EE122: Introduction to Computer Networks Homework 1
Department of Electrical Engineering and Computer Sciences SOLUTIONS
UNIVERSITY OF CALIFORNIA BERKELEY

Total points = 10

Question 1 (2 points)

Note that it is impossible to detect errors over an arbitrary unreliable link all the time. However, any protocol which works all the time would require detection of link communication errors all the time. Therefore, such a protocol would be impossible. For example, suppose host A wishes to terminate the connection but host B does not. Because of unreliable link, messages from B to A might transform to messages which say that B wishes to terminate the connection. When this happens, it is impossible for host A to know that these messages are due to error. As a result, A terminates the connection even though it should not have done so.

Question 2 (2 points)

(a) Grouping 5 consecutive 1's, we can rewrite the received string as,

$$01^5101^5011001^5001^501^50110001^510101^50.$$

Destuffing, we get $01^601^511001^501^51^5110001^60101^5$. The end of frame markers are marked with a bar, $\overline{01^60}1^511001^501^51^51100\overline{01^60}101^5$. Rewriting, we get the destuffed sequence as:

$$\overline{01111110}\ 1111111001111101111111111111100\ \overline{01111110}\ 1011111.$$

(b) The destuffing rule will now be: after observing 01^5, remove the next bit if it is a 0, and declare the data complete if it is a 1. Grouping 5 consecutive 1's, we rewrite the received string as $01101^501^601^50101^60$. Destuffing, we get $01101^51^601^51\ \overline{01^60}$. Rewriting, we get the destuffed sequence as

$$0110111111111110111111\ \overline{01111110}.$$

Question 3 (1 point)

(a) Since this is a packet-switched network, the packets need to be stored first and then forwarded. So, the transmission delay over each link is same. Transmission delay over each link = total packet size including overhead/link bandwitdh = $(F + h)/R$ seconds. Therefore, total delay = setup time + transmission delays = $t_s + Q(F + h)/R$ seconds.

(b) We use the same arguments as in part (a). The packet length including header is now $F + 2h$ bits. Therefore, total delay is = transmission delays = $Q(F + 2h)/R$ seconds.

(c) There are no store and forward delay at the links, so the transmission delay = packet length including header/link bandwidth = $(F+h)/R$ seconds. Including the setup time, we get the total time to transfer = $t_s + (F + h)/R$ seconds.

Question 4 (1 point)

(a) d_{prop} = length of link/speed over link = m/s seconds.

(b) d_{trans} = packet length/link bandwidth = L/R seconds.

(c) $d_{\text{end-to-end}} = d_{\text{prop}} + d_{\text{trans}} = m/s + L/R$ seconds.

(d) Since the transmission time is d_{trans}, the last bit is just leaving Host A.

(e) The first bit is on the link and has not yet reached Host A.

(f) The first bit has reached Host B.

(g) Want $m/s = L/R$. So, $m = Ls/R = 100 \cdot 2.5 \cdot 10^8/(28 \cdot 10^3) = 892857$.

Question 5 (1 point)

(a) $t_{\text{prop}} = 10000 \cdot 10^3/(2.5 \cdot 10^8) = 0.04$ seconds. So, $R \cdot t_{\text{prop}} = 40,000$ bits.

(b) Maximum number of bits that will be in the link at any given time = min(bandwidth-delay product, packet size) = 40,000 bits.

(c) The bandwidth-delay product of a link is the maximum number of bits that can be in the link.

(d) Width of a bit = length of link/bandwidth-delay product = $10000 \cdot 10^3/40000$ meters = 250 meters, which is longer than a football field.

(e) Width of a bit = $m/(R \cdot t_{\text{prop}}) = m/(R \cdot m/s) = s/R$.

Question 6 (1 point)

(a) From previous problem part (a), prop $= 0.04$ seconds. So, $R \cdot t_{\text{prop}} = 40,000,000$ bits.

(b) Maximum number of bits that will be in the link at any given time = min(bandwidth-delay product, packet size) = 400,000 bits.

(c) Width of bit = $s/R = 0.25$ meters.

Question 7 (2 points)

We first state the analogy with queuing. The number of people in the restaurant can be thought of as the length of the queue. The arrival rate can be thought of as the rate at which customers arrive. The queuing delay can be thought of as the time delay between the arrival time of the customer and the time when the customer leaves the restaurant. Easy to see that the arrival rate is 5/min. The average queuing delay is 0.5×5 min$+0.5 \times (5+20)$ min $= 15$ min. Using Little's Law, we get that the average queue length is 5/min $\times$ 15 min $= 75$. Therefore, on average there are 75 people in the restaurant.