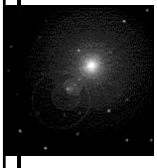
CS 4/54201

Computer Network

Kent State University
Computer Science

www.cs.kent.edu/~javed/



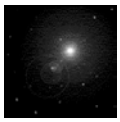
A Course on Networking and

Computer Communication

Today's Topic

Unit background and administrivia

Introduction to Computer Communication



COMPUTER COMMUNICATION NETWORK

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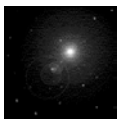
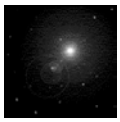
- Web Page: **http://www.cs.kent.edu/~javed/**
- Books:
- Text: Computer Networks, 3/e,Andrew S. Tanenbaum, Prentice Hall Professional Technical Reference,, 4th Edition
- Ref: Computer Networks: A Systems Approach by Larry L. Peterson and Bruce S. Davie, The Morgan Kaufmann,1996, ISBN 1-55860-368-9



COMPUTER COMMUNICATION NETWORK

What is Expected Out of You?



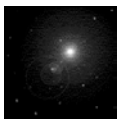
COMPUTER COMMUNICATION NETWORK

- At least 12 hours per week (to pass)

- Learning by doing
- questions and exercises
- reading textbook & Materials
- asking questions
- taking part in discussions

- Read/Listen Think Do Ask

Grading



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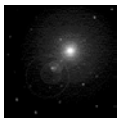
Test Type	Frequency	Weight
Project	1	20%
End Term Exam	1	20%
Mid Term Exam	1	20%
Take Home Assignments	4-5	20%
Term Paper	1	20%
Unannounced Quiz	2-5	20%

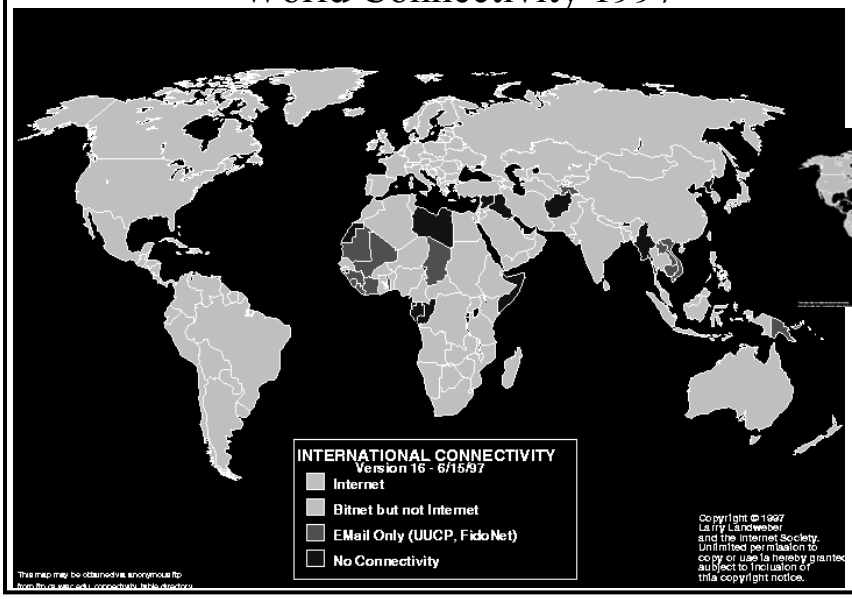
Why You Should Study Computer Networking?

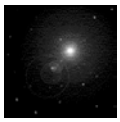
- If you have to select a branch of basic computer science and engineering that has made the most significant influence on our society in last decade, it is computer networks.
- The wonder of Web and, in general the information revolution was built on top of computer networks.
- It is extremely important to understand the foundation of general purpose computer networking to understand the future.



COMPUTER COMMUNICATION NETWORK

World Connectivity 1997



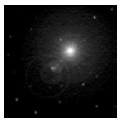


COMPUTER COMMUNICATION NETWORK

Global Village

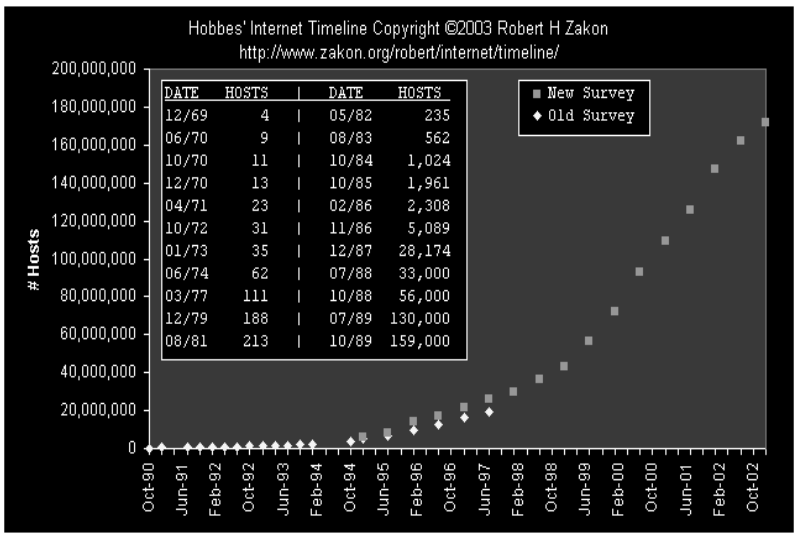
As of January 1998, 205 countries had at least one connection to the Internet. Thus only 11 new countries joined the Internet in 1997. This is a diminished Internet spread rate, but it occurs for the simple reason that there aren't many new countries to join.

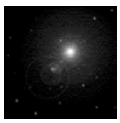
Matrix Inc.



COMPUTER COMMUNICATION NETWORK

Growth of Internet Hosts

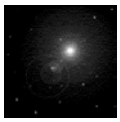




COMPUTER COMMUNICATION NETWORK

Expectations

- This class **IS** about...
  - Principles and Concepts
  - General-Purpose Computer Networks
  - Internet Perspective
  - Network Software
  - Designing and Building a System



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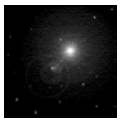
- This class **IS NOT** about...
  - Survey of existing protocol standards
  - Specialized networks (e.g., CATV, telephone)
  - OSI Perspective
  - Network Hardware (we do survey)
  - Queuing Theory



COMPUTER COMMUNICATION NETWORK

What You Will Learn..

- Physical Connection
  - Theoretical basis of data communication, Error Correction Codes, TDM, CSMA,
- Packet Switching
  - Routing Algorithms, ATM Cell switching,
  - Switch Architectures: Batcher, Knpockout
- Internetworking
  - subnetting, IP6, Route Propagation, multicasting
- Congestion Control & Aviodance
  - FIFO, Fair Queing, Virtual Clock
- High Speed Networking
- Wireless Communication
  - Cellular network, Mobile Phone, Communication Satellites
- AAL, ARP, CDMA, HIPPI, VSAT, FDM, VHF, ASN, ATM, OSFP, IPv6, PCM
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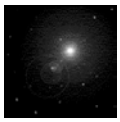

INTRODUCTION

COMPUTER
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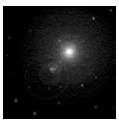
NETWORK

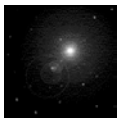
Perspective

- Network users: services that their applications need, e.g., guarantee that each message it sends will be delivered without error within a certain amount of time
- Network designers: cost-effective design e.g., that network resources are efficiently utilized and fairly allocated to different users
- Network providers: system that is easy to administer and manage e.g., that faults can be easily isolated and it is easy to account for usage



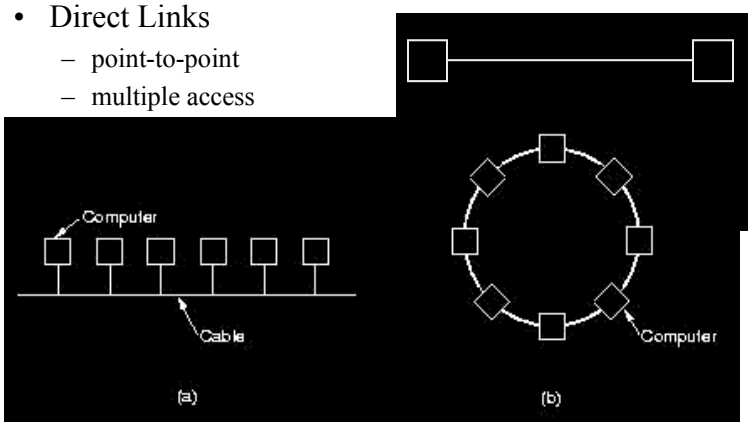
COMPUTER
COMMUNICATION
NETWORK

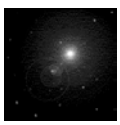
Requirements



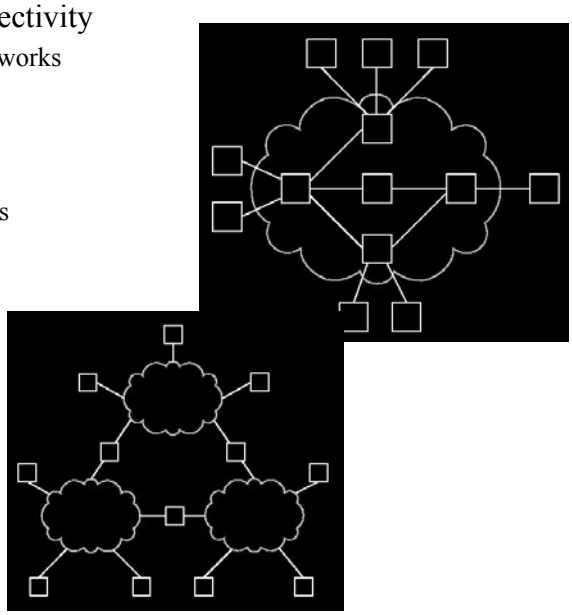
Connectivity

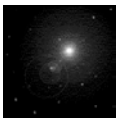
- Building Blocks
  - links: coax cable, optical fiber, wireless medium
  - nodes: general-purpose workstations...
- Direct Links
  - point-to-point
  - multiple access





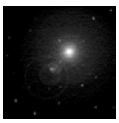
- Indirect Connectivity
  - switched networks
  - internetworks





COMPUTER COMMUNICATION NETWORK

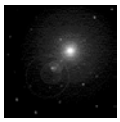
- Switching Strategies
  - circuit switching: dedicated circuit; send/receive a bit stream
  - packet switching: store-and-forward; send/receive messages (packets)
- Addressing and Routing
  - address: byte-string that identifies a node; usually unique
  - routing: process of determining how to forward messages towards the destination node based on its address
  - types of addresses
    - unicast: node-specific
    - broadcast: all nodes on the network
    - multicast: some subset of nodes on the network



COMPUTER COMMUNICATION NETWORK

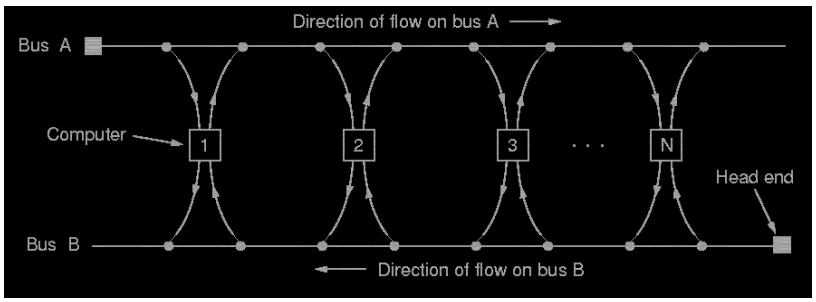
Network by Size

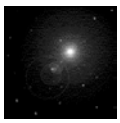
Interprocessor distance	Processors located in same	Example
0.1 m	Circuit board	Data flow machine
1 m	System	Multicomputer
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1,000 km	Continent	
10,000 km	Planet	The internet



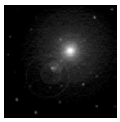
- LAN
- WAN
- MAN
- DAN

MAN
(Distributed Queue Dual Bus)





Wireless and Mobile Technology



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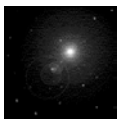
NETWORK

Wireless	Mobile	Applications
No	No	Stationary workstations in offices
No	Yes	Using a portable in a hotel; train maintenance
Yes	No	LANs in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory

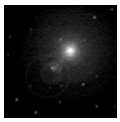
Wireless and Mobile Technology



COMPUTER
COMMUNICATION
NETWORK

- Easier to Setup
- Less Bandwidth (1-2 MB)
- Much Error

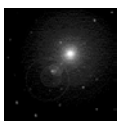
Wireless	Mobile	Applications
No	No	Stationary workstations in offices
No	Yes	Using a portable in a hotel; train maintenance
Yes	No	LANs in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory



COMPUTER COMMUNICATION NETWORK

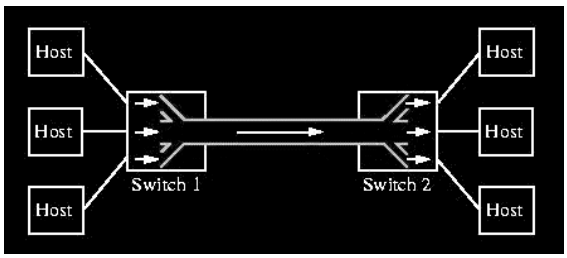
A network can be defined recursively as two or more nodes connected by a physical link, or by two or more networks connected by one or more nodes.

Cost-Effective Resource Sharing



COMPUTER COMMUNICATION NETWORK

Must share (*multiplex*) network resources (nodes and links) among multiple users.



Analogous to time sharing of CPU

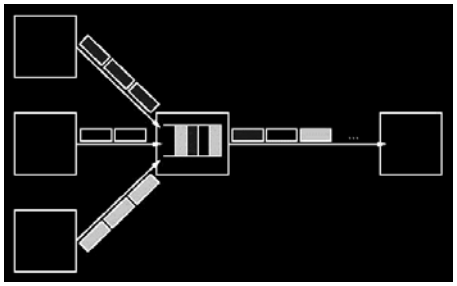
Common Multiplexing Strategies

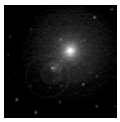
- Synchronous Time-Division Multiplexing (STDM)
- Frequency-Division Multiplexing (FDM)

Problems with simple STDM and FDM:
What if one is not using his slot?
The total number of slots are fixed.

Statistical Multiplexing

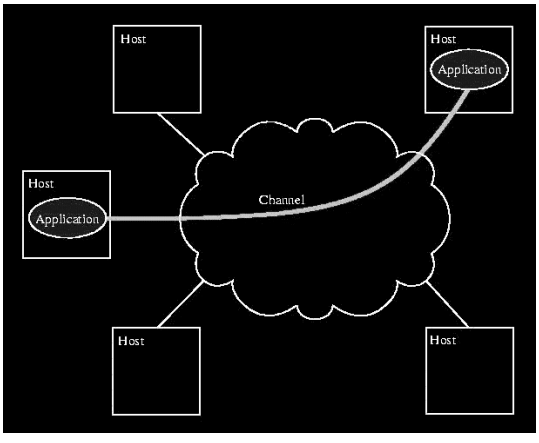
- Time-division, but on demand rather than fixed
- Reschedule link on a per-packet basis
- Packets from different sources interleaved on the link
- Buffer packets that are *contending* for the link
- Packet queue may be processed FIFO
- Buffer overflow is called *congestion*





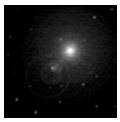
Functionality

Application programs running on the hosts connected to the network must be able to communicate in a meaningful way.



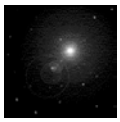
Network is complex: But many of these complex operations are common.

Examples are Error correction, flow control, packetization etc. The challenge is to identify these common tasks and hide the complexity from the top level programs.



Network supports common process-to-process channels; e.g.,

- Request/Reply: for file access and digital libraries
- Message Stream: for video applications
  - video: sequence of frames
  - resolution: 1/4 TV-size image = 352 x 240 pixels;
  - 24-bit color: frame = (352 x 240 x 24)/8 = 247.5KB;
  - frame rate: 30 fps = 7500KBps = 60Mbps
  - video on-demand versus video-conferencing



What Goes Wrong in the Network?

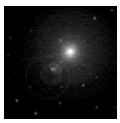
- Bit-level errors (electrical interference)
- Packet-level errors (congestion)
- Link and node failures

1 bit in 10^{6-7} in copper

1 bit in 10^{12-14} in fiber

- Messages are delayed
- Messages are deliver out-of-order
- Third parties eavesdrop

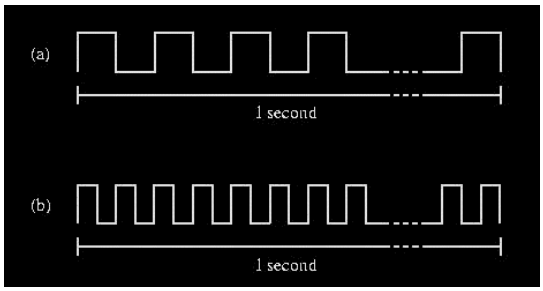
The key problem is to fill in the gap between what applications expect and what the underlying technology provides.

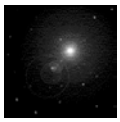


Performance

Bandwidth (throughput)

- Amount of data that can be transmitted per time unit
- Example: 10Mbps
- link versus end-to-end
- Notation
  - KB = 2^{10} bytes
  - Mbps = 10^6 bits per second
- Bandwidth related to "bit width"





Hz vs. Bps

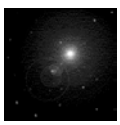
Latency (delay)

- Time it takes to send message from point A to point B
- Example: 24 milliseconds (ms)
- Sometimes interested in in round-trip time (RTT)
- Components of latency

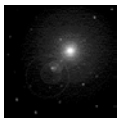
  Latency = Propagation + Transmit + Queue

  Propagation = Distance / SpeedOfLight

  Transmit = Size / Bandwidth



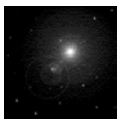
- Speed of light
  - 3.0×10^8 meters/second in a vacuum
  - 2.3×10^8 meters/second in a cable
  - 2.0×10^8 meters/second in a fiber
- Notes
  - no queuing delays in direct link
  - bandwidth not relevant if Size = 1 bit
  - process-to-process latency includes software overhead
  - software overhead can dominate when Distance is small



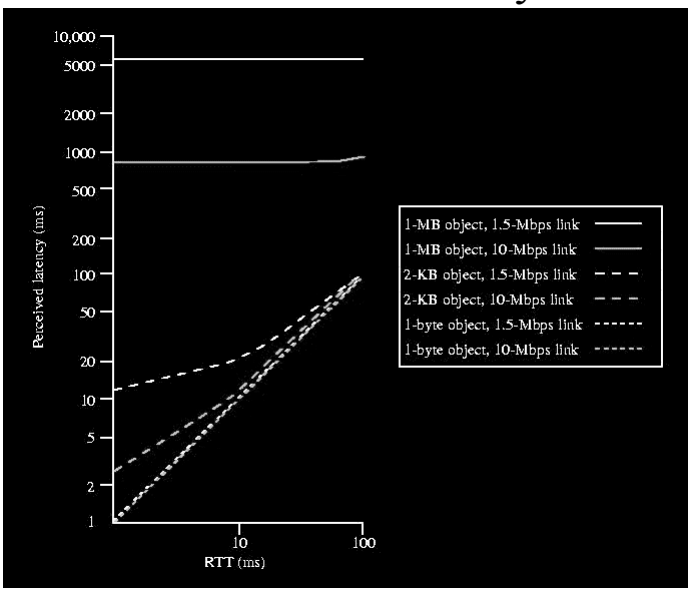
Can Speed Grow Indefinitely?

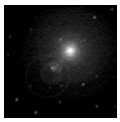
24 ms time it takes for light wave to travel 3000 miles width of the US

- Queuing and Bandwidth will improve. But Latency will stay.



Effect of Latency

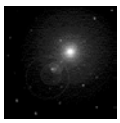




- Relative importance of bandwidth and latency
  - small message (e.g., 1 byte): 1ms vs 100ms dominates 1Mbps vs 100Mbps
  - large message (e.g., 25 MB): 1Mbps vs 100Mbps dominates 1ms vs 100ms
- Delay x Bandwidth Product

e.g., 100ms RTT and 45Mbps Bandwidth = 560KB of data

- Application Needs
  - bandwidth requirements: burst versus peak rate
  - jitter: variance in latency (inter-packet gap)



Next Class

Network Software Architecture