CSE/EE 461 Winter 2001

Introduction to Computer Communication Networks

David Wetherall
djw@cs.washington.edu

This Lecture

1. Administrative stuff
2. Course Intro
3. Statistical multiplexing

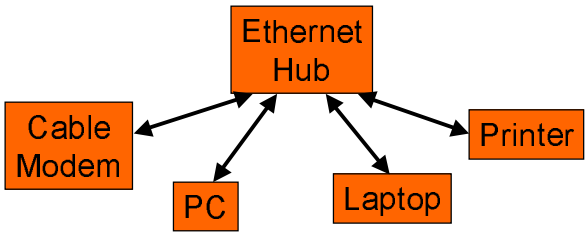
1. Administrative Stuff

- Everything you need to know is on the handout and course web page
  - www.cs.washington.edu/education/course/461/01wi

2. Intro – What is a Network?

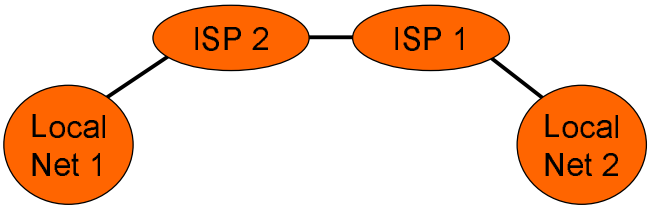
- Links carry information (bits)
  - Wire, wireless, fiber optic, smoke signals …
  - May be point-to-point or broadcast
- Switches move bits between links
  - Routers, gateways,bridges, CATV headend, PABXs, …
- Hosts are the communication endpoints
  - PC, PDA, cell phone, tank, toaster, …
- Also called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

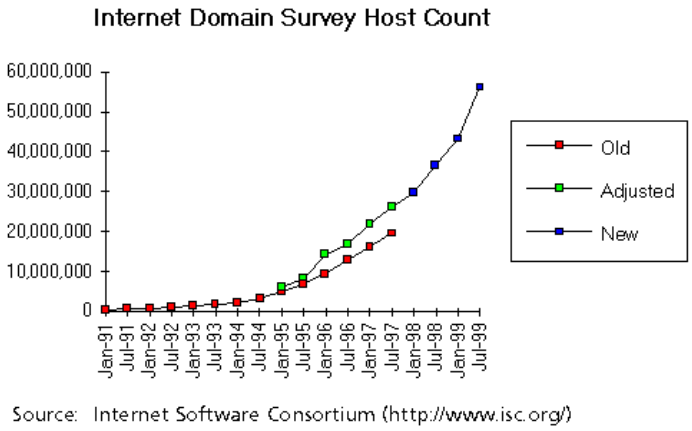
Other Networks

- You've all used networks:
  - Telephone, Cable TV,
  - ATMs, Processor Interconnects
- We are interested in networks that are:
  - Distributed
  - Large scale
  - Multi-purpose

The meaning of "Distributed"

- There are distributed and parallel networks:
  - Cash machines versus a parallel computer
- What is the essential difference?
  - Tolerance of failed components
  - Decentralized operation
  - Heterogeneity
- Hard to get it right
  - "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 "Multi-purpose"

- 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

Why Build Networks?

- To enable communication at a distance
  - Want performance sufficient to given task
    - Video conference, etc.
- To gain the benefits of resource sharing
  - Networks are shared among users
  - Fundamental issues concern the effective sharing of distributed resources
    - Effective = cost, control, secure, reliable, …

Goal of this Course

- For you to understand the design of *large*, *distributed computer* networks.
- Fundamental problems in building networks
  - That are fast, efficient, secure and robust
- Design principles of proven value
  - Networking is young and there are few!
- Common implementation technologies
  - These will change of course …

Topics and Key Problems

- Multi-access (Ethernet)
- Routing (IP)
- Transport (TCP)
- Congestion control (TCP)
- Multicast (Mbone)
- Real time (DiffServ)
- Naming (DNS)
- Security (IPSEC)
- Coordination
- Robust operation
- Reliable delivery
- Resource allocation
- Efficient delivery
- Multimedia
- Distributed state
- Authentication/Privacy

Lecture Emphasis

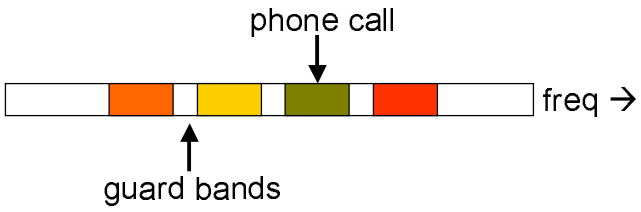
- What we do cover:
  - Communications
  - Internetworking ← We focus here
  - Distributed systems
- What we don't cover:
  - Design of communications hardware
  - Queuing theory
  - Protocol standards

3. Multiplexing

- 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

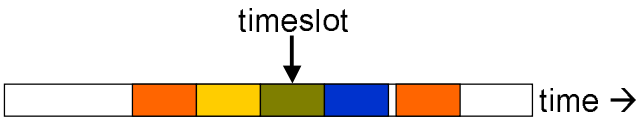
- Simultaneous transmission in different frequency bands
  - Analog: Radio/TV, AMPS cell phones (800MHz)
  - Also called Wavelength DMA (WDMA) for fiber



"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"

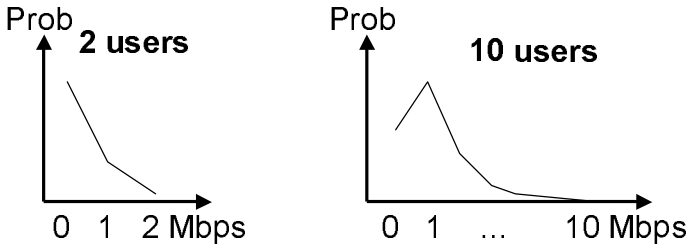
- Advantage: lower delay; Disadvantage: synchronization

Statistical Multiplexing

- Static partitioning schemes work well for a fixed number of users that always have data to send
- Not suited to data communications: peak>>average
- If we share on demand we can support more users
  - Based on the statistics of their transmissions
  - Occasionally we might be oversubscribed
- 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}
- So keep adding users …
- For 35 users, Prob(>10 active users) = 0.17%

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

Key Concepts

- Networks are used to share distributed resources
  - Key problems revolve around effective resource sharing
- Statistical multiplexing
  - It's well-suited to data communications