Reminders

- Before midnight tonight: email me your idea and/or team request for ps9
- Wednesday’s class: Gary McGraw

Who Invented the Internet?

Who Invented Networking?

What is a Network?

A group of three or more connected communicating entities

Beacon Chain Networking

Thus, from some far-away beleaguered island, where all day long the men have fought a desperate battle from their city walls, the smoke goes up to heaven; but no sooner has the sun gone down than the light from the line of beacons blazes up and shoots into the sky to warn the neighboring islanders and bring them to the rescue in their ships.

Iliad, Homer, 700 BC

Chain of beacon's signaled Agamemnon's return (~1200BC), spread on Greek peaks over 600km.
Pony Express

- April 1860 – October 1861
- Missouri to California
  - 10 days
  - 10-15 miles per horse, ~100 miles per rider
- 400 horses total (not per station like Kahn's)

Chappe’s Semaphore Network

First Line (Paris to Lille), 1794
Mobile Semaphore Telegraph
Used in the Crimean War 1853-1856

Government and Networking
Chappe wanted a commercial network

The use of novel methods that modify established habits, often hurts the interests of those who profit the most from the older methods. Few people, with the exception of the inventors, are truly interested in helping projects succeed while their ultimate impact is still uncertain. . . Those in power will normally make no effort to support a new invention, unless it can help them to augment their power; and even when they do support it, their efforts are usually insufficient to allow the new ideas to be fully exploited. (Claude Chappe, 1824)

Anyone performing unauthorized transmissions of signals from one place to another, with the aid of telegraphic machines or by any other means, will be punished with an imprisonment of one month to one year, and a fine of 1,000 to 10,000 Francs. French Law passed in 1837 made private networking illegal

Measuring Networks

- Latency
  Time from sending a bit until it arrives
  seconds (or seconds per geographic distance)

- Bandwidth
  How much information can you transmit per time unit
  bits per second

Latency and Bandwidth

- Napoleon’s Network: Paris to Toulon, 475 mi
- Latency: 13 minutes (1.6s per mile)
  - What is the delay at each signaling station, how many stations to reach destination
  - At this rate, it would take ~1 hour to get a bit from California
- Bandwidth: 2 symbols per minute (98 possible symbols, so that is ~13 bits per minute
  - How fast can signalers make symbols
  - At this rate, it would take you about 9 days to get ps8.zip

Improving Latency

- Less transfer points
  - Longer distances between transfer points
- Semaphores: how far can you see clearly
  - Curvature of Earth is hard to overcome
- Use wires (electrical telegraphs, 1837)
- Faster transfers
  - Replace humans with machines
  - Faster travel between transfers
    - Hard to beat speed of light ( semaphore network)
Lecture 33: Networking

How many transfer points between here and California?

tracert

```
$ tracert www.cs.berkeley.edu
Tracing route to hyperion.cs.berkeley.edu [169.229.60.105]
over a maximum of 30 hops:
1     3 ms     3 ms     4 ms  128.143.69.1
2    <1 ms    <1 ms    <1 ms  carruthers-6509a-x.misc.Virginia.EDU [....]
3    <1 ms    <1 ms    <1 ms  new-internet-x.misc.Virginia.EDU [128.....
4     4 ms     4 ms     4 ms  nwv-nlrl3.misc.Virginia.EDU [192.35.48.30
5     5 ms     5 ms     5 ms  nlrl3-router.networkvirginia.net [192.7...
6    18 ms    18 ms    18 ms  atla-wash-64.layer3.nlr.net [216.24.186.20
7    43 ms    43 ms    42 ms  hous-atla-70.layer3.nlr.net [216.24.186.8
8    73 ms    73 ms    73 ms  losa-hous-87.layer3.nlr.net [216.24.186.30
9    72 ms    72 ms    72 ms  hpr-lax-hpr--nlr-packenet.cenic.net [137..
10   80 ms    81 ms    81 ms  svl-hpr--lax-hpr-10ge.cenic.net [137.16...
11  145 ms    81 ms    81 ms  hpr-ucb-ge--svl-hpr.cenic.net [137.164....
12   81 ms    81 ms    81 ms  g3-12.inr-201-eva.Berkeley.EDU [128.32....
13   81 ms    82 ms    83 ms  evans-soda-br-5-4.EECS.Berkeley.EDU [...
14   83 ms    84 ms    83 ms  sbd2a.EECS.Berkeley.EDU [169.229.59.226
15   83 ms    84 ms    83 ms  hyperion.CS.Berkeley.EDU [169.229.60.105
```

Packet complete.

tracert

```
tracert www.cs.berkeley.edu [169.229.60.105]
```

Bandwidth

How much data can you transfer in a given amount of time?

Improving Bandwidth

- Faster transmission
  - Train signalers to move semaphore flags faster
  - Use something less physically demanding to transmit
- Bigger pipes
  - Have multiple signalers transmit every other letter at the same time
- Better encoding
  - Figure out how to code more than 98 symbols with semaphore signal
  - Morse code (1840s)
**Morse Code**

Represent letters with series of short and long electrical pulses:

<table>
<thead>
<tr>
<th>Letter</th>
<th>Morse Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>- - - -</td>
</tr>
<tr>
<td>C</td>
<td>- - -</td>
</tr>
<tr>
<td>D</td>
<td>- -</td>
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<tr>
<td>E</td>
<td>-</td>
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<td>F</td>
<td>- - -</td>
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<tr>
<td>G</td>
<td>- - - - -</td>
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<tr>
<td>H</td>
<td>- - - -</td>
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<td>I</td>
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<td>J</td>
<td>- - - - -</td>
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<td>K</td>
<td>- - -</td>
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<td>L</td>
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<td>M</td>
<td>- - - -</td>
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<td>N</td>
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<td>Q</td>
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<tr>
<td>X</td>
<td>- - - - -</td>
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<tr>
<td>Y</td>
<td>- - - - -</td>
</tr>
<tr>
<td>Z</td>
<td>- - - - -</td>
</tr>
</tbody>
</table>

**Circuit Switching**

- Reserve a whole path through the network for the whole message transmission.

Interleave messages – send whenever the next link is free.

**Packet Switching**

- Use one link at a time.

**Circuit and Packet Switching**

- (Land) Telephone Network (back in the old days)
  - Circuit: when you dial a number, you have a reservation on a path through the network until you hang up.
- The Internet
  - Packet: messages are broken into small packets, that find their way through the network link by link.

**internet**

A collection of multiple networks connected together, so messages can be transmitted between nodes on different networks.

**The First internet**

- 1800: Sweden and Denmark worried about Britain invading
- Edelcrantz proposes link across strait separating Sweden and Denmark to connect their (signaling) telegraph networks
- 1801: British attack Copenhagen, network transmit message to Sweden, but they don’t help.
- Denmark signs treaty with Britain, and stops communications with Sweden
First Use of Internet

- October 1969: First packets on the ARPANet from UCLA to Stanford. Starts to send "LOGIN", but it crashes on the G.
- 20 July 1969: Live video (b/w) and audio transmitted from moon to Earth, and to millions of televisions worldwide.

Okay, so who invented the Internet?

The Modern Internet

- Packet Switching: Leonard Kleinrock (UCLA) thinks he did, Donald Davies and Paul Baran, Edelcrantz's signalling network (1809)
- Internet Protocol: Vint Cerf, Bob Kahn
- Vision, Funding: J.C.R. Licklider, Bob Taylor
- Government: Al Gore (first politician to promote Internet, 1986; act to connect government networks to form "Interagency Network")

The World Wide Web

Available within the network will be functions and services to which you subscribe on a regular basis and others that you call for when you need them. In the former group will be investment guidance, tax counseling, selective dissemination of information in your field of specialization, announcement of cultural, sport, and entertainment events that fit your interests, etc. In the latter group will be dictionaries, encyclopedias, indexes, catalogues, editing programs, teaching programs, testing programs, programming systems, data bases, and – most important – communication, display, and modeling programs. All these will be – at some late date in the history of networking - systematized and coherent; you will be able to get along in one basic language up to the point at which you choose a specialized language for its power or terseness.

J. C. R. Licklider and Robert W. Taylor, The Computer as a Communication Device, April 1968

The “Desk Wide Web”

Memex Machine
Vannevar Bush, As We May Think, LIFE, 1945
Lecture 33: Networking

The World Wide Web

- Tim Berners-Lee, CERN (Switzerland)
- First web server and client, 1990
- Established a common language for sharing information on computers
- Lots of previous attempts (Gopher, WAIS, Archie, Xanadu, etc.)

World Wide Web Success

- World Wide Web succeeded because it was simple!
  - Didn’t attempt to maintain links, just a common way to name things

HyperText Transfer Protocol

Client (Browser)

GET /cs150/index.html HTTP/1.0

Server

<html>
<head>
  ...
</head>
<body>
  Contents of file
  ...
</body>
</html>

HTML: HyperText Markup Language

- Language for controlling presentation of web pages
- Uses formatting tags
  - Enclosed between < and >
- Not a universal programming language
  - Proof: no way to make an infinite loop

HTML Grammar Excerpt

Document ::= <html> Header Body </html>
Header ::= <head> HeadElements </head>
HeadElements ::= HeadElement HeadElements
HeadElement ::= <title> Element </title>
Body ::= <body> Elements </body>
Elements ::= Element Elements
Element ::= <p> Element </p>
  - Make Element a paragraph.
Element ::= <center> Element </center>
  - Center Element horizontally on the page.
Element ::= <b> Element </b>
  - Display Element in bold.
Element ::= Text

Popular Web Site: Strategy 1
Static, Authored Web Site

Drawbacks:
- Have to do all the work yourself
- The world may already have enough Twinkie-experiment websites

http://www.twinkiesproject.com/
Popular Web Site: Strategy 2
Dynamic Web Applications

eBay in 1997

Popular Web Site: Strategy 2
Dynamic Web Applications

Advantages:
• Users do most of the work
• If you’re lucky, they might even pay you for the privilege! (not using UVA’s servers)

Disadvantages:
• Lose control over the content (you might get sued for things your users do)
• Have to know how to program a web application

Dynamic Web Sites
• Programs that run on the client’s machine
  – Java, JavaScript, Flash, etc.: language must be supported by the client’s browser (so they are usually flaky and don’t work for most visitors)
  – Used mostly to make annoying animations to make advertisements more noticeable
  – Occasionally good reasons for this: need a fancy interface on client side (like Google Maps)
• Programs that run on the web server
  – Can be written in any language, just need a way to connect the web server to the program
  – Program generates regular HTML – works for everyone
  – (Almost) Every useful web site does this

Dynamic Web Site
Client (Web Browser)
“HTML Interpreter”

Processing a GET Request

Client
GET .../show-restaurants.cgi

File Server
Read:_/public_html/cs150/hooshungry/show-restaurants.cgi

Request Processor
#!/uva/bin/python
import cgi
import headers
import restaurants
import restaurant
import reviews
headers.printHeader("Restaurants")
headers.endHeader()
print "<h1>Restaurants</h1>"
...
Using a Database

- HTTP is stateless
  - No history of information from previous requests
- We probably need some state that changes as people visit the site
- That’s what databases are for – store, manipulate, and retrieve data

SQL

- Structured Query Language (SQL)
  - (Almost) all databases use it
- Database is tables of fields containing values
- All fields have a type (and may have other attributes like UNIQUE)
- Similar to procedures from PS5

Charge

- Combining Python, SQL and HTML is very powerful
  - Query can be a string generated by your program!
  - Code can be generated based on what is in the database
- PS8: Lots of new tools to learn and code to understand, little code to write
- PS9: Build your own dynamic web application
- Send ideas and team requests by midnight!

Charge

- Next class:
  - Who invented the Internet?
  - How to make a dynamic web application
  - Password Authentication (similar to Trick-or-Treat)
- Before Wednesday:
  - Read through PS7 handout