Universal Addressing

- One key aspect of internetworks is **unique addresses**.
- Sending host puts destination internetworking address in the packet.
- Destination addresses can be interpreted by any intermediate router/gateway.
- Router/gateway examines address and forwards packet on to the destination.

IP Addresses

- Each machine on the Internet has a unique **IP address**.
- The IP address is different from the “physical”/“MAC” address.
  - The “physical address” is the address of a computer (actually, of a NIC) in the LAN.
    - It is only known within the LAN.
  - The IP address is a universal address.
  - When a packet arrives in a LAN, there needs to be a conversion from IP to MAC address (local “address resolution”).

IP Addresses (cont’d)

- An IP address is represented by a binary number with 32 bits.
  - Meaning that there are around 4 billion addresses.
  - Often IP addresses are represented in “dotted decimal”, such as 128.114.144.4.
    - Each group of numbers can go from 0 to 255.
**IP Address Organization**

- Each IP address is divided into a **prefix** and a **suffix**
  - **Prefix** identifies **network** to which computers are attached.
  - **Suffix** identifies computers within that network.

**Network and Host Numbers**

- Every network in a TCP/IP internet is assigned a unique **network number**.
- Each host on a specific network is assigned a **host address** that is unique within that network.
- Host’s IP address is the combination of the network number (prefix) and host address (suffix).
- Assignment of network numbers must be coordinated globally; assignment of host addresses can be managed locally.

**IP Address Format**

- IP address are 32 bits long.
- There are different **classes of addresses**, corresponding to different subdivisions of the 32 bits into prefix and suffix.
  - Some address classes have **large prefix, small suffix**.
    - Many such networks, few hosts per network.
  - Other address classes have **small prefix, large suffix**.
    - Few such networks, many hosts per network.

**IP Address Format (cont’d)**

- How can we recognize to which class an IP address belongs to?
  - Look at the first 4 bits!

<table>
<thead>
<tr>
<th>Class</th>
<th>Prefix</th>
<th>Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>0</td>
<td>prefix</td>
</tr>
<tr>
<td>Class B</td>
<td>10</td>
<td>prefix</td>
</tr>
<tr>
<td>Class C</td>
<td>110</td>
<td>prefix</td>
</tr>
<tr>
<td>Class D</td>
<td>1110</td>
<td></td>
</tr>
<tr>
<td>Class E</td>
<td>1111</td>
<td></td>
</tr>
</tbody>
</table>
**IP Address Format (cont’d)**

- Class A, B and C are **primary classes**.
  - Used for ordinary addressing.
- Class D is used for **multicast**, which is a limited form of **broadcast**.
  - Internet hosts join a **multicast group**.
  - Packets are delivered to all members of the group.
  - Routers manage delivery of single packets from source to all members of multicast group.
- Class E is reserved.

**IP Addresses (cont’d)**

- Another way to determine the address class is by looking at the first group of numbers in the dotted decimal notation

<table>
<thead>
<tr>
<th>Class</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0 through 127</td>
</tr>
<tr>
<td>B</td>
<td>128 through 191</td>
</tr>
<tr>
<td>C</td>
<td>192 through 223</td>
</tr>
<tr>
<td>D</td>
<td>224 through 239</td>
</tr>
<tr>
<td>E</td>
<td>240 through 255</td>
</tr>
</tbody>
</table>

**Networks and Hosts in Each Class**

<table>
<thead>
<tr>
<th>Address Class</th>
<th>Bits In Prefix</th>
<th>Maximum Number of Networks</th>
<th>Bits In Suffix</th>
<th>Maximum Number Of Hosts Per Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>128</td>
<td>24</td>
<td>16777216</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
<td>16384</td>
<td>16</td>
<td>65536</td>
</tr>
<tr>
<td>C</td>
<td>21</td>
<td>2097152</td>
<td>8</td>
<td>256</td>
</tr>
</tbody>
</table>

**Understanding IP Addresses**

- Remember: the first 3 digits determine the class of the address
- Depending on the class of an address, we can find out its prefix and its suffix
  - If Class A: `ppp.sss.sss.sss` (with 0 ≤ `ppp` ≤ 127)
  - If Class B: `ppp.ppp.sss.sss` (with 128 ≤ `ppp` ≤ 191)
  - If Class C: `ppp.ppp.ppp.sss` (with 192 ≤ `ppp` ≤ 223)
- Examples:
  - 10.0.0.37 (class A)
  - 128.10.0.1 (class B)
  - 192.5.48.3 (class C)
**Example: A Private Internet**

- **prefix 128.10**
  - 128.10.0.1
  - 128.10.0.2

- **prefix 128.211**
  - 128.211.6.115
  - 128.211.28.4

- **prefix 10**
  - 10.0.0.37
  - 10.0.0.49

- **prefix 192.5.48**
  - 192.5.48.3
  - 192.5.48.65

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**IP addresses: how to get one?**

- The **network numbers** are assigned by the Network Information Center.
- How does **host** get its IP address in the network? 2 possibilities:
  - 1: Hard-coded by system administrator in a file inside the host.
  - 2: **DHCP**: “Dynamic Host Configuration Protocol”
    - Dynamically get address: “plug-and-play”.

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**DHCP**

- DHCP allows a computer to join a new network and automatically obtain an IP address. The network administrator establishes a pool of addresses for DHCP to assign.
- When a computer boots, it broadcasts a **DHCP request** to which a server sends a **DHCP reply**.
- DHCP allows non-mobile computers that run server software to be assigned a **permanent address** (won’t change when the computer reboots).
  - The permanent address actually needs to be renegotiated after a certain period of time.