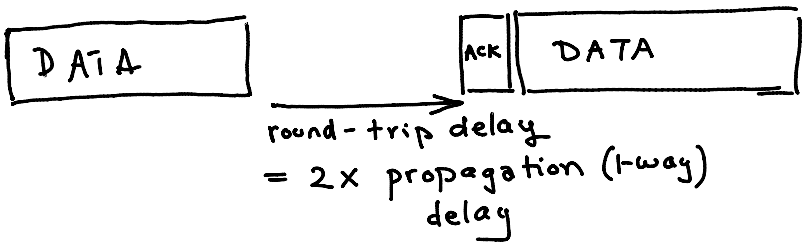
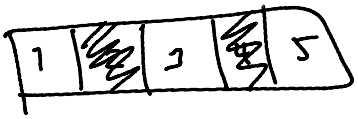
ARQ and Flow Control

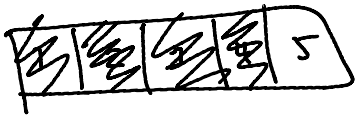
Exercise 1: Considering only the propagation delays, what is the minimum delay between transmitted frames if no ACKs are lost?



Exercise 2: Create a table summarizing the three different types of ARQ. Include: throughput, transmitter memory, receiver memory and relative complexity.

	throughput			memory		complexity
	low delay	high delay, low error	high delay, high error	transmit	receive	
stop & wait	H	Low (1 frame / 2x delay)	Low	1	1 or 0	simplest,
go-back N	H	H (no ACK wait)	L (need to retransmit N frames per error)	N	1 or 0	medium complexity
sel. repeat.	H	H	H (only retransmit lost frames)	N	N	most Complex



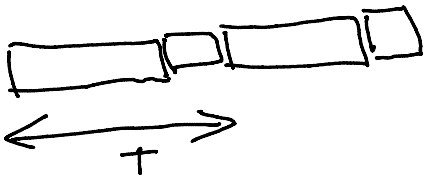


Exercise 3: A data communication system operates at 1 Mb/s and uses 10000-bit data frames and 100-bit ACK frames. What are the frame durations? What is the throughput if there is no channel delay and no errors? If the round-trip channel delay is a 0.5s (typical for satellite links)? If go-back-N ARQ is used, assuming the transmitter can store all unacknowledged frames?

assuming stop & wait

DATA: $\frac{10{,}000 \text{ bits}}{1 \text{ Mb/s}} = 10 \text{ ms}$ ACK: $\frac{100}{10^6} = 0.1 \text{ ms}$.

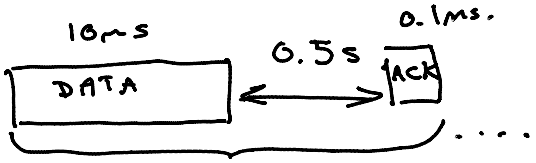
assuming no delays:



$\text{throughput} = \frac{\text{number of bits}}{\text{total time}} = \frac{10{,}000 \text{ bit}}{10 + 0.1 \text{ ms}}$

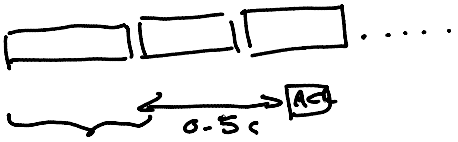
$\approx$ 1 Mb/s.

assuming stop & wait:



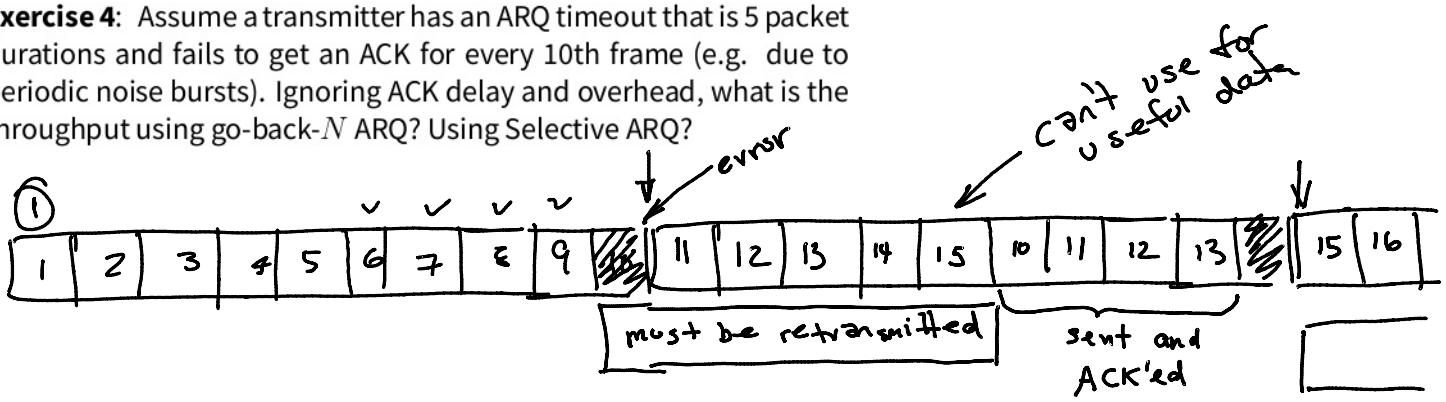
$\text{throughput} = \frac{10{,}000}{0.5 + 0.01 + 0.0001} \approx$ 20 kb/s

assuming go-back-N:



$\text{throughput} = \frac{10{,}000}{10 \text{ ms}} \approx$ 1 Mb/s.

Exercise 4: Assume a transmitter has an ARQ timeout that is 5 packet durations and fails to get an ACK for every 10th frame (e.g. due to periodic noise bursts). Ignoring ACK delay and overhead, what is the throughput using go-back-N ARQ? Using Selective ARQ?

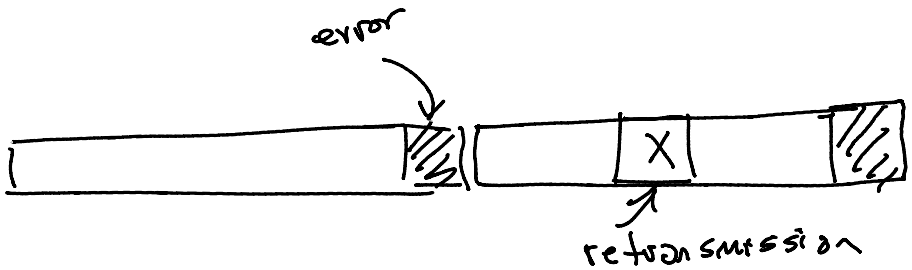


period is 10 frames

$$\text{throughput} = \frac{\text{useful frames}}{\text{10 frame durations}} = \frac{\text{4 frames of data}}{\text{10 frame durations}}$$

$$= 0.4 = 40\% \text{ of maximum data rate.}$$

Selective Repeat



$$\text{throughput} = \frac{\text{8 useful frames}}{\text{10 frame durations.}} = 0.8$$

Exercise 5: Which of the above flow control methods can be used with frame-oriented protocols? Which can be used on unidirectional links?

	frame-based	unidirectional
- hardware	?	If have handshaking in other direction
- software	?	NO.
- end-to-end (ACK, ARQ).	required.	NO. (can't receive Ack frames).