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

```
<table>
<thead>
<tr>
<th>Prefix</th>
<th>Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET ID</td>
<td>HOST ID</td>
</tr>
</tbody>
</table>
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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
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
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

Class D: 1 1 1 0
- IP multicast

Class E: 1 1 1 1 0
- reserved
6A4C703E

a) $6A = 01101010 \quad \text{CLASS A}$

b) $\text{NET ID} = 6A$

c) $\text{HOST ID} = 4C703E$

d) $\begin{array}{cccc}
128 & 64 & 32 & 16 \\
0 & 1 & 1 & 0 \\
0 & 1 & 0 & 0 \\
0 & 1 & 1 & 1 \\
0 & 0 & 1 & 1 \\
\end{array}$

\[ \text{106} \]
\[ \text{76} \]
\[ \text{123} \]
\[ \text{62} \]

. 
B4C7D1FA

a) \( B4 = \boxed{1011 0100} \)  
   **CLASS B**

b) \( NETID = B4C7 \)

c) \( HOSTID = D1FA \)

d)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
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<td>10</td>
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<td>0</td>
</tr>
<tr>
<td>11</td>
<td>00</td>
<td>0</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>00</td>
<td>01</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td></td>
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<td>180</td>
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<td>199</td>
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<tr>
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<td></td>
<td></td>
<td>250</td>
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</tbody>
</table>

180.197.209.250
C8753ABC

a) C8 = 1100 1000  
   CLASS C

b) NETID = C8753A

c) HOSTID = BC

d)

```
<table>
<thead>
<tr>
<th></th>
<th>1100 1000 200</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0111 0101 117</td>
</tr>
<tr>
<td></td>
<td>0011 1010 58</td>
</tr>
<tr>
<td></td>
<td>1011 1100 188</td>
</tr>
</tbody>
</table>
```

200.117.58.188
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

<table>
<thead>
<tr>
<th>Class</th>
<th>Lowest Address</th>
<th>Highest Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.0.0.0</td>
<td>126.0.0.0</td>
</tr>
<tr>
<td>B</td>
<td>128.1.0.0</td>
<td>191.255.0.0</td>
</tr>
<tr>
<td>C</td>
<td>192.0.1.0</td>
<td>223.255.255.0</td>
</tr>
<tr>
<td>D</td>
<td>224.0.0.0</td>
<td>239.255.255.255</td>
</tr>
<tr>
<td>E</td>
<td>240.0.0.0</td>
<td>255.255.255.254</td>
</tr>
</tbody>
</table>
## Summary Of Address Conventions

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>all 0s</td>
<td>This host ¹</td>
</tr>
<tr>
<td>all 0s</td>
<td>Host on this net ¹</td>
</tr>
<tr>
<td>all 1s</td>
<td>Limited broadcast (local net) ²</td>
</tr>
<tr>
<td>net</td>
<td>Directed broadcast for net ²</td>
</tr>
<tr>
<td>127</td>
<td>Loopback ³</td>
</tr>
</tbody>
</table>

*Notes:*

1. Allowed only at system startup and is never a valid destination address.
2. Never a valid source address.
An Example Of IP Addresses
Example Host Addresses

ETHERNET 128.10.0.0

128.10.2.3
MERLIN (multi-homed host)

128.10.2.8
GUENEVERE (Ethernet host)

128.10.2.26
LANCELOT (Ethernet host)

128.210.0.3

128.210.0.0

128.210.0.1

TALIESYN (router)

128.210.0.6 128.210.50

128.10.0.0

WI-FI NETWORK

GLATISANT (router)

128.10.2.70

To ISP
Another Addressing Example

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

Rest of the Internet

Router to Internet → R1

Site with three networks

128.10.0.0

192.5.48.0

128.211.0.0

128.211.0.9

H1

Example host

Hosts and routers using other addresses
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