

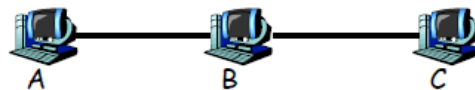
Device A is sending frames to device C via another device B. Devices A and B use a Go-back-N Sliding window protocol with $SWS = 3$. Devices B and C use SR sliding window with $SWS=RWS=4$. There are a total of 7 frames (starting with F_0 and ending with F_6) generated at device A and destined to device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

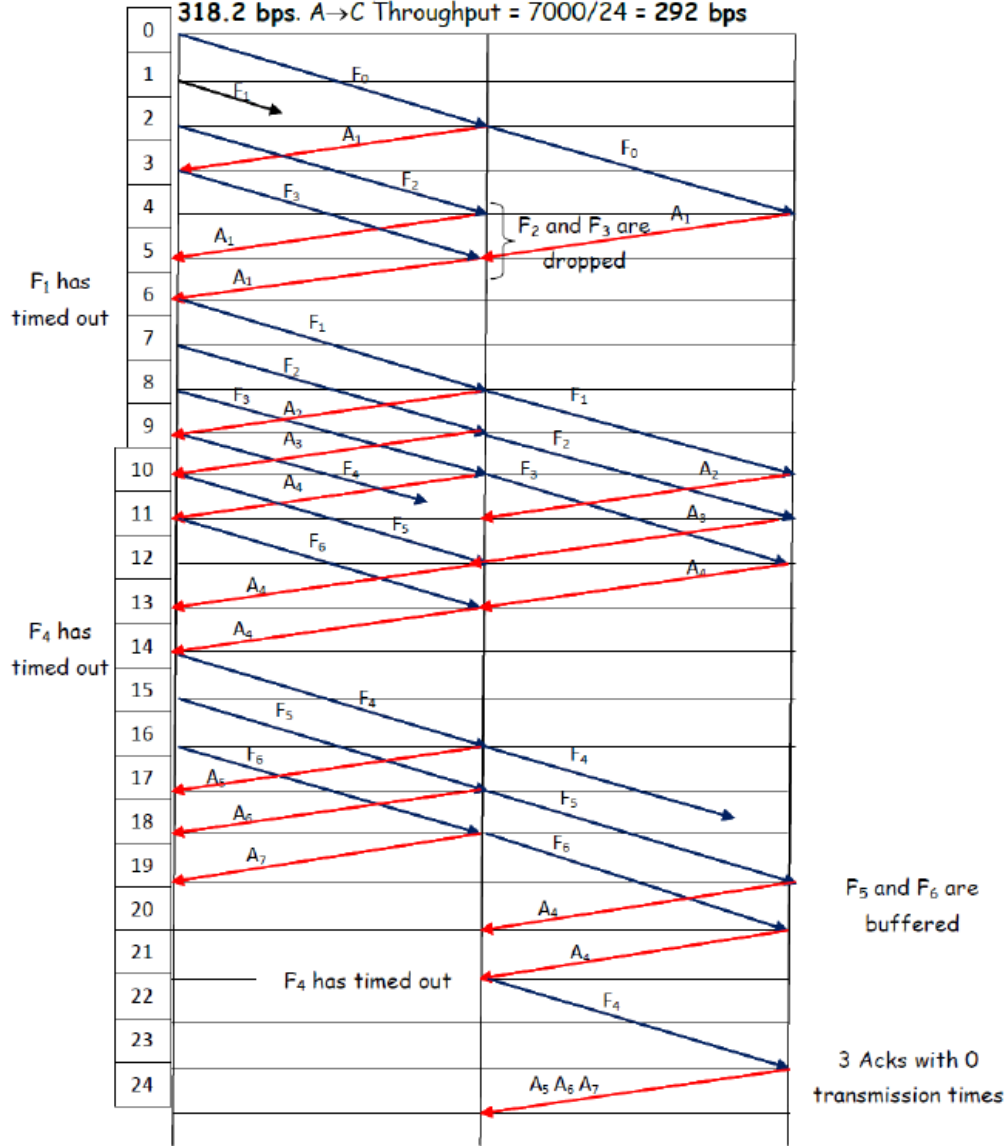
Sketch, side-by-side, the Timing diagram for frame transmissions over links A---> B and B---> C under the following scenario:

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.



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



2. Consider the use of 1000 bits frames on a 1 Mbps satellite link with a 270 msec propagation delay.. Find the maximum link utilization for
- Stop and Wait Flow Control
 - Continuous Flow Control with window size 7
 - Continuous Flow Control with window size 127

Solutions:

- a) In S&W ARQ, only one frame is transmitted per RTT

Link Utilization

$$= T_f / (T_f + 2T_p)$$

$$= (10^3/10^6) / \{ (10^3/10^6) + 0.27(2) \}$$

$$= 0.001848$$

- b) For Continuous ARQ, We are transmitting SWS frames in one RTT, hence the link utilization is $7T_f / (T_f + 2T_p) = 0.012939$

- c) For Continuous ARQ, We are transmitting SWS frames in one RTT, hence the link utilization is $127T_f / (T_f + 2T_p) = 0.234750$