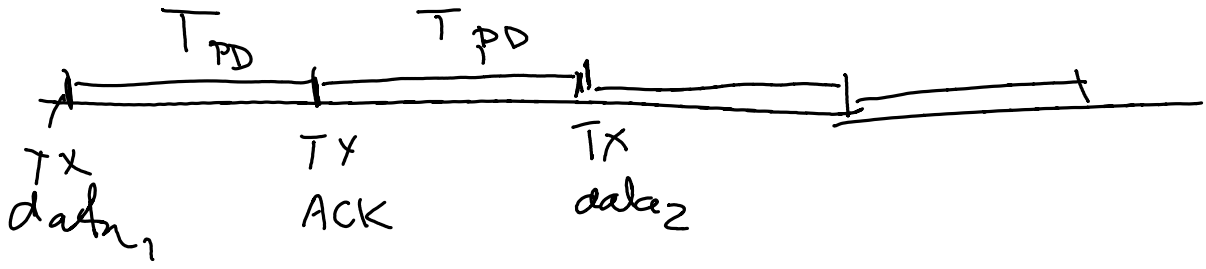
ARQ and Flow Control

Exercise 1: Assuming propagation delays are much longer than the frame transmission time, what is the minimum delay between transmitted frames if no ACKs are lost?



min delay = 2 x propagation delay

$$\frac{20 \times 10^6 \text{ m}}{2 \times 10^8 \text{ m/s}} = 10 \times 10^{-2} \text{ s} = 10 \times 10^1 \times 10^{-2} \times 10^{-1} = 100 \times 10^{-3} \text{ s.}$$

100 ms.

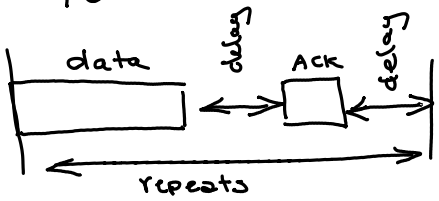
$$\frac{1000 \text{ bits}}{10 \text{ Mb/s}} = \frac{10^3}{10^7} = 10^{-4} = 0.1 \text{ ms}$$

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

	Stop & wait	go-back N	selective repeat
throughput	low delay: High	High	High
	high delay: Low	error rate: Low: High	High
			High
transmitter memory (frames)	1	N	1
receiver memory (")	1	1	N
Complexity	Low	Med.	High

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?

$$\frac{10^4 \text{ b}}{10^6 \text{ b/s}} = 10^{-2} \text{ s} = 10 \text{ ms} \qquad \frac{10^2}{10^6} = 10^{-4} = 0.1 \text{ ms}$$



$$\text{throughput} = \frac{10^4 \text{ b}}{10 \text{ ms} + 2 \times \text{delay} + 0.1 \text{ ms}}$$

if delay = 0 $\quad \text{throughput} = \frac{10^4}{10.1 \text{ ms}} \approx 1 \text{ Mb/s}$

if delay = 560ms $\quad \text{Throughput} = \frac{10^4}{2 \times 0.5 + 10.1 \text{ ms}} \approx 10 \text{ kb/s}$

With go-back-N, no delay between transmissions throughput $\approx$ 1 Mb/s.

Exercise 4: Assume a transmitter transmits 1000 data packets per second and has to retransmit an average of 5 packets when using go-back-N ARQ and only one packet using Selective-Repeat ARQ. If 10% of the data frames are lost, what is the throughput using go-back-*N* ARQ? Using Selective ARQ? Ignore delays and other overhead.

$$\text{throughput} = \frac{\text{data received}}{\text{time}} = \frac{1000 - (1000 \times 10\% \times 5)}{1\text{s.}}$$

$$= 500 \text{ packets/second for go-back-N } (N=5)$$

$$= \frac{1000 - (1000 \times 10\% \times 1)}{1\text{s}}$$

$$= 900 \text{ packets/second for selective repeat.}$$

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

unidirectional – hardware

ARQ delay – frame oriented.