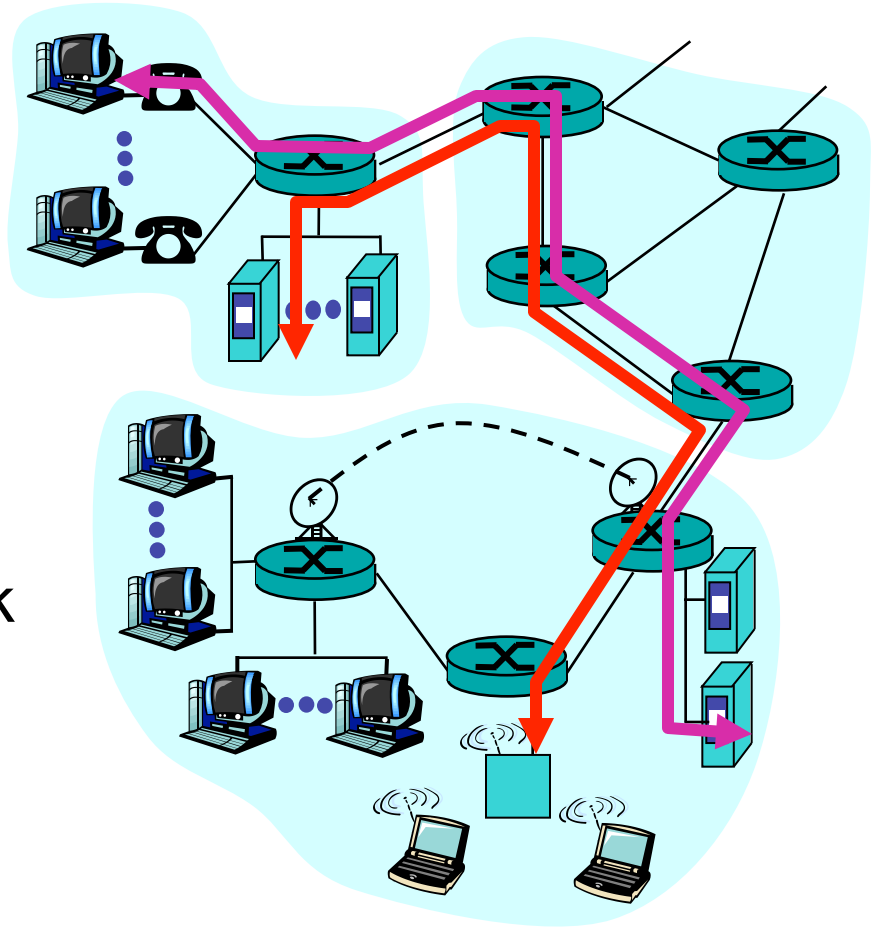
CS 457 - Lecture 2
Network Performance

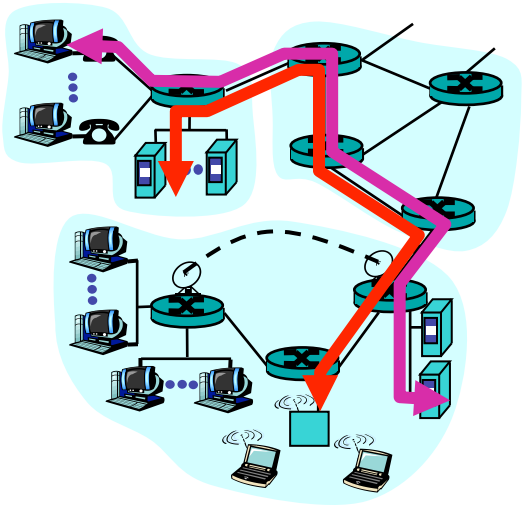
Fall 2011

How Is the Link Shared? Circuit Switched or Packet Switched

- Circuit switching
  - dedicate link bandwidth & switch capacity to each “call”
  - Requires call setup
  - Guaranteed performance
- Packet switching
  - Packet: small chunks of data
  - Send packets as soon as link available
  - Switch receives a full packet then forwards it towards the destination

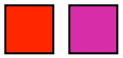


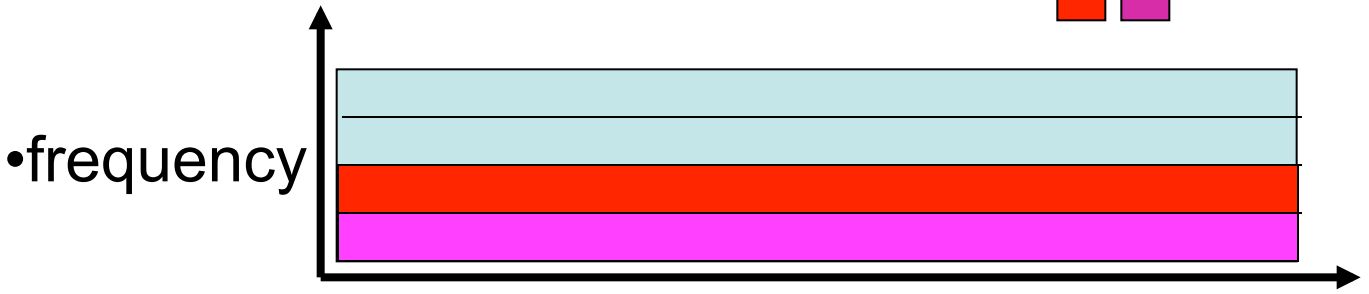
Circuit Switching: FDM and TDM



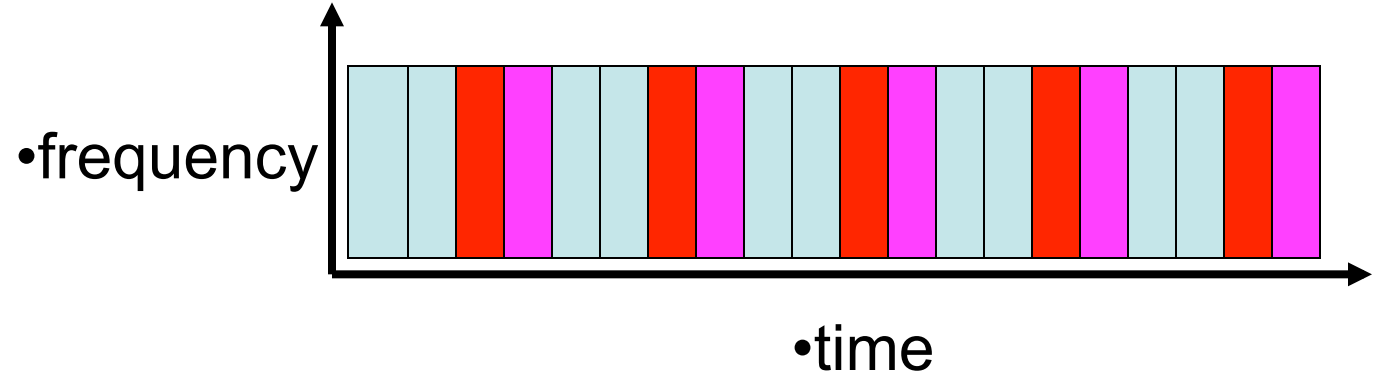
FDM

•Example: •2 users

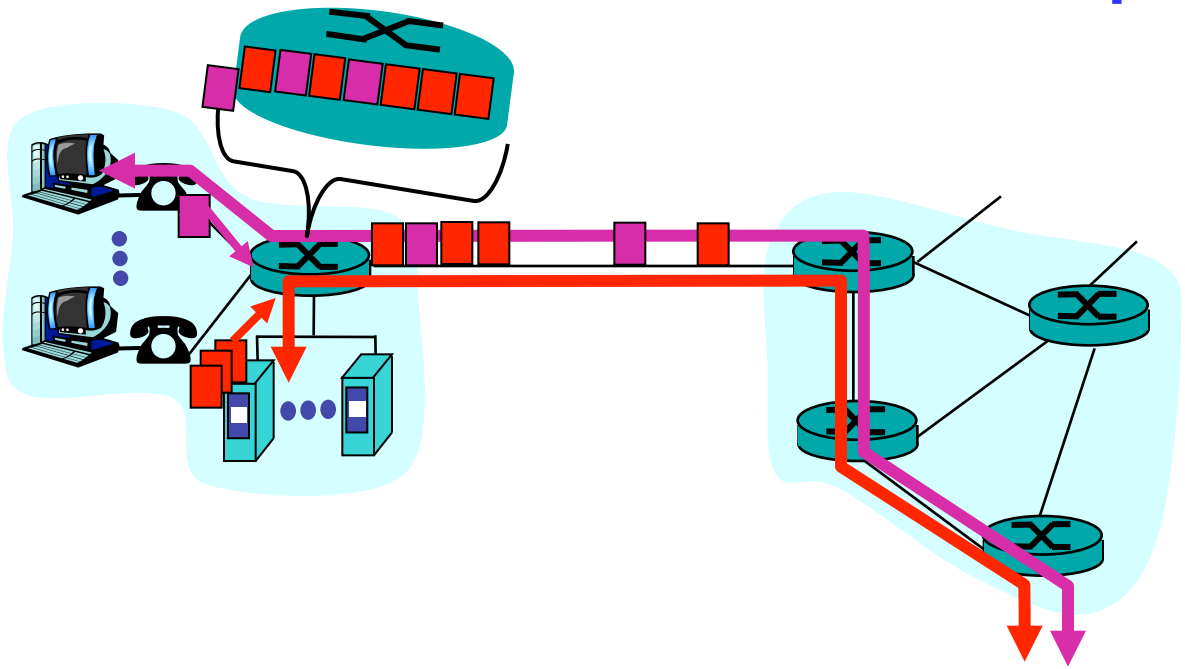




• **TDM**



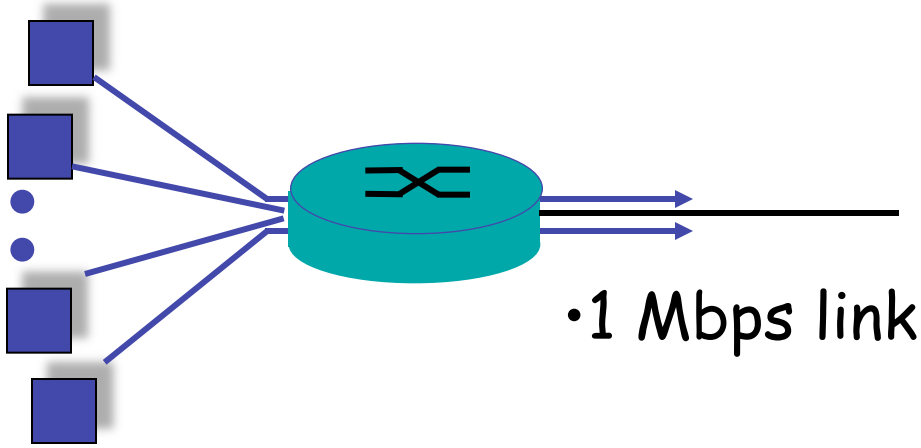
Packet Switching: Statistical Multiplexing



- Store-and-forward
- Packet switch can temporarily buffer up packets
  - Introduces ***queueing delay***
  - Packets get ***dropped*** when the queue is full

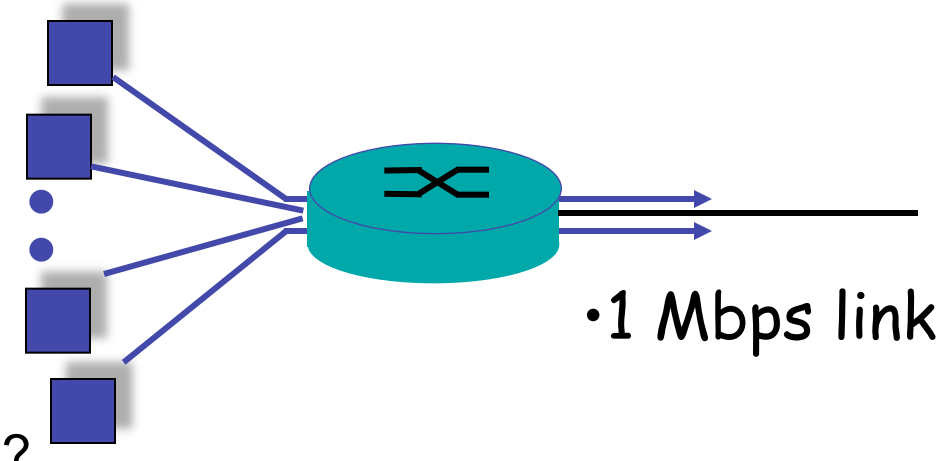
How Many Users Can Share?

- Given 1 megabits/sec (1 Mbps) link
- Assume each user:
  - User send 100,000 bits/sec when “active”
  - User is active 10% of time
  - 100% of capacity used if 10 active users.
- Circuit-switching:
  - Link can support 10 users
- Packet Switching:
  - Link can support 35 users
  - Prob.(n > 10) < 0.0004



Circuit Switching Performance

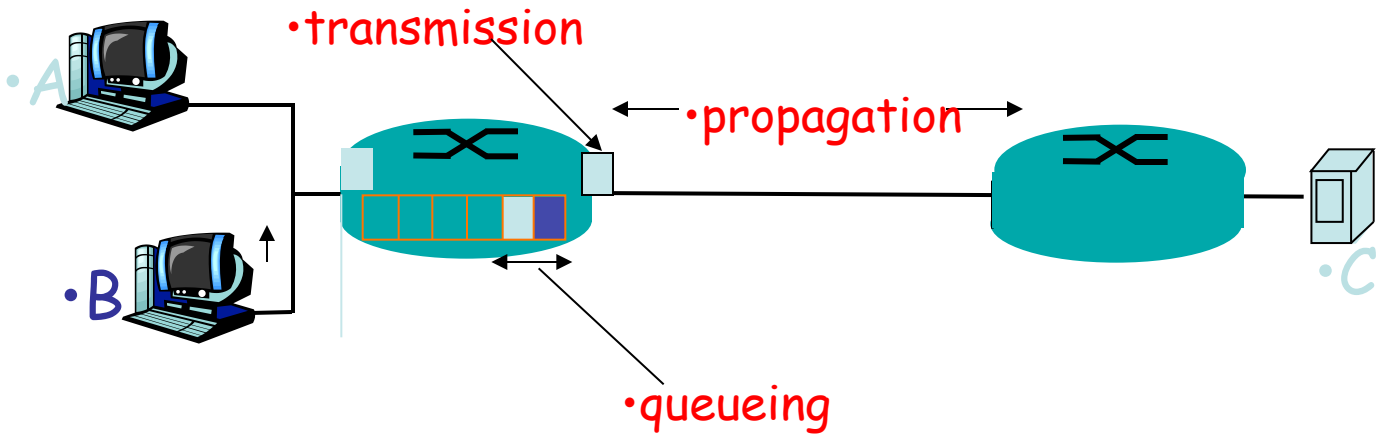
- Given 1 megabits/sec (1 Mbps) link
  - Divided into 10 distinct slices (TDM or FDM)
    - No Interaction between users
  - Potential bandwidth for my connection is 1 Mbps/10 = **100,000 bps**
- How long to send 4 Mb file?
  - 4 Mb / 100,000 bps = 40 sec
  - Plus some delay to setup connection
    - Assume 1 seconds
  - Total of 41 seconds
    - **Throughput = 97,560 bps**
- How long to send 100,000b file?
  - 100,000b / 100,000bps = 1 sec
  - Total of 2 seconds
    - **Throughput = 50,000 bps**



Packet Switching Performance

- Transmission = L / R
  - R = link bandwidth (bps)
  - L = packet length (bits)
- Propagation = d/s
  - d = length of physical link
  - s = propagation speed in medium (~$2x10^8$ m/sec)

Queueing = #packets in queue X transmission time of each packet



Delay on A Single Link

- Relevant Specifications
  - Bandwidth: R = 1 Mbps
  - Packet Size: L = 1000 bits
  - Link length: d=100 km
  - Propagation Speed: s = 2.0 x 10^8 m/sec (typical fiber)
- Assumptions
  - qlength = 2 Packets in queue when our packet arrives
- Total Delay = transmit + prop + queue

  = (L/R) + (d/s) + (qlength * L/R)

  = (1000/1000000) + (100000/2 x 10^8) + (2*1000/1000000)

  = 3.5 ms

Some Comments about Units (See Page 45 of 4th Edition)

- Bits or Bytes
  - Bits denoted by “b”
  - Bytes denoted by “B”
  - Mb = megabits while MB = megabytes
  - Kb = kilobits while KB = kilobytes
- How big is K and M? It depends….
  - Mega = 2^20, Kilo = 2^10
  - Mega = 10^6, Kilo = 10^3
- Bandwidth uses powers of 10
  - Tied to MHz which is 10^6 hertz
  - So bandwidth of 1 Mbps = 10^ bits per second
- Messages use powers of 2
  - Tied to computer memory measures in powers of 2
  - So packet/file/message of 1 Mb = 2^20 bits

Chapter 1 Problem 6a

- Find total time to transfer a file assuming
  - File size is 1.5 MB, RTT is 80 ms, Packet size is 1KB
  - Initial 2*RTT “handshake” before sending data
  - Bandwidth is 10 Mbps and packets sent continuously
- Total Time to get all bytes to receiver is:

Handshake + transmit + prop

2*RTT + FileSize/R + ½ RTT

2 * 80 ms + 1.5 MB/ 10 Mbps + ½ 80 ms

160 ms + 12,582.912 b/ 10,000,000 b/s + 40 ms

approx 1.458 seconds

Chapter 1 Problem 6b

- Find total time to transfer a file assuming
  - File size is 1.5 MB, RTT is 80 ms, Packet size is 1KB
  - Initial 2*RTT "handshake" before sending data
  - Bandwidth is 10 Mbps & must wait 1 RTT after sending each packet
- Need to Send 1.5 MB/1 KB = 1,536 packets

Handshake + transmit packet 1 + RTT
+ transmit packet 2 + RTT + ….
+ transmit packet 1536 + prop delay

2*RTT + 1536*(1KB/10Mbps + RTT) + ½ (RTT)

2*RTT + 1.5MB/10Mbps + ½(RTT) + 1536*RTT

1.458 + 122.8 = 124.258 seconds

Chapter 1 Problem 6c

- Find total time to transfer a file assuming
  - File size is 1.5 MB, RTT is 80 ms, Packet size is 1KB
  - Initial 2*RTT "handshake" before sending data
  - Bandwidth is infinite, but only 20 packets per RTT
- 1536/20 = 76.8 bursts of 20 packets

Handshake + 1 RTT to transmit packet 1-20
+ 1 RTT to transmit packets 21-40 + …
+ 1 RTT to transmit packets 1501-1520
+ time transmit 1521-1536 + prop delay

Handshake + 76 * RTT + bits/infinity + ½ RTT
2 * RTT + 76 * RTT + 0 + ½ * RTT

78.5 * RTT = 78.5 * 80 ms = 6280 ms = 6.28 s

What's Next

- Read Chapter 1, Chapter 2.1
- Next Lecture Topics from Chapter 2.1
  - Wrap Up Network Performance
  - Application Layer Design
- Project 1
  - Due on Friday 9/9
- Homework 1
  - Due Tues, Homework 2 due Thurs 9/1