U = W/(1+2a)

a = Tprop / Tframe = 10ms / (80*8 / 64) , Tframe = packet size in bits / bit rate of line
= 10/10 = 1

U = W / 3

For throughput >= 32Kbps, U <= 32/64 = 0.5
0.5 <= W/3, W >= 1.5 = 2
window size = 2^3 = 8

SC2008-CE3005-CZ2006 (Computer Network)

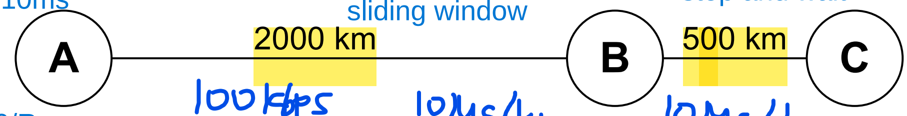
Part I: Tutorial – 2

1. A 64kpbs leased line connects two bank branches and is used for transferring secure bank information. A link layer protocol with 3-bit sequence number is deployed. Determine the minimum window size required to ensure that the throughput is at least 32 Kbps. Assume that the average packet size is 80 bytes, the signal propagation delay between the two sites is 10 *ms*, and the probability of error is negligible. (Hint: *flow control*)

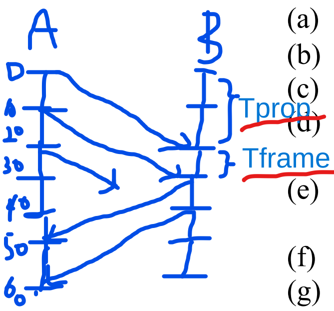
AB:
Tprop = 10us*2000 = 20ms
Tframe = 1000/(100*10^3) = 10ms

BC:
Tprop = 10us*500 = 5ms
Transmission time = x = 1000/R ms
R = Data rate btw B&C in kbps

2. In the figure below, frames are generated at node A and sent to node C through node B.



Determine the minimum transmission rate required between nodes B and C so that the buffers of node B are not flooded, based on the following:



(a) The data rate between A and B is 100 *Kbps*.
(b) The propagation delay is 10 *μsec/km* for both links.
(c) The lines are full duplex between the nodes.
(d) All data frames are 1000 bit long; ACK frames are separate frames of negligible length.
(e) Between A and B, a sliding-window protocol with a window size of 3 is used, and each frame is acknowledged individually.
(f) Between B and C, a stop and wait is used.
(g) There is no error, and the processing delay at the nodes is negligible.

(Hint: *outgoing rate from B should be at least the same as its incoming rate*)

AB: 50ms to transmit 3 frames
BC: 10+x ms to transmit 1 frame
50 = 3(10+x)
x = 20/3 = 1000/R
R = 1000/x = 150kbps

3. Consider a communication link between two cities of City *S* and City *D*. The frame transmission rate on the link is 100 *kbps* and the frame length is 25 bytes. The distance between City *S* and City *D* is 5 *km* and the propagation delay 3 *ms*/*km*. The communication link suffers from an average frame error probability of 0.2 and we adopt a Selective-Reject ARQ mechanism between City *S* and City *D* for reliable communication.

a)
Tprop = 5 * 3 = 15ms
frame length = 25Bytes = 25*8 bits = 200bits
Tframe = 200/(100*10^3)
= 2ms

a = Tprop/Tframe =
15/2 = 7.5

2a+1 = 7.5*2 + 1 = 16
W = 10

U = (10(1-0.2)) / (1+2a)
= 8/16 = 0.5 = 50%

a) If the window size is 10, compute the link utilization from City S to City D.

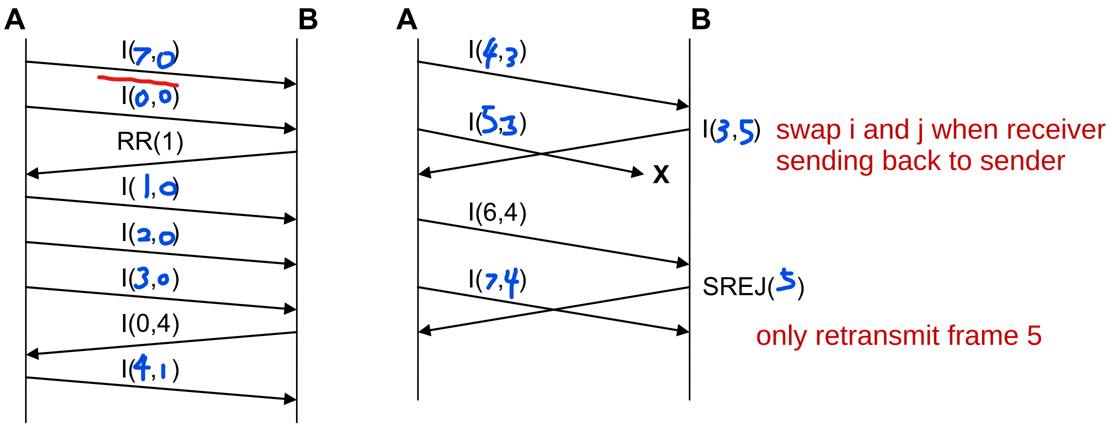
b) Compute the minimum window size and the corresponding number of bits reserved for frame sequence in the header, in order to maximize the link utilization between City S and City D.

Max link utilisation when W>=2a+1
U = 1-P = 1-0.2 = 0.8,
Min window size,W for max link utilisation = 16

For selective reject ARQ, for a k bit sequence,
min window size: 16 = W <= 2^k-1
min number of bit for sequencing is 5

(Hint: *ARQ scheme has window size limit*)

4. Let us define a specific link layer protocol with three types of frames: 1) Information Frame I(*i*,*j*) with *i* indicating the current sender sequence and *j* acknowledging receiver sequence (i.e., ready for receiving the *j*-th frame from the receiver), 2) Receiver Ready (or ACK) frame RR(*j*), and Selective Reject (or NACK) frame SREJ (*j*). Complete the time sequence diagram by adding the send and receive sequence numbers to the frames. Also include the next few frames that are sent by A and B to completely recover from the error if any. Assume that 3 bits are allocated for sequence numbering. (Hint: *using a divide-&-conquer strategy*)



(a) (b)

increment j when receiver send back to sender, not when acknowledge done