15-744: Computer Networking

L-1 Intro to Computer Networks

Outline

• Administrivia

• Layering

Who’s Who?

• Professor: Srinivasan Seshan
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  • Office hours: by appt.

• TA: Xi Liu
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• Course info
  • http://www.cs.cmu.edu/~srini/15-744/F10/

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/videos
- Announcements
- Assignments
- Project ideas
- Exams

Discussion Site

- http://sourcery.cmcl.cs.cmu.edu:4000/
  - Please visit http://sourcery.cmcl.cs.cmu.edu:4000/ and create an account. Open the collection CMU 15-744: Computer Networks -- Fall 10. You should then add yourself to the collection using the subscription code: "15744"

Discussion Site

- For each lecture, post a brief comment about each paper:
  - Since I would like to read the reviews before the lecture, you should have this done by 5pm the day before the lecture.
  - Learn to critique and appreciate systems papers
    - 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?
    - What would have done differently?

- Each student will present a 10 minute broader critique in class once this semester and post longer "public" review once
  - Looking at related work, etc.
  - Email signup

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 (15%)
  • 4 Problem sets & hands-on assignments
• Class + discussion site participation (10%)
• Midterm exam + final exam (35%)
  • Closed book, in-class
• 2 or 3 person project (40%)
  • Main focus of class work
  • Make project productive for you!

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
• Machine rooms
• Mobility/wireless
• QoS
• Security
• Network measurement
• Overlay networks
• P2P applications
+ 2 TBD slots

Homework 0

• Email xil@cs.cmu.edu & srini@cs.cmu.edu
• 4 lecture choices for critique/public review
• 1 topic choice for first TBD lecture
• 1 sentence version of project interest & list of project partner
  • E.g., I want to apply game theory to network routing.
• Register on discussion site
• Post response for 1st two papers (extended deadline – 9am Friday)
Outline

• Administrivia

• Layering

This/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
  • [CT90] Architectural Considerations for a New Generation of Protocols

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

Positives
• Interleave packets from different sources
• Efficient: resources used on demand
  • Statistical multiplexing
• General
  • Multiple types of applications
  • Allows for bursty traffic
  • Addition of queues

Challenges
• Store and forward
  • Packets are self contained units
  • Can use alternate paths – reordering
• Contention
  • Congestion
  • Delay

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

Internet[work]
• A collection of interconnected networks
• Host: network endpoints (computer, PDA, light switch, …)
• Router: node that connects networks
  • How do we translate?
How To Find Nodes?

- Need naming and routing

Naming

- What's the IP address for www.cmu.edu?
  - It is 128.2.11.43

Routing

- Routers send packets 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

Solution: Fragment data across packets
- On Ethernet, max IP packet is 1.5kbytes
- Typical web page is 10kbytes
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)

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
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

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Layer Encapsulation

- Diagram of layered protocol stack
  - User A
  - User B
  - Connection ID
  - Source/Destination
  - Link Address
  - Get index.html
Protocol Demultiplexing

- Multiple choices at each layer