



**Problem 12 [20 Points]:** A 1-Mbps satellite link with 199 ms one-way propagation delay is used to transmit data packets of 2000 bits. Both the header of the data packets and the acknowledgment packets are of negligible size. How many bits of sequence numbers are needed to achieve a link utilization of 100% under the following protocols.

- (a) a go-back-N protocol [10 Points]

$$1 = \frac{N \cdot D_T}{D_T + RTT}$$

$$D_T = \frac{L}{R} = \frac{2000}{1 \cdot 10^6} = 2 \text{ ms}$$

$$RTT = 2D_P = 2 \cdot 199 = 398 \text{ ms}$$

$$1 = \frac{N \cdot d}{400} \quad N = 200 \Rightarrow 2^k \geq N + 1 \Rightarrow 2^k \geq 201$$

$$k = \lceil \log_2 201 \rceil = 8 \text{ bits}$$

- (b) a selective repeat protocol [10 Points]

Same as GBN but  
w/  $2K \geq 2N$