EECS 122: 
Introduction to Computer Networks
Course Goals and Overview

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- Office hours: TBD

Overview

- Administrivia
- Overview and History of the Internet
Administrivia

- Course Web page:
  - [http://inst.eecs.berkeley.edu/~ee122/](http://inst.eecs.berkeley.edu/~ee122/)
  - Check often to get the latest information

- Deadlines
  - HWs: due 3:50 pm on the indicated date (10 minutes before lecture)

- Exams are closed-book, with open crib sheet
- Come to office hours, request an appointment, communicate by e-mail
  - We are here to help, including general advice!
  - TAs first line for help with programming problems

- Give us suggestions/complaints as early as possible

Course Goals

- Learn the main architectural concepts and technological components of communication networks, with the Internet as the overarching example
  - Understand how the Internet works
  - And why the Internet is the way it is

- Apply what you learned in three mini-class projects
Class Workload

- Four homeworks spread over the semester
  - Strict deadlines and due dates (no slip days!)
- Three (mini-)projects
  - 1st and 3rd are part of a larger project, which involves implementing a comprehensive network application
    - C (or C++) required
  - 2nd is a simulation project
- One midterm exams
  - October 17
- Final exam
  - December 17
  - Note dates and plan your travel accordingly!

Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeworks</td>
<td>20%</td>
</tr>
<tr>
<td>Projects</td>
<td>40%</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam</td>
<td>20%</td>
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</table>

- Consultation on HWs is OK, but must hand in own work
  - Correlation between understanding HWs and doing well on exams
- Course graded to mean of B
  - Relatively easy to get a B, harder to get an A or a C
  - 10% A, 15% A-, 15% B+, 20% B, 15% B-, 15% C+, 10% C
  - A+ reserved for superstars (only 1 or 2 per class)
  - Mean can shift up for an especially great class
Overview

- Administrivia
  - Overview and History of the Internet
    - See http://www.isoc.org/internet/history/ for more details

What do this two have in Common?

- First printing press
- Key idea: splitting up text in individual components
  - E.g., lower, upper case letters

The Internet

Both lower the cost of distributing information
What is a Communication Network? (End-system Centric View)

- Network offers one basic service: move information
  - Bird, fire, messenger, truck, telegraph, telephone, Internet …
  - Another example, transportation service: move objects
    - Horse, train, truck, airplane …
- What distinguish different types of networks?
  - The services they provide
- What distinguish the services?
  - Latency
  - Bandwidth
  - Loss rate
  - Number of end systems
  - Service interface (how to invoke the service?)
  - Others
    - Reliability, unicast vs. multicast, real-time…

What is a Communication Network? (Infrastructure Centric View)

- Communication components:
  - Links – carry bits from one place to another (or maybe multiple places): fiber, copper, satellite, …
  - Interfaces – attach devices to links
  - Switches/routers – interconnect links: electronic/optic, crossbar/Banyan
  - Hosts – communication endpoints: workstations, PDAs, cell phones, toasters
- Protocols – rules governing communication between nodes
  - TCP/IP, ATM, MPLS, SONET, Ethernet, X.25
- Applications: Web browser, X Windows, FTP, …
# Network Components (Examples)

<table>
<thead>
<tr>
<th>Links</th>
<th>Interfaces</th>
<th>Switches/routers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibers</td>
<td>Ethernet card</td>
<td>Large router</td>
</tr>
<tr>
<td>Coaxial Cable</td>
<td>Wireless card</td>
<td>Telephone switch</td>
</tr>
</tbody>
</table>

# Types of Networks

- **Geographical distance**
  - Local Area Networks (LAN): Ethernet, Token ring, FDDI
  - Metropolitan Area Networks (MAN): DQDB, SMDS
  - Wide Area Networks (WAN): X.25, ATM, frame relay
  - Caveat: LAN, MAN, WAN may mean different things
    - Service, network technology, networks
- **Information type**
  - Data networks vs. telecommunication networks
- **Application type**
  - Special purpose networks: airline reservation network, banking network, credit card network, telephony
  - General purpose network: Internet
Types of Networks

- Right to use
  - Private: enterprise networks
  - Public: telephony network, Internet
- Ownership of protocols
  - Proprietary: IBM System Network Architecture (SNA)
  - Open: Internet Protocol (IP)
- Technologies
  - Terrestrial vs. satellite
  - Wired vs. wireless
- Protocols
  - IP, AppleTalk, SNA

The Internet (cont’d)

- Global scale, general purpose, heterogeneous-technologies, public, computer network
- Internet Protocol
  - Open standard: Internet Engineering Task Force (IETF) as standard body (http://www.ietf.org)
  - Technical basis for other types of networks
    - Intranet: enterprise IP network
- Developed by the research community
Services Provided by the Internet

- Shared access to computing resources
  - telnet (1970's)
- Shared access to data/files
  - FTP, NFS, AFS (1980's)
- Communication medium over which people interact
  - email (1980's), on-line chat rooms, instant messaging (1990's)
  - audio, video (1990's, early 00's)
    - replacing telephone network?
- Medium for information dissemination
  - USENET (1980's)
  - WWW (1990's)
    - replacing newspaper, magazine?
  - Audio, video (late 90's, early 00's)
    - replacing radio, TV?
  - File sharing (late 90's, early 00's)

Growth of the Internet

Number of Hosts on the Internet:

- Aug. 1981: 213
- Oct. 1984: 1,024
- Dec. 1987: 28,174
- Oct. 1990: 313,000
- Oct. 1993: 2,056,000
- Apr. 1995: 5,706,000
- Jan. 1997: 16,146,000
- Jan. 1999: 56,218,000
- Jan. 2001: 109,374,000
- Jan. 2003: 171,638,297
- Jan. 2005: 317,646,084

Data available at: http://www.isc.org/

Estimated number of users: http://www.internetworldstats.com/stats.htm
Internet vs. Telephone Net

<table>
<thead>
<tr>
<th>Internet: “intelligent” edge, “dump” core</th>
<th>Telephone Net: “dump” edge, “intelligent” core</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td></td>
</tr>
<tr>
<td>- Intelligence at ends</td>
<td>- No end-point intelligence</td>
</tr>
<tr>
<td>- Decentralized control</td>
<td>- Excellent voice performance</td>
</tr>
<tr>
<td>- Operates over heterogeneous access technologies</td>
<td>- Achieves performance by overprovisioning resources</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>- Difficult to add new services to “Intelligent Network” due to complex call model</td>
</tr>
<tr>
<td>- No differential service</td>
<td>- Expensive approach for reliability</td>
</tr>
<tr>
<td>- Variable performance delay</td>
<td></td>
</tr>
<tr>
<td>- New functions difficult to add since end nodes must be upgraded</td>
<td></td>
</tr>
<tr>
<td>- No trusted infrastructure</td>
<td></td>
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</tbody>
</table>

History of the Internet

- 68-70’s: started as a research project, 56 kbps, initially 4 nodes (UCLA, UCSB, SRI, Utah) then < 100 computers
- 80-83: TCP/IP, DNS; ARPANET and MILNET split
- 85-86: NSF builds NSFNET as backbone, links 6 Supercomputer centers, 1.5 Mbps, 10,000 computers
- 87-90: link regional networks, NSI (NASA), ESNet (DOE), DARTnet, TBWNet (DARPA), 100,000 computers
- 90-92: NSFNET moves to 45 Mbps, 16 mid-level networks
- 94: NSF backbone dismantled, multiple private backbones; Introduction of Commercial Internet
- Today: backbones run at 10 Gbps, close to 200 millions computers in 150 countries
The ARPANet

- Paul Baran
  - RAND Corp, early 1960s
  - Communications networks that would survive a major enemy attack
- ARPANet: Research vehicle for “Resource Sharing Computer Networks”
  - 2 September 1969: UCLA first node on the ARPANet
  - December 1969: 4 nodes connected by phone lines

ARPANet Evolves into Internet

|---------|--------|-------|--------|--------|----------------------------------|-----|-----|------|------|------|------|------|------|

SATNet: Satellite network
PRNet: Radio Network

Web Hosting
Multiple ISPs
Internet2 Backbone
Internet Exchanges
Application Hosting
ASP: Application Service Provider
AIP: Application Infrastructure Provider (e-commerce toolkit, etc.)
Network “Cloud”

Regional Nets + Backbone

LAN: Local Area Network
Computers Inside the Core

The Evolution of the Enterprise
The Evolution of the Enterprise

1995

Dedicated facilities/computer centers

Private Corporate Network

Limited customer/external access

Internal users

Outsourced "Enterprise Resource Planning" Apps
e.g., PeopleSoft

1997

Outsourced Web Hosting

Internet

ISP Mesh

Virtual Private Network

Dedicated Facility Outsourced ERP Apps

External Customers

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The Evolution of the Enterprise

1997

- Virtual Private Network
- Internet
- ISP Mesh
- Dedicated Facility
  Outsourced ERP Apps
- External Customers
- Internal users

1999

- Content Delivery "Net"
- 3rd Party
  Facilities Mgmt
- Internet Services
- Outsourced
  Web Hosting
- Applications
  Service Provider
- Caching + Media Servers
- Customers
- VPNs
Services Within the Network: Content Distribution

"ISP Mesh"
Parallel Network Backbones
Internet Exchange Points

Co-Location
Scalable Servers

Web Caches

P2P Services in the Internet: Napster, Gnutella, BitTorrent, ...

Directory Service
(can be distributed across peers)

Coldplay  Speed of Sound
Britney Spears  Cinderella

Register my copy
Find me a copy
Look here

Grid computing: sharing resources/enabling collaboration
Summary

- Course administrative trivia
- Internet history and background