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: None!
• Course info
  • http://www.cs.cmu.edu/~srini/15-744/F09/

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

  - Please visit [http://great-white.cmcl.cs.cmu.edu:3000](http://great-white.cmcl.cs.cmu.edu:3000) and create an account. Open the collection CMU 15-744: Computer Networks -- Fall 09. You should then add yourself to the collection using the subscription code: “15744”.
  - 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?

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
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
• Active networks
• QoS
• Security
• Network measurement
• Overlay networks
• P2P applications

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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
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

Packet Switching (Internet)

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

Back in the Old Days...

- 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?

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**

| GET index.html | Internet | GET windex.html |

**Solution: Add a checksum**

| 0,9 9  | 6,7,8,21 | 4,5,7 1,2,3,6 |
What if Network is Overloaded?

Problem: Network Overload
- Short bursts: buffer
- What if buffer overflows?
  - Packets dropped
  - Sender adjusts rate until load = resources → "congestion control"

Solution: Buffering and Congestion Control

What if the Data gets Lost?

Problem: Lost Data
- Internet

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

What if the Data is Out of Order?

Problem: Out of Order
- Internet

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:

![Layering Example Diagram]

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

OSI Layers and Locations
Protocol Demultiplexing

- Multiple choices at each layer

![Diagram of network protocols]

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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