ECE363 Assignment 1

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1. Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the 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.

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

   (c) Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.

   (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?

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

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

   (g) Suppose $s = 2.5 \times 10^8$ meters/sec, $L = 100$ bits, and $R = 28$ kbps. Find the distance m so that $d_{prop} = d_{trans}$.

2. Consider the queueing delay in a router buffer. Suppose all packets are L bits, and the transmission rate is R bps.

   (a) Suppose that N packets simultaneously arrive at the buffer every LN/R seconds. Find the average queueing delay of a packet. (***Hint:*** The queueing delay for the first packet is zero; for the second packet L/R; for the third packet $2L/R$. The Nth packet has already been transmitted when the second batch of packets arrives.)

   (b) Suppose that N packets arrive at the buffer every LN/R seconds, and the inter-arrival time of two adjacent packets is $L/(2R)$ (that is, if the first packet arrives at t_0, the 2nd packet arrives at $t_0 + L/(2R)$, the 3rd packet arrives at $t_0 + 2L/(2R)$, ..., and the Nth packet arrives at $t_0 + (N-1)L/2R$). Find the average queueing delay of a packet.

3. Suppose there is a $R = 10$ Mbps microwave link between a geostationary satellite and its base station on Earth. The distance between the satellite and the base station is $36,000$ km. 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.

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

   (b) What is the bandwidth-delay product, $R \times d_{prop}$?

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

4. In a few sentences, please compare the following terms and explain the relationship between them: link bandwidth (in Hertz), baud rate (in sample-per-second), symbol rate (in symbol-per-second), and data rate (in bit-per-second).

5. In traditional telephone systems, local loop (i.e., between a telephone set and its nearest telephone switch) link bandwidth is about 3KHz.

   a) If using 16-QAM, what is the maximum achievable data rate (assume noiseless channel)? [Hint: Nyquist limit]

   b) If the signal-to-noise ratio imposed by the system between two remote telephone sets is about 30dB, what is the maximum achievable data rate? [Hint: Shannon's Limit]

   c) In a few sentences, please explain how telecommunication companys can achieve a data rate higher than the one calculated above.