CS123a: Lecture 1, Introduction and Layering

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Lecture Plan

• Class Structure (10 minutes)
• About myself (10 minutes)
• Why study networking (5 minutes)
• Layering, the first big idea in networking
Course Structure

- Web page: http://www-cse.ucsd.edu/users/varghese/TEACH/cs123/main.html (OR: Google for my name, go to Teaching, cs123) has course structure. 4-5 HWs (35%), 1 midterm (30%), final (30%). HW has 2-4 questions, we randomly pick 2. Closed book exams with 1 page page cheat-sheet.

- Textbook is my notes (not slides, real notes) for first 9 lectures, followed by Perlman’s Interconnections for last 10. Copy in Reference Library + my slides, so don’t have to buy. Other readings in Outline on web site.
Why Study Networking?

- Because its already part of your life: witness Napster, MP3, the web. Wouldn’t you like to know how it works?
- Because its the hip place to be: some thing new happening all the time: Ebay, Webcams, spam, worms. Wouldn’t you like it to be all geek (as opposed to greek) to you?
- Because there’s lots of cool work to do. Internet startups are redefining networking and bringing great products to market. Wouldn’t like to know enough to at least get in the door of a great startup?
- Connects hardware for physical communication (wires, signals) to networking software (email, web).
HAT TRANSFER ANALOGY

"A Plumed Hat, Please"

HAZELS HATS BOSTON

"3 Shipments of Plumed Hats"
"Check Inventory"

HAZELS MOROCCO

"Did shipment arrive?"

BIGWIG IMPORT EXPORT

"Whoa, too fast"

BIGWIG MOROCCO

BOSTON POST OFFICE

RIO POST OFFICE

MOROCCO POST OFFICE

VARIG AIR (LOGAN)

VARIG B.S. RIO RIO

CASABLANCA BALLOON STATION

Airline

Balloon
MAIL FROM BOSTON TO PARIS
MAIL: POE TO PROUST

"Hi, Marcel"

POE'S MAIL PROGRAM

"New mail"

MARCEL'S MAIL PROGRAM

POE'S TRANSPORT PROGRAM

"Did message arrive?"

MARCEL'S TRANSPORT PROGRAM

"Whoa, too fast"

POE'S ROUTING PROGRAM

BOSTON ROUTER

MARCEL'S ROUTING PROGRAM

ETHERNET D.L. BOSTON

ETHER I/F

SATELLITE D.L.

SATELLITE I/F

Ethernet

Satellite
Layering

- In Hazel’s Hats analogy, we simplified a complex task (transferring hats) by outsourcing reliable transmission to an import-export agency who in turn outsourced package delivery etc.

- Similarly, in networking, an email transfer is simplified by subcontracting reliable delivery to a transport like TCP who subcontracts packet delivery to the network layer who subcontracts to the Data Link etc.

- This division of labor in networking is called layering. Each horizontal slice (layer) is given a number starting with 1 for physical, 2 for data link etc. While TCP only uses bottom 4 layers, most general model is OSI/ISO model shown next.
application

presentation

session

transport
(e.g. TCP)

network
(e.g., IP)

data link
(e.g., Ethernet)

physical

APDU

PPDU

SPDU

TPDU
(segments)

NPDU
(packets)

DPDU
(frames)

PhSDU

PhPDU
(bits, symbols)

(e.g., bits as voltages)
Some layering concepts and terminology

- **Protocol**: Rules governing *horizontal* communication between peer layer entities.

- **Interface**: Rules governing *vertical* communication between a Layer N entity and a Layer N+1 entity on the same computer.

- **PDU**: Protocol Data Units are the messages that are exchanged between peer entities. N-PDU between Layer N-entities. In Internet, TPDU = Segment, NPDU = Packet, DPDU = Frame.

- **SDU**: Data Unit passed across an interface. N-SDU passed to and from layer N from Layer N+1.

- **PDU versus SDU**: Normally, N-PDU is N-SDU together with a Layer N header. However, one SDU can be split into multiple PDUs if the protocol allows only small PDUs.
Watch those headers!

- Communication between layer entities shares physical medium by using a layer header for each layer in each message. Think of data in envelope with transport header, stuffed in envelope with routing header, stuffed in envelope with DL header.

- Sharing headers saves postage and also trivially coordinates headers with corresponding data (compared to out-of-band transmission between layers).

- **Strict Layering**: Each layer only looks at its header and interface data to do its job. Software engineering: changes to one layer do not cause other layers to be reimplemented. Information can be passed between layers via interface.

- As data moves down the layers, each layer adds its header. As data moves up, each layer strips off its header. Read text, 1.1 – 1.3
From Files to Voltage Levels

- File Transfer implemented by two FTP processes on each machine. Shared queue is simplest asynchronous interface, which is what TCP provides.

- TCP implements shared queue abstraction by sending numbered segments, retransmitting if acks are not received. Requires being able to send segments to arbitrary destinations, which is what IP provides.

- IP computes routes (routing) and then forwards packet hop-by-hop. At each hop, IP requires sending a frame to directly connected neighbor, which is what Data Link provides.

- Data Link uses physical layer to send each bit of a frame; then puts together bits at receiver to form a frame and does error checks. Physical layer sends bits by transforming 0s and 1s into physical energy that can travel distance.
So why a 20 lecture class?

All layers have common problems: synchronization in the face of errors and asynchrony, addressing, multiplexing, interconnection. Sample problems you will learn the answer to:

- **Transport:**
  - **Congestion Control.** How does a TCP sender know how to speed up or slow down depending on current Internet speed? Slow-start.
  - **Connection Management:** How does TCP prevent old conversations between the same pair of machines from mixing in with new conversations. 3-way handshakes

- **Routing:**
  - **CIDR:** How does IP allow various sizes of networks in allocating addresses.
  - **BGP:** How does IP calculate routes between multiple competing providers?
• **Data Link:**
  
  – **Min Packet Sizes:** How does Ethernet ensure that if one node detects a collision, all nodes do?
  
  – **Dynamic Backoff:** How can Ethernet sort out 2 sender collisions quickly while being able to sort out even 32 sender collisions?

• **Physical Layer:**
  
  – **Clock Recovery:** How does a receiver reconstruct bits from physical signals despite speed differences?
  
  – **Media Issues:** When should a manager use wireless versus fiber versus satellite?