

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

Consider two hosts A and B, connected by links of rate 1.5 Mbps. Each link is 309 Km long. The propagation speed along the link is  $2 \times 10^8$  m/s. There are 3 routers between hosts A and B. Each router spends 1.5 ms to perform error detection. Assume there is no congestion in the network. Host A is to send a 1,200-byte packet to host B.

- (a) At what time the last bit of the packet leaves host A?
- (b) At what time the last bit of the packet reaches the first router?
- (c) What is the total end-to-end delay for the packet to reach host B?

### Question 4

Suppose there are 120 client-server pairs. Each server link has the rate of 10 Mbps. Each client link has the rate of 100 Mbps. The network link has the rate of 1 Gbps. What is the maximum end-to-end throughput between the server and client?