Digital Communications over Packet-Switched Networks

(ECE 446 – Lecture #1)

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Course Web Page and Mailing List

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Outline of Lecture #1

- Administrativia.
- Some History on Communication Networks.
- Basic Networking Principles.
- Overview of the Syllabus.

Course Staff

- Instructor:
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  Office hours: W 4-6pm, 326 RH.

- TAs:
  - Ron Dabora – `rd97@cornell.edu`
  - An-swol Hu – `ach25@cornell.edu`
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  Office hours: MF 1-2:30pm, 338 RH.

Syllabus and Reading Materials

- Detailed course syllabus (discussed later), available at

  `http://cn.ece.cornell.edu/teaching/fall2005ug/syllabus/`

  Main topics to cover:

  – Current networking technology (from now until mid-October).
  – Basic algorithms and modern applications (mid-October until the end).

- Main reference texts:

  J. Walrand, P. Varaiya.
  High Performance Communication Networks.
  Morgan-Kaufmann Publishers, 2000.

  D. Bertsekas, R. G. Gallager.
  Data Networks (2nd ed)
  Prentice-Hall, 1992.

Grading

- Quiz on background material: 5%.
- Homeworks: 15%. Late homework policy:
  - 0-24 hours: subtract 10%.
  - 24-48 hours: subtract 25%.
  - 48-72 hours: subtract 50%.
  - after 72 hours: subtract 100%.

  Homeworks not heavily emphasized in grade, but central to your ability to do well in this class. Take them seriously, and spend time on them.
- Midterm: 20%; Comprehensive Final: 20%.
  - Open book / notes / calculators / anything-but-network-connection.

- Scribe Assignment: 10%
  - For each topic in the syllabus (starting on 9/06), about 5 people must turn in typeset copies of my lectures.
  - TAs will select those about 5 people the week before, and let them know by email.
  - TAs responsible for grading the quality of your writeup, and possibly asking you to do changes.

  Rationale: develop a coherent set of notes for this class; give you practice in technical writing.

- Machine Problems + Presentation: 30%

  Will discuss more about it later in the semester (around Fall break). At this point, plan on a report and a presentation, to start work on after the break.

Lectures

- Myself most of the time. Lecture notes available on the web.
- Occasionally I will have to travel $\Rightarrow$ TAs will substitute for me.
- Occasionally I will be in the classroom, and still the TAs will lecture.

  Part of their learning to teach, and helps me see how they perform.
- My trips:
  - 9/04-09: Australia, to attend annual Information Theory symposium.
  - 9/18-23: Germany, to present an invited lecture in a workshop.
  - 10/30-11/02: California, to present an invited lecture at a conference.

Things You Should and Should NOT Do in this Class

- DO:
  - Read a lot.
  - Ask lots of questions.
  - Work hard.
  - *Have fun with the material!*
- DON'T:
  - Work optimizing grades (optimize absorption instead!).
  - Slack off.
  - Cheat.

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Some History: Telephone Networks

1876**:** A. G. Bell invents the first pair of telephones.

≈ 1890**:** Some simple, manually operated networks.

Circuit Switching (manual, mechanical, electronic).

≈ 1988**:** Analog line from telephone to switch, digital network of switches.

- Control/voice signals separate, but carried over the same network.
- Switches are networked computers.
- Easy deployment of services such as call waiting, call forwarding, ...

≈ 1990's?: Service integration (first ISDN, then DSL):

Voice networks start carrying data traffic.

Some History: Computer Networks

≈ 1969**:** RS-232-C standard for serial communication.

- Computer to peripheral device (printer, fax, ...).
- Computer to computer.
- Store and forward transmission across multiple computers.
- Statistical multiplexing.

≈ 1960's?: DARPA began funding work on *packet-switched* networks.

1969**:** Arpanet operational, with four nodes.

- Single packet format, common addressing mechanism.
- Interoperability. Abstractions.

1970's: Multiaccess communication.

- Cost reductions for local interconnects necessary.
- Ethernet / Token Ring / FDDI / ATM / Gigabit Ethernet / ... ?

1990's: World Wide Web.

- Multimedia applications, real-time traffic.

2000's and beyond: Wireless networks, sensor networks.

- Fast wireless access (WiFi, 802.11).
- Physically embedded sensing and actuation.

The next step is anyone's guess...

Some History: Cable TV Networks

≈ 1940's: CaTV (Community Antenna TV)

- Send TV signal from an antenna with good reception to other receivers with worse reception, over a coax cable.
- Frequency-division multiplexing of analog channels
  (Bandwdith of analog NTSC: $\approx$ 4.5MHz.)

$\approx$?: Use optical fiber for long-haul links.

- Much lower attenuation than coax, enables coverage of long distances with small number of amplifiers.
- Hybrid fiber/coax, *fiber-to-the-curb*.

≈ 1990's?: Digital TV

(Bandwidth of 1.5 Mbits/sec MPEG1 stream: $\approx$ 600 MHz.)

≈ 2000's?: Uplink as well

- Video on Demand, other interactive TV services.
- Internet access through cable.
- Telephone service through cable.

Towards a Complete Integration of Services

- Telephone network $\rightarrow$ access to data networks ...
- Cable TV network $\rightarrow$ access to data networks ...
- ... and Data Networks $\rightarrow$ real-time traffic!
- (Plus, wireless access to all of these enables mobility.)

There is a very clear trend towards merging all these networks, into what is now known as the *Internet*. The trend will continue for the foreseeable future. What drives this trend?

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Basic Networking Principles

- Digitization:
  - Signals (*all signals*) can be represented by streams of bits.
  - It is cheaper to manipulate digital signals (rather than analog).

- Economies of Scale:

  Cost-per-user decreases as number of users increases

  - Cost of a link grows slower than its rate.
  - Fixed costs can be amortized over more users, per-user share decreases.

- Network Externalities:

  Value to users increases as number of users increases

  - More people have a telephone, more useful my telephone becomes.
  - Strong incentive for internetworking... if the networks are compatible.

(Observe: the combination of externalities with economies of scale creates a positive feedback loop on supply and demand of network services, a major driver in network growth.)

- Service Integration:

  - Putting a new service on an existing network may be cheaper than creating a new separate network to provide that service ...
  - ... if the old network is good enough to provide the new service!

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In This Course

Our main goal:

> *Understand the technological developments (primarily), and the economic factors (to put engineering in context), that are at the heart of the proliferation and fusion of networks taking place today.*

To accomplish this, we will do the following:

- Study the state-of-the-art in networking technologies.
- Study the basic algorithms underlying those technologies.
- Implement a toy version of a modern application (transport of compressed video over a network overlay).

Syllabus

- Part I: Networking Technology
  - Network Services and Layering.
  - Packet-Switched Networks.
  - The Internet and TCP/IP Networks.
  - Circuit-Switched Networks.

  (Recap and first midterm at the end of Part I.)

- Part II: Network Algorithms and Applications
  - Aloha, Window flow control, Graph algorithms for routing, ...
  - Multimedia compression, video over IP, ...

What Next

- *Review your background material on probability by 8/30.*
- Read Chapter 1 of Walrand/Varaiya.
- Office hours start on Monday.