



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

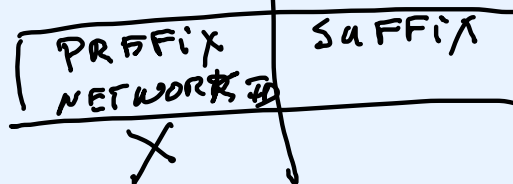
IP Address Details

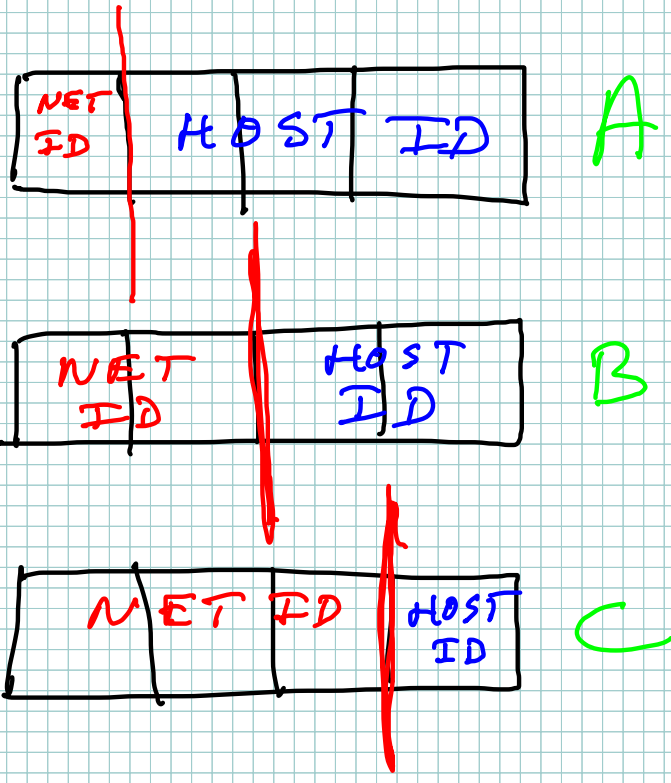
- 4 BYTES — IPv4
32-bit binary value
- Unique value assigned to each host in Internet
- Values chosen to make routing efficient

IPv6 — 128 bits
16 BYTES

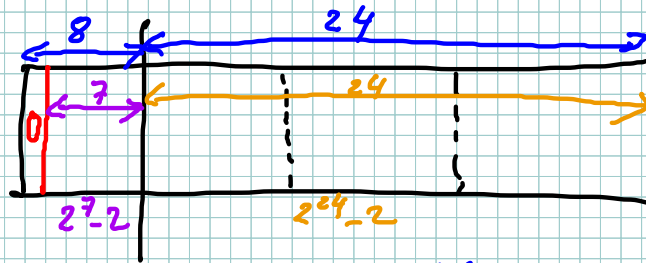
IP Address Division

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



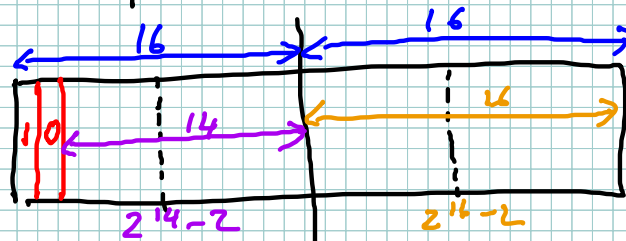


$$(2^7 - 2) \times (2^{24} - 2)$$



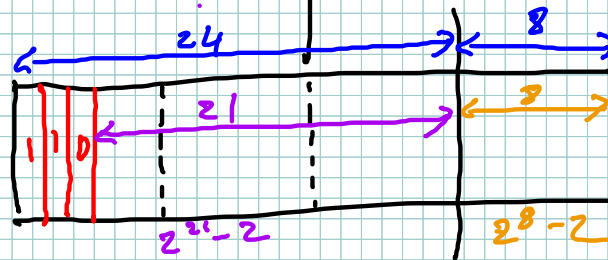
A

$$(2^{14} - 2)(2^{16} - 2)$$

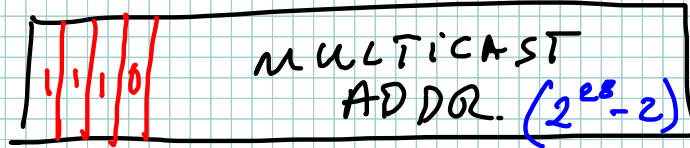


B

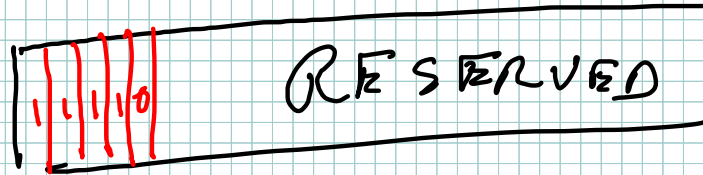
$$(2^4 - 2)(2^9 - 2)$$



C



CLASS D



CLASS E

7E 2E 3D B1

a) 7E → 0111 1110 CLASS A

b) NET ID → 7E

c) HOST ID → 2E 3D B1

d) 126 . 46 . 61 . 177
 ↑ ↑ ↑ ↑
 7E 2E 3D B1

AC 257C3F

- a) AC → 1010 1100 CLASS B
- b) NETWORK ID → AC 25
- c) HOST ID → FC 3F
- d) 172.37.124.63

D4789BF3

- a) D4 → 1101 0100 CLASS C
- b) NET ID → D4789B
- c) HOST ID → F3
- d) 212.120.155.243

Classful Addressing

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

Desirable Properties Of An Internet Addressing Scheme

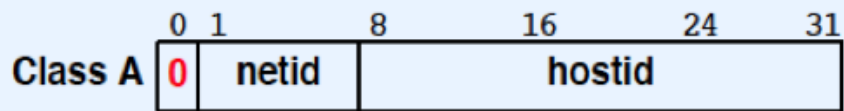
- Compact (as small as possible)
- Universal (big enough)
- Works with all network hardware
- Supports efficient decision making
 - Test whether a destination can be reached directly
 - Decide which router to use for indirect delivery
 - Choose next router along a path to the destination

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

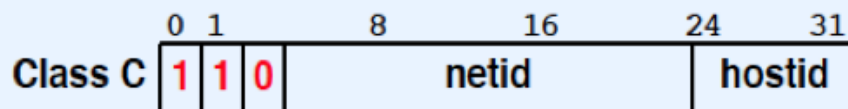


Class B Addresses are used for intermediate size networks that have up to 2^{16} (i.e. up to 65,536) hosts.

- 14 Bits for netid
- 16 Bits for hostid

Original IPv4 Address Classes

Three Principle Classes

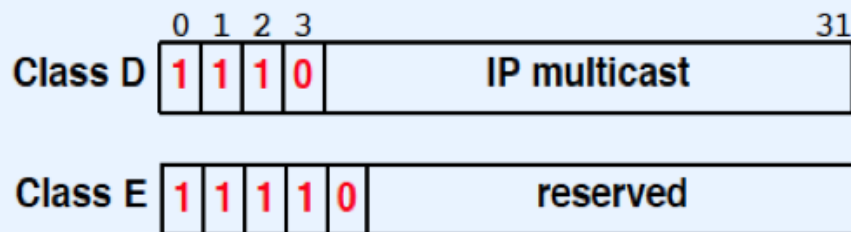


Class C Addresses are used for networks that have less than 2^8 (i.e. less than 256) hosts.

- 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
 - 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

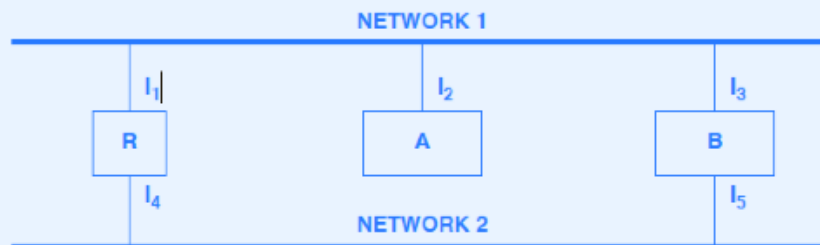
Internet Multicast

- 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 I₃ is down, host A can send to the interface I₅

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

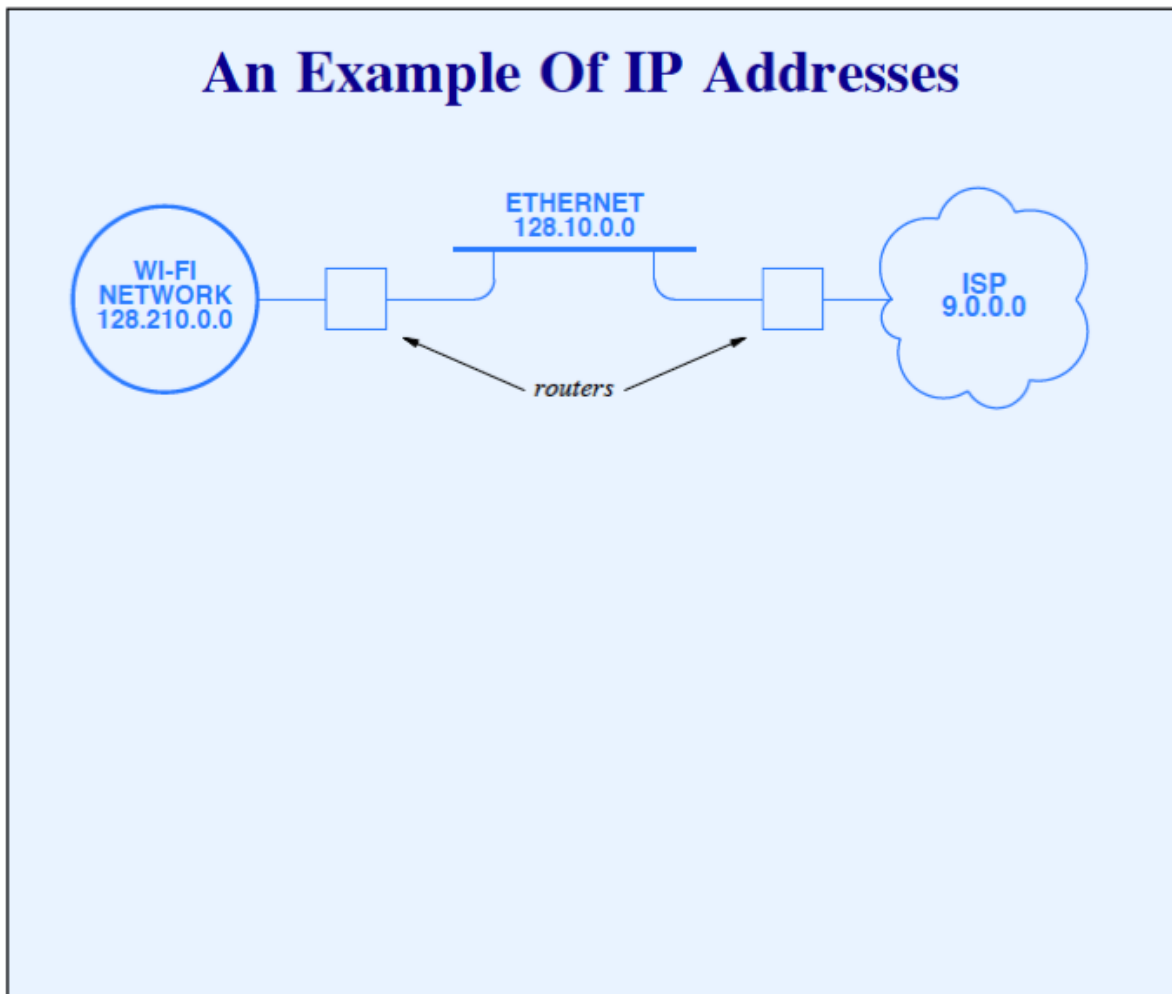
Classful Address Ranges

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

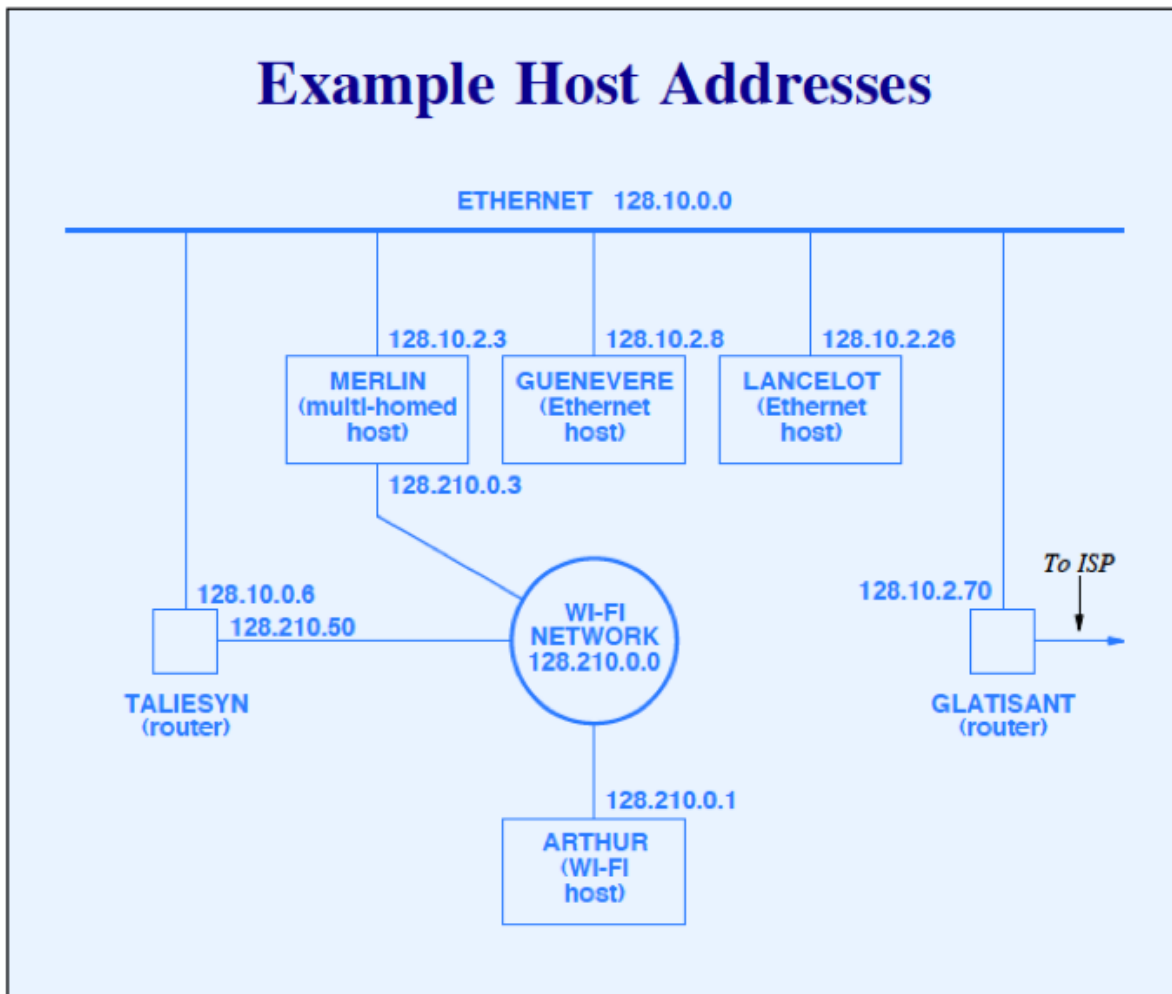
Summary Of Address Conventions

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

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

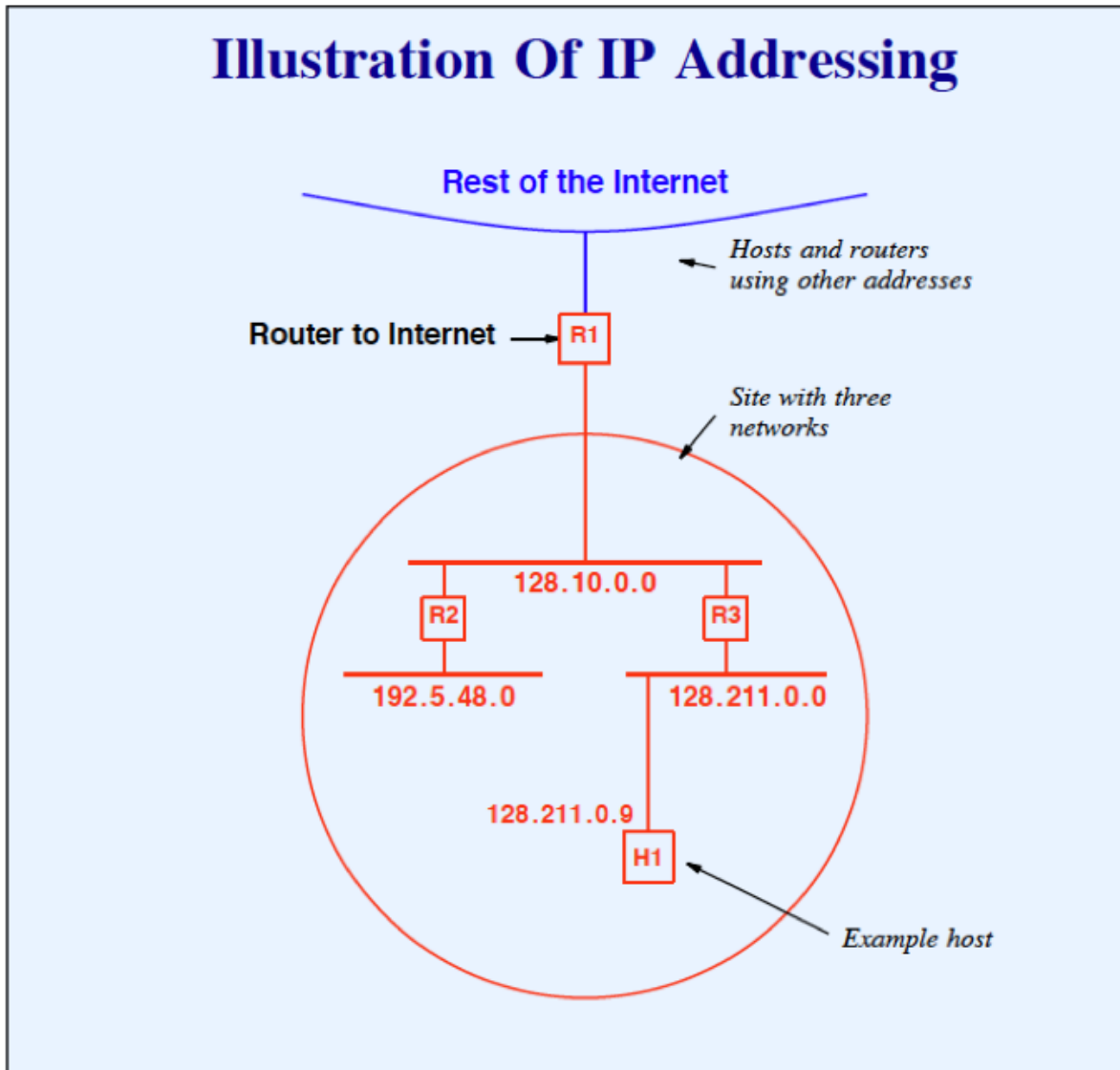


Example Host Addresses



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