Sample Midterm Solutions

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1. A transcontinental channel with a one-way latency of 30 ms and a bandwidth of 10 Mbps can hold how many Megabits (Mb) at a given instant?

   Solution:

   Volume of the pipe = delay * bandwidth (Textbook page 49)

   .030 s * 10 Mb/s = .3 Mb

2. Let's say you have a sender, a receiver, a one-way latency of 30 ms, and the bandwidth is 10 Mbps. Let's say the receiver tells the sender to stop transmitting. The receiver may receive up to how many megabits (Mb) of data from the sender before the sender stops transmitting?

   Solution:

   If the sender is expecting the receiver to somehow signal that bits are starting to arrive, and it takes another channel latency for this signal to propagate back to the sender, then the sender can send up one RTT × bandwidth worth of data before hearing from the receiver that all is well. (Textbook page 49)

   Roundtrip time (RTT) = 2 * 30 ms = 60 ms = .060 s
   .060 s * 10 Mb/s = 6 Mb

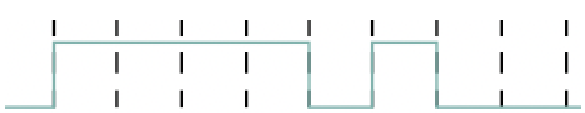
3. What is the wavelength, in kilometers (km), when a 700 Hz wave travels through copper? Assume speed of light through copper is (2/3) * 3* 10^8 m/s.

   Round your answer to one decimal place.

   Solution: (Textbook page 76)

   Speed of light in copper / frequency = (2/3) * 3* 10^8 m/s divided by 700 Hz = 285,714.29 m = 285.7 km

4. What is the NRZ encoding of the below stream?



   Solution:

011110100

Textbook page 78 and 79.

For questions 5 to 7, consider a 3 Mbps link with a 75 ms round trip time (RTT). The three questions are related to each other.

5. What is the delay x bandwidth product? Provide your answer in kilobits (Kb).

Solution:

75*(10^-3) seconds * 3*(10^6) bits/seconds = 225000 bits = 225 Kb

6. Assuming a frame size of 2 KB and the network uses the Stop and Wait Protocol, what is the maximum sending rate? Assume 2 KB = 2*1,000 bytes = 2,000 bytes. Provide your answer in bps and round to the nearest whole number.

   Solution:

   Bits per frame divided by time per frame = 2,000 bytes * 8 bits/byte / .075 s = 213,333 bps

7. Continuing from question 6, what fraction of the link's total capacity is being used in this network using the Stop and Wait Protocol?
   Provide your answer as a percentage, rounded to the nearest decimal.

   Solution:

   215,893 bps/3,000,000 bps = 0.07196, which is about 7.2%

8. Suppose you are designing a sliding window protocol for a 1-Mbps point-to-point link to the stationary satellite revolving around the Earth at an altitude of 3*10^4 km. Assuming that each frame carries 1 KB of data, what is the minimum number of bits you need for the sequence number in the following cases?
   Assume the speed of light is 3 * 10^8 m/s and assume 1 KB = 1,000 bytes.

   a. RWS=1

   b. RWS=SWS

   RWS stands for receiving window size.

   SWS stands for sending window size.

   Solution:

   Determine the number of frames the link can hold at a given roundtrip time:

   Roundtrip Time * Bandwidth / Frame Size

To find the roundtrip time:

Delay = Distance/Speed

3*10^4 km = 3*10^7 m

3*10^7 m / 3*10^8 m/s = .1 s

Roundtrip is double that: 2*.1 s = .2 s

Number of packets the link can hold at a given roundtrip time:

Frame size is 1,000 bytes * 8 bits/bytes = 8,000 bits

.2 s * 1,000,000 bps / 8,000 b = 25 packets

Thus, SWS needs to be 25 frames large.

a. If RWS = 1, then the max sequence number needs to be at least 1 + SWS = 26. So 5 bits are needed. See slide 75 of chapter 2 slide deck for background.

b. If RWS = SWS, see slide 76 of the chapter 2 slide deck:
   SWS < (MaxSeqNum + 1)/2
   2*SWS < MaxSeqNum + 1
   2*SWS-1 < MaxSeqNum
   2*25 - 1 < MaxSeqNum

   So at a minimum, MaxSeqNum needs to be (2*25-1) + 1 = 50. So that would require 6 bits.