Homework 2

Due date: 2019/10/22 13:10

Late submission: R508

1. (30%) Consider an application that transmits data at a steady rate (for example, the sender generates an *N*-bit unit of data every *k* time units, where *k* is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Answer the following questions, briefly justifying your answer:
   a. (15%) Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?
   b. (15%) Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Is some form of congestion control needed? Why?

2. (20%) Suppose users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of statistical multiplexing in Section 1.3.)
   a. (5%) When circuit switching is used, how many users can be supported?
   b. (5%) For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.
   c. (5%) Suppose there are 120 users. Find the probability that at any given time, exactly n users are transmitting simultaneously. (Hint: Use the binomial distribution.)
   d. (5%) Find the probability that there are 21 or more users transmitting simultaneously.

3. (35%) This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. 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. (5%) Express the propagation delay, d_{prop}, in terms of *m* and *s*.
   b. (5%) Determine the transmission time of the packet, d_{trans}, in terms of *L* and *R*.
   c. (5%) Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
   d. (5%) 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. (5%) Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?

f. (5%) Suppose d_{prop} is less than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?

g. (5%) Suppose $s = 2.5 \cdot 10^8$, $L = 120$ bits, and $R = 56$ kbps. Find the distance m so that d_{prop} equals d_{trans}.

4. (15%)

   a. (5%) Which layers in the Internet protocol stack does a router process?

   b. (5%) Which layers does a link-layer switch process?

   c. (5%) Which layers does a host process?