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**
  - frequency

- **TDM**
  - frequency

Example: 2 users
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 = \textbf{100,000} \text{ 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
    - \textbf{Throughput} = 97,560 bps

- How long to send 100,000b file?
  - 100,000b / 100,000bps = 1 sec
  - Total of 2 seconds
    - \textbf{Throughput} = 50,000 bps
Packet Switching Performance

- **Transmission** = \( \frac{L}{R} \)
  - \( R \) = link bandwidth (bps)
  - \( L \) = packet length (bits)

- **Propagation** = \( \frac{d}{s} \)
  - \( d \) = 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: \( R = 1 \text{ Mbps} \)
  – Packet Size: \( L = 1000 \text{ bits} \)
  – Link length: \( d = 100 \text{ km} \)
  – Propagation Speed: \( s = 2.0 \times 10^8 \text{ m/sec (typical fiber)} \)

• Assumptions
  – \( q\text{length} = 2 \text{ Packets in queue when our packet arrives} \)

• Total Delay \( = \) transmit + prop + queue
  \[= \left(\frac{L}{R}\right) + \left(\frac{d}{s}\right) + \left(q\text{length} \times \frac{L}{R}\right)\]
  \[= \left(\frac{1000}{1000000}\right) + \left(\frac{100000}{2 \times 10^8}\right) + \left(2 \times \frac{1000}{1000000}\right)\]
  \[= 3.5 \text{ ms}\]
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 = $10^6$ 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

\[2 \times RTT + 1536 \times (1\text{KB}/10\text{Mbps} + RTT) + \frac{1}{2} (RTT)\]

\[2 \times RTT + \frac{1.5\text{MB}}{10\text{Mbps}} + \frac{1}{2}(RTT) + 1536 \times RTT\]

\[1.458 + 122.8 = 124.258 \text{ seconds}\]
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