CSE/EE 461 Fall 2005

Introduction to Computer Communication Networks

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This Lecture

1. Administrative stuff
2. Introduction to Networks
3. Statistical Multiplexing

1. Administrative Stuff

- Everything you need is on the course web page
  - http://www.cs.washington.edu/cse461
- Your TODO list:
  - Join the mailing list cse461@cs.washington.edu
  - Gain access to the CSE Labs (form for non-majors)
  - Get Computer Networks by Peterson and Davie
  - Read chapters 1 and 2
  - Go to section
  - Start on Fishnet assignment 1

TAs

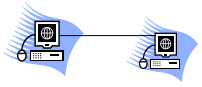
- Lillie Kittredge (covering the AB section)
- Safeer Jiwan (covering the AA section)

What is a Network?

Main Entry: **[1]net·work**
Pronunciation: 'net-"w&rk
Function: *noun*
1 : a fabric or structure of cords or wires that cross at regular intervals and are knotted or secured at the crossings
2 : a system of lines or channels resembling a network
3 a : an interconnected or interrelated chain, group, or system <a *network* of hotels> **b :** a system of computers, terminals, and databases connected by communications lines
4 a : a group of radio or television stations linked by wire or radio relay **b :** a radio or television company that produces programs for broadcast over such a network

A Network in 461

- "Network" is clearly an overloaded word:
  - Economic networks, regulatory networks, social networks…
  - Telephone, Cable TV, Bank tellers, computer clusters
- For 461, a network is what you get anytime you connect two or more computers together by some kind of a link.



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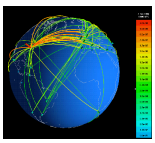
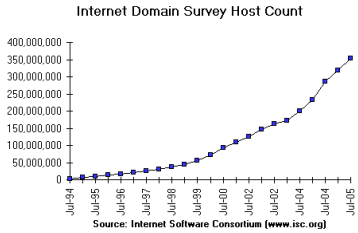


2. The networks we study

- We are interested in networks that are:
  - Large scale
  - Intrinisically Unreliable
  - Distributed
  - Heterogeneous

The meaning of "Large-scale"



Intrinsic Unreliability

- Information sent from a first place to a second
  - May not arrive
  - May arrive more than once
  - May arrive in garbled fashion
  - May arrive out of order
  - May be read by others
  - May be modified by others
- Why build intrinsically unreliable networks?

Distributed

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

- (Hopefully) independent failure modes
- Exposed and hidden dependencies
- Independent administrative controls
- Leads to…

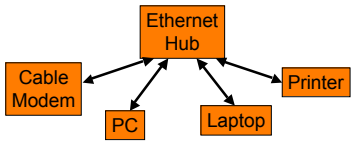
Heterogeneous Networks

- Heterogeneous: Made up of different kinds of stuff
- Homogeneous: Made up of the same kind of stuff
- Principles
  - Homogeneous networks are easier to deal with
  - Heterogeneous networks lead to greater innovation and scale
  - Consider telephone network vs. Internet
  - Reasons?

Model of a Network

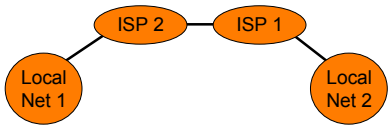
- Links carry information (bits)
  - Wire, wireless, fiber optic, smoke signals …
  - May be point-to-point or broadcast
- Switches move bits between links
  - Routers, gateways,bridges, CATV headend, PABXs, …
- Hosts are the communication endpoints
  - PC, PDA, cell phone, tank, toaster, …
  - Hosts have names
- Much other terminology: channels, nodes, intermediate systems, end systems, and much more.

Example – Local Area Network



- Your home network
  - Ethernet is a broadcast-capable multi-access LAN

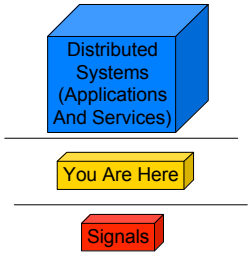
Example – An Internetwork



- Internetwork is a network of networks
- The Internet is a global internetwork in which all participants speak a common language
  - IP, the Internet Protocol

Goal of this Course

- You will understand how to design and build *large, distributed computer* networks.
  - Fundamental problems in building networks
  - Design principles of proven value
  - Common implementation technologies
- This is a systems course, not queuing theory, signals, or hardware design.
- We focus on networks, rather than applications or services that run on top of them (distributed systems).

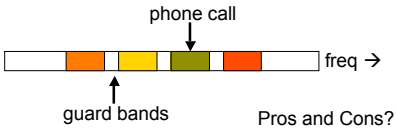


3. An example technical problem: multiplexing

- Networks are shared among users
  - This is an important benefit of building them
    - (why we can't just buy everybody their own network!)
- How should you multiplex (share) a resource amongst multiple users?
  - e.g., how do you share a network link?
- First Solution: Static Partitioning
  - (Synchronous) Time Division Multiplexing (TDM, STDM)
  - Frequency Division Multiplexing (FDM)

Frequency Division Multiplexing

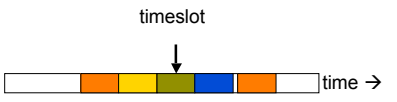
- Simultaneous transmission in different frequency bands
- "Speaking at different pitches"
  - e.g., take one 3MHz signal and break it into 1000 3KHz signals
    - Analog: Radio, TV, AMPS cell phones (800MHz)
  - also called Wavelength DMA (WDMA) for fiber



Pros and Cons?

Time Division Multiplexing

- "Slice up" the given frequency band between users
- Speaking at different times
  - Digital: used extensively inside the telephone network
  - T1 (1.5Mbps) is 24 x 8 bits/125us; also E1 (2Mbps, 32 slots)



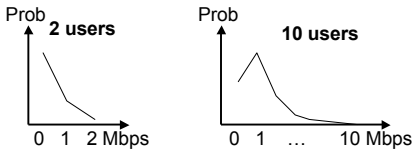
Pros and Cons?

Statistical Multiplexing

- Static partitioning schemes are not well-suited to data networks
  - why? because peak rate >> average rate.
    - it's rare for many clients to want to transmit at the same time.
    - so, statically assigning fractions of the link wastes capacity, since users tend to underuse their fraction
  - (Q: When would S.P. schemes be well suited to communications?)
- If we share on demand we can support more users
  - Based on the statistics of their transmissions
    - If you need more, you get more. If you need less, you get less.
    - It's all supposed to "balance out" in the end
  - Occasionally we might be oversubscribed
  - This is called statistical multiplexing -- used heavily in data networks

Why We Like Statistical Multiplexing

- One user sends at 1 Mbps and is idle 90% of the time.
  - 10 Mbps channel; 10 users if statically allocated
- Two scenarios: 2 users in the population, or 10 users in population
  - what is the probability of a certain bandwidth consumption at any given moment in time?



Example continued

- For 10 users, Prob(need 10 Mbps) = 10^{-10} = 0.0000000100%
- Not likely! So keep adding users …
- For 35 users, Prob(>10 active users) = 0.17%, which is acceptably low
- With statistical multiplexing, we can support three times as many users than static allocation!
- What's the rub?

Key Concepts

- Networks are comprised of links, switches and hosts
- Networks are used to share distributed resources
  - Key problems revolve around effective resource sharing
- Multiplexing lets multiple users share a resource

- Static multiplexing is simple
  - but not efficient unless the workloads are static
- Statistical multiplexing is more complicated
  - not guaranteed to work
  - but well-suited to data communications (bursty traffic)