Course goals and overview

EECS 489 Computer Networks
http://www.eecs.umich.edu/~zmao/eecs489
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Tuesday Sept 7, 2004

Acknowledgement: Some slides taken from Kurose/Ross and Katz/Stoica

Instructors

- Instructor
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- GSI:
  - Matt England (moenglan@umich.edu)
  - 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 parcelled 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 messages
  - 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

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)
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

Right to use
- Private: enterprise networks
- Public: telephone 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](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, TWBNNet (DARPA), 100,000 computers
- 90-92: NSFNET moves to 45 Mbps, 16 midlevel 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

WEB HOSTING
- Internet2 Backbone
- Internet Exchanges

Application Hosting
- ASP: Application Service Provider
- AIP: Application Infrastructure Provider (e-commerce toolkit, etc.)

ARPANet
SATNet
PRNet
TCP/IP
NSFNet
Deregulation
Commercialization
ISP
ASP
AIP
WWW
ATP

WWW
ISP
ASP
AIP

NSFNET T1 Network 1991

The Old NSFNET Backbone

UUNET's Global Internet Backbone

The Abilene Network
Summary

- Course administrative trivia
- Internet history and background