Spring'00-2
Computer Networks
TelCom 2310
http://www.cs.pitt.edu/~znati/tel2310.html

Homework 3
Due Date 02/09/00

Problem 1

Consider a stop-and-wait system with two-way traffic between nodes A and B. Assume that data frames are all of the same length and require D seconds for transmission. Acknowledgement frames require R seconds for transmission and there is a propagation delay P on the link. Assume that A and B both have an unending sequence of packets to send, assume that no transmission errors occur, and assume that the time-out interval at which a node resends a previously transmitted packet is very large. Finally, assume that each node sends new data packets and acknowledgments as fast as possible, subject to the rules of the stop-and-wait protocol.

1. Show that the rate at which packets are transmitted in each direction is $(D + R + 2P)^{-1}$. Show that this is true whether or not the starting time between A and B is synchronized.
2. Assume, in addition, that whenever a node has both an acknowledgment and a data packet to send, the acknowledgment is piggybacked onto the data frame (which still requires D seconds). Assume that node B does not start transmitting data until the instant that it receives the first frame from A (i.e., B's first frame contains a piggybacked acknowledgement). Show the rate in each direction is now $(2D + 2P)^{-1}$. Is this rate always higher than one computed above (i.e., 1.1)?

Problem 2

Two nodes A and B use the stop-and-wait protocol for flow control. Acknowledgments are sent as soon as correct packets are received. The processing time is negligible. The transmission time of a a packet is $TRANS_P$, and the transmission time of an acknowledgment is $TRANS_A$. A fraction α of the packets and a fraction β of the ACKs are corrupted by transmission errors.

1. Find the average time, T, needed to send a correct packet from A to B, as a function of $TRANS_P$, $TRANS_A$, α, β, the timeout $timeout$, and the propagation delay $PROP$.
2. What value of $timeout$ would you select both for half-duples and full-duplex links? (Explain why)

Problem 3

Suppose that a long message is sent as a sequence of frames f_1, f_2, ..., f_n. The scheme used to send the frames is Stop-and-Wait. Assume that the time to initiate a sequence is small and the time to process a frame is negligible. The length of an acknowledgment is $\frac{1}{10}$ of the length of the frame. Furthermore, let:

- T_d be the time to transmit the whole data, and
- t_p the propagation delay: the time it takes a frame or an acknowledgment to reach the receiver.

1. Compute an expression of T_d as a function of t_f and t_p.
2. Let B,D,L and V represent the baud rate, the length of the link, the length of the frame and the velocity (speed of light $= 3 \times 10^8 m/s$), respectively. Compute an expression of the line efficiency, U, as a function of B,D,L and V.
3. Compute the efficiency of a $10km$ line, with a baud rate of 10 Mbps and a frame size of 500 bits.

Problem 4

A transmitter and a receiver are directly connected through a full-duplex 5-km coaxial cable with a 10-Mbps transmission rate. Packets and their acknowledgments are 100 bits long. The transmitter and receiver are both equipped with a CRC chip to control errors and their processing time is considered negligible. Assume that that a Stop-and-Wait protocol is used to control the flow between the transmitter and a receiver.

1. Assuming no transmission errors, how many packets are transmitted every second?

Assume that 10 transmission lines, identical to the one described above, are connected in series. A buffer is used at each connection between the links to store the packets as required.

2. How many packets will go through the ten links every second?

Assume now that a packet or its acknowledgment can be corrupted on any given link with a probability, p.

3. What is the new transmission rate through the ten links?
4. Compare this rate with the transmission rate when a single 50-km link is used and when there is no transmission error.
5. What transmission error probability, p', should be assumed for the 50-km link to be consistent with the probability p for each link?
6. What does the transmission rate become with this error probability?