

## Sample Problems (From Previous Exams)

1)

Frames are generated at node A and sent to node C through node B. Determine the minimum data rate on the link connecting nodes B and C so that the buffer at node B does not overflow. The following is given

- Data Rate on link A-B is 100 Kbps
- Propagation delay is 5  $\mu$ sec/km on both links
- Links are FDX
- Data Frames are 1000 bits long. ACK frames are of negligible length
- Link A-B is 4000 Km, Link B-C is 1000 Km
- "A" can transmit 3 frames to "B" before it has to stop and wait for ACK from "B". While "B" can transmit ONLY one frame to "C" before it has to stop and wait for ACK from "C".

2)

Sender wants to transmit MSG=10011010. The generator pattern is 1101. What is the FCS pattern? What is the transmitted pattern? Suppose the MSB and LSB of the transmitted pattern are flipped (i.e. in error), will the receiver be able to detect the error?

3)

Device A is sending frames to device C via another device B. Devices A and B use a Go-back-N Sliding window protocol with  $SWS = 3$ . Devices B and C use SR sliding window with  $SWS=RWS=4$ . There are a total of 7 frames (starting with  $F_0$  and ending with  $F_6$ ) generated at device A and destined to device C. The following information is given:

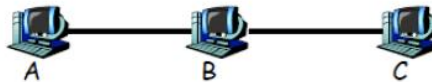
- Frame length = 1000 bits
- Frame Transmission Time = 1 sec
- One-way Propagation Delay (on each link) is 1 sec.
- Transmission Time for Acknowledgment = 0 (negligible)
- Processing/Queuing Delay = 0 (negligible, at any node)
- Time-out (at both devices A and B) is 4 seconds. The timer, for any frame, starts immediately after the device finish transmitting that frame.
- Acknowledgements are sent on a link per link basis and are NOT relayed (which means when device C receives a frame from device B, device B does not relay the acknowledgement to device A. Sequence number for ACK is that of the "next" frame expected to be received (similar to class notation)
- No accumulative acknowledgements are used (i.e. each frame is acknowledged separately)

Sketch, side-by-side, the Timing diagram for frame transmissions over links A---> B and B---> C under the following scenario:

$F_1$  and  $F_4$  get lost in their first transmission from A---> B

$F_4$  gets lost in its first transmission from B---> C

Calculate the Throughput over each link and the end-to-end throughput.





# Solution

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- A -> B:

Propagation time =  $4000 \times 5 \mu\text{sec} = 20 \text{ msec}$

Transmission time per frame =  $\frac{1000}{100 \times 10^3} = 10 \text{ msec}$

- B -> C:

Propagation time =  $1000 \times 5 \mu\text{sec} = 5 \text{ msec}$

Transmission time per frame =  $x = 1000/R$

R = data rate between B and C (unknown)



# Solution Continued

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- A can transmit three frames to B and then must wait for the acknowledgment of the first frame before transmitting additional frames. The first frame takes 10 msec to transmit; the last bit of the first frame arrives at B 20 msec after it was transmitted and therefore 30 msec after the frame transmission began. It will take an additional 20 msec for B's acknowledgment to return to A.

*Thus, A can transmit 3 frames in 50 msec.*



# Solution Continued

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- B can transmit one frame to C at a time. It takes  $5 + x$  msec for the frame to be received at C and an additional 5 msec for C's acknowledgment to return to B. Thus, B can transmit one frame every  $10 + x$  msec, or 3 frames every  $30 + 3x$  msec. Thus:

$$30 + 3x = 50$$

$$x = 6.66 \text{ msec}$$

$$**$R = 1000/x = 150 \text{ kbps}$**$$



# Sender: Example

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- Sender wants to transmit MSG=10011010  
MSG=10011010 ,  $n=8$  corresponds to  $M(x) = x^7 + x^4 + x^3 + x^1$   
Divisor=1101 ,  $k=3$  corresponds to  $G(x) = x^3 + x^2 + 1$
- Multiply  $M(x)$  by  $x^k$   
In this example, we get:  
 $M(x).x^3 = x^{10} + x^7 + x^6 + x^4 = 10011010000$
- Divide result by  $G(x) = 1101$  (Subtraction or addition is XOR in polynomial arithmetic)  
The remainder is  $E(x) = x^2 + 1 = 101$
- Send  $P(x) = M(x).x^k + E(x)$  which is exactly divisible by  $G(x)$   
i.e. Send  $10011010000 + 101 = 10011010101$ , since this is exactly divisible by  $G(x) = 1101$

5. A→B Throughput =  $7000/19 = 368.4\text{bps}$ . B→C Throughput =  $7000/(24-2) = 318.2\text{ bps}$ . A→C Throughput =  $7000/24 = 292\text{ bps}$

