



EE4204/TEE4204/EE4204E Computer Networks(Part 1)

Semester 2, 2020-21

TUTORIAL 1: PROBLEMS & SOLUTIONS

Lecturer: Assoc. Prof. Mohan Gurusamy



Problem 1

- Problem:

- It is desired to transmit a sequence of computer screen images over an optical fiber. The screen has 480×640 pixels and supports 256 different colors. There are 60 screen images per second. How much bandwidth (in Mbps) is required for this purpose?

- Solution:

- Since there are 256 different colors we need 8 bits to represent a pixel.
- Therefore, bandwidth required = $480 \times 640 \times 8 \times 60 = 147.456$ Mbps



Problem 2

■ Problem:

- Suppose a 100 Mbps link is being set up between the earth and a new lunar colony. The distance from the moon to the earth is approximately 385,000 km, and data travels over the link at the speed of light (3×10^8 m/s). A camera on the lunar base takes pictures of the earth and saves them in digital format to disk. Suppose *Mission Control* on earth wishes to download the most current image, which is 25 MB. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished? Determine the effective throughput for the above case.



Problem 2 (contd.)

■ Solution:

- Transmission time = $25 \text{ MB} / 100 \text{ Mbps} = 2.097 \text{ s}$
- Propagation time from the earth to lunar base
= $385,000 \text{ km} / (3 \times 10^8 \text{ m/s}) = 1.283 \text{ seconds}$
- RTT = $2 \times 1.283 = 2.566 \text{ seconds}$.
- The transfer time includes the propagation time for the request to go from the earth to lunar base, image transmission time, and propagation time from the lunar base to the earth. Therefore, the transfer requires 1 RTT plus transmission time = $2.566 + 2.097 = 4.663 \text{ seconds}$.
- Effective Throughput = (Message size / Message transfer time) = $25 \text{ MB} / 4.663 = 44.974 \text{ Mbps}$



Problem 3

■ Problem:

- How many 10-Mbps inputs can be multiplexed onto an 100-Mbps output in cases (i) fixed TDM and (ii) statistical TDM?

■ Solution:

- Fixed TDM: At most ten 10-Mbps inputs can be multiplexed onto an 100-Mbps output
- Statistical TDM: There is no limit on the number of 10-Mbps inputs that can be multiplexed onto an 100-Mbps output. It depends on how active the inputs are and how much buffer is available to queue the excess traffic when the sum of the input data rates exceeds the output data rate.



Problem 4

- Problem:

- A 20km long link is able to hold only 10 bits in one direction. What is the bandwidth of the link? Assume that the propagation speed on the link is 2×10^8 m/s.

- Solution:

- Number of bits that can be held = (propagation) delay \times bandwidth
- Therefore, bandwidth = (No of bits held on the link / propagation time) = $10 / (20000 / [2 \times 10^8]) = 100$ kbps



Problem 5

- Problem:

- A disadvantage of a broadcast network is that the capacity is wasted due to multiple hosts attempting to access the channel at the same time. As a simplistic example, suppose that time is divided into discrete slots, with each of the n hosts attempting to use the channel with probability p during each slot. What fraction of the slots is wasted due to collisions only?



Problem 5 (contd.)

Solution:

- Binomial probability $B(n,r)$: probability of exactly r successes on n trials (with p the success probability on a trial)
 - $B(n,r) = nCr p^r (1-p)^{n-r}$
- p = probability that a host attempts to use the channel in a slot
- q_0 = probability that no host attempts to use the channel in a slot = $B(n,0)$
- q_1 = probability that exactly one host attempts to use the channel in a slot = $B(n,1)$
- q = probability for collision occurrence in a slot
- Collision occurs when two or more hosts attempt to use the channel during a slot. Therefore, $q = B(n,2)+B(n,3)+\dots+B(n,n)$
 $q = 1 - [q_0 + q_1]$
 $= 1 - [(1-p)^n + n \times p \times (1-p)^{n-1}]$

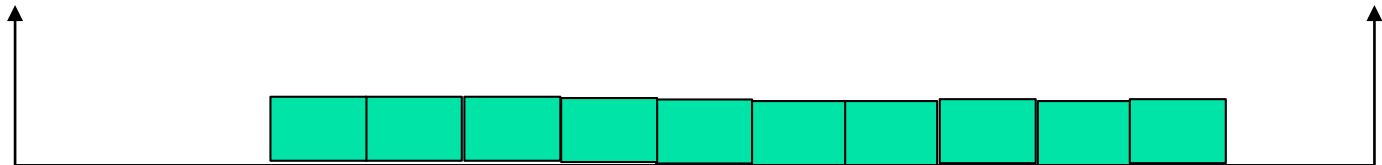


Problem 6

- Calculate the total time required to transfer a 1000 KB file in the following cases, assuming an RTT of 100 ms, a packet size of 1 KB of data, and an initial $2 \times \text{RTT}$ of “handshaking” before data is sent.
 - (a) The bandwidth is 1.5 Mbps, and data packets can be sent continuously.
 - (b) The bandwidth is 1.5 Mbps, but after we finish sending each data packet we must wait one RTT before sending the next.

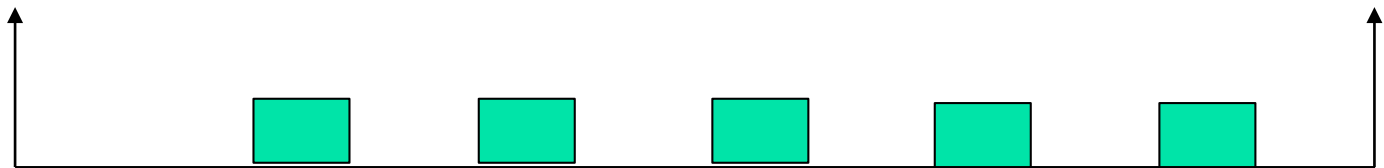
Problem 6_{T_t} (Contd.)

- Number of packets = 1000, RTT = 100 ms
- Packet transmission time $T_t = 1\text{KB}/1.5\text{ Mbps} = 5.461\text{ ms}$
- (a) Total time (T) required is initial RTTs plus transmission time of 1000 packets plus propagation time (for 1000th packet) from sender to receiver plus propagation time from receiver to sender (for acknowledgement). Therefore, $T = 2\text{ RTTs} + 1000 \times 5.461\text{ ms} + \text{RTT} = 5.761\text{ seconds}$.
- $2\text{RTT} + T_t + T_t + T_t + \dots + T_t + \text{RTT}$



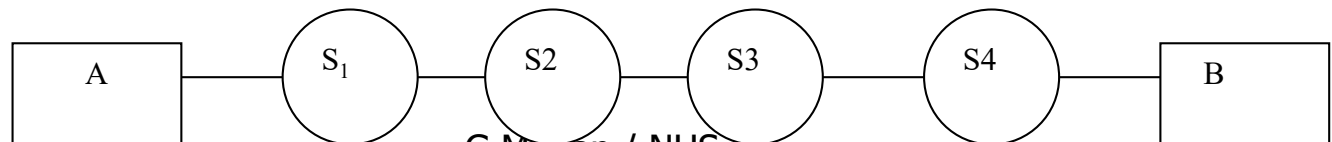
Problem 6 (Contd.)

- (b) $T = 2 \text{ RTTs} + 1000 \times \text{packet transmission time} + 1000 \text{ RTTs}$
 $= 100.2 + 5.461 = 105.661 \text{ seconds.}$
- $2\text{RTT} + T_t + \text{RTT} + T_t + \text{RTT} + \dots + T_t + \text{RTT}$



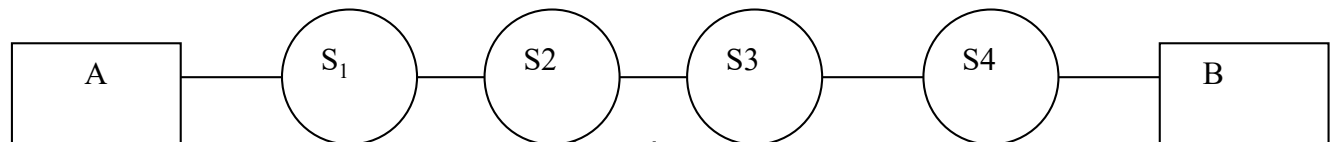
Problem 7

- Problem: Calculate the latency (from first bit sent to last bit received) for the following:
 - a) A packet of 5000 bits is sent over a 10 Mbps Ethernet from node A to node B through four store-and-forward switches in the path as shown in the following figure. Assume that each link introduces a propagation delay of $10\ \mu\text{s}$, and that the switch begins retransmitting immediately after it has finished receiving the packet.
- Solution:
 - Packet transmission time = $5000\text{bits}/10\text{Mbps} = 500\ \mu\text{s}$.
 - Propagation delay on one link = $10\ \mu\text{s}$.
 - The packet traverses 5 links. It needs to be transmitted at 5 nodes (1 source and 4 switches). Therefore, latency = $5 \times 10 + 5 \times 500\ \mu\text{s} = 2.55\ \text{ms}$.



Problem 7 (contd.)

- Problem: Calculate the latency (from first bit sent to last bit received) for the following:
 - b) Same as (a), but 5000 bits are sent in 5 packets each carrying 1000 bits. The packets are transmitted continuously with no time gap between two consecutive packet transmissions.
- Solution:
 - Packet transmission time = $1000\text{bits}/10\text{Mbps} = 100 \mu\text{s}$.
 - Propagation delay on one link = $10 \mu\text{s}$.
 - Node A completes transmission of last packet at $5 \times 100 = 500 \mu\text{s}$. The last packet needs to be transmitted at each of the 4 switches. This packet experiences propagation delay at each of the 5 links.
 - Therefore, latency = $500 + 4 \times 100 + 5 \times 10 \mu\text{s} = 950 \mu\text{s}$



Problem 7 (contd.)

- **Problem:** Calculate the latency (from first bit sent to last bit received) for the following:
 - c) Same as (a), but assume that each switch implements “cut-through” switching: It is able to begin retransmitting the packet immediately after receiving the first 200 bits.
- **Solution:**
 - The packet is delayed for a period of “packet transmission” time ($500\ \mu\text{s}$) at the source A and is delayed for a period of 200 bits time at each of the 4 switches. The packet experiences propagation delay at each of the five links.
 - $200\text{ bit delay} = 200\text{bits}/10\text{Mbps} = 20\ \mu\text{s}$
 - $\text{latency} = 500 + 4 \times 20 + 5 \times 10\ \mu\text{s} = 630\ \mu\text{s}$

