Course goals and overview

EECS 489 Computer Networks
http://www.eecs.umich.edu/~zmao/eecs489
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Acknowledgement: Some slides taken from Kurose&Ross and Katz&Stoica
Instructors

- **Instructor**
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- **GSI:**
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  - Office hours: Monday from 12:00-1:00, Tuesday 3:30-4:30, and Friday 2:00-3:00.
    Location: GSI Zoo, Duerstadt Center
Text books

Overview

- Administrivia
- Overview of computer networks
Logistics

- Course web page
  - http://www.eecs.umich.edu/~zmao/eecs489
  - Check often to get the latest information

- Exams are closed book, with open crib sheet

- Come to office hours, request an appointment, communicate by email

- Please attend the lectures and discussion sections

- Give 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 Internet works
  - Understand how Internet is the way it is today
- Apply what you learned in course project consisting of several mini-projects
Class Workload

- CS489 is a 4 unit course
  - Final Exam: 20%
  - Two midterm exams: 30%
  - Course project/Assignments: 40%
  - Class participation: 10%
Grading

- Consultation on assignments is okay, but must hand in own work
- Discussion and working in groups is encouraged for course project
- Exams are to be completed individually
- Cheating is severely punished
- No late homeworks and projects are accepted
- Five working days for regrading after the grade is assigned
How do people use networks?

- **Phone Network**
  - Parses number dialed
  - Sets up a circuit to friend's phone (100k to 200k circuits/switch)
  - Sends signal to ring friend's phone

- **Signaling network for setting up connection**

- **Circuit-switched network:**
  - a circuit is set up between the two ends.
The Internet

- The Internet is a packet switched network (PSN)
- Data parcellled into packets.
- Each packet carries destination address.
- Each packet can ``take the path less traveled'' (be routed independently).
- Packets can arrive out of order.
- Packets may not arrive at all.
What’s the Internet: “nuts and bolts” view

- millions of connected computing devices: hosts = end systems
- running network apps
- communication links
  - fiber, copper, radio, satellite
  - transmission rate = bandwidth
- routers: forward packets (chunks of data)
What’s the Internet: “nuts and bolts” view

- protocols control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, FTP, PPP

- Internet: “network of networks”
  - loosely hierarchical
  - public Internet versus private

- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force
What’s the Internet: a service view

- communication infrastructure enables distributed applications:
  - Web, email, games, e-commerce, file sharing
- communication services provided to apps:
  - Connectionless unreliable
  - connection-oriented reliable
What’s a protocol?

human protocols:
- “what’s the time?”
- “I have a question”
- introductions

... specific msgs sent
... specific actions taken when msgs received, or other events

network protocols:
- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt
What’s a protocol?

A human protocol and a computer network protocol:

Q: Other human protocols?
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, …
Network Components (Examples)

**Links**
- Fibers
- Coaxial Cable

**Interfaces**
- Ethernet card
- Wireless card

**Switches/routers**
- Large router
- Telephone switch
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: SNA
  - Open: 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
Internet vs. Telephone Net

- **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

- **Strengths**
  - No end-point intelligence
  - Heterogeneous devices
  - Excellent voice performance

- **Weaknesses**
  - Achieves performance by overallocating resources
  - Difficult to add new services to “Intelligent Network” due to complex call model
  - Expensive approach for reliability
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, TWBNet (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

| 1965 | ARPANet
| 1975 | TCP/IP
| 1985 | NSFNet
| 1995 | Deregulation & Commercialization
| 2005 | ISP
|  | ASP
|  | AIP

Web Hosting
Multiple ISPs
Internet2 Backbone
Internet Exchanges

Application Hosting
ASP: Application Service Provider
AIP: Application Infrastructure Provider (e-commerce toolkit, etc.)
ARPANET GEOGRAPHIC MAP, OCTOBER 1980

SATELLITE CIRCUIT

- IMP
- TIP
- PLURIBUS IMP
- PLURIBUS TIP
- C30

(Note: This map does not show ARPA's experimental satellite connections)
Names shown are IMP names, not (necessarily) host names.

Mao F04 26
The Old NSFNET Backbone

45 Mbs National Network Facility

- NSFNET Backbone
- Mid-level Connections
- Geographic Area of Mid-level Network
- Mid-level Network Hub
- Supercomputer Center & Mid-level Network Hub
The Abilene Network

completed connections:
194 participants
49 connectors + 3 NGIXs + STAR TAP
35 connections to 21 peer networks
Summary

- Course administrative trivia
- Internet history and background