L-1 Intro to Computer Networks

Outline

• Administrivia

• Layering
Dramatis Personae

- Professor: Randy H. Katz
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  - Office hours: M 3:00-4:00, W 1:00-2:00, 413 Soda Hall
- Sorry, no Teaching Assistant!
- Course Info

Goals and Objectives

- Understand state-of-the-art in network protocols, architectures, and applications
- Understand process of networking research
  - Typical constraints and thought processes used in networking research
- Different from undergraduate networking (EECS 122)
  - i.e., training network programmers vs. training network researchers
When Thinking About Research …

“Look for what is so obvious to everyone else that it’s no longer on their radar, and put it on yours. Seek to uncover assumptions so implicit, they are no longer being questioned. Question them.”

• Rodney Brooks, Co-director of CSAIL, MIT

Particularly relevant advice for network research

• Is the current network architecture and decisions appropriate for wireless networks, sensor networks, real-time networks, enterprise networks, datacenter networks, etc.?

Web Page

• Check regularly!!

• Course schedule
• Reading list
• Lecture notes
• Announcements
• Project ideas
• Exams
CS 268 Blog Assignments

- For each lecture, you will create a “public review” of paper(s) due for that class that:
  - Briefly summarizes paper (1-2 paragraphs)
  - Provides background/related material (1-2 paragraphs)
  - Critiques paper and suggests discussion topics (2-3 paragraph)
    - Try to be positive…
    - Why or why not keep this paper in syllabus?
    - What issues are left open for future research?
    - What are the important implications of the work?
  - Select another student’s blog entry to critique before class; change each class meeting

Materials on Course Syllabus Page

- Research papers
  - Links to pdfs on Web page
  - Two papers per class meeting
  - Combination of classic and recent work
  - ~40 papers
- Lecture “Notes”
  - ppt posted, but I will minimize its in-class usage
  - Seminar/discussion style and participation counts!
- Recommended textbooks
  - For those who need to review their networking background
  - Peterson & Davie/4ed or Kurose & Ross/4ed
Laptop Policy

- Closed Laptops!
  - Focus on in class discussion
    —this worked very well last year
  - I will minimize use of powerpoint myself
    —white board
  - Check your email/twitter/facebook updates at the mid-lecture break

Course Grading

- Class + paper blog participation (20%)
  - Ensures you read the papers before class
- Two person research project (40%)
  - Substantial independent research project
  - You learn a lot by working together
  - Several class meetings dedicated to projects
- Two Quizzes (40%)
  - Closed book, in-class
  - Ensures you understood the papers
Class Topic Coverage

- Little on physical and data link layer
- Little on undergraduate material
  - Supposedly you already know this, though some revisiting/overlap is unavoidable
  - Focus on the why, not the what
- Focus on network to application layer
- We will deal with:
  - Protocol rules and algorithms
  - Investigate protocol trade-offs
  - Why this way and not another?

Lecture Topics

**Traditional**
- Layering
- Internet architecture
- Routing (IP)
- Transport (TCP)
- Queue management (FQ, RED)
- Naming (DNS)

**Recent Topics**
- Botnets
- Datacenter networking
- Multicast
- Mobility/wireless
- Network energy
- Network measurement
- Overlay networks
- P2P applications

Modified from F08 based on feedback from last year’s class: QoS, SensorNets, “Future Network” Architecture eliminated
Outline

• Administrivia

• Layering

What is the Objective of Networking?

• Communication between applications on different computers
• Must understand application needs/demands
  • Traffic data rate
  • Traffic pattern (bursty or constant bit rate)
  • Traffic target (multipoint or single destination, mobile or fixed)
  • Delay sensitivity
  • Loss sensitivity
Back in the Old Days...

Packet Switching (Internet)
Packet Switching

- Interleave packets from different sources
- Efficient: resources used on demand
  - Statistical multiplexing
- General
  - Multiple types of applications
- Accommodates bursty traffic
  - Addition of queues

Characteristics of Packet Switching

- Store and forward
  - Packets are self contained units
  - Can use alternate paths – reordering
- Contention
  - Congestion
  - Delay
Internet[work]

- A collection of interconnected networks
- Host: network endpoints (computer, PDA, light switch, …)
- Router: node that connects networks
- Internet vs. internet

Challenge

- Many differences between networks
  - Address formats
  - Performance – bandwidth/latency
  - Packet size
  - Loss rate/pattern/handling
  - Routing
- How to translate between various network technologies?
How To Find Nodes?

Internet

Computer 1

Need naming and routing

Computer 2

Naming

What's the IP address for www.cmu.edu?

It is 128.2.11.43

Computer 1

Local DNS Server

Translates human readable names to logical endpoints
**Routing**

Routers send packet towards destination

- **H**: Hosts
- **R**: Routers

**Meeting Application Demands**

- Reliability
  - Corruption
  - Lost packets
- Flow and congestion control
- Fragmentation
- In-order delivery
- Etc...
What if the Data gets Corrupted?

Problem: Data Corruption

Solution: Add a checksum

What if Network is Overloaded?

Problem: Network Overload

Solution: Buffering and Congestion Control

- Short bursts: buffer
- What if buffer overflows?
  - Packets dropped
  - Sender adjusts rate until load = resources → “congestion control”
What if the Data gets Lost?

Problem: Lost Data
GET index.html

Solution: Timeout and Retransmit
GET index.html
GET index.html

What if the Data Doesn't Fit?

Problem: Packet size
- On Ethernet, max IP packet is 1.5kbytes
- Typical web page is 10kbytes

Solution: Fragment data across packets
ml x.ht inde GET

GET index.html
What if the Data is Out of Order?

Problem: Out of Order

Solution: Add Sequence Numbers

Lots of Functions Needed

- Link
- Multiplexing
- Routing
- Addressing/naming (locating peers)
- Reliability
- Flow control
- Fragmentation
- Etc….
What is Layering?

• Modular approach to network functionality
• Example:

```
+----------------+
| Application    |
+----------------+
| Application-to-application channels |
+----------------+
| Host-to-host connectivity |
+----------------+
| Link hardware |
```

Protocols

• Module in layered structure
• Set of rules governing communication between network elements (applications, hosts, routers)
• Protocols define:
  • Interface to higher layers (API)
  • Interface to peer
    • Format and order of messages
    • Actions taken on receipt of a message
Layering Characteristics

• Each layer relies on services from layer below and exports services to layer above
• Interface defines interaction
• Hides implementation - layers can change without disturbing other layers (black box)

Layering: technique to simplify complex systems
E.g.: OSI Model: 7 Protocol Layers

- Physical: how to transmit bits
- Data link: how to transmit frames
- Network: how to route packets
- Transport: how to send packets end2end
- Session: how to tie flows together
- Presentation: byte ordering, security
- Application: everything else
Layer Encapsulation

Protocol Demultiplexing

- Multiple choices at each layer
Is Layering Harmful?

• Sometimes …
  • Layer N may duplicate lower level functionality (e.g., error recovery)
  • Layers may need same info (timestamp, MTU)
  • Strict adherence to layering may hurt performance

Next Lecture: Design Considerations

• How to determine split of functionality
  • Across protocol layers
  • Across network nodes

• Assigned Reading
  • R1: End-to-end Arguments in System Design
  • R2: Design Philosophy of the DARPA Internet Protocols

• Friend me on Facebook so I can invite you to join the CS 268 facebook group
• Set up your blog site and send me its URL