Lecture 13: Naming

CSE 123: Computer Networks
Alex C. Snoeren

Some material courtesy Mike Freedman
Lecture 13 Overview

Packet forwarding example

Discovering addresses (DHCP/ARP)

User-friendly names (DNS)
Forwarding example

• Packet to 10.1.1.6 arrives

• Path is R2 – R1 – H1 – H2
Forwarding example (2)

- Packet to 10.1.1.6
- Matches 10.1.0.0/23

Forwarding table at R2

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>127.0.0.1</td>
<td>loopback</td>
</tr>
<tr>
<td>Default or 0/0</td>
<td>10.1.16.1</td>
</tr>
<tr>
<td>10.1.8.0/24</td>
<td>interface1</td>
</tr>
<tr>
<td>10.1.2.0/23</td>
<td>interface2</td>
</tr>
<tr>
<td><strong>10.1.0.0/23</strong></td>
<td><strong>10.1.2.2</strong></td>
</tr>
<tr>
<td>10.1.16.0/24</td>
<td>interface3</td>
</tr>
</tbody>
</table>

H1 10.1.1/24  10.1.16/24  10.1.101
10.1.1.1  10.1.1.1.5  10.1.1.6
10.1.0.1  10.1.0.2  10.1.0/24

R2 10.1.16/24  10.1.16.2
10.1.8/24  10.1.8.1

CSE 123 – Lecture 13: Naming
Forwarding example (3)

- Packet to 10.1.1.6
- Matches 10.1.1.4/30
- Longest prefix match

Routing table at R1

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>127.0.0.1</td>
<td>loopback</td>
</tr>
<tr>
<td>Default or 0/0</td>
<td>10.1.2.1</td>
</tr>
<tr>
<td>10.1.0.0/24</td>
<td>interface1</td>
</tr>
<tr>
<td><strong>10.1.1.0/24</strong></td>
<td>interface2</td>
</tr>
<tr>
<td>10.1.2.0/23</td>
<td>interface3</td>
</tr>
<tr>
<td><strong>10.1.1.4/30</strong></td>
<td>10.1.1.101</td>
</tr>
</tbody>
</table>

CSE 123 – Lecture 13: Naming
Forwarding example (4)

- Packet to 10.1.1.6
- Direct route
  - Longest prefix match

Routing table at H1

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>127.0.0.1</td>
<td>loopback</td>
</tr>
<tr>
<td>Default or 0/0</td>
<td>10.1.1.1</td>
</tr>
<tr>
<td>10.1.1.0/24</td>
<td>interface1</td>
</tr>
<tr>
<td>10.1.1.4/30</td>
<td>interface2</td>
</tr>
</tbody>
</table>
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 alphanumerical characters

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

**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 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

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

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
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
Whence come IP Addresses?

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 Sprint and get a /24 from one of their address blocks

You get one directly from a routing 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 You And I Get One?

Well from your provider!

But how do you know what it is?

Manual configuration
  - They tell you and 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
- 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: shout to discover a server who can help
- Install a special server on the LAN to answer 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
- Host may 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

Unnamed root

generic domains

country domains

com
edu
org

bar
west
east

foo
my

my.east.bar.edu

ac
uk
zw

ac
cam
usr

usr.cam.ac.uk

CSE 123 – Lecture 13: Naming
DNS Root Servers

13 root servers (see http://www.root-servers.org/)

- Labeled A through M

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

CSE 123 – Lecture 13: Naming
Using DNS

Local DNS server ("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
Example

Host at cis.poly.edu wants IP address for gaia.cs.umass.edu

CSE 123 – Lecture 13: Naming
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

- NO CLASS WEDNESDAY

- Study for the Midterm
  - Previous year’s exam on the website

- Project 1 due Wednesday!
  - Lose a letter grade for each day late