One-Slide Summary

- **Bandwidth** is the throughput of a communication resource, measured in **bits per second**. **Latency** is the time delay between the moment when communication is initiated and the moment the first bit arrives, measured in **seconds**.
- In **circuit switching**, a path through a network is reserved (high quality-of-service, used in telephones). In **packet switching**, each packet is routed individually (internet, postal service).
- The **world wide web** involves simple schemes for retrieving resources (URL, HTTP) and a simple language for displaying information (HTML). HTTP is **stateless**, so long-running sessions store info on the client (cookies) or server (database).
- A **dynamic website** generates content by running a program on the client (e.g., Google maps interface) or the server (e.g., rest of PS8).

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

- Fewer 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?
```
K:\>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 [...]
  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    82 ms    83 ms  evans-soda-br-5-4.EECS.Berkeley.EDU [...
 13    83 ms    84 ms    83 ms  sbd2a.EECS.Berkeley.EDU [169.229.59.226]
 14    83 ms    84 ms    83 ms  hyperion.CS.Berkeley.EDU [169.229.60.105]
Trace complete.
```
**Circuit Switching**

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

- (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

**Packet Switching**

- Use one link at a time

- Interleave messages – send whenever the next link is free.

**Internetwork**

An internetwork is 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.
Liberal Arts Trivia: Psychology

• This series of social psychology experiments at Yale University measured the willingness of study participants to obey an authority figure who instructed them to perform acts that conflicted with their personal conscience. The scientist devised the experiments to address the question: “Could it be that Eichmann and his million accomplices in the Holocaust were just following orders? Could we call them all accomplices?” Participants played the role of a “teacher” helping a “learner” with a memory study and were instructed to deliver electric shocks until the “learner” “died”.

Liberal Arts Trivia: Medieval Studies

• This English legal charter, originally issued in Latin in 1215, required King John of England to proclaim certain rights (to nobles), respect certain legal procedures, and generally accept that his will could be bound by the law. It notably included the writ of habeus corpus, allowing appeal against unlawful imprisonment. It led to the rule of constitutional law today in the English-speaking world.

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.

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
  - Uniform Resource Locators (URL)

HyperText Transfer Protocol (HTTP)

- Apache HTTP Server
- GET /cs150/index.html HTTP/1.0
- Contents of file

HTML: HyperText Markup Language

- HTML is a 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 ::=<title> Element </title>
Body ::= <body> Elements </body>
Elements ::= Element Elements
Element ::= Text
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.
```

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

What is a HTML interpreter?

http://www.twinkiesproject.com/
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

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>"
...

Processing a GET Request

Python Code: Evaluate using Python interpreter, send output to client

Python Interpreter

Client

GET http://www.cs.virginia.edu/cs150/hooshungry
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

Liberal Arts Trivia: Linguistics (and Sociology)

- This linguistic relativity hypothesis postulates a systematic relationship between the grammatical categories of a language and how the speaker understands and behaves in the world. In essence, it holds that a language’s nature influences the habitual thought of its speakers: different languages yield different patterns of thought. Ideas that are prevalent in the culture can be stated concisely (in few words); foreign thoughts are difficult to express.

Liberal Arts Trivia: Latin American Studies, Archaeology

- This civilization began as a Cuzco-area tribe around 1200 and grew to absorb other Andean communities, becoming the largest empire in pre-Columbian America. They invented the quipu (“talking knots”) for recording decimal numbers in knotted strings of llama hair. They also performed the first successful skull surgery, as well as using coca leaves to deaden pain. Machu Picchu is a World Heritage site associated with this culture.

Secure Programming

- **“Honor System” Programming**
  - cs150
  - All your users are nice and honest
  - Nothing terribly bad happens if your program misbehaves
  - Enough to (hopefully) make you dangerous!
- **“Real World” Programming**
  - cs205
  - Some users are mean and dishonest
  - Bad things happen if your program misbehaves
Buffer Overflows

```c
int main (void) {
  int x = 9;
  char s[4];
  gets(s);
  printf ("s is: %s\n", s);
  printf ("x is: %d\n", x);
}
```

Stack

```
<program name="Stack">
</program>
```

C Program

```
int main (void) {
  int x = 9;
  char s[4];
  gets(s);
  printf ("s is: %s\n", s);
  printf ("x is: %d\n", x);
}
```

Return address

```
(int)
```

Code Red

Security in cs150

Can you have a Buffer Overflow vulnerability in Scheme, Charme, LazyCharme, StaticCharme, or Python?

No (unless there is a bug in the underlying implementation)! Memory is managed by the interpreter, so you don’t have to allocate it, or worry about how much space you have.

Web Application Security

- Malicious users can send bad input to your application
- Authentication: most interesting applications need user logins
Cross-Site Scripting

Output pages contain information provided by other users!

Python Code:
Evaluate using Python interpreter, send output

Preventing Cross-Site Scripting

• Never never never ever trust users!
• Everything you generate from user input needs to be checked and sanitized (remove the tags)

For your ps9 websites, you may assume all users are bound by the UVa Honor Code and won’t do anything evil. But, don’t forget how irresponsible it is to put something like this on the web!

How would I prove that I am a professor and not a ninja?

How do you authenticate?

• Something you know
  - Password
• Something you have
  - Physical key (email account?, transparency?)
• Something you are
  - Biometrics (voiceprint, fingerprint, etc.)

Serious authentication requires at least 2 kinds

Early Password Schemes

Login does direct password lookup and comparison.

<table>
<thead>
<tr>
<th>UserID</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>alyssa</td>
<td>fido</td>
</tr>
<tr>
<td>ben</td>
<td>schemer</td>
</tr>
<tr>
<td>weimer</td>
<td>Lx_Ly.x</td>
</tr>
</tbody>
</table>

Login: alyssa
Password: spot
Failed login. Guess again.
Login Process

Terminal

- Login: alyssa
- Password: fido

Eve

Trusted Subsystem

Eve

Password Problems

- Need to store the passwords
  - Dangerous to rely on database being secure
- Need to transmit password from user to host
  - Dangerous to rely on Internet being confidential

First Try: Encrypt Passwords

- Instead of storing password, store password encrypted with secret $K$.
- When user logs in, encrypt entered password and compare to stored encrypted password.

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>alyssa</td>
<td>$\text{encrypt}_K(\text{&quot;fido&quot;})$</td>
</tr>
<tr>
<td>ben</td>
<td>$\text{encrypt}_K(\text{&quot;schemer&quot;})$</td>
</tr>
<tr>
<td>weimer</td>
<td>$\text{encrypt}_K(\text{&quot;Lx.Ly.x&quot;})$</td>
</tr>
</tbody>
</table>

Problem if $K$ isn’t so secret: $\text{decrypt}_K(\text{encrypt}_K(P)) = P$

Homework

- PS8 Due Today
- PS9 Description Due Wednesday
- Exam 2 Out Wednesday
  - On your honor: you may attend the review session at the structured lab hours if you have yet not looked at the exam.