4F
- d) 123.60.46.79

AC2D457B

10101100

0010 1101  
0100 0101  
0111 1011

- a) CLASS B
- b) NET ID = AC2D
- c) HOST ID = 457B
- d) 172.45.69.123

C45F7E3F

1100 0100

0101 111  
0111 1110  
0011 111

- a) CLASS C
- b) NETID = C45F7E
- c) HOST ID = 3F
- d) 196.95.126.63

## Desirable Properties Of An Internet Addressing Scheme

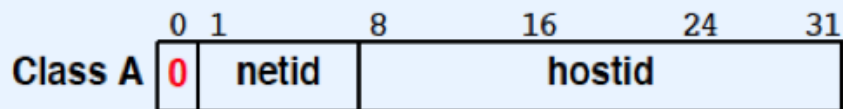
- Compact (as small as possible)
- Universal (big enough)
- Works with all network hardware
- Supports efficient decision making
  - Test whether a destination can be reached directly
  - Decide which router to use for indirect delivery
  - Choose next router along a path to the destination

## Division Of Internet Address Into Prefix And Suffix

- How should division be made?
  - Large prefix, small suffix means many possible networks, but each is limited in size
  - Large suffix, small prefix means each network can be large, but there can only be a few networks
- Original Internet address scheme designed to accommodate both possibilities
  - Known as *classful* addressing

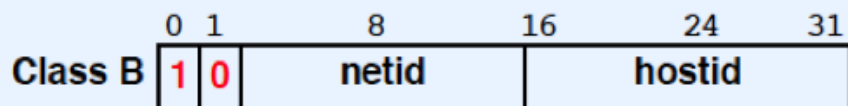
## Original IPv4 Address Classes

Three Principle Classes



Class A Addresses are used for the handful of networks that have more than  $2^{16}$  (i.e. more than 65,536) hosts.

- 7 Bits for netid
- 24 Bits for hostid

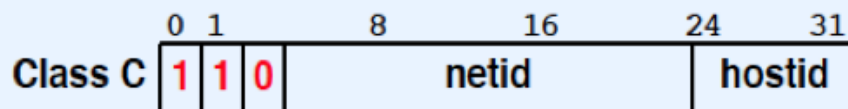


Class B Addresses are used for intermediate size networks that have up to  $2^{16}$  (i.e. up to 65,536) hosts.

- 14 Bits for netid
- 16 Bits for hostid

## Original IPv4 Address Classes

Three Principle Classes



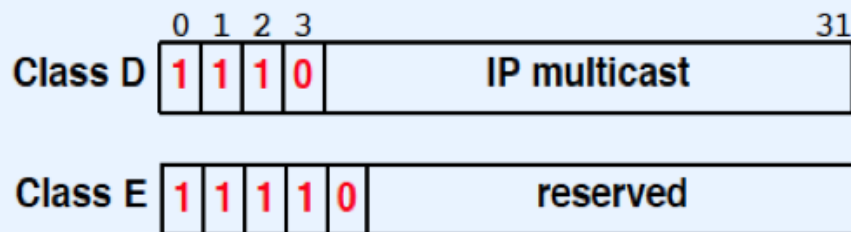
Class C Addresses are used for networks that have less than  $2^8$  (i.e. less than 256) hosts.

- 21 Bits for netid
- 8 Bits for hostid



## Original IPv4 Address Classes

Other (seldom used) Classes



## Important Property

- Classful addresses are *self-identifying*
- Consequences
  - Can determine boundary between prefix and suffix from the address itself
  - No additional state needed to store boundary information
  - Both hosts and routers benefit

## Endpoint Identification

*Because IP addresses encode both a network and a host on that network, they do not specify an individual computer, but a connection to a network.*

## IP Address Conventions

- When used to refer to a network
  - Host field contains all 0 bits
- Broadcast on the local wire **FFFFFFFF**
  - Network and host fields both contain all 1 bits
- Directed broadcast: broadcast on specific (possibly remote) network
  - Host field contains all 1 bits
  - Nonstandard form: host field contains all 0 bits

## Assignment Of IP Addresses

- All hosts on same network assigned same address prefix
  - Prefixes assigned by central authority
  - Obtained from ISP
- Each host on a network has a unique suffix
  - Assigned locally
  - Local administrator must ensure uniqueness

## **Advantages Of Classful Addressing**

- Computationally efficient
  - First bits specify size of prefix / suffix
- Allows mixtures of large and small networks

## Directed Broadcast

*IP addresses can be used to specify a **directed broadcast** in which a packet is sent to all computers on a network; such addresses map to hardware broadcast, if available. By convention, a directed broadcast address has a valid netid and has a hostid with all bits set to 1.*

## Limited Broadcast

- All 1's
- Broadcast limited to local network only (no forwarding)
- Useful for bootstrapping



## All Zeros IP Address

- Can only appear as source address
- Used during bootstrap before computer knows its address
- Means “this” computer

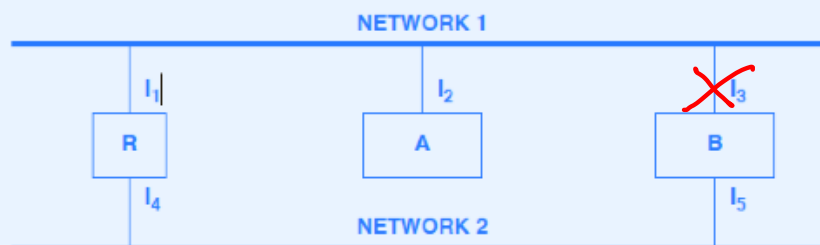
## Internet Multicast

- IP allows Internet multicast, but no Internet-wide multicast delivery system currently in place
- Class D addresses reserved for multicast
- Each address corresponds to group of participating computers
- IP multicast uses hardware multicast when available
- More later in the course

## Consequences Of IP Addressing

- If a host computer moves from one network to another, its IP address must change
- For a multi-homed host (with two or more addresses), the path taken by packets depends on the address used

## Multi-Homed Hosts And Reliability



- Knowing that B is multi-homed increases reliability
- If interface I<sub>3</sub> is down, host A can send to the interface I<sub>5</sub>

## **Dotted Decimal Notation**

- Syntactic form for expressing 32-bit address
- Used throughout the Internet and associated literature
- Represents each octet in decimal separated by periods (dots)

### Example Of Dotted Decimal Notation

- A 32-bit number in binary

10000000 00001010 00000010 00000011

- The same 32-bit number expressed in dotted decimal notation

128.10.2.3

## Loopback Address

- Used for testing
- Refers to local computer (never sent to Internet)
- Address is 127.0.0.1

## Classful Address Ranges

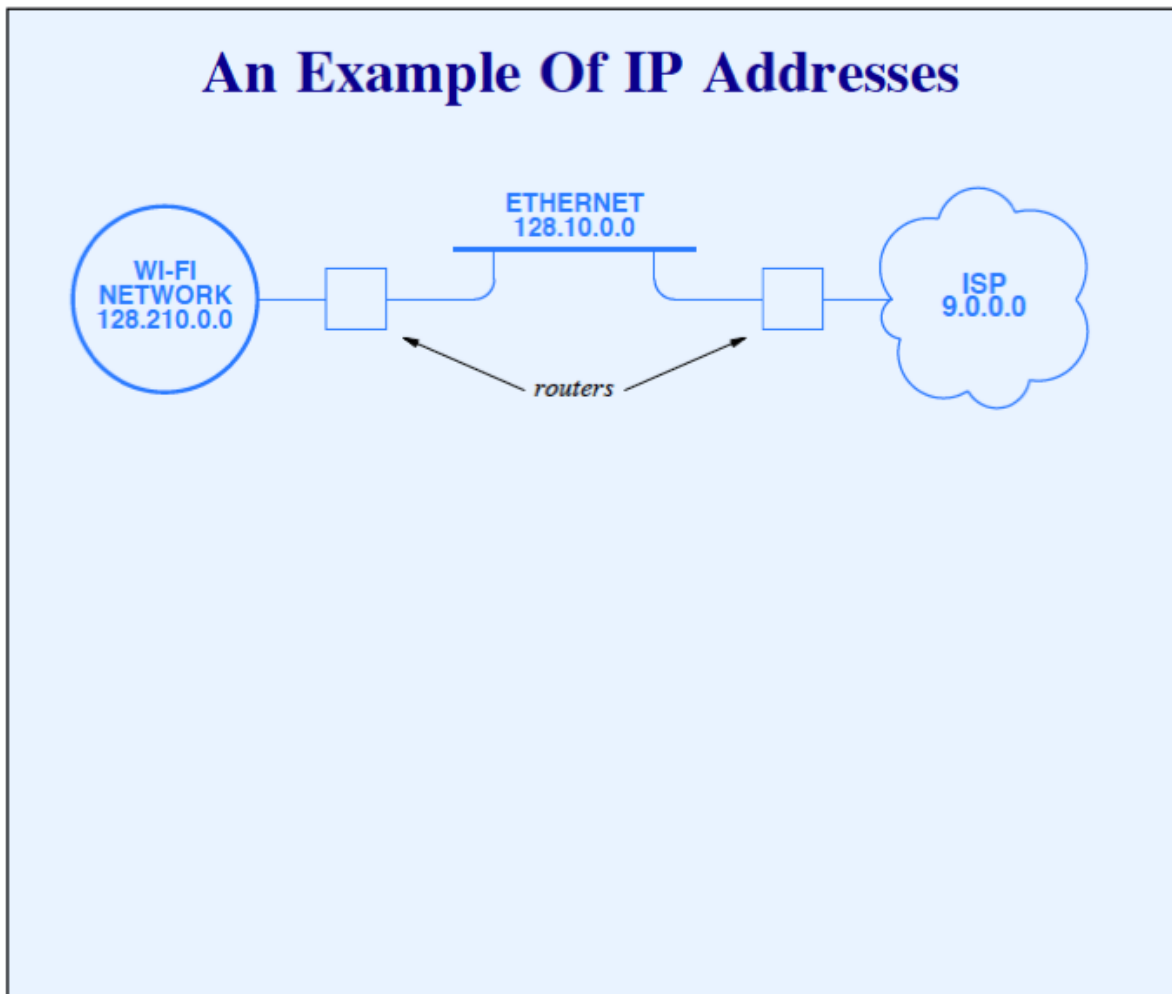
<b>Class</b>	<b>Lowest Address</b>	<b>Highest Address</b>
<b>A</b>	<b>1.0.0.0</b>	<b>126.0.0.0</b>
<b>B</b>	<b>128.1.0.0</b>	<b>191.255.0.0</b>
<b>C</b>	<b>192.0.1.0</b>	<b>223.255.255.0</b>
<b>D</b>	<b>224.0.0.0</b>	<b>239.255.255.255</b>
<b>E</b>	<b>240.0.0.0</b>	<b>255.255.255.254</b>



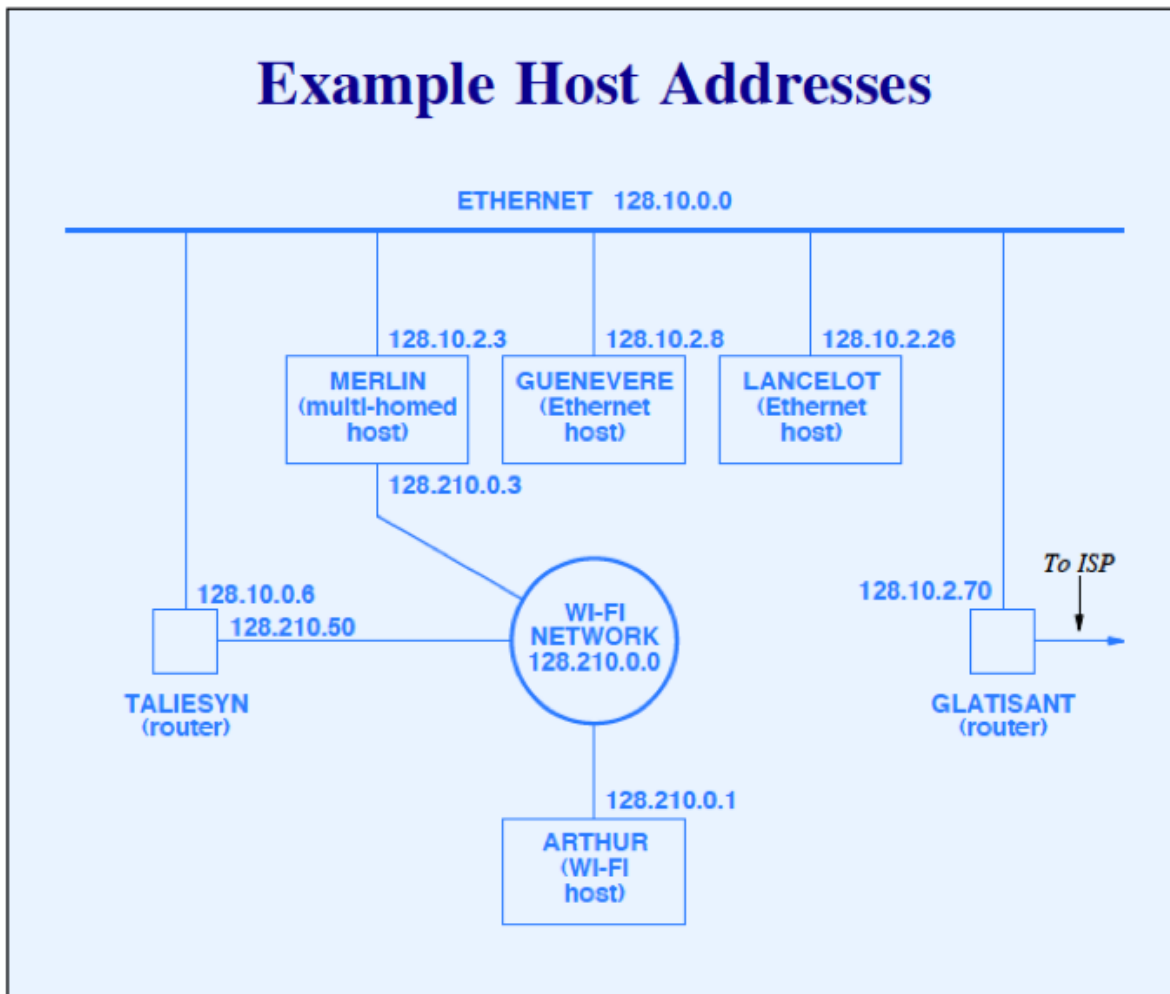
## Summary Of Address Conventions

all 0s		This host <sup>1</sup>
all 0s	host	Host on this net <sup>1</sup>
all 1s		Limited broadcast (local net) <sup>2</sup>
net	all 1s	Directed broadcast for net <sup>2</sup>
127	anything (often 1)	Loopback <sup>3</sup>

Notes: <sup>1</sup> Allowed only at system startup and is never a valid destination address.  
<sup>2</sup> Never a valid source address.  
<sup>3</sup> Should never appear on a network.

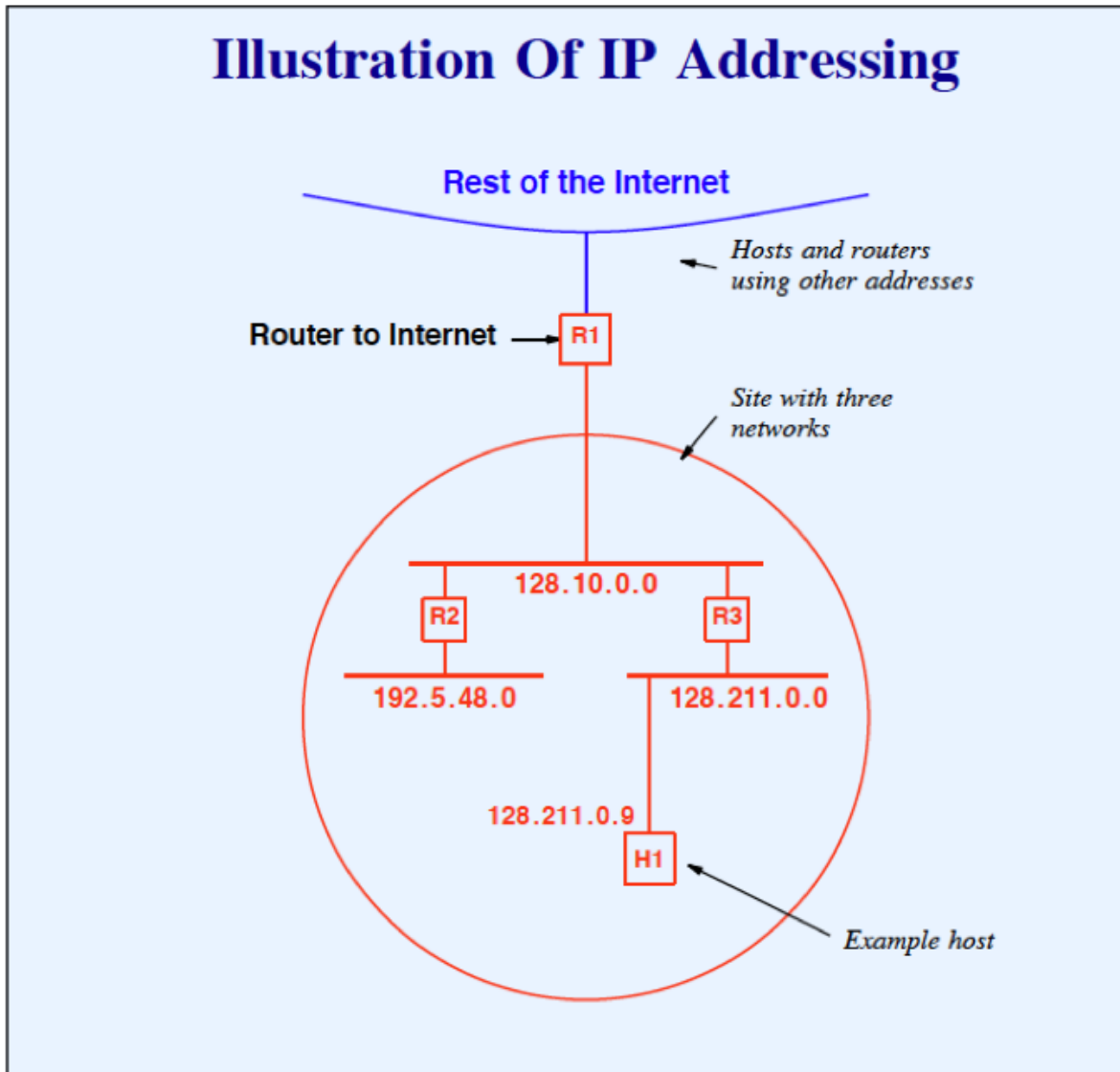


## Example Host Addresses



### **Another Addressing Example**

- Assume an organization has three networks
- Organization obtains three prefixes, one per network
- Host address must begin with network prefix



## Summary

- IP address
  - 32 bits long
  - Prefix identifies network
  - Suffix identifies host
- Classful addressing uses first few bits of address to determine boundary between prefix and suffix

## **Summary (continued)**

- Special forms of addresses handle
  - Limited broadcast
  - Directed broadcast
  - Network identification
  - This host
  - Loopback