CSCI 4273 Problem Set 1

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Question 1.

What advantage does a circuit-switched network have over a packet-switched network?

The circuit-switched network has several things over the packet-switched network. First, the circuit-switched network has more predictable performance because of the direct connection. Also because of this the circuit-switched network can produce reliable in-order delivery whereas there is no guarantee of this for packet. Another advantage is that the circuit switched network doesn't have the overhead of packet headers when transmitting data.

Question 2.

What advantage does TDM have over FDM in a circuit switched network?

TDM can be setup such that data can be streamed on demand and so the network is used more effectively. FDM maintains dedicated frequencies for each connection and so if nothing is being transmitted between two pairs that frequency remains idle. This all caps the number of transmissions that can accommodated on the network.

Question 3.

Consider two hosts, A and B, which are connected by a link (**R** bps). Suppose that the two hosts are separated by **m** meters, and the speed along with link is **s** meters/sec. Host A is to send a packet of size **L** bits to Host B.

(a) Express the propagation delay, d_{prop}, in terms of **m** and **s**.

$d_{prop} = \frac{\boldsymbol{m}}{\boldsymbol{s}}$

(b) Determine the transmission time of the packet, d_{trans}, in terms of **L** and **R**.

$d_{trans} = \frac{\boldsymbol{L}}{\boldsymbol{R}}$

(c) Ignoring processing and queuing delays, obtain an expression for the end-to-end delay (one-way delay from Host A to Host B).

Delay $= d_{prop} + d_{trans} = \frac{\boldsymbol{m}}{\boldsymbol{s}} + \frac{\boldsymbol{L}}{\boldsymbol{R}}$

(d) Suppose Host A begins to transmit the packet at time $t = 0$, At time $t = d_{trans}$, where is the last bit of the packet?

Since the d_{trans} represents the time it takes to put the packet on the link. At time $t = d_{trans}$ the last bit of the packet would be at the very start of the link (sender's side).

(e) Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?

If $d_{prop} > d_{trans}$ the first bit of the packet would still be in transit at time d_{trans}. It would have $d_{prop} - d_{trans}$ time left until it is received and would have traveled $\frac{d_{prop}-d_{trans}}{d_{prop}} * \boldsymbol{m}$ meters.

(f) Suppose d_{prop} is less than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?

If $d_{prop} < d_{trans}$ the first bit of the packet would have been received at time $t = d_{trans}$

(g) Suppose $s = 2.5 * 10^8$, $L = 120bits$, and $R = 56Kbps$. Find the distance **m** so that d_{prop} equals d_{trans}.

$$d_{prop} = d_{trans}$$

$$\frac{\boldsymbol{m}}{\boldsymbol{s}} = \frac{\boldsymbol{L}}{\boldsymbol{R}}$$

$$\frac{\boldsymbol{m}}{2.5 * 10^8 m/s} = \frac{120bits}{56Kbps}$$

$$\frac{\boldsymbol{m}}{2.5 * 10^8 m/s} = \frac{120bits}{56 * 10^3 bps}$$

$$\boldsymbol{m} = \frac{120}{56 * 10^3} s * 2.5 * 10^8 m/s = \frac{300}{56} * 10^5 \approx \mathbf{5.36 * 10^5} m$$

Question 4.

We consider sending real-time voice from Host A to Host B over a packet-switched network. Host A converts analog voice to a digital 65kbps bit stream and send these bits into 56-byte packets. There is one link between Hosts A and B and the transmission rate is 1 Mbps and its propagation delay is 20 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits into an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

The time it takes for Host A to create a packet from its analog signal is $\frac{56B}{65kbps} = \frac{448bits}{65*10^3 bps} \approx 6.9 * 10^{-3}$ seconds.

The transmission time for this packet is then $\frac{56B}{1Mbps} = \frac{448bits}{10^9 bps} = 4.48 * 10^{-6}$ seconds.

Lastly the packet must propagate all the way to host B which takes 20 ms. Altogether the time is $6.9ms + 20ms + .0048ms = \mathbf{26.9048}\boldsymbol{ms}$

Question 5.

Consider a Go-Back-N sliding window algorithm (1 packet is 250 bytes long) running over a 100km point-to-point fiber link with bandwidth of 100 Mbps.

(a) Compute the one-way propagation delay for this link, assuming that the speed of light is 2 x 10^8 m/s in the fiber.

First, $100km = 10^2 km = 10^5 m$

Then, $\frac{10^5}{2*10^8} = \mathbf{.5 * 10^{-3}}$ **seconds**

(b) Suggest a suitable timeout value for the algorithm to use. List factors you need to consider.

Since, these points are connected directly a suitable timeout could theoretically be equal to the RTT. In practice you would likely want to additional time for transmission latency and queue latency. A very safe value for this would be 2 * RTT assuming that the propagation latency is the dominant form of latency.

(c) Suggest N to achieve 100% utilization in this link.

$BDP = 2 * 5 * 10^{-4} s * 10^8 bps = 10^5 bits = 1250 Bytes$

$N = \frac{1250bytes}{250bytes} = 5$

Question 6.

Suppose a 1-Gbps point-to-point 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) Calculate the minimum RTT for the link.

To get like unites I know that $385,000km = 3.85 * 10^5 km = 3.85 * 10^8 m$. That means the RTT $= 2 * \frac{3.85*10^8}{3*10^8} = \mathbf{1.9}$ **seconds**.

(b) Using the RTT as the delay, calculate the delay * bandwidth product for the link.

$1Gbps * 1.9s = 10^9 bps * 1.9s = \mathbf{1.9 * 10^9} \boldsymbol{bits}$

(c) What is the significance of the delay * bandwidth product computed in (b) ?

This is the amount of bits that the colony could send before getting any communication from the people still on Earth.

Question 7.

Host A wants to send a 1,000 KB file to Host B. The Round Trip Time (RTT) of the Duplex Link between Host A and B is 160ms. Packet size is 1KB. A handshake between A and B is needed before data packets can start transferring which takes 2*RTT. Calculate the total required time of file transfer in the following cases. The transfer is considered complete when the acknowledgement for the final packet reaches A.

(a) The bandwidth of the link is 4Mbps. Data packets can be continuously transferred on the link.

For the handshake, $2 * RTT = 320ms$. The time to transmit each packet would be $\frac{1KB}{4Mbps} = \frac{8000bit}{4*10^6 bps} = 2 * 10^{-3}$ seconds $= 2ms$. To transmit the $1,000KB$ file would take $2ms * 1000 = 2,000ms$. As this would leave us with the final packet just entering the pipeline we would need to wait 1 RTT past this point to receive the ACK for this packet. In total, $320ms + 2,000ms + 160ms = 2,480ms =$ **2.48 seconds**

(b) The bandwidth of the link is 4Mbps. After sending each packet, A need to wait one RTT before the next packet can be transferred.

Transmit delay is same as above. Now we must wait for the RTT on each packet too. Effectively this makes the time for each packet $2ms + 160ms = 162ms$. The total time is now $320ms + 1000 * 162ms = 162,320ms =$ **162.32 seconds**. This doesn't need an additional RTT like last time because now the calculation includes the delay for receiving the final ACK.

(c) Assume we have "unlimited" bandwidth on the link, meaning that we assume transmit time to be zero. After sending 50 packets, A need to wait one RTT before sending next group of 50 packets.

If transit time is negligible we just need the amount of RTT we will wait for. This is $\frac{1000}{50} = 20$. This total will again include all the final acknowledgement and as such the total time would be $320ms + 20 * 160ms = 3,520ms =$ **3.52 seconds**.

(d) The bandwidth of the link is 4Mbps. During the first transmission A can send one (2^{1-1}) packets, during the 2nd transmission A can send 2^{2-1} packets, during the 3rd transmission A can send 2^{3-1} packets, and so on. Assume A still need to wait for 1 RTT between each transmission.

The time to transmit the packages (including the RTT) is modeled by $\sum_{i=0}^{k} \left[2^i * 2ms + 160ms\right]$ where k is large enough so enough packets are service (we will need to subtract off excess packets since 1000 isn't a power of 2). The total time taken would be $320ms + \sum_{i=0}^{9} \left[2^i * 2ms + 160ms\right] - 2 * 23ms$. (Subtracting $2 * 23ms$ is because this would tell us how long it takes for 1023 packets and not 1000 (RTT is still included). This becomes $320ms + 2642ms - 2 * 23ms = 2916ms =$ **2.916 seconds**.

Question 8.

Determine the width of a bit on a 10 Gbps link. Assume a copper wire, where the speed of propagation is $2.3 * 10^8$ m/s.

Assuming I have a wire of length $2.3 * 10^8 m$ this would yield a latency of $\frac{2.3*10^8}{2.3*10^8} = 1s$. The BDP would then be $10 * 10^9 * 1 = 10^{10} bits$. The length of a single bit would be $\frac{2.3*10^8}{10^{10}} = \boldsymbol{.023m}$

Question 9.

Suppose two hosts, A and B, are separated by 20,000 kilometers and they are connected by a direct link of R=1Gbps. Suppose the propagation speed over the link is $2.5 * 10^8$ meters/sec.

(a) Calculate the bandwidth delay product (BDP) of the link.

First, $20,000km = 2 * 10^4 km = 2 * 10^7 m$. Now with like units I can get the propagation delay $= \frac{2*10^7 m}{2.4*10^8 m/s} \approx .083s$. For the BDP first I know that $1Gbps = 10^9 bps$ and I can then get BDP $= 10^9 bps * .083s \approx \boldsymbol{83 * 10^6 bits}$

(b) Consider sending a file of 800,000 bits from Host A to Host B as one large message. What is the maximum number of bits that will be in the link at any given time?

The maximum number of bits would be the minimum between the BDP and the file size. Therefore, since $800,000 < 83 * 10^6$ the maximum number of bits would be $\mathbf{800,000}$

(c) What is the width (in meters) of a bit in the link?

The width of a bit is equivalent to $\frac{2*10^7 m}{83*10^6} = \frac{20}{83} \approx \boldsymbol{.24m}$

(d) Suppose now the file is broken up into 20 packets with each packet containing 40,000 bits. Suppose that each packet is acknowledged by the receiver and the transmission time of an acknowledgement packet is negligible. Finally, assume that the sender cannot send a packet until the preceding one is acknowledged. How long does it take to send the file?

This would be equal to $20 * RTT$ since transmission latency is negligible. $20 * 2 * .083 =$ **3.32 seconds**.

Question 10.

Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth. Every minute the satellite takes a digital photo and sends it to the base station. Assume a propagation speed of $2.4 * 10^8$ meters/sec. Geostationary satellite is 36,000 kilometers away from earth surface

(a) What is the propagation delay of the link?

The propagation delay would be equivalent to the distance over the speed of light through the medium. So first, $36,000km = 36,000,000m = 3.6 * 10^7 m$. Then we can take $\frac{3.6*10^7 m}{2.4*10^8 m/s} = .15s$ which means the propagation delay is **.15 seconds**.

(b) What is the bandwidth-delay product, R x (propagation delay)?

$10^7 bit/s * .15s = \boldsymbol{1.5 * 10^6 bits}$

(c) Let x denote the size of the photo. What is the minimum value of x for the microwave link to be continuously transmitting?

To get the amount of bits that can be sent in the minute between photos: $10^7 bit/s * 60s = 6 * 10^8 bits$ this equals $75 * 10^6 Bytes = \boldsymbol{75MB}$