CSE/EE 461 Autumn 2002

Introduction to Computer Communication Networks

David Wetherall
djw@cs.washington.edu

This Lecture

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

1. Administrative Stuff

- Everything you need is on the course web page
  - www.cs.washington.edu/education/course/461/02au
- 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
  - Start on Fishnet assignment 1

2. The networks we study

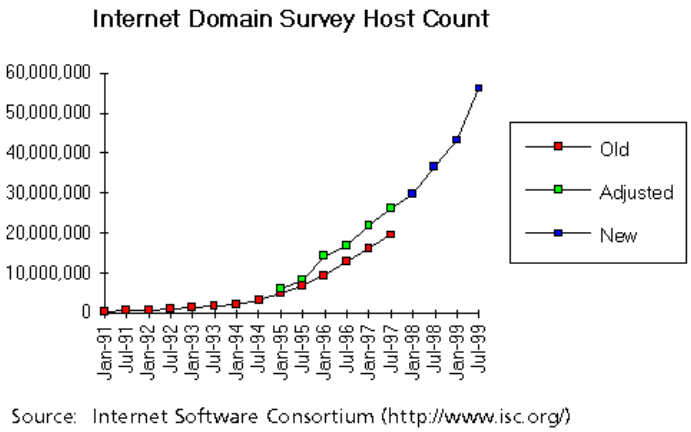
- "Network" is an overloaded word:
  - Economic networks, regulatory networks, …
  - Telephone, Cable TV, Bank tellers, computer clusters
- We are interested in networks that are:
  - Distributed
  - Large scale
  - Heterogeneous

The meaning of "Distributed"

- There are distributed and parallel networks:
  - Cash machines versus a parallel computer
  - Both support concurrent computation
- What is the essential difference?
  - Tolerance of failed components
  - Decentralized operation

"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

The meaning of "Large-scale"



Source: Internet Software Consortium (http://www.isc.org/)

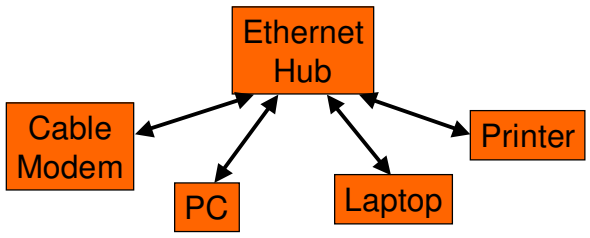
The meaning of "Heterogeneous"

- Telephone network
  - Designed for telephone calls
- Internet
  - Web, email, Quake, e-commerce, audio/video, …
  - But evolution was at work: Web/email a "surprise"
- Computer networks
  - Carry digital information and support a rich variety of distributed applications

Model of a Network

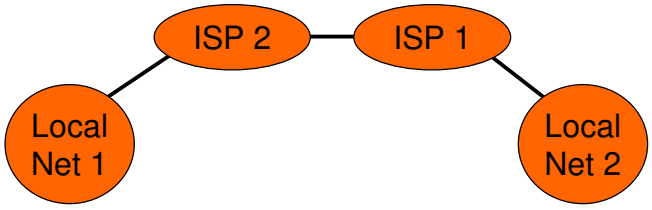
- Links carry information (bits)
  - Wire, wireless, fiber optic, smoke signals …
  - May be point-to-point or broadcast
- Switches move bits between links
  - Routers, gateways,bridges, CATV headend, PABXs, …
- Hosts are the communication endpoints
  - PC, PDA, cell phone, tank, toaster, …
- Much other 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

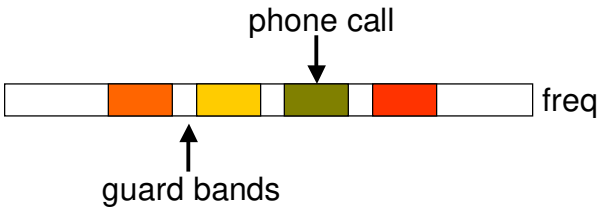
- For you to understand how to design and build *large, distributed computer* networks.
  - Fundamental problems in building networks
  - Design principles of proven value
  - Common implementation technologies
- This is a systems course, not queuing theory, signals, or hardware design.
- We focus on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

3. Statistical Multiplexing

- Networks are shared among users
  - This is an important benefit of building them
  - Fundamental design issues concern effective sharing of distributed resources (effective = cost, control, secure, reliable, …)
- Problem: How to multiplex (share) a resource amongst multiple users, especially sharing a link?
- Well, we could statically partition the link:
  - Frequency Division Multiplexing (FDM)
  - (Synchronous) Time Division Multiplexing (TDM, STDM)

Frequency Division Multiplexing

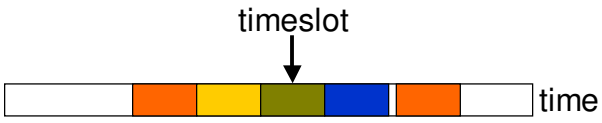
- Simultaneous transmission in different frequency bands
  - Analog: Radio/TV, AMPS cell phones (800MHz)
  - Also called Wavelength DMA (WDMA) for fiber



"Speaking at different pitches"

Time Division Multiplexing

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



"Speaking at different times"

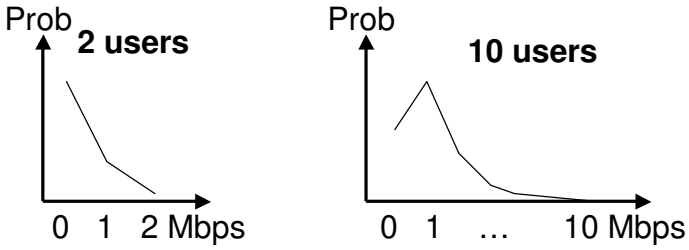
- Advantage: lower delay; Disadvantage: synchronization

Statistical Multiplexing

- Static partitioning schemes are not suited to data communications because peak rate >> average rate.
- If we share on demand we can support more users
  - Based on the statistics of their transmissions
  - Occasionally we might be oversubscribed
  - This is called statistical multiplexing
- Statistical multiplexing is heavily used in data networks

Example

- One user sends at 1 Mbps and is idle 90% of the time.
  - 10 Mbps channel; 10 users if statically allocated



- What are the likely loads if we share on demand?

Example continued

- For 10 users, Prob(need 10 Mbps) = 10^{-10}
- Not likely! So keep adding users …
- For 35 users, Prob(>10 active users) = 0.17%, which is acceptably low

- We can support three times as many users!
- But: there is an important caveat here …

Key Concepts

- Networks are comprised of links, switches and hosts
- Networks are used to share distributed resources
  - Key problems revolve around effective resource sharing
- Statistical multiplexing
  - It's well-suited to data communications (bursty traffic)