Lecture 11 Exercises

Exercise 1

$$\frac{10{,}000 \text{ bits}}{1 \times 10^{6} \text{ b/s}} = \frac{1 \times 10^{4}}{1 \times 10^{6}} \text{ s} = 10^{-2} \text{ s} = 10 \text{ ms.}$$

$$\frac{100 \text{ bits}}{1 \times 10^{6}} = \frac{10^{2}}{10^{6}} = 10^{-4} \text{ s} = 0.1 \text{ ms}$$

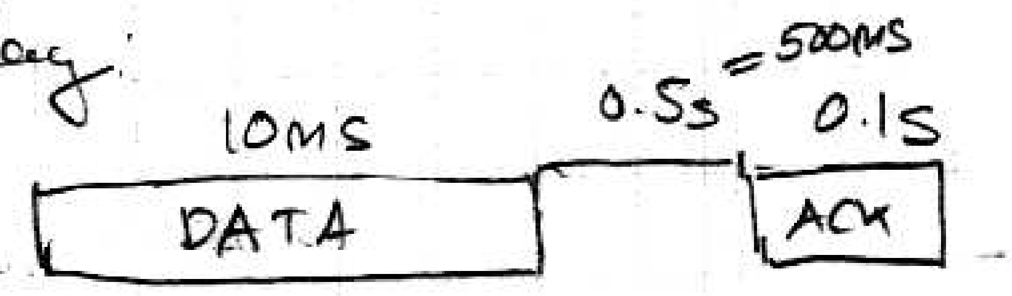
1 data frame + 1 ack = 10,100 bits

w/ no delay:

duration = 10.1 ms

$$\text{throughput} = \frac{10{,}000 \text{ bits}}{10.1 \text{ ms}} = 990 \text{ kb/s.}$$

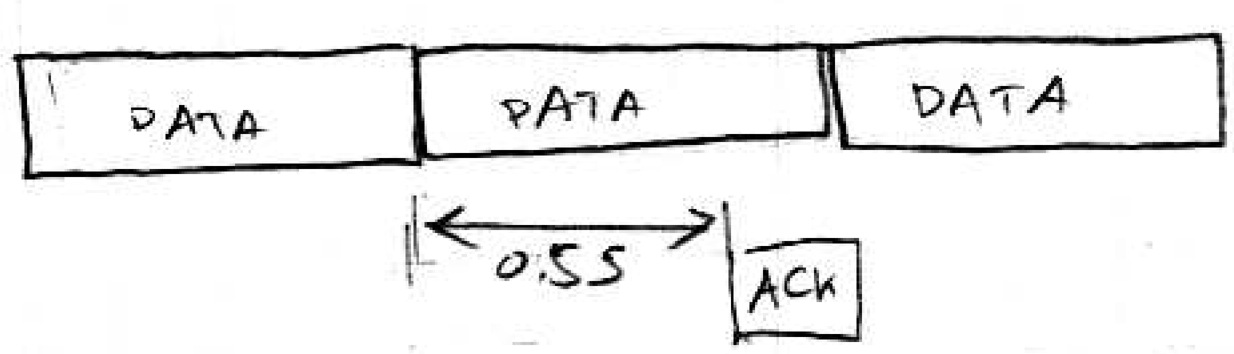
w/ 0.5s delay:



duration = 510.1 ms.

$$\text{throughput} = \frac{10{,}000 \text{ bits}}{510.1 \text{ ms}} = 19.6 \text{ kb/s}$$

w/ 0.5s delay and go-back-N:



(forward channel).

(return channel, assumed independent)

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

Exercise 2

- modulo-2 sum: remainder after dividing by 2
- $1+0+1 = 2$ $\quad \frac{2}{2} = 1$ remainder 0 $\quad (2 \bmod 2 = 0)$
- if number of 1's is even,
  the sum is an even number & the remainder = 0
  modulo-2 sum is zero (0).

Exercise 3

$(n, k) =$ n total bits
k data bits
n-k parity bits

- there are 2^k possible data values.
  & also 2^k possible code words
  (each code word has only one valid/correct set of parity bits).

- there are 2^{n-k} patterns of parity bits
  (only on of which is the correct one for any given codeword).

Exercise 4 :

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                  11100
                  11011
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XOR = different → 00111  ← Hamming distance = 3
                           (3 bits are different)
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Exercise 5 :

2 codewords:	101	010
received:	110	110
differences:	011	100
Hamming distances:	2	1
		← this one
"closest" codeword:		010