National University of Singapore
School of Computing

CS2105 **Problem Set 1** Semester 2 05/06

1. **(KR, Chapter 1, Problem 6)** 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 queueing 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 $s = 2.5 \times 10^8$, $L = 100$ bits, and $R = 28$ kbps. Find the distance m so that d_{prop} equals d_{trans}.

2. **(KR, Chapter 1, Problem 8)** Suppose users share a 1 Mbps link. Also suppose each user requires 100 kbps when transmitting, but each user transmits only 10 percent of the time. (See Section 1.3, KR).
   (a) When circuit switching is used, how many users can be supported?
   (b) For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.
   (c) Suppose there are 40 users. Find the probability that at any given time, exactly n users are transmitting simultaneously. (Hint: Use the binomial distribution).
   (d) Find the probability that there are 11 or more users transmitting simultaneously.

3. **(KR, Chapter 1, Problem 14)** Suppose two hosts, A and B, are separated by 100,000 kilometers and are connected by a direct link of $R = 1$ Mbps. Suppose the propagation speed over the link is 2.5×10^8 meters/sec.
   (a) Calculate the bandwidth-delay product, $R \times t_{prop}$.
   (b) Consider sending a file of 400,000 bits from Host A to Host B. Suppose the file is sent continuously as one big message. What is the maximum number of bits that will be in the link at any given time?
   (c) Provide an interpretation of the bandwidth-delay product.
   (d) What is the width (in meters) of a bit in the link? Is it longer than a soccer field? (A standard soccer field is between 90 to 120 m long)
   (e) Derive a general expression for the width of a bit in terms of the propagation speed s, the transmission rate R, and the length of the link m.

4. **(KR, Chapter 1, Problem 20)** In modern packet-switched networks, the source host segments long, application-layer messages (for example, an image or a music file) into smaller packets and sends the packets into the network. The receiver then reassembles the packets back into the original message. We refer to this process as *message segmentation.* (See Figure 1.21 in KR, page 67).

   Consider a message that is 7.5×10^6 bits long that is to be sent from a source to destination, through two packet switches. Suppose each link in the figure is 1.5 Mbps. Ignore propagation, queuing and processing delays.

   (a) Consider sending the message from source to destination *without* message segmentation. How long does it take to move the message from the source host to the first packet switch? Keeping in mind that each switch uses store-and-forward packet switching, what is the total time to move the message from source host to destination host?

   (b) Now suppose that the message is segmented into 5,000 packets, with each packet being 1,500 bits long. How long does it take to move the first packet from source host to the first switch? When the first packet is being sent from the first switch to the second switch, the second packet is being sent from the source host to the second switch. At what time will the second packet be fully received at the first switch?

   (c) How long does it take to move the file from source host to destination host when message segmentation is used? Compare this result with your answer in part (a) and comment.

   (d) Discuss the drawbacks of message segmentation.

5. **(KR, Chapter 1, Problem 22)** Consider sending a large file of F bits from Host A to Host B. There are two links (and one switch) between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 40 bits of headers to each segment, forming packets of $L = 40 + S$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.