Lecture 11: Fragmentation & Addressing

CSE 123: Computer Networks
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Project 1 due next Friday
Lecture 11 Overview

- Fragmentation

- Addressing
  - Subnetting
Different networks may have different frame limits (MTUs)
- Ethernet 1.5K, FDDI 4.5K

Router breaks up single IP packet into two or more smaller IP packets
- Each fragment is labeled so it can be correctly reassembled
- End host reassembles them into original packet

CSE 123 – Lecture 11: Fragmentation & Addressing
IP ID and Bitflags

- Source inserts unique value in identification field
  - Also known as the IPID
  - Value is copied into any fragments

- Offset field indicates position of current fragment (in bytes)
  - Zero for non-fragmented packet

- Bitflags provide additional information
  - More Fragments bit helps identify last fragment
  - Don’t Fragment bit prohibits (further) fragmentation
  - Note recursive fragmentation easily supported—just requires care with More Fragments bit
Fragmentation Example

One large datagram becomes several smaller datagrams
Costs of Fragmentation

- Interplay between fragmentation and retransmission
  - A single lost fragment may trigger retransmission
  - Any retransmission will be of entire packet (why?)

- Packet must be completely reassembled before it can be consumed on the receiving host
  - Takes up buffer space in the mean time
  - When can it be garbage collected?

- Why not reassemble at each router?
Path MTU Discovery

- Path MTU is the smallest MTU along path
  - Packets less than this size don’t get fragmented

- Fragmentation is a burden for routers
  - We already avoid reassembling at routers
  - Avoid fragmentation too by having hosts learn path MTUs

- Hosts send packets, routers return error if too large
  - Hosts can set “don’t fragment” flag
  - Hosts discover limits, can size packets at source
  - Reassembly at destination as before
IP Addresses

- 32-bits in an IPv4 address
  - Dotted decimal format a.b.c.d
  - Each represent 8 bits of address

- Hierarchical: Network part and host part
  - E.g. IP address 128.54.70.238
    - 128.54 refers to the UCSD campus network
    - 70.238 refers to the host ieng6.ucsd.edu

- Which part is network vs. host?
Class-based Addressing

- Most significant bits determines “class” of address
  
<table>
<thead>
<tr>
<th>Class</th>
<th>Network</th>
<th>Host</th>
<th>Networks</th>
<th>Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class B</td>
<td>1</td>
<td>0</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Class C</td>
<td>1</td>
<td>1</td>
<td>21</td>
<td>8</td>
</tr>
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<td></td>
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</tr>
</tbody>
</table>

- Special addresses
  - Class D (1110) for multicast, Class E (1111) experimental
  - 127.0.0.1: local host (a.k.a. the loopback address)
  - Host bits all set to 0: network address
  - Host bits all set to 1: broadcast address
Router needs to know where to forward a packet

Forwarding table contains:
- List of network names and next hop routers
- Local networks have entries specifying which interface
  - Link-local hosts can be delivered with Layer-2 forwarding

E.g. www.ucsd.edu address is 132.239.180.101
- Class B address – class + network is 132.239
- Lookup 132.239 in forwarding table
- Prefix – part of address that really matters for routing
Subnetting

- Individual networks may be composed of several LANs
  - Only want traffic destined to local hosts on physical network
  - Routers need a way to know which hosts on which LAN

- Networks can be arbitrarily decomposed into subnets
  - Each subnet is simply a prefix of the host address portion
  - Subnet prefix can be of any length, specified with netmask
For Next Time

- Read 3.2.5-6, 9.3.1 in P&D
- Project 1 due a week from today!