CS118 Discussion 1D, Week 6

Zengwen Yuan
Boelter Hall 2760, Friday 4:00—5:50 p.m.
Outline

• Network Layer
  • Overview: data v.s. control plane
  • IP
• Project 2 spec
Network layer: overview

• Basic functions for network layer
  • Forwarding/Routing

• Network service model
  • Guaranteed delivery
  • Guaranteed delivery w/ bounded delay
  • In-order packet delivery
  • Guaranteed minimal bandwidth
Network layer: overview

• Connection v.s. connection-less delivery
  • circuit switch/packet switch

• Network layer protocols
  • Addressing and fragmentation: IPv4, IPv6
  • Routing: RIP, OSPF, BGP, DVMRP, PIM
  • Others: DHCP, ICMP, NAT
IPv4 Header

- **Header length**: 4-byte unit
- **Length**: 1-byte unit
- **Fragmentation**: id + MF/DF + offset (8-byte unit)
- **TTL**: time to live
- **Checksum**
  - Is it redundant?
  - Why is it just checksum for header?
- **Protocol**: identifies the upper layer protocol
- **Source and destination IP addresses**
IP address

- Globally recognizable identifier
- IPv4: 0.0.0.0~255.255.255.255
  - Most IP addresses are globally unique
  - Exception — why?
- Network id, host id
- CIDR address
# IP address classes


<table>
<thead>
<tr>
<th>Class</th>
<th>1st Octet Decimal</th>
<th>1st Octet High Order Bits</th>
<th>Network/Host ID (N=Network, H=Host)</th>
<th>Default Subnet Mask</th>
<th>Number of Networks</th>
<th>Hosts per Network (Usable Addresses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1 – 126*</td>
<td>0</td>
<td>N.H.H.H</td>
<td>255.0.0.0</td>
<td>126 (2^7 – 2)</td>
<td>16,777,214 (2^{24} – 2)</td>
</tr>
<tr>
<td>B</td>
<td>128 – 191</td>
<td>10</td>
<td>N.N.H.H</td>
<td>255.255.0.0</td>
<td>16,382 (2^{14} – 2)</td>
<td>65,534 (2^{16} – 2)</td>
</tr>
<tr>
<td>C</td>
<td>192 – 223</td>
<td>110</td>
<td>N.N.N.H</td>
<td>255.255.255.0</td>
<td>2,097,150 (2^{21} – 2)</td>
<td>254 (2^{8} – 2)</td>
</tr>
<tr>
<td>D</td>
<td>224 – 239</td>
<td>1110</td>
<td></td>
<td>Reserved for Multicasting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>240 – 254</td>
<td>1111</td>
<td></td>
<td>Experimental; used for research</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>Private Networks</th>
<th>Subnet Mask</th>
<th>Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.0.0.0</td>
<td>255.0.0.0</td>
<td>10.0.0.0 - 10.255.255.255</td>
</tr>
<tr>
<td>B</td>
<td>172.16.0.0 - 172.31.0.0</td>
<td>255.240.0.0</td>
<td>172.16.0.0 - 172.31.255.255</td>
</tr>
<tr>
<td>C</td>
<td>192.168.0.0</td>
<td>255.255.0.0</td>
<td>192.168.0.0 - 192.168.255.255</td>
</tr>
</tbody>
</table>
Hierarchical addressing

- subnet: a portion of addressing space
  - extend bits from the network id
  - `<network address>/<subnet mask>`
- route aggregation
CIDR address

- a.b.c.d/x
  - x: # bits in network ID portion of the address
  - address: a.b.c.d, network mask: $2^{32} - 2^{(32-x)}$

**CIDR**  \[ \text{11001000 00010111 00010000 00000000} \]

**IP prefix**  \[ 200.23.16.0/23 \]

**netmask**  \[ \text{11111111 11111111 111111110 00000000} \]

255.255.254.0
IP fragmentation and reassembly

- MTU: maximum transmission unit
- identifier
- flag bit:
  - DF (Do not Fragment) = 0
  - MF (More Fragments) = 0?
- offset
Forwarding

- Longest prefix matching

<table>
<thead>
<tr>
<th>Destination Address Range</th>
<th>Link interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>11001000 00010111 00011000 *********</td>
<td>0</td>
</tr>
<tr>
<td>11001000 00010111 00010*** *********</td>
<td>1</td>
</tr>
<tr>
<td>11001000 00010111 0001**** *********</td>
<td>2</td>
</tr>
<tr>
<td>******** ******** ******** ********</td>
<td>3</td>
</tr>
</tbody>
</table>

- Linear lookup
DHCP: Dynamic Host Configuration Protocol

- Dynamically allocates the following info to a host
  - IP address for the host
  - IP address for default router
  - Subnet mask
  - IP address for DNS caching resolver
- Allows address reuse
DHCP: operations

- Host broadcasts “DHCP discovery” msg
- DHCP server responds with “DHCP offer” msg
- Host requests IP address: “DHCP request” msg
- DHCP server sends address: “DHCP ack” msg
Project 2 Spec

• Questions?

• Two major parts
  • packet format design
  • message handling