Networking

INFO/CSE 100, Spring 2006
Fluency in Information Technology

http://www.cs.washington.edu/100
Readings and References

• Reading
  – Fluency with Information Technology
    » Chapter 3, Making the Connection
Networks…

- Computers are useful alone, but are even more useful when connected (networked)
  - Access more information and software than is stored locally
  - Help users to communication, exchange information.. Changing ideas about social interaction
  - Perform other services -- printing, audio, video
  - Immediate answers: for example, Google
Networking Changes Life

• The Internet is making fundamental changes
... the FIT text gives 5 ways
  – Nowhere is remote -- access to information is no longer bound to a place
  – Connection with others -- email is great! But what about spam?!?
  – Revised human relationships -- too much time spent online could be bad
  – English is becoming a universal language
  – Enhanced freedom of speech, assembly
Network Structure

• Internet: all of the wires, fibers, switches, routers, etc… connecting named computers
  – Networks are structured differently based (mostly) on how far apart the computers are
    » Local area network (LAN)
      – A small area such as a room or building
    » Wide area networks (WAN)
      – Large area, e.g. distance is more than 1Km
  » What do you think a PAN might be?!?
Local Area Network

Mac disk and printers available on the nearby Windows PC

Windows disk and printers available on the nearby Mac
Wide Area Network

UW servers

router

Internet

instant messenger

world wide web

The Information School of the University of Washington

networks @ university of washington

Apr-3-06
Protocol Rules!

• To communicate, computers need to know how to set-up the info to be sent and to interpret the info received
  – Communication rules are a *protocol*
  – Example protocols:
    » Ethernet for physical connection in a LAN
    » TCP/IP -- transmission control protocol/internet protocol
    » HTTP -- hypertext transfer protocol (for the WWW)
    » FTP -- file transfer protocol (for transferring files)
LAN in the Lab

- Ethernet is a popular LAN protocol
  - Recall that it’s a “party line” protocol

Connection to campus network infrastructure

Typical MGH or OUGL Lab

Ethernet Cable

PC PC PC PC PC PC PC
Campus & The World

- The campus sub-networks interconnect computers of the UW domain which connects to the Internet via a gateway
  - The protocol used is TCP/IP
IP -- Like Using Postcards

• Information is sent across the Internet using the Internet Protocol -- postcard analogy
  – Break message into fixed size units
  – Form IP Packets with destination address, sequence number, and content
  – Each makes it way separately to destination, possibly taking different routes
  – Reassembled at destination forming message
    » Taking separate routes lets packets by-pass congestion and out-of-service switches
IP con’d

DEST ADDRESS | SIZE | # | DATA

Source

Destination
A Trip to Switzerland

• A packet sent from UW to ETH (Swiss Federal Technical University took 21 hops

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Node Name</th>
<th>Location</th>
<th>ms</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>128.95.1.207</td>
<td>spiff.cs.berkeley.edu</td>
<td></td>
<td></td>
<td>University of Washington WASHINGTON</td>
</tr>
<tr>
<td>1</td>
<td>129.95.1.100</td>
<td>-</td>
<td></td>
<td></td>
<td>University of Washington WASHINGTON</td>
</tr>
<tr>
<td>2</td>
<td>140.142.160.30</td>
<td>uwbr2-GE0-1.cac.washington.edu</td>
<td></td>
<td></td>
<td>University of Washington UW-SEA</td>
</tr>
<tr>
<td>3</td>
<td>198.107.150.1</td>
<td>hmspt1-wes-ge-0-3-0-3.pnw-gigapop.net</td>
<td></td>
<td></td>
<td>Verio Inc. VRIO-198-106</td>
</tr>
<tr>
<td>4</td>
<td>198.48.91.78</td>
<td>abilene-pnw.pnnw-gigapop.net</td>
<td></td>
<td></td>
<td>University of Washington UW-SEA</td>
</tr>
<tr>
<td>5</td>
<td>198.32.11.12</td>
<td>stting-stt寥abilene.uchicago.edu</td>
<td></td>
<td>0</td>
<td>University of Washington UW-SEA29</td>
</tr>
<tr>
<td>6</td>
<td>198.32.8.50</td>
<td>dnr-stt利亚bilenenc.uchicago.edu</td>
<td></td>
<td>5</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>7</td>
<td>198.32.11.111</td>
<td>-</td>
<td></td>
<td>35</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>8</td>
<td>198.32.8.14</td>
<td>kscy-dmv利亚bilenenc.uchicago.edu</td>
<td></td>
<td>27</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>9</td>
<td>198.32.11.111</td>
<td>kscyng-kscy利亚bilenenc.uchicago.edu</td>
<td></td>
<td>40</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>10</td>
<td>198.32.8.80</td>
<td>iplsg-kscy利亚bilenenc.uchicago.edu</td>
<td></td>
<td>34</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>11</td>
<td>198.32.8.76</td>
<td>chinng-iplsg利亚bilenenc.uchicago.edu</td>
<td></td>
<td>281</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>12</td>
<td>198.32.8.83</td>
<td>rycrrng-chinng利亚bilenenc.uchicago.edu</td>
<td></td>
<td>52</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>13</td>
<td>198.32.8.46</td>
<td>rycrrng-wash利亚bilenenc.uchicago.edu</td>
<td></td>
<td>72</td>
<td>Exchange Point Blocks NET-EP-1</td>
</tr>
<tr>
<td>14</td>
<td>62.40.103.25</td>
<td>abilene-gren.de2.de.geant.net</td>
<td>(United Kingdom)</td>
<td>165</td>
<td>IP allocation for GEANT network</td>
</tr>
<tr>
<td>15</td>
<td>62.40.90.62</td>
<td>de.ilt.it.geant.net</td>
<td>(United Kingdom)</td>
<td>171</td>
<td>IP allocation for GEANT network</td>
</tr>
<tr>
<td>16</td>
<td>62.40.96.33</td>
<td>ch.1.ch.ch.geant.net</td>
<td>(United Kingdom)</td>
<td>183</td>
<td>IP allocation for GEANT network</td>
</tr>
<tr>
<td>17</td>
<td>62.40.103.18</td>
<td>switCE2-P6-1.switch.ch</td>
<td>(United Kingdom)</td>
<td>178</td>
<td>IP allocation for GEANT network</td>
</tr>
<tr>
<td>18</td>
<td>130.69.36.42</td>
<td>switCE2-P6-2.switch.ch</td>
<td>(Switzerland)</td>
<td>187</td>
<td>SWITCH Teleinformatics Services SWITCH-LAN</td>
</tr>
<tr>
<td>19</td>
<td>192.33.92.1</td>
<td>rou-eth-switch-1-giga-to-switch.ethz.ch</td>
<td>(Switzerland)</td>
<td>192</td>
<td>Swiss Federal Institute of Technology ETH-ETHER</td>
</tr>
<tr>
<td>20</td>
<td>129.132.99.15</td>
<td>rou-uz1-mega-transit-2.ethz.ch</td>
<td>(Switzerland)</td>
<td>198</td>
<td>Swiss Federal Institute of Technology ETH-ETHER</td>
</tr>
<tr>
<td>21</td>
<td>129.132.14.15</td>
<td>eth.ch</td>
<td>(Switzerland)</td>
<td>192</td>
<td>Swiss Federal Institute of Technology ETH-ETHER</td>
</tr>
</tbody>
</table>

Roundtrip time to eth.ch, average = 192ms, min = 187ms, max = 204ms — 14-Nov-02 1:39:08 PM
Check Internet Hops

- There are numerous Trace Route utilities
  - Windows: tracert, OSX: Network Utility
Email Headers!

Received: via smtp-2000(13) (invoked by user suzka) for suzka; Sun, 3 Apr 2005 23:30:05 -0700 (PDT)
Received: from mxe5.u.washington.edu (mxe5.u.washington.edu [140.142.32.168])
    by bp05.u.washington.edu (8.13.3+UN05.01/8.13.3+UN05.01) with ESMTP id j346U4o0113924
    for <suzka@bp05.u.washington.edu>; Sun, 3 Apr 2005 23:30:05 -0700
Received: from smtp.ufl.edu (sp4zen1.nerdc.ufl.edu [128.227.74.42])
    by mxe5.u.washington.edu (8.13.3+UN05.01/8.13.3+UN05.01) with ESMTP id j346U2Rpo027860
    (version=TLSv1/SSLv3 cipher=EDH-RSA-DES-CBC3-SHA bits=168 verify=FAIL);
    Sun, 3 Apr 2005 23:30:03 -0700
Received: from spnode30 (sp30fe.nerdc.ufl.edu [128.227.128.110])
    by smtp.ufl.edu (8.13.1/8.13.1/2.5.0) with ESMTP id j346QvqN0700808;
    Mon, 4 Apr 2005 02:28:50 -0400
Received: from LISTS.UFL.EDU by LISTS.UFL.EDU (LISTSERV-TCP/IP release 1.8d)
    with spool id 154118 for SOCNET@LISTS.UFL.EDU; Mon, 4 Apr 2005
    02:27:54 -0400
Received: from smtp.ufl.edu (sp44en1.nerdc.ufl.edu [128.227.74.44]) by
    spnode30.nerdc.ufl.edu (8.12.8/8.12.3/2.3.0) with ESMTP id
    j346RrWW113254 (version=TLSv1/SSLv3 cipher=EDH-RSA-DES-CBC3-SHA
    bits=168 verify=FAIL) for <SOCNET@lists.ufl.edu>; Mon, 4 Apr 2005
    02:27:53 -0400
Received: from dep.oprit.rug.nl (dep.oprit.rug.nl [129.125.36.9]) by
    smtp.ufl.edu (8.13.1/8.13.1/2.5.0) with ESMTP id j346RpxXR152370 for
    <SOCNET@lists.ufl.edu>; Mon, 4 Apr 2005 02:27:52 -0400
Received: from jwesie (GN-LOC003-COM05-193-52.kabela.oprit.rug.nl
    with ESMTP id j346RnTx025288; Mon, 4 Apr 2005 08:27:50 +0200 (MEST)

MIME-Version: 1.0
Priority: normal
X-mailer: Pegasus Mail for Windows (4.21c)
Content-type: text/plain; charset=US-ASCII
Content-transfer-encoding: 7BIT
Content-description: Mail message body
X-Spam-Status: hits=0.161, required=5, tests=BAYES_50,NO_REAL_NAME
X-UHIF_Spam-Status: hits=0.161 required=5 tests=BAYES_50 NO REAL NAME
Naming Computers

- Computers connected to the Internet are part of a network domain
  - A hierarchical scheme that groups computers

  .edu
  - All educational computers
  .washington.edu
  - All computers at UW
    - dante.u. washington.edu
    - A UW computer
    - .ischool.washington.edu
    - iSchool computers
    - .cs.washington.edu
    - CSE computers
    - aloha.ischool.washington.edu
    - an iSchool computer
Domains

• .edu, .com, .mil, .gov., .org, .net domains are the “top level domains” in the USA
  – Recently added TLD names include:
    » .biz, .info, .name, .pro, .aero, .coop, .museum, .tv

• Each country has a TLD name: .ca (Canada), .es (Spain), .de (Germany), .au (Australia), .uk (England), .us (USA)

• The FIT book contains the complete list of country domains
Naming Computers con’d

• Computers are named by IP address, four numbers in the range 0-255
  – cse.washington.edu: 128.95.1.4
  – ischool.washington.edu: 128.208.100.150
    » Remembering IP address would be brutal for humans, so we use domain names
    » Computers find the IP address for a domain name from the Domain Name System (DNS)
      – An IP address-book for the computer
Logical vs. Physical

• There are 2 ways to view the Internet
  – Humans see a hierarchy of domains relating computers
    » Logical network
  – Computers see groups of four-number IP addresses
    » Physical network
  – Both are ideal for the “users” needs

• Domain Name System (DNS) relates the logical network to the physical network by translating domains to IP addresses
Anatomy of it All

• Domain name:
  dante.u.washington.edu

• IP address:
  140.142.14.73
Client/Server Structure

• The Internet computers rely on the client/protocol: servers provide services, clients use them
  – Example servers: email server, web server, ftp server
  – UW servers: dante, students, www
  – Frequently, a “server” is actually many computers acting as one, e.g. dante is a group of more than 50 servers

• Protocol governs the communication
  – client packages a request and sends it to a server;
  – Server does the service and sends a reply
World Wide Web

- World Wide Web (WWW) is a collection of web servers on the Internet
- Subset of Internet computers
  - WWW is not the same as the Internet!
- They give access to information using the HTTP protocol
  - The “server” is a web site computer and the “client” is a web browser (like Internet Explorer)
  - Many Web server’s domain names begin with www by tradition, but any name is OK
  - Often multiple servers map to the same site: moma.org and www.moma.org
History of the WWW

• Web beginnings
  – 1989: Tim Berners-Lee
    » URLs, http, first browser (HTTP 1.0)
  – 1993: NCSA Mosaic
    » HTTP 1.1 supported images
    » Then Netscape, then Mozilla
    » http://w3.org/
    » Standards organization for Web protocols and formats
  – 1994-5: Web crawlers and search engines
    » WebCrawler, Lycos, AltaVista, Yahoo
World Wide Web

- **URL** -- uniform resource locator
  - Web page addresses

- **HTTP** -- hypertext transfer protocol
  - Client-server communication rules

- **HTML** -- hypertext markup language
  - A specific format for making the pages universally readable by all clients
Dissecting a URL

- Web addresses are URL (uniform resource locator)
  - A server address and a path to a particular file
  - URLs are often redirected to other places

  » http://www.cs.washington.edu/100
  » http://www.cs.washington.edu/education/courses/cse100/CurrentQtr/calendar100.html

protocol = http://
Web server = www
domain = .cs.washington.edu
path = /education/courses/cse100/CurrentQtr/ dirs(folders)
file = calendar100
file extension = .html             hypertext markup language
Client/Server Interaction

- For Web pages, the client requests a page the server returns it: there’s no permanent connection, just a short conversation
  - Details of the conversation are specified by HTTP
Simple HTTP Request

GET /pub/WWW/TheProject.html HTTP/1.1
Host: www.w3.org
A Typical Browser Request

GET /pub/WWW/TheProject.html HTTP/1.1
Accept: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, application/vnd.ms-powerpoint, application/vnd.ms-excel, application/msword, application/x-shockwave-flash, */*
Accept-Language: en-us
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; APC)
Host: www.w3.org
Connection: Keep-Alive
Server Response

HTTP/1.1 200 OK
Date: Monday, 23 May 2005 22:38:34 GMT
Server: Apache/1.3.27 (Unix) (Red-Hat/Linux)
Etag: "3f80f-1b6-3e1cv03b"
Accept-Ranges: bytes
Content-Length: 438
Connection: close
Content-Type: text/html

<html>
<head><title>A Sample Page</title></head>
<body>
...

Summary

• Networking is changing the world
  – Internet: named computers using TCP/IP
  – WWW: servers providing access to information via the HTTP protocol
  – Principles
    » Local network of domain names
    » Physical network of IP address
    » Protocols rule: LAN, TCP/IP, HTTP
    » Domain Name System connects the two
    » Client/Server, fleeting relationship on WWW