CSE 123b
Communications Software

Spring 2003

Lecture 1: Introduction & Review

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Class Overview

- Course Material
  - Class lectures, textbook readings, and handouts
- Course Assignments
  - Homework questions from book and handouts
    - » Handed out on Tuesdays due the following Tuesday
    - » Roughly every 2-3 weeks
  - Network protocol programming projects (3-5)
    - » We will implement routing protocols, transport protocols, etc.
- Exams
  - Midterm and Final
  - I will be explicit about what is covered in each

Grading

- Homework 25%
- Projects 25%
- Midterm 20%
- Final 30%

- Extra credit for class participation

Some hints

- Come to lecture
  - Yes, I will distribute the slides online, and yes the material is in the book
  - However, lecture materials are the basis for exams
- Do the homework
  - You will have a hard time with the exams without doing the homework
  - Its 25% of your grade (easily the difference between an A and C)

Some hints (2)

- Ask questions
  - In class, via e-mail and at office hours
  - Inevitably you won't understand something… that's my fault, but you need to help
- Start assignments early
  - There is a statistical relationship between when you start and what grade you get
- Sleep

Administrativa

- Web page
  http://www-cse.ucsd.edu/classes/sp03/cse123B/
  (will be up shortly)
- Textbook (required)
  Computer Networks: A Systems Approach (2nd ed) by Peterson and Davie
- TA's
  - Yuchung Cheng, Cristian Estan and Alvin Auyoung
- Mailing list, office hours, discussion section (TBA)

Common questions

- Can I take this class concurrently with X? (where X is typically 120)
  - Yes, but this may be challenging. We assuming basic knowledge about OS structure and some of the issues that are discussed in 120 that related to networking. Fair warning.
- How much programming is there?
  - The projects will require that you can understand and write code in C. If you're a proficient programmer and don't know C, you should be able to pick it up quickly. If you've done almost no programming, then this class may be painful.

Course material

- The key aspects of modern computer networks and network services
  - Reliable communication
  - Congestion control
  - Routing (intradomain and interdomain)
  - Naming
  - Mobility
  - Web service, caching, load balancing, CDNs
  - E-mail
  - Peer-to-peer networks
  - Security

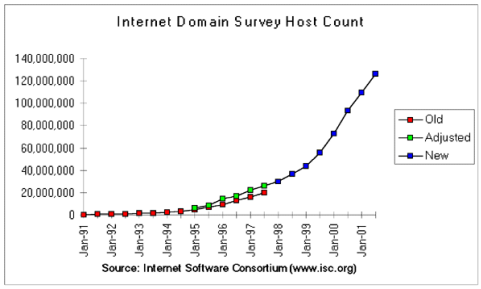
We will not cover

- Queuing theory
- Signals
- Hardware design
- Switching design
- Physical/data link layers

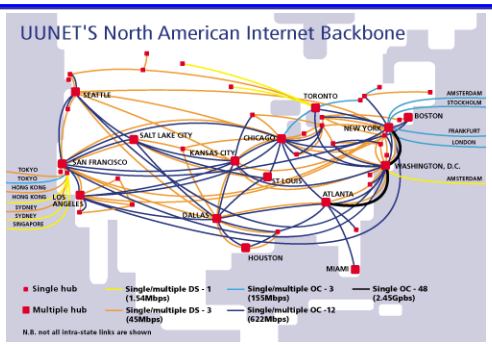
Overall goals

- **Understand how to large scale, heterogeneous distributed networks are built**
  - Fundamental problems
  - Established design principles
  - Standard Internet protocols and implementations

Large scale?



Large scale? (2)



Heterogeneous?

- Homogenous network: the telephone system
  - Designed for making phone calls
  - Known call duration distribution, bandwidth, service constraints, service model
- Heterogenous: the Internet
  - Supports E-mail, web, e-commerce, audio, video, multi-player games…
  - Few underlying assumptions – a strength and a weakness

Distributed?

- Decentralized components
  - Must update/manage changes in state
- Long communication latency
  - Actions take time
- Partial failures
  - Must tolerate failures

"A distributed system is a system in which I can't do my work because some computer has filed that I've never even heard of" – Leslie Lamport

Some review

- Elementary components
- Circuit switching vs packet switching
- Basic network model/metrics
- Layering/protocols
  - Layering by example: fetching a Web page

Network components

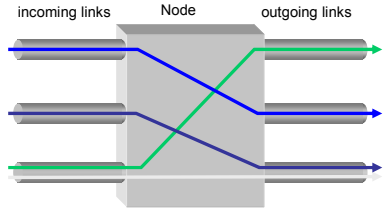
- **Hosts**: endpoints that communicate
  - e.g. workstation, server, PDA
- **Links**: transmission medium
  - e.g. Ethernet, 802.11b, FDDI
- **Routers/Switches**: moves bits between links
  - Circuit switching: guaranteed channel for a session (Telephone system)
  - Packet switching: statistical multiplexing of independent pieces of data (Internet)

Circuit Switching

- Three phases
  1. circuit establishment (dial)
  2. data transfer (talk)
  3. circuit termination (hang up)
- If circuit not available: "Busy signal"
- Examples
  - Telephone networks
  - ISDN (Integrated Services Digital Networks)

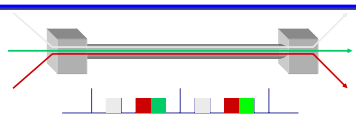
Circuit Switching

- A node (switch) in a circuit switching network



Slide courtesy Ion Stoica

Circuit switching: time division multiplexing



- Time divided in frames and frames divided in slots
  - Relative slot position inside a frame determines which conversation the data belongs to
  - Needs synchronization between sender and receiver
- In case of non-permanent conversations
  - Need to dynamically bind a slot to a conservation
  - Signaling protocol

Slide courtesy Ion Stoica

Packet Switching

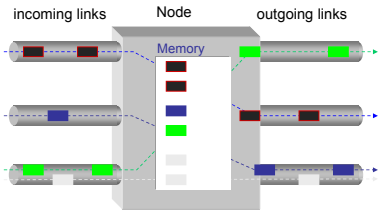
- Data is sent in a bundle of bit-sequences, called a packet.
- Packets have the following structure:

  - » Header and Trailer carry control information (e.g., destination address, check sum)
- Each packet is passed through the network from node to node along some path (**Routing**)
- At each node the entire packet is received, stored briefly, and then forwarded to the next node (**Store-and-Forward Networks**)
- Typically no capacity is pre-allocated for packets

Slide courtesy Ion Stoica

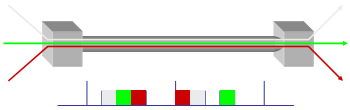
Packet Switching

- A node in a packet switching network



Slide courtesy Ion Stoica

Packet Switching: Statistical multiplexing



- Data from any conversation can be transmitted at any given time
- How to tell them apart?
  - use **header** to describe data

Slide courtesy Ion Stoica

Pro/cons of packet switching

- Efficiency
  - Can share network up to its capacity – no overhead for reserving bandwidth that is unused
  - Can support many different service types
- Low complexity
  - Don't need to maintain state about each "call"
- Harder to guarantee bandwidth/delay

We will focus on packet switching in this class

Simple network model

Network is a pipe connection two computers

Basic Metrics

- Bandwidth, delay, overhead, error rate and message size

Network metrics

- Bandwidth
  - Data transmitted at a rate of R bits/sec
- Delay or Latency
  - Takes D seconds for bit to propagate down wire
- Overhead
  - takes O secs for CPU to put message on wire
- Error rate
  - Probability P that message will not arrive intact
- Message size
  - Size M of data being transmitted

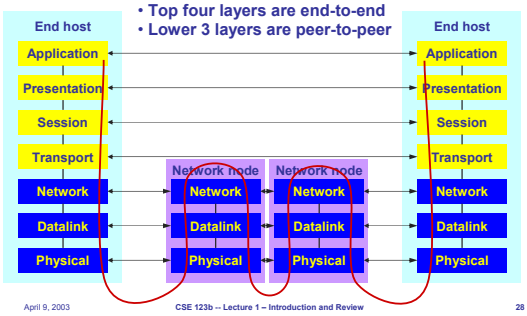
How long to send a message?

- Transmit time T = M/R + D
  - 10Mbps Ethernet LAN (M=1KBbyte, or 8000bits)
    - » M/R=0.8ms, D ~=5us
  - 155Mbps cross country ATM (M=1KB)
    - » M/R = ~51us, D ~= 40-100ms
- R*D is the "storage" of pipe (also called *bandwidth delay product*)

Layering

- What is layering?
  - Decomposition of a complex system into an **ordered** series of distinct abstractions
  - The services provided by a layer depend **only** on the services provided by the previous, less abstract, layer
- Layering in networking
  - **Service**: what a layer **does** (e.g. message delivery)
  - **Interface**: how to **use** the service (e.g. packet format)
  - **Protocol**: how the service is **implemented** (e.g. TCP)
  - **Protocol stack**: collection of protocols implementing a series of layers (e.g. Ethernet/IP/TCP/Web)

The OSI layering Model



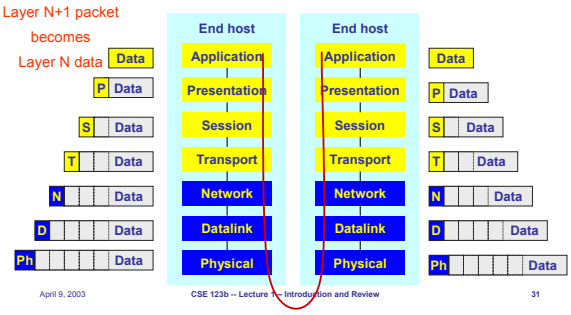
What the layers are for?

- **Application**: any service (e.g. WWW, SMTP)
- **Presentation**: data format conversion (e.g. XDR)
- **Session**: connection management, synchronization (e.g. SMIL)
- **Transport**: error-control, flow-control, channel multiplexing (e.g. TCP, UDP)
- **Network**: Routing (e.g. IP)
- **Datalink**: Framing, media access (e.g. Ethernet, FDDI, SONET)
- **Physical**: Transmission/modulation (e.g. 100BaseT)

Benefits of layering

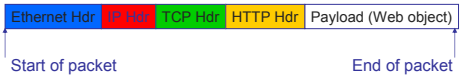
- **Encapsulation**
  - Functionality inside a layer is self-contained; one layer doesn't need to reason about other layers
- **Modularity**
  - Can replace a layer without impacting other layers
  - Lower layers can be reused by higher layers (e.g. TCP and UDP both are layered upon IP)
- One obvious drawback
  - Information hiding can produce **inefficient implementations**

Layer encapsulation



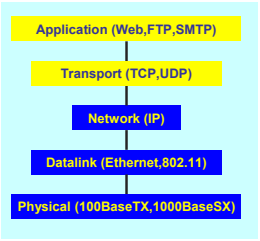
Layer Encapsulation (2)

- Typical Web packet



- Notice that layers add overhead
  - Space (headers), effective bandwidth
  - Time (processing headers, peeling the onion), latency

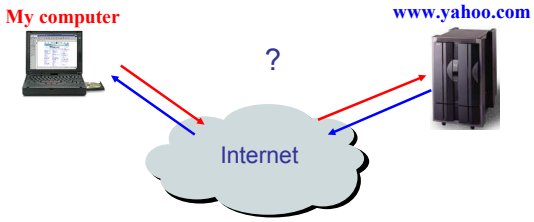
The Internet layering model



- So-called "hourglass" model
  - One network layer protocol
  - Significant diversity at other layers
- No presentation or session layers
- Implementations more important than interfaces

Layering by example...

- **ROUGHLY**, what happens when I click on a Web page from UCSD?

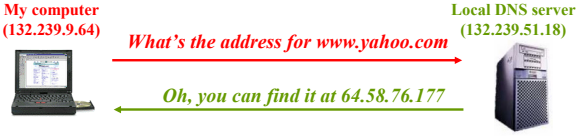


Application layer (HTTP)

- Turn click into HTTP request

Application layer? Name resolution (DNS)

- Where is www.yahoo.com?

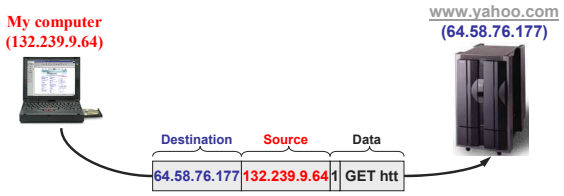


Transport layer (TCP)

- Break message into packets (TCP segments)
- Should be delivered reliably & in-order

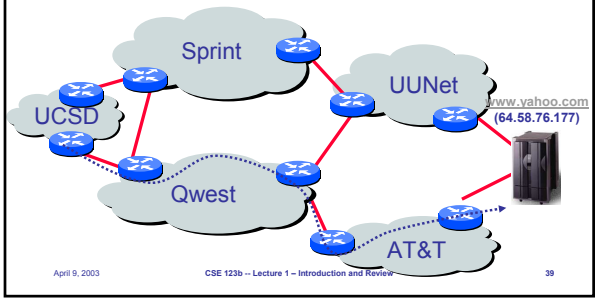
Network layer: IP Addressing

- Address each packet so it can traverse network and arrive at host



Network layer: IP Routing

- Each router forwards packet towards destination

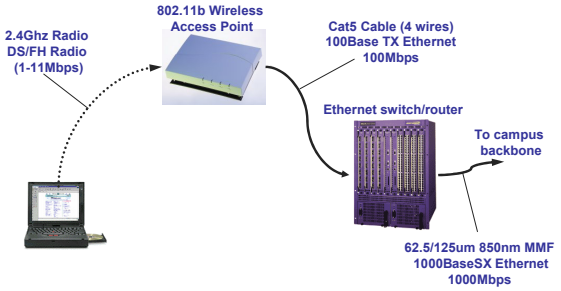


Datalink layer (Ethernet)

- Too boring for a picture (sorry)

- Break message into frames
- Media Access Control (MAC)
- Send frame

Physical layer



Summary

- Packets switching is an efficient and simple architecture for data communications
  - Gives up guarantees on service
- Layering is a technique for managing complexity in systems
  - Encapsulate related functionality in a layer and provide an interface to upper and lower layers
  - A **model**: implementations do not necessarily respect layers

For Next Time...

- ATTENTION – Wake up!
  - **Thursday's class is *cancelled***
  - The next class will be **Tuesday April 8th**
- For then:
  - Get the textbook
  - Review Patterson&Davie Chap1
  - Read Chap 4.1 - 4.1.4