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
  - 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 2nd 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>Percentage</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>
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<tr>
<td>Final exam</td>
<td>20%</td>
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</tbody>
</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

What do this two have in Common?

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

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 medium: electron, photon
- Network 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, ...

Overview

- Adminastrivia
  - Overview and History of the Internet
    - See [http://www.isoc.org/Internet/history/](http://www.isoc.org/Internet/history/) for more details
Network Components (Examples)

- **Links**:
  - Fibers
  - Coaxial cable

- **Interfaces**:
  - Ethernet card
  - Wireless card

- **Switches/routers**:
  - Large router
  - Telephone switch

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

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
- **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

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)

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

Growth of the Internet

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Hosts on the Internet</th>
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</thead>
<tbody>
<tr>
<td>1981</td>
<td>Aug. 213</td>
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<tr>
<td>1984</td>
<td>Dec. 1,024</td>
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<tr>
<td>1987</td>
<td>Apr. 28,174</td>
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<td>1990</td>
<td>Oct. 313,000</td>
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<td>1993</td>
<td>Oct. 2,056,000</td>
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<td>1995</td>
<td>Jan. 5,706,000</td>
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<td>1997</td>
<td>Jan. 16,146,000</td>
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<td>1999</td>
<td>Jan. 56,218,000</td>
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<td>2001</td>
<td>Jan. 109,374,000</td>
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<td>2003</td>
<td>Jan. 171,638,927</td>
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<td>2005</td>
<td>Jan. 317,646,084</td>
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</table>
Internet vs. Telephone Net

**Internet**: “intelligent” edge, “dump” core

- **Strengths**
  - Intelligence at ends
  - Decentralized control
  - Operates over heterogeneous access technologies
- **Weaknesses**
  - No differential service
  - Variable performance delay
  - New functions difficult to add since end nodes must be upgraded
  - No trusted infrastructure

**Telephone Net**: “dump” edge, “intelligent” core

- **Strengths**
  - No end-point intelligence
  - Excellent voice performance
- **Weaknesses**
  - Achieves performance by overprovisioning resources
  - Difficult to add new services to “Intelligent Network” due to complex call model
  - Expensive approach for reliability

ARPANet Evolves into Internet

<table>
<thead>
<tr>
<th>Year</th>
<th>ARPA Net</th>
<th>SATNet</th>
<th>PNNet</th>
<th>TCP/IP</th>
<th>NSFNet</th>
<th>Demultiplex &amp; Commercialization</th>
<th>ISP</th>
<th>WWW</th>
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<td>1985</td>
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<td>2005</td>
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History of the Internet

- 60-70'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, TWINet (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

The BBN team that implemented the interface message processor.

ARPANET GEOGRAPHIC MAP, OCTOBER 1989

NSFNET T1 NETWORK 1991
Computers Inside the Core

The Evolution of the Enterprise

1997

The Evolution of the Enterprise

Late-1980s

The Evolution of the Enterprise

1995

The Evolution of the Enterprise

1999

Dedicated facilities/computer centers

Limited customer/external access

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

ISP

Satellite Fixed Wireless

Cingular

Cell

Cell

Sprint

AOL

@home

DSL Always on

Cable Head Ends

NAP

NAP
Summary

- Course administrative trivia
- Internet history and background