CMPE 150 – Winter 2009

• Lecture 18

• March 10, 2009

P.E. Mantey
CMPE 150 -- Introduction to Computer Networks

- Instructor: Patrick Mantey
  mantey@soe.ucsc.edu
  http://www.soe.ucsc.edu/~mantey/
- Office: Engr. 2 Room 595J
- Office hours: Tues 3-5 PM, Mon 5-6 PM*
- TA: Anselm Kia
  akia@soe.ucsc.edu
- Web site: http://www.soe.ucsc.edu/classes/cmpe150/Winter09/
- Text: Tannenbaum: Computer Networks
  (4th edition – available in bookstore, etc.)
<table>
<thead>
<tr>
<th>Lecture</th>
<th>Date</th>
<th>Topic</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6-Jan</td>
<td>Intro / Overview</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>2</td>
<td>8-Jan</td>
<td>Internet Architecture</td>
<td>Chapter 1, 2</td>
</tr>
<tr>
<td>3</td>
<td>13-Jan</td>
<td>Physical Layer</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>4</td>
<td>15-Jan</td>
<td>Physical Layer</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>5</td>
<td>20-Jan</td>
<td>Link Layer</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>6</td>
<td>22-Jan</td>
<td>Link Layer / MAC</td>
<td>Chapter 3, 4</td>
</tr>
<tr>
<td>7</td>
<td>27-Jan</td>
<td>MAC Sublayer</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>8</td>
<td>29-Jan</td>
<td>Wireless</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>9</td>
<td>3-Feb</td>
<td>Bridges (and Review)</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>10</td>
<td>5-Feb</td>
<td><strong>Midterm Exam 1</strong></td>
<td>Chapter 4</td>
</tr>
<tr>
<td>11</td>
<td>10-Feb</td>
<td>Intro to Network Layer</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>12</td>
<td>12-Feb</td>
<td>Routing and Routers</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>13</td>
<td>17-Feb</td>
<td>Congestion Control, QOS</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>14</td>
<td>19-Feb</td>
<td>Internet / IP</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>15</td>
<td>24-Feb</td>
<td>Transport Layer / Services/ Protocols</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>16</td>
<td>26-Feb</td>
<td>Internet Transport Protocols: UDP, TCP</td>
<td>Chapter 6</td>
</tr>
<tr>
<td>17</td>
<td>3-Mar</td>
<td>RPC/ TCP/ ·Performance / Applications / Review</td>
<td>Chapter 6, 7</td>
</tr>
<tr>
<td>18</td>
<td>5-Mar</td>
<td><strong>Midterm Exam 2</strong></td>
<td>Chapter 7</td>
</tr>
<tr>
<td>19</td>
<td>10-Mar</td>
<td>Applications / Multimedia</td>
<td>Chapter 7</td>
</tr>
<tr>
<td>20</td>
<td>12-Mar</td>
<td>Buffer / Review</td>
<td>Chapter 7</td>
</tr>
<tr>
<td><strong>Final Exam</strong></td>
<td>18-Mar</td>
<td>12-3 PM</td>
<td></td>
</tr>
</tbody>
</table>
Reading Assignment

- Chapter 7 – Applications Layer
Internet Layering

- Level 5  -- **Application** Layer
  (rlogin, ftp, SMTP, POP3, IMAP, HTTP..)
- Level 4  -- **Transport** Layer (a.k.a. Host-to-Host)
  *(TCP, UDP)*
- Level 3  -- **Network** Layer (a.k.a. Internet)
  *(IP, ICMP, ARP)*
- Level 2  -- *(Data)* **Link** Layer / MAC sub-layer
  (a.k.a. Network Interface or Network Access Layer)
- Level 1  -- **Physical** Layer
Today’s Agenda

- Transport Layer
  - Performance
- Applications Layer
  - DNS
    - dig
    - nslookup
  - Akami
Transitional TCP

(a) RPC using normal TCP.
(b) RPC using T/TCP.
Performance Issues

- Performance Problems in Computer Networks
- Network Performance Measurement
- System Design for Better Performance
- Fast TPDU Processing
- Protocols for Gigabit Networks
Performance Problems in Computer Networks

The state of transmitting one megabit from San Diego to Boston
(a) At \( t = 0 \), (b) After 500 \( \mu \text{sec} \), (c) After 20 \( \text{msec} \), (d) after 40 \( \text{msec} \).
Network Performance Measurement

- The basic loop for improving network performance.
- Measure relevant network parameters, performance.
- Try to understand what is going on.
- Change one parameter.
pathchar (Jacobsen)

rat,

Here's what I got letting it run all night:

pathchar to 4.26.134.96 (4.26.134.96)
can't find path mtu - using 1500 bytes.
doing 32 probes at each of 45 sizes (64 to 1500 by 32)
0 localhost
  49 Mb/s, 93 us (430 us)
1 e2-g (128.114.56.1)
  725 Mb/s, 5 us (458 us)
2 comm-g-GE3-10.ucsc.edu (128.114.0.73)
  884 Mb/s, 10 us (492 us)
3 isp-g-GE1-1.ucsc.edu (128.114.1.65)
  535 Mb/s, 0.92 ms (2.36 ms)
4 inet-svl-isp--inet-ucsc-ucsc2-egm.cenic.net (137.164.24.149)
  ?? b/s, -53 us (2.19 ms)
5 so-1-0.hsai.SanJose1.Level3.net (209.247.159.109)
  255 Mb/s, 12 us (2.26 ms)
6 ge-10-0.core1.SanJose1.Level3.net (4.68.123.6)
  75 Mb/s, 13 us (2.44 ms)
7 vol-dhcp-egress1.wbar3.SanJose1.Level3.net (4.9.2.133)
  *
8 *
9 *
10 *
11 *

It appears that whoever your service provider is, when the path
jumps from Level3 to your provider, they block the kinds of packets
pathchar uses to do its measurements. Also interesting how the
links in Level3 are much smaller pipes than I would have expected
(the last one must be a 100Mb link).

Brad
Response as a function of load.
System Design for Better Performance (3)

Four context switches to handle one packet with a user-space network manager.
Fast TPDU Processing

The fast path from sender to receiver is shown with a heavy line. The processing steps on this path are shaded.
Fast TPDU Processing (2)

(a) TCP header.  (b) IP header. In both cases, the shaded fields are taken from the prototype without change.
Fast TPDU Processing (3)

Slot

0  Pointer to list of timers for T + 12
1
2
3
4  Current time, T
5
6
7  Pointer to list of timers for T + 3
8
9
10
11
12
13
14  Pointer to list of timers for T + 10
15

A timing wheel.
Protocols for Gigabit Networks

Time to transfer and acknowledge a 1-megabit file over a 4000-km line.
DNS

- Hierarchical name space.
- Distributed database.
- RFCs 1034 and 1035.
History

Original approach (ARPANET, 1970’s):

- File *hosts.txt* listed all hosts and their IP addresses.
- Every night every host fetches file from central repository.
- OK for a few hundred hosts.
- Scalability?
  - File size.
  - Centrally managed.
How is it used?

- Client-server model.
  - Client DNS (running on client hosts), or resolver.
  - Application calls resolver with name.
  - Resolver contacts local DNS server (using UDP) passing the name.
  - Server returns corresponding IP address.
DNS Name Space

Tree-based hierarchy.
Name Space Structure

- Top-level domains:
  - Generic.
  - Countries.
- Leaf domains: no sub-domains.
- In practice all US organizations are under a generic domain, while everything outside the US is under the corresponding country domain.
DNS Names

- Domain names:
  - Concatenation of all domain names starting from its own all the way to the root separated by “.”.
  - Refers to a tree node and all names under it.
  - Case insensitive.
  - Components up to 63 characters.
  - Full name less than 255 characters.
Name Space Management

- Domains are autonomous.
  - Organizational boundaries.
  - Each domain manages its own name space independently of other domains.

- Delegation:
  - When creating new domain: register with parent domain.
    - For name uniqueness.
    - For name resolution.
Resource Records

- Entry in the DNS database.
- Several types of entries or RRs.
- Example: RR “A” contains IP address.
- Name <-> several resource records.
- RR format: five-tuple.
  - Name.
  - TTL (in seconds).
  - Class (usually “IN” for Internet info).
  - Type: type of RR.
  - Value.
RR Types 1

- **SOA**: start of authority.
  - Marks beginning of zone’s database.
  - Provides general info about the zone: e-mail address of admin, default TTL, etc.
- **A**: address.
  - Contains 32-bit IP address.
  - Single name <-> several A RRs.
- **MX**: mail exchange.
  - Name of mail server for this domain.
RR Types 2

- **NS**: name server.
  - Name of name server for this domain.
- **CNAME**: canonical name.
  - Alias.
- **HINFO**: host description.
  - Provides information about host, e.g., CPU type, OS, etc.
- **TXT**: arbitrary string of characters.
  - Generic description of the domain, where it is located, etc.
Name Servers

- Entire database in a single name server.
  - Practical?
  - Why?
- DNS database is partitioned into zones.
- Each zone contains part of the DNS tree.
- Zone <-> name server.
  - Each zone may be served by more than 1 server.
  - A server may serve multiple zones.
- Primary and secondary name servers.
Application wants to resolve name.
Resolver sends query to local name server.
  – Resolver configured with list of local name servers.
  – Select servers in round-robin fashion.
If name is local, local name server returns matching authoritative RRs.
  – *Authoritative* RR comes from authority managing the RR and is always correct.
  – *Cached* RRs may be out of date.
Name Resolution 2

• If information not available locally (not even cached), local NS will have to ask someone else.
  – It asks the server of the top-level domain of the name requested.
Recursive Resolution

- Recursive query:
  - Each server that doesn’t have info forwards it to someone else.
  - Response finds its way back.
- Alternative:
  - Name server not able to resolve query, sends back the name of the next server to try.
  - Some servers use this method.
  - More control for clients.
Example

• Suppose resolver on flits.cs.vu.nl wants to resolve linda.cs.yale.edu.
  – Local NS, cs.vu.nl, gets queried but cannot resolve it.
  – It then contacts .edu server.
  – .edu server forwards query to yale.edu server.
  – yale.edu contacts cs.yale.edu, which has the authoritative RR.
  – Response finds its way back to originator.
  – cs.vu.nl caches this info.
• Not authoritative (since may be out-of-date).
• RR TTL determines how long RR should be cached.
# Resource Records

The principal DNS resource records types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOA</td>
<td>Start of Authority</td>
<td>Parameters for this zone</td>
</tr>
<tr>
<td>A</td>
<td>IP address of a host</td>
<td>32-Bit integer</td>
</tr>
<tr>
<td>MX</td>
<td>Mail exchange</td>
<td>Priority, domain willing to accept e-mail</td>
</tr>
<tr>
<td>NS</td>
<td>Name Server</td>
<td>Name of a server for this domain</td>
</tr>
<tr>
<td>CNAME</td>
<td>Canonical name</td>
<td>Domain name</td>
</tr>
<tr>
<td>PTR</td>
<td>Pointer</td>
<td>Alias for an IP address</td>
</tr>
<tr>
<td>HINFO</td>
<td>Host description</td>
<td>CPU and OS in ASCII</td>
</tr>
<tr>
<td>TXT</td>
<td>Text</td>
<td>Uninterpreted ASCII text</td>
</tr>
</tbody>
</table>
Resource Records (2)

<table>
<thead>
<tr>
<th>Host</th>
<th>Type</th>
<th>Class</th>
<th>TTL</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs.vu.nl</td>
<td>SOA</td>
<td>IN</td>
<td>86400</td>
<td>star boss (952771,7200,7200,2419200,86400)</td>
</tr>
<tr>
<td>flits.cs.vu.nl</td>
<td>TXT</td>
<td>IN</td>
<td>86400</td>
<td>&quot;Divisie Wiskunde en Informatica.&quot;</td>
</tr>
<tr>
<td><a href="http://www.cs.vu.nl">www.cs.vu.nl</a></td>
<td>MX</td>
<td>IN</td>
<td>86400</td>
<td>1 zephyr.cs.vu.nl</td>
</tr>
<tr>
<td>ftp.cs.vu.nl</td>
<td>MX</td>
<td>IN</td>
<td>86400</td>
<td>2 top.cs.vu.nl</td>
</tr>
<tr>
<td>flits.cs.vu.nl</td>
<td>IN</td>
<td>A</td>
<td>86400</td>
<td>130.37.16.112</td>
</tr>
<tr>
<td>flits.cs.vu.nl</td>
<td>MX</td>
<td>IN</td>
<td>86400</td>
<td>192.31.231.165</td>
</tr>
<tr>
<td>flits.cs.vu.nl</td>
<td>MX</td>
<td>IN</td>
<td>86400</td>
<td>1 flits.cs.vu.nl</td>
</tr>
<tr>
<td>flits.cs.vu.nl</td>
<td>MX</td>
<td>IN</td>
<td>86400</td>
<td>2 zephyr.cs.vu.nl</td>
</tr>
<tr>
<td>flits.cs.vu.nl</td>
<td>MX</td>
<td>IN</td>
<td>86400</td>
<td>3 top.cs.vu.nl</td>
</tr>
<tr>
<td><a href="http://www.cs.vu.nl">www.cs.vu.nl</a></td>
<td>CNAME</td>
<td>IN</td>
<td>86400</td>
<td>star.cs.vu.nl</td>
</tr>
<tr>
<td>ftp.cs.vu.nl</td>
<td>CNAME</td>
<td>IN</td>
<td>86400</td>
<td>zephyr.cs.vu.nl</td>
</tr>
<tr>
<td>rowboat</td>
<td>A</td>
<td>IN</td>
<td></td>
<td>130.37.56.201</td>
</tr>
<tr>
<td>rowboat</td>
<td>MX</td>
<td>IN</td>
<td></td>
<td>1 rowboat</td>
</tr>
<tr>
<td>rowboat</td>
<td>MX</td>
<td>IN</td>
<td></td>
<td>2 zephyr</td>
</tr>
<tr>
<td>rowboat</td>
<td>HINFO</td>
<td>IN</td>
<td></td>
<td>Sun Unix</td>
</tr>
<tr>
<td>little-sister</td>
<td>A</td>
<td>IN</td>
<td></td>
<td>130.37.62.23</td>
</tr>
<tr>
<td>little-sister</td>
<td>HINFO</td>
<td>IN</td>
<td></td>
<td>Mac MacOS</td>
</tr>
<tr>
<td>laserjet</td>
<td>A</td>
<td>IN</td>
<td></td>
<td>192.31.231.216</td>
</tr>
<tr>
<td>laserjet</td>
<td>HINFO</td>
<td>IN</td>
<td></td>
<td>&quot;HP Laserjet IIISi&quot; Proprietary</td>
</tr>
</tbody>
</table>

A portion of a possible DNS database for cs.vu.nl.
DNS – The Domain Name System

- The DNS Name Space
- Resource Records
- Name Servers
The DNS Name Space

A portion of the Internet domain name space.
Name Servers

Part of the DNS name space showing the division into zones.
Name Servers (2)

How a resolver looks up a remote name in eight steps.
NSLookup

This DNS utility is provided by ZoneEdit.Com, the industry leader in DNS and domain management solutions. Click here to sign up for a free, no obligation trial of our dns services. Click here to use our SMTP test utility. Click here to use our global whois utility (domain ownership info).

DNS Lookup

1. Enter a host name for Forward DNS Lookup: (IE: yahoo.com)
2. Select record type (optional): Ip Address (A)
3. Enter server name or IP (optional):
4. Look it up

Reverse Lookup

1. Enter an IP address for Reverse Lookup: (IE: 216.115.108.245)
2. Enter server name or IP (optional):
3. Look it up

*Network lookups can take a long time, please wait for the server to respond.

http://www.zoneedit.com/lookup.html