# Tutorial 2

Question 1

Consider an application that transmits data at a steady rate of $L$ bps. When the application starts, it will run for a long period of time. Would a packet-switched network or circuit-switched network be more appropriate for this application? Why?

Question 2

Consider two hosts A and B, connected by a single link of rate $R$ bps. A and B are separated by $d$ meters. The propagation speed along the link is $s$ m/s. Host A is to send a packet of size $L$ bits to host B.

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

(b) Suppose host A begins to transmit the packet at time $t = 0$. At time $t = d_{trans}$ (transmission delay), where is the last bit of the packet?

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

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

(e) Suppose $s = 2.5 \times 10^8$ m/s, $L = 120$ bits, and $R = 56$ Kbps. Find $d$ so that $d_{prop} = d_{trans}$.

Question 3

Suppose users share a 3 Mbps link. Each user requires 150 Kbps when transmitting, but each user transmits only 10% of the time.

(a) When circuit switching is used, how many users can be supported?

(b) When packet switching is used, find the probability that a given user is transmitting.

(c) Suppose there are 120 users. Obtain an expression for the probability that at any given time, exactly $n$ users are transmitting simultaneously.

(d) Obtain an expression for the probability that there are 21 or more users transmitting simultaneously. Find the probability.

Question 4

Suppose there are $M$ client-server pairs. Denote $R_s$, $R_c$, and $R$ for the rates of server links, client links, and the network link. Obtain an expression for the throughput in terms of $R_s$, $R_c$, $R$, and $M$.