15-744: Computer Networking

L-1 Intro to Computer Networks
Outline

• Administrivia

• Layering
Who’s Who?

• Professor: Srinivasan Seshan
  • http://www.cs.cmu.edu/~srini
  • srini@cmu.edu
  • Office hours: Friday 4:00-5:00

• TA: Vijay Vasudevan
  • vrv+744@cs.cmu.edu
  • Office hours: Tuesday 2-3PM (or by appointment)

• Course info
  • http://www.cs.cmu.edu/~srini/15-744/S08/
Objectives

• Understand the state-of-the-art in network protocols, architectures and applications
• Understand how networking research is done
  • Teach the typical constraints and thought processes used in networking research
• How is class different from undergraduate networking (15-441)
  • Training network programmers vs. training network researchers
Web Page

- Check regularly!!
- Course schedule
- Reading list
- Lecture notes
- Announcements
- Assignments
- Project ideas
- Exams
Discussion Site

  - Currently using slashcode → will be updated in a few weeks

- For each lecture, two students will create a “public review” of paper(s) 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?
Course Materials

- Research papers
  - Links to ps or pdf on Web page
  - Combination of classic and recent work
  - ~40 papers
  - Optional readings

- Recommended textbooks
  - For students not familiar with networking
  - Peterson & Davie or Kurose & Ross
Grading

• Homework assignments (20%)
  • 4 Problem sets & hands-on assignments
• Class + discussion site participation (10%)
• 2 person project (35%)
• Midterm exam + final exam (35%)
  • Closed book, in-class
Waitlist

• Class is heavily over-subscribed
  • 26 enrolled, 22 on wait-list ➔ target size = low 20’s
  • Unlikely to take any more students
• If you are trying to add class
  • Position on waitlist irrelevant
  • You must show up for the first couple lectures and sign in
  • Current wait-list order will not be used, priority will be given in the following order
    • Any PhD student
    • Any SCS student
    • Other students with research needs
Class Coverage

• Little coverage of physical and data link layer
• Little coverage of undergraduate material
  • Students expected to know this
• 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
• Multicast
• Mobility/wireless
• Active networks
• QoS
• Security
• Network measurement
• Overlay networks
• P2P applications
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?

Computer 1

Internet

Computer 2

Need naming and routing
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

Solution: Timeout and Retransmit
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

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

Problem: Out of Order

Solution: Add Sequence Numbers

GET x.ht

GET index.html
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:

<table>
<thead>
<tr>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application-to-application channels</td>
</tr>
<tr>
<td>Host-to-host connectivity</td>
</tr>
<tr>
<td>Link hardware</td>
</tr>
</tbody>
</table>
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

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
OSI Layers and Locations

Application
Presentation
Session
Transport
Network
Data Link
Physical

Host
Switch
Router
Host
Layer Encapsulation

User A

Get index.html
Connection ID
Source/Destination
Link Address

User B
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
  • [SRC84] End-to-end Arguments in System Design
  • [Cla88] Design Philosophy of the DARPA Internet Protocols

• Optional Reading
  • [Cla02] Tussle in Cyberspace: Defining Tomorrow’s Internet