Lecture 10: Addressing

CSE 123: Computer Networks
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HW 2 due Friday
Lecture 10 Overview

- Class-based addressing
- Subnetting
- Classless addressing
IP Forwarding

- Router needs to know where to forward a packet

- Forwarding table contains:
  - List of network names (e.g., LANs) and next-hop routers
  - Attached (local) networks have entries specifying which interface
    » Link-local hosts are delivered using Layer-2 forwarding

- Address of incoming internetwork packet needs to say:
  - What is the destination network? (For use by most routers)
  - What is the destination host? (For use by the final router)
Addressing Considerations

- Fixed length or variable length addresses?

- Issues:
  - Flexibility
  - Processing costs
  - Header size

- Engineering choice: IP uses fixed length addresses
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
  - Class A: 0 Network 16 Host
    - 127 nets, 16M hosts
  - Class B: 1 0 Network 16 Host
    - 16K nets, 64K hosts
  - Class C: 1 1 0 Network 8 Host
    - 2M nets, 254 hosts

- 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

To what class network does 132.239.180.101 belong?

A. A
B. B
C. C
D. Can’t tell
Routing over LANs: 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**

<table>
<thead>
<tr>
<th>Network</th>
<th>Subnet</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Prefix</td>
</tr>
</tbody>
</table>
Subnet Addresses

- Every (sub)network has an address and a **netmask**
  - Netmask tells which bits of the network address is important
  - Convention suggests it be a proper prefix

- Netmask written as an all-ones (bits) IP address
  - E.g., Class B netmask is 255.255.0.0 (i.e, 11111111111111110000000000000000)
  - Sometimes expressed in terms of number of 1s, e.g., /16

- Need to size subnet appropriately for each LAN
  - Only have remaining bits to specify host addresses

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What is the prefix of 132.239.180.101 if the netmask is 255.255.192.0?

A. 132.239.0.0  
B. 132.239.192.0  
C. 132.239.180.0  
D. 132.239.128.0
IP Address Problem (circa 1991)

- Address space depletion
  - In danger of running out of classes A and B

- Why?
  - Class C too small for most organizations (only ~250 addresses)
  - Very few class A – very careful about giving them out (who has 16M hosts anyway?)
  - Class B – greatest problem
Classless Inter-Domain Routing (1993)

- Networks described by variable-length prefix and length
- Allows arbitrary allocation between network and host address

- e.g. 10.95.1.2 contained within 10.64.0.0/10:
  - 10.64.0.0 is network and remainder (31.1.2) is host
  - 0000101001 / 0111110000000100000010

- Pro: Finer grained allocation; aggregation
- Con: More expensive lookup: longest prefix match

CIDR
Longest Matching Prefix

- Forwarding table contains many prefix/length tuples
  - They need not be disjoint!
  - E.g. 200.23.16.0/20 and 200.23.18.0/23
  - What to do if a packet arrives for destination 200.23.18.1?
  - Need to find the longest prefix in the table which matches it (200.23.18.0/23)

- Not a simple table, requires multiple memory lookups
  - Lots and lots of research done on this problem
  - Lots of this work was historically done by UCSD faculty

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Can an IP address match two forwarding table entries of the same length?

A. Yes
B. No
C. Only if the least significant bit is zero
Route Aggregation

- Combine adjacent networks in forwarding tables
  - Helps keep forwarding table size down

- Organization 0: 200.23.16.0/23
- Organization 1: 200.23.18.0/23
- Organization 2: 200.23.20.0/23
- Organization 7: 200.23.30.0/23

- Fly-By-Night-ISP: "Send me anything with addresses beginning 200.23.16.0/20"

- ISPs-R-Us: "Send me anything with addresses beginning 199.31.0.0/16"

- Internet
But what if address range is not contiguous?

- Organization 0
  - 200.23.16.0/23

- Organization 2
  - 200.23.20.0/23

- Organization 7
  - 200.23.30.0/23

- Organization 1
  - 200.23.18.0/23

- ISP - R-Us

- Fly-By-Night-ISP

- "Send me anything with addresses beginning 200.23.16.0/20"

- "Send me anything with addresses beginning 199.31.0.0/16 or 200.23.18.0/23"

- Internet
For Next Time

- Read 4.2
- Finish up Homework 2
- Keep plugging on Project 1b