Lecture 13:
Naming and Autoconfig

CSE 123: Computer Networks
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Discovering addresses of hosts (link and network layer)
  - Link Layer (ARP)
  - Network Layer (DHCP)

Human-friendly names for hosts (DNS)
Layers of Identifiers

- **Host name** (e.g., www.ucsd.edu)
  - Used by *humans* to specify host of interest
  - Unique, selected by host administrator
  - Hierarchical, variable-length string of alphanumeric characters

- **IP address** (e.g., 128.54.70.238)
  - Used by *routers* to forward packets
  - Unique, topologically meaningful locator
  - Hierarchical namespace of 32 bits (or 128 bits for IPv6)

- **MAC address** (e.g., 58:B0:35:F2:3C:D9)
  - Used by *network adaptors* to identify interesting frames
  - Unique, hard-coded identifier burned into network adaptor
  - Flat name space (of 48 bits in Ethernet)
Host name: www.ucsd.edu
- Domain: registrar for each top-level domain (e.g., .edu)
- Host name: local org. administrator assigns to each host

IP addresses: 128.54.70.238
- Prefixes: ICANN, regional Internet registries, and ISPs
- Hosts: static configuration, or dynamic using DHCP

MAC addresses: 58:B0:35:F2:3C:D9
- OIDs: assigned to vendors by the IEEE
- Adapters: assigned by the vendor from its block
Mapping Between Identifiers

- **Address Resolution Protocol (ARP)**
  - Given an **IP address**, provide the **MAC address**
  - To enable communication within the Local Area Network

- **Dynamic Host Configuration Protocol (DHCP)**
  - Automates host boot-up process
  - Given a **MAC address**, assign a unique **IP address**
  - … and tell host other stuff about the Local Area Network

- **Domain Name System (DNS)**
  - Given a **host name**, provide the **IP address**
  - Given an **IP address**, provide the **host name**
Address Resolution Protocol

- Every node maintains an ARP table
  - (IP address, MAC address) pair
- Consult the table when sending a packet
  - Map destination **IP address to MAC address**
  - Encapsulate and transmit the data packet
- What if the IP address is not in the table?
  - Broadcast: “Who has IP address x.x.x.x?”
  - Sender caches the result in its ARP table
You already have a bunch from the days when you called Jon Postel and asked for them (e.g. BBN)

You get them from another provider
- E.g. buy service from Level 3 and get a /24 from one of their address blocks
- UCSD or Spectrum/AT&T are giving you addresses now…

You get one directly from a Internet number registry
- ARIN: North America, APNIC (Asia Pacific), RIPE (Europe), LACNIC (Latin America), AFRINIC (Africa)
- Registries get address from IANA (Internet Assigned Numbers Authority)
How Do Hosts Get One?

- Well from your provider!

- But how do you know what it is?

- Manual configuration
  - They tell you over the phone or email, you type that number into your computer (along with the default gateway, DNS server, etc.)

- Automated configuration
  - Dynamic Host Resolution Protocol (DHCP)
Bootstrapping Problem

- Host doesn’t have an IP address yet at boot
  - So, host doesn’t know what source address to use

- Host doesn’t know who to ask for an IP address
  - So, host doesn’t know what destination address to use

- Solution: broadcast to discover a server who can help
  - Install a special server on the LAN to answer IP distress calls
**DHCP**

- Broadcast-based LAN protocol algorithm
  - Host broadcasts “DHCP discover” on LAN (e.g. Ethernet broadcast)
  - DHCP server responds with “DHCP offer” message
  - Host requests IP address: “DHCP request” message
  - DHCP server sends address: “DHCP ack” message w/IP address

- Easy to have fewer addresses than hosts (e.g. UCSD wireless) and to *renumber* network (use new addresses)

- What if host goes away (how to get address back?)
  - Address is a “lease” not a “grant”, has a timeout
  - Can a host have different IP addresses at different times?
Domain Name System (DNS)

- Distributed administrative control
  - Hierarchical name space divided into zones
  - Distributed over a collection of DNS servers

- Hierarchy of DNS servers
  - Root servers
  - Top-level domain (TLD) servers
  - Authoritative DNS servers

- Performing the translations
  - Local DNS servers
  - Resolver software
DNS: Distributed Database

Root (A,B,C,D,E…)

com  edu  org

bar

west  east

foo  my

my.east.bar.edu

generic domains

country domains

ac  uk  zw

ac  cam  usr

usr.cam.ac.uk

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DNS Root Servers

- 13 root servers (see http://www.root-servers.org/)
  - Labeled A through M

- A Verisign, Dulles, VA
- C Cogent, Herndon, VA (also Los Angeles)
- D U Maryland College Park, MD
- G US DoD Vienna, VA
- H ARL Aberdeen, MD
- J Verisign, (11 locations)
- E NASA Mt View, CA
- F Internet Software C. Palo Alto, CA (and 17 other locations)
- K RIPE London (+ Amsterdam, Frankfurt)
- I Netnod, Stockholm (plus 3 other locations)
- M WIDE Tokyo

B USC-ISI Marina del Rey, CA
L ICANN Los Angeles, CA

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Using DNS

- Local DNS resolver ("default name server")
  - Usually near the end hosts who use it
  - Local hosts configured with local server (e.g., /etc/resolv.conf) or learn the server via DHCP

- Client application
  - Extract server name (e.g., from the URL)
  - Do `gethostbyname()` to trigger resolver code

- Server application
  - Extract client IP address from socket
  - Optional `gethostbyaddr()` to translate into name
Host at \texttt{cis.poly.edu} wants IP address for \texttt{gaia.cs.umass.edu}
Reliability

- DNS servers are replicated
  - Name service available if at least one replica is up
  - Queries can be load balanced between replicas

- UDP used for queries
  - Need reliability: must implement this on top of UDP
  - Try alternate servers on timeout
  - Exponential backoff when retrying same server

- Cache responses to decrease load
  - Both at end hosts and local servers
Summary

- IP to MAC Address mapping
  - Dynamic Host Configuration Protocol (DHCP)
  - Address Resolution Protocol (ARP)

- Domain Name System
  - Distributed, hierarchical database
  - Distributed collection of servers
  - Caching to improve performance
For Next Time

- Read P&D section 3.4
- Homework 2 due Wednesday
- Project 2 due Wednesday
- Midterm next Monday