Network Layer Addressing

CS640, 2015-02-17

Announcements

- Quiz 2 is Thursday
- Project 2 has been released

Overview

- Motivation for Network Layer
- Network Layer Addressing

Motivation for Network Layer

- ***What are some scalability problems with using link layer forwarding?***
  - Switches broadcast packets when the path to the destination is not known
    => volume of traffic increases as number of hosts and size of network increases
  - Link layer addresses have no hierarchy
    => size of forwarding tables grows linearly as number of hosts increases
  - Can address some scalability issues using virtual local area networks (VLANs)
- Want to create a network-of-networks (i.e., an "internetwork") to address these issues
- Two main concerns for network layer
  - Addressing -- want something hierarchical
  - Routing -- want better control over forwarding

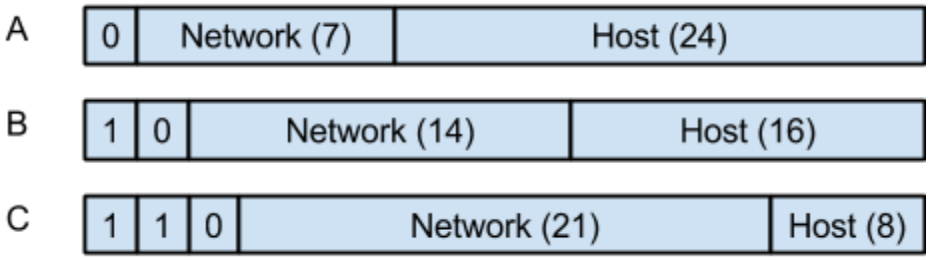
Addressing

- Requirements
  - Global uniqueness -- every interface (on host or router) must have an IP address that's not used by any other node on the Internet
  - Hierarchical -- provide a way to organize networks and reduce forwarding table size
- Representation
  - 32-bit integer
  - Typically written in dotted-decimal form -- each byte is written as a decimal number and the decimals are separated by dots; e.g., 128.105.14.122
- ***How do we provide hierarchy?***
  - Class-based addressing; subnets

Class-Based Addressing

- Divide 32-bits into two parts
  - Network: same for all hosts in a switched network
  - Host: unique to each host

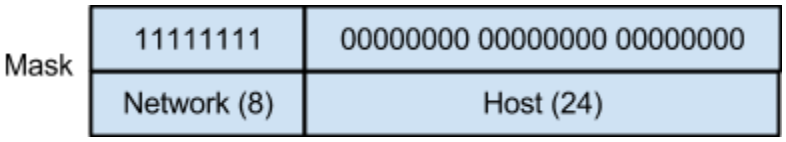
- Three classes: A, B, & C



  - First few bits determine class
  - Number of host bits determines the maximum number of hosts within a network
    - A: 2^24 - 2 = about 16.7 million
    - B: 2^16 - 2 = 65,534
    - C: 2^8 - 2 = 254
    - All-zeros host value reserved for network address
    - All-ones host address reserved for broadcast address
- Limitation: allocation is too coarse grained
  - Only allows for extremely large, moderate, and extremely small networks
    - If number of hosts is in-between, then addresses are wasted -- e.g., network with 255 hosts requires class B, which wastes >65K addresses
    - Could assign multiple class C's to avoid wasting part of a class B, but now you need multiple entries in forwarding tables in routers
  - Only allows for 127 networks with more than 65,534 hosts
  - ***How do we address these issues?***

Classless Interdomain Routing (CIDR)

- Do not limit network sizes to three classes
- Assign network numbers in powers of 2
- Use a mask to identify number of bits used for network number

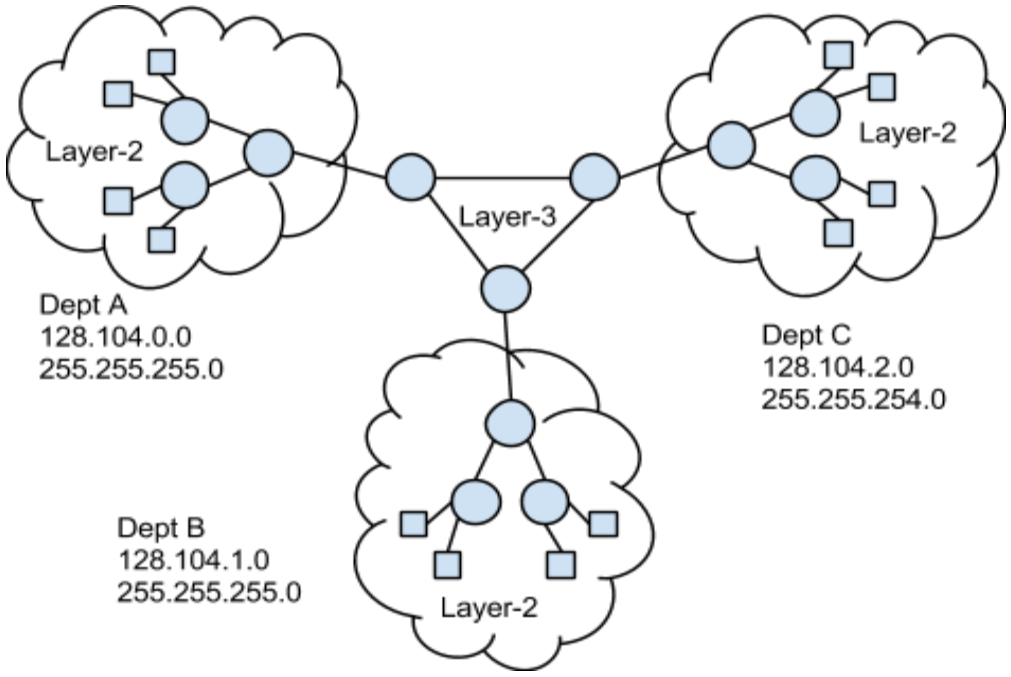


- Two ways to specify netmask
  - In dotted-decimal form -- e.g., 255.0.0.0 is 8-bit netmask
  - In slash notation -- e.g., /8 is 8-bit netmask
  - Conversion: dotted-decimal to slash
    - For each octet of 255: add 8
    - For each octet between 0 and 255: add 8 - $\log_2$(256-octet)
  - Conversion: slash to dotted-decimal
    - While ≥ 8: add 255 octet, subtract 8
    - Add octet 256 - $2^{(8\text{-remain})}$
    - Add 0 octets until there are four octets
  - ***What is the slash notation for the netmask 255.255.0.0?*** -- /16
  - ***What is the netmask for the slash notation /20?*** -- 255.255.240.0
- Backwards compatible with class-based addressing

    - Class A -- 255.0.0.0 or /8
    - Class B -- 255.255.0.0 or /16
    - Class C -- 255.255.255.0 or /24
- Number of hosts = $2^{(32\text{-slash})}$ - 2
    - ***What netmask should be used if a network should accommodate up to 62 hosts?*** -- 255.255.255.192
    - ***What slash notation should be used if a network should accommodate up to 510 hosts?*** -- /23
- Network address = bitwise AND of IP address and mask
    - Also referred to as “network prefix”
    - ***What is the network address if a host’s IP is 172.0.10.10 and netmask is 255.255.255.0?*** -- 172.0.10.0
    - ***What is the network address if a host’s IP is 172.0.35.128/20?*** -- 172.0.32.0

Subnetting

- May want to divide a network into multiple subnetworks
    - E.g., UW-Madison network is divided into subnets by department
        - Link layer switching used within department
        - Network layer routing used within core (i.e., between departments)



    - Network = single administrative domain
- Define subnets by using a longer mask

Mask	11111111 11111111		00000000 00000000
	Network (8)	Subnet (8)	Host (24)

    - Given a subnet mask, we don’t know how many bits are for network and how many are for subnet, but this division doesn’t matter
- We’ll use the terms “netmask” and “subnet mask” interchangeably

- We'll also use the terms "network address", "network prefix", "subnet address", and "subnet prefix" interchangeably