

Lecture 33: Networking

Memex Machine
Vannevar Bush, *As We May Think*, LIFE, 1945 David Evans
<http://www.cs.virginia.edu/evans>

CS Department Fireside Chat
All are welcome!
Wed Nov 18, 5-6pm, Ols 228e/236d
Kim Hazelwood and Wes Weimer
Meet and ask them questions in a non-academic setting.
Learn how they became interested in computer science,
what they wish they had known when they were students,
and what their lives are like outside of the office. **Ask them anything!**

Reminders

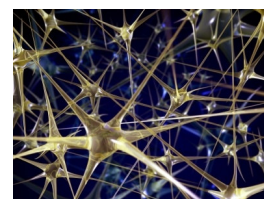
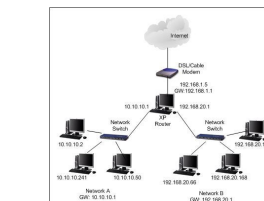
- Team Assignments: if you sent a complete team, you should have already received an email response from me that you are a team
 - I will finish the rest of the team assignments tomorrow
 - If you have team preferences, you can still send in late requests today
- Go through the Django Tutorial by Sunday: nothing graded for this, but send email when you finish it (details at end of tutorial)

AC's Exam 2 Review Session: Monday or Tuesday Evening?

Who Invented the Internet?

Who Invented Networking?

What is a Network?



Neural Network



<http://flowingdata.com/2008/03/12/17-ways-to-visualize-the-twitter-universe/>

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 Agammemnon'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



Chappe's Semaphore Network



First Line (Paris to Lille), 1794



Mobile Semaphore Telegraph
Used in the Crimean War 1853-1856

Networking and Power

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

Chappe wanted a commercial network

Government wants a Monopoly on Communications

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

Rate at which can you transmit
bits per second

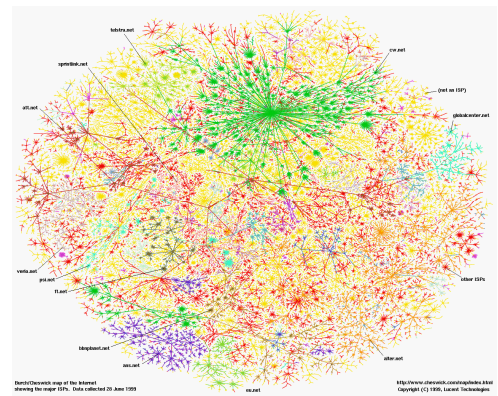
Latency and Bandwidth

- 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 signallers make symbols
 - At this rate, it would take you about 9 days to get *ps7.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)
 - Electrons in copper: about 1/3rd speed of light

How many transfer points between here and California?



tracert

```
K:\>tracert www.cs.berkeley.edu

Tracing route to hyperion.cs.berkeley.edu [169.229.60.105]
over a maximum of 30 hops:

  0  3 ms   3 ms   4 ms  128.143.69.1
  1  <1 ms  <1 ms  <1 ms  carruthers-6509a-x.misc.Virginia.EDU [...] UVA
  2  <1 ms  <1 ms  <1 ms  new-internet-x.misc.Virginia.EDU [128.128.128.128]
  3  4 ms   4 ms   4 ms  nrv-nlr13.misc.Virginia.EDU [192.35.48.30]
  4  5 ms   5 ms   5 ms  nlr13-router.networkvirginia.net [192.7.1.1]
  5  18 ms  18 ms  18 ms  atla-wash-64.layer3.nlr.net [216.24.186.20]
  6  43 ms  43 ms  42 ms  hous-atla-70 Atlanta → Houston → LA?
  7  73 ms  73 ms  73 ms  losa-hous-87
  8  72 ms  72 ms  72 ms  hpr-lax-hpr-nlr-packetnet.cenic.net [137.16.1.1]
  9  80 ms  81 ms  81 ms  svl-hpr-lax-hpr-10ge.cenic.net [137.16.1.1]
 10 145 ms  81 ms  81 ms  hpr-ucb-ge-svl-hpr.cenic.net [137.164.1.1] UCB
 11  81 ms  81 ms  81 ms  g3-12.inr-201-eva.Berkeley.EDU [128.32.1.1]
 12  81 ms  82 ms  83 ms  evans-soda-br-5-4.EECS.Berkeley.EDU [...]
 13  83 ms  84 ms  83 ms  abd2a.EECS.Berkeley.EDU [169.229.59.226]
 14  83 ms  84 ms  83 ms  hyperion.CS.Berkeley.EDU [169.229.60.105]
 15

Trace complete.
```

```
>>> cvilleberkeley = 3813 # kilometers
>>> seconds = 84.0/1000
>>> speed = cvilleberkeley / seconds
>>> speed
45392.857142857138
>>> light = 299792.458 # km/s
>>> speed / light
0.15141427321316114
```

Packets are traveling average at 15% of the speed of light (includes transfer time through 15 routers)

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)

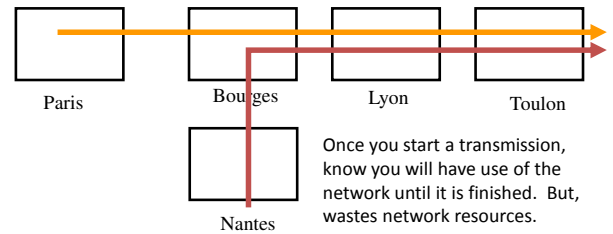
Morse Code

Represent letters with series of short and long electrical pulses

A	B	C	D
· -	- · · ·	- · · ·	- · · ·
E	F	G	H
·	· · · -	- · -	· · · ·
I	J	K	L
· ·	· - · ·	- · · ·	· · · ·
M	N	O	P
- -	- ·	- · ·	· - · ·
Q	R	S	T
- · - ·	· · ·	· · ·	-
U	V	W	X
· · ·	· · · ·	· · · ·	· · · ·
Y	Z		
- · - -	- · · ·		

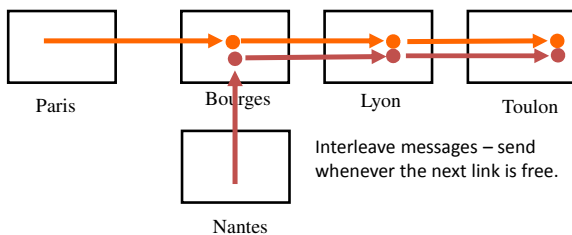
Circuit Switching

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



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

internetwork

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)

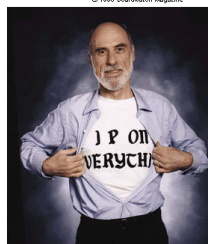
Internet Protocol: Vint Cerf, Bob Kahn

Vision, \$: J.C.R. Licklider, Bob Taylor

Government: Al Gore

First politician to promote Internet, 1986; act to connect government networks to form "Interagency Network"

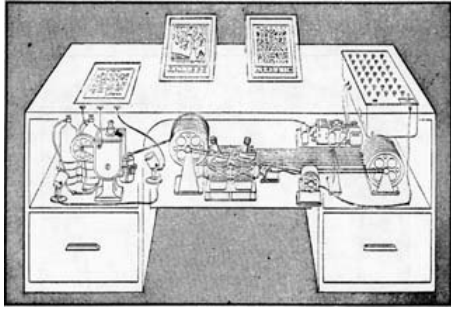
From Computer Desktop Encyclopedia
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Vint Cerf (Google's Internet Evangelist)
Talk at UVA: January 29

The World Wide Web

The “Desk Wide Web”



Memex Machine
Vannevar Bush, *As We May Think*, LIFE, 1945

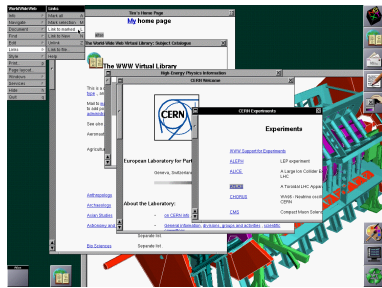
Available within the network will be functions and services to which you subscribe on a regular basis and others that you call for when you need them. In the former group will be investment guidance, tax counseling, selective dissemination of information in your field of specialization, announcement 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

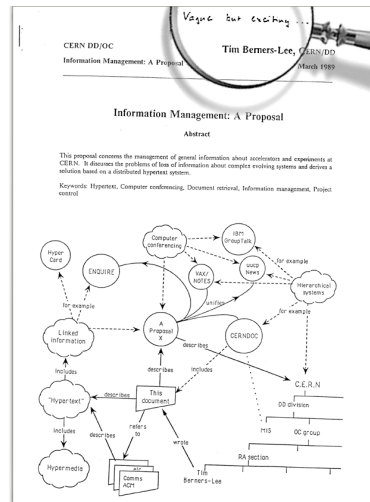
WorldWideWeb



Sir Tim Berners-Lee
CERN (Switzerland)



First web server and client, 1990
(This picture, 1993)



- Established a *common language* for sharing information on computers
- Lots of previous attempts (Gopher, WAIS, Archie, Xanadu, etc.)

World Wide Web Success

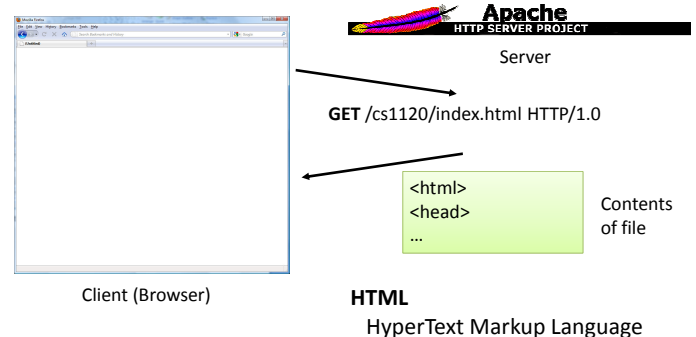
- World Wide Web succeeded because it was **simple!**
 - Didn't attempt to maintain links, just a common way to name things
 - Uniform Resource Locators (URL)

`http://www.cs.virginia.edu/cs1120/index.html`

Service Hostname File Path

HyperText Transfer Protocol

HyperText Transfer Protocol



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

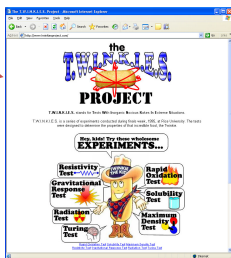
```
Document ::= <html> Header Body </html>
Header ::= <head> HeadElements </head>
HeadElements ::= HeadElement HeadElements
HeadElements ::=
HeadElement ::= <title> Element </title>

Body ::= <body> Elements </body>
Elements ::= Element Elements
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 ::= <a href=URL>Element</a>
Element ::= Text
                What is a HTML interpreter?
```

Popular Web Site: Strategy 1 Static, Authored Web Site



Web Programmer,
Content Producer



<http://www.twinkiesproject.com/>

Drawbacks:

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

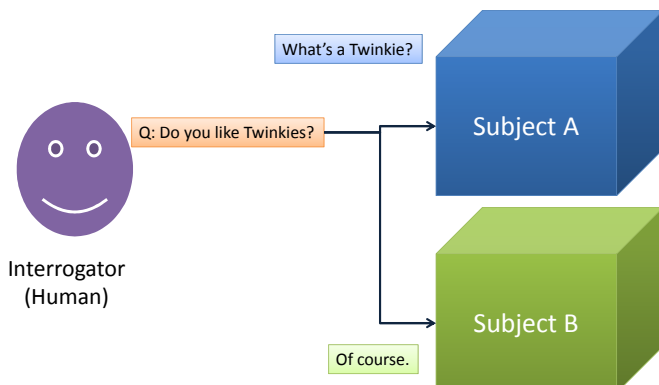


Turing Test

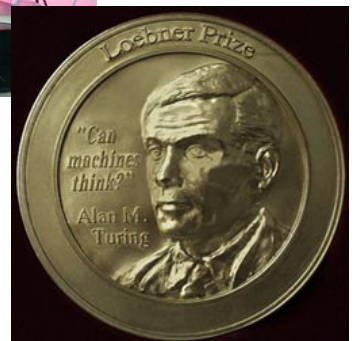
“I propose to consider the question ‘Can machines think?’”

Alan Turing, *Computing Machinery and Intelligence*, 1950.

Imitation Game



Loebner Prize



Human or Machine?

Hi how is it going?

Great. You?

Where do you come from?

I'm from the U.S.

Where in the States?

Do you know where Albuquerque is?

NM. I am sort of from NY.

Yep.

Sort of?

I lived in Westchester four 4 years, and before that I did my degree at Brandeis.

What do you do in Alb?

I'm an engineer -- electrical

Working on?

Systems to integrate speaker recognition

Hi, how is it going?

Hello. How are you doing?

Good, who are you?

Well, I am studying engineering. That ought to give you an idea about who I am.

No, not really?

I have a terrific yearning to know something more about experiments?

Where are you from?

I don't know, but don't forget I can't be in three places at once.

What city do you live in?

What city -- that's rather a tricky question. The trouble is, one city seems to be much like another.

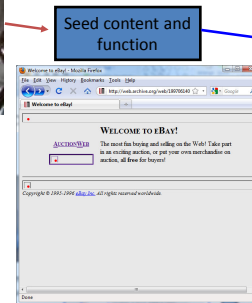
Not really. Where do you live?

In the old dairy next to the river, I believe.

Popular Web Site: Strategy 2 Dynamic Web Applications



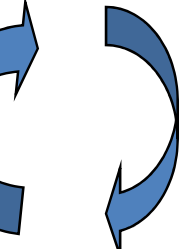
Web Programmer,
Content Producer



eBay in 1997

<http://web.archive.org/web/19970614001443/http://www.ebay.com/>

Attracts users

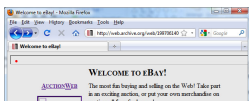


Produce more content

Popular Web Site: Strategy 2 Dynamic Web Applications

Seed content and function

Attracts users



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**



eBay in 2009

Produce more content

Dynamic Web Sites

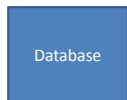
- Programs that run on the client's machine
 - Java, JavaScript, Flash, etc.: language must be supported by the client's browser (so they are usually flaky and don't work for most visitors)
 - Occasionally good reasons for this: need a fancy interface on client side (like Google Maps)
- Programs that 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

Django Web Framework

GET /overheardit/ HTTP/1.0



django



urls.py

```
...
urlpatterns = patterns('',
    (r'^overheardit/login/$',
     'django.contrib.auth.views.login'),
    ...
    # default to index page if nothing else
    matches
    (r'', 'overheardit.stories.views.index'),
)
```

Server: alonzo.cs.virginia.edu

overheardit.stories.views.index

In `overheardit/stories/views.py`:

Request to database, produces
Python list of Story objects

def index(request):

latest_story_list = Story.objects.all().order_by('-upvotes')[:20]

return render_to_response('stories/index.html', \

Template for producing
html output page

{'latest_story_list': latest_story_list, \

'user': request.user})

Dictionary defining variables to
use in the template.



```
<style type="text/css">
...
<div id="header">Overheardit at UVA</div>
...
<div id="story"> Posted by <em>alonzo_church</em> on November
13, 2009 at 2:37 a.m. [up votes: 1 / down votes: 3]
<blockquote> A &quot;Twinkle&quot; passed the Turing test!
</blockquote>
...
```


From Tim Berners-Lee's "Answers for Young People"
<http://www.w3.org/People/Berners-Lee/Kids.html>

Charge

I think the main thing to remember is that any really powerful thing can be used for good or evil. Dynamite can be used to build tunnels or to make missiles. Engines can be put in ambulances or tanks. Nuclear power can be used for bombs or for electrical power. So the what is made of the Web is up to us. You, me, and everyone else.

Here is my hope: The Web is a tool for communicating. With the Web, you can find out what other people mean. You can find out where they are coming from. The Web can help people understand each other. Think about most of the bad things that have happened between people in your life. Maybe most of them come down to one person not understanding another. Even wars. Let's use the web to create neat new exciting things. Let's use the Web to help people understand each other.

Do the Django tutorial by Sunday