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).

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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**

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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`

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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
>>> 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)

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 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.

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 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)
    Service Hostname File Path
    HyperText Transfer Protocol
**HyperText Transfer Protocol (HTTP)**

- **Client (Browser)**
  - GET /cs1120/index.html HTTP/1.0
  - <html> <head> ... </head> <body> ... </body> </html>
  - Contents of file
  - Apache HTTP Server Project

**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 ::= <p> Element </p>
      ::= <center> Element </center>
      ::= <b> Element </b>
      ::= 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


**Web Programmer, Content Producer**

**Popular Web Site: Strategy 2**

**Dynamic Web Applications**

- **Seed content and function**
  - eBay in 1997
  - Produce more content
  - 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
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

Processing a GET Request

```python
#!/usr/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

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: Chinese History
• This beverage is made solely of the leaves of Camellia sinensis that have undergone minimal oxidation during processing. The drink originated in China more than 4000 years ago but has spread (e.g., it is also ubiquitous in Japan).

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs1120</td>
<td>“Honor System” Programming</td>
<td>All your users are nice and honest. Nothing terribly bad happens if your program misbehaves. Enough to (hopefully) make you dangerous!</td>
</tr>
<tr>
<td>cs2110</td>
<td>“Real World” Programming</td>
<td>Some users are mean and dishonest. Bad things happen if your program misbehaves.</td>
</tr>
</tbody>
</table>
The Problem With Post-Its

- You're planning a surprise balloon party for a friend and writing notes to yourself.
  - You've already noted the address.
  - Now you remind yourself to buy “balloons for 82”
- What could go wrong?

Buffer Overflows

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

Stack

C Program

Note: your results may vary (depending on machine, compiler, what else is running, time of day, etc.). This is what makes C “fun”!

Security in cs1120

Can you have a Buffer Overflow vulnerability in Java, Charme, LazyCharme, StaticCharme, or Python?
Security in cs1120

Can you have a Buffer Overflow vulnerability in Java, 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

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

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 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

<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 does direct password lookup and comparison.

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

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>
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<tr>
<td>alyssa</td>
<td>encrypt$_K$ (“fido”)</td>
</tr>
<tr>
<td>ben</td>
<td>encrypt$_K$ (“schemer”)</td>
</tr>
<tr>
<td>weimer</td>
<td>encrypt$_K$ (“Lx.Ly.x”)</td>
</tr>
</tbody>
</table>

Problem if $K$ isn't so secret: decrypt$_K$ (encrypt$_K$ ($P$)) $= P$

PS9

- Let's talk about PS9 work requirements.
- And perhaps view the teams …
Homework

• PS8 Due Today
• **PS9 Team Requests Were Due @ Noon**
• **PS9 Design Review Scheduling (NOW!)**
• Exam 2 Out Tue Nov 27