

Lecture 15 - ARQ and Flow Control

Exercise 1: Create a table summarizing the three different types of ARQ. Include: throughput, transmitter memory, receiver memory and relative complexity.

| | Throughput | TX memory | Rx memory | complexity |
|------------------|--|-----------|-----------|------------|
| stop & wait | - short delay : high - long " : low | 1 frame | 1 ? | low |
| go back - N | | | | |
| selective repeat | | | | |

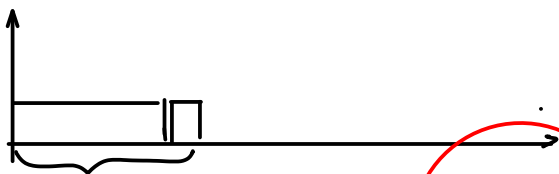
Exercise 2: A data communication system operates at 1 Mb/s and uses 10000-bit data frames and 100-bit ACK frames. What are the frame durations? What is the throughput if there is no channel delay and no errors? If the round-trip channel delay is a 0.5s (typical for satellite links)? If go-back-N ARQ is used, assuming the transmitter can store all unacknowledged frames?

$$f_b = 1 \text{ Mb/s}$$

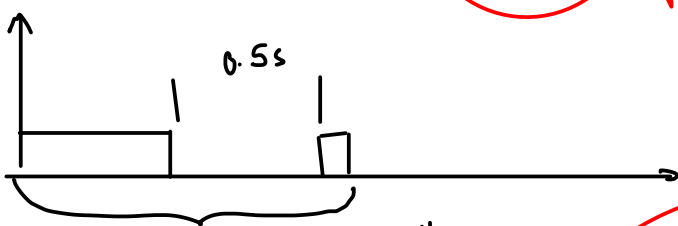
$$10,000 \text{ bits}$$

$$T_{\text{frame}} = \frac{N_b}{f_b} = \frac{10^4}{10^6} = 10^{-2} \text{ s}$$

$$\frac{10^2}{10^6} = 10^{-4} \text{ s}$$



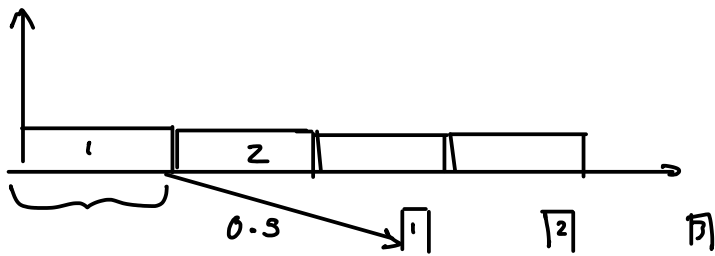
$$\text{Throughput} = \frac{10^4}{10^{-2} + 10^{-4}} \approx 10^6 \text{ b/s.}$$



$$\text{Throughput} = \frac{10^4}{10^{-2} + 0.5 + 10^{-4}} \approx \underline{\underline{20 \text{ kb/s}}}$$

low delay

high delay



$$\frac{10,000}{10^{-2}} \approx \underline{\underline{10^6 \text{ b/s}}}$$

Exercise 3: A communication system loses every 10th frame (e.g. due to periodic noise bursts). Ignoring ACK overhead, what is the throughput using go-back-N ARQ? Using Selective ARQ? → assuming an average of 10 unacknowledged frames.

$$\frac{10 \times 10,000 \text{ bits}}{(10+10) \times 10^{-2}} \approx 560 \text{ kb/s.}$$

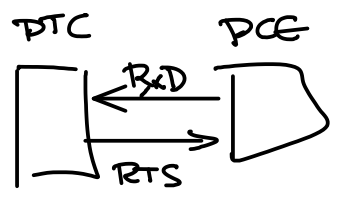
error-free frames (under 10), *retransmitted frames.* (under 10)

$$\frac{10 \times 10,000}{(10+1) \times 10^{-2}} \approx 900 \text{ kb/s.}$$

transmissions (under 10), *repeats.* (under 1)

1 2 3 ... 9 X
 ↑
 go-back N
 ← selective repeat

Exercise 4: Which of the above flow control methods can be used with frame-oriented protocols? On unidirectional links?



| | n/w | s/w | delay ACK |
|----------------|---------|--------------|-----------|
| frame oriented | depends | probably not | Y |
| unidirectional | Y | N | N |

