Question 1

(1) Idle BISYNC sender transmits SYN:

00010110 00010110 00010110 ...

(2) Transmitted frame is:

(SYN)	(SYN)	(DLE)	(SOH)
00010110	00010110	00010000	00000001

stuffed

01111110 00010000 00010000

Header

(DLE)	(STX)
00010000	00000010

stuffed

00000011 00010000 00010000 01111110

Message

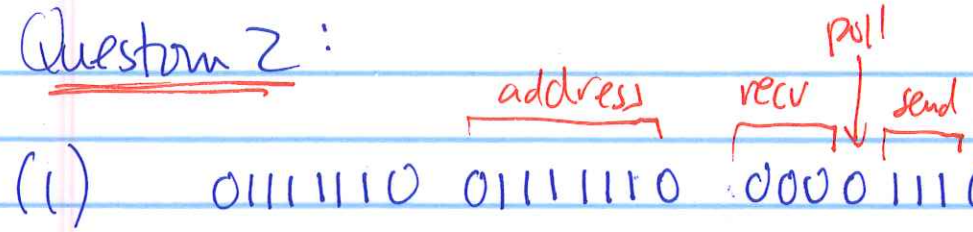
(DLE)	(ETX)
00010000	00000011

No need to stuff!!!

01111111 00010000

CRC

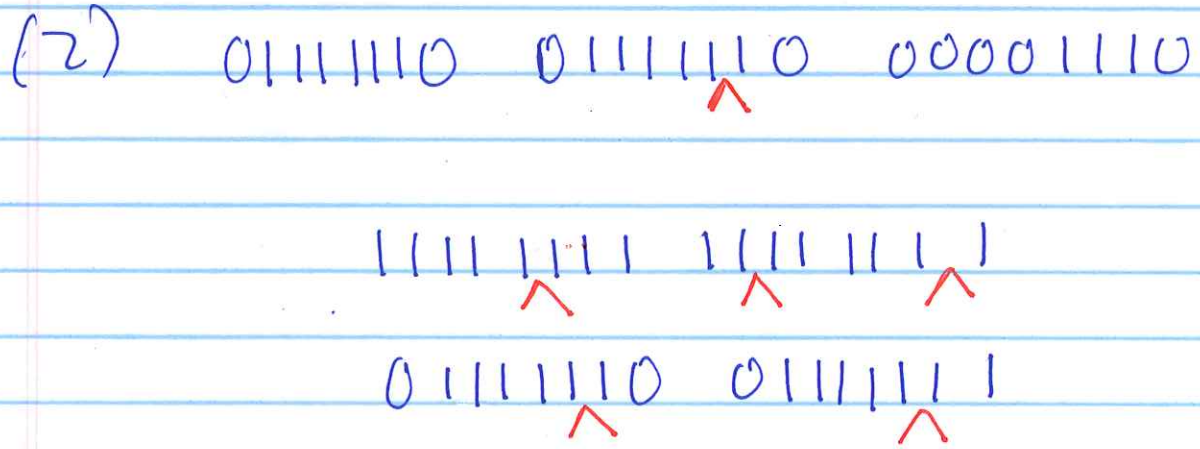
Question 2:



11111111 11111111 & data

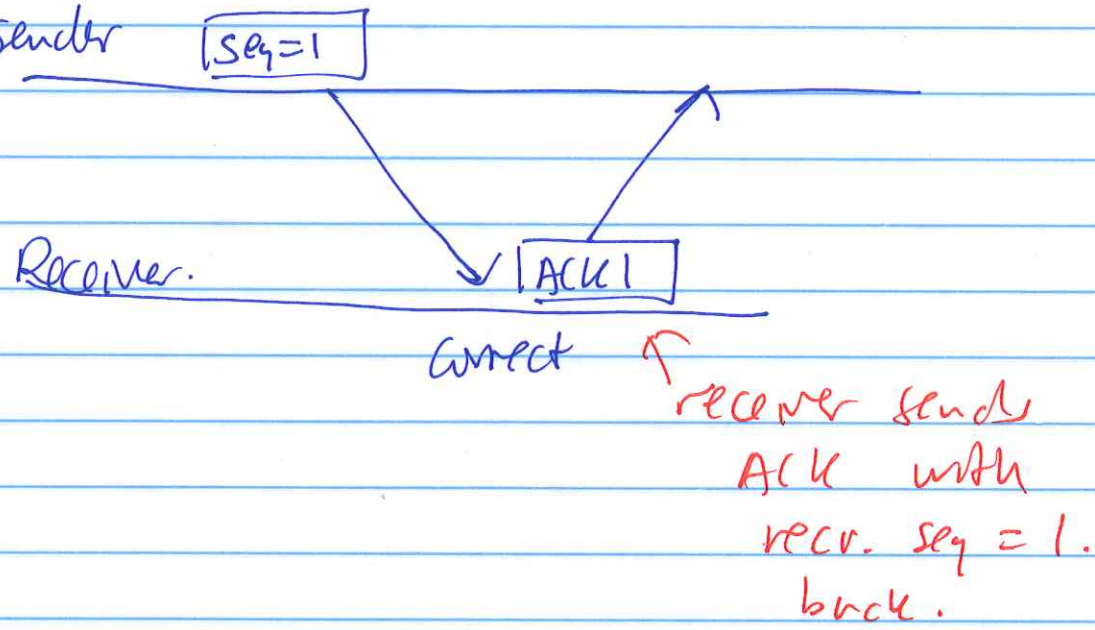
01111110 01111111 & FCS.

01111110 & flag (ends frame).

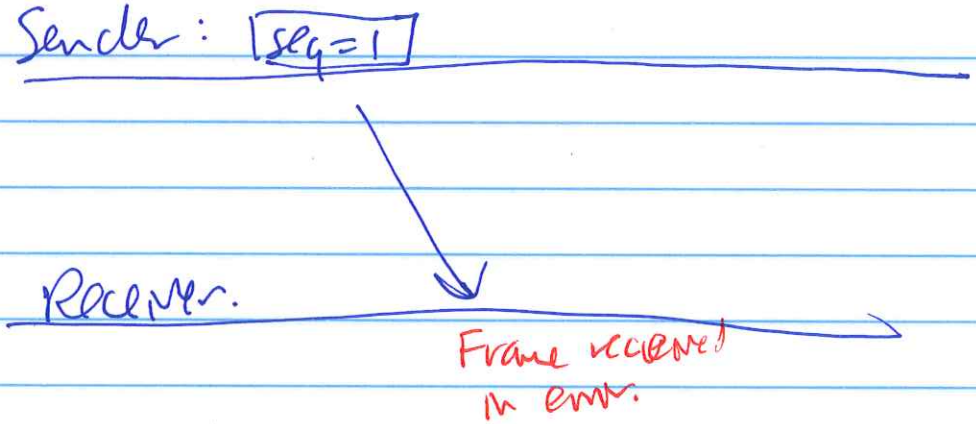


Question 3:

(1)



(2)

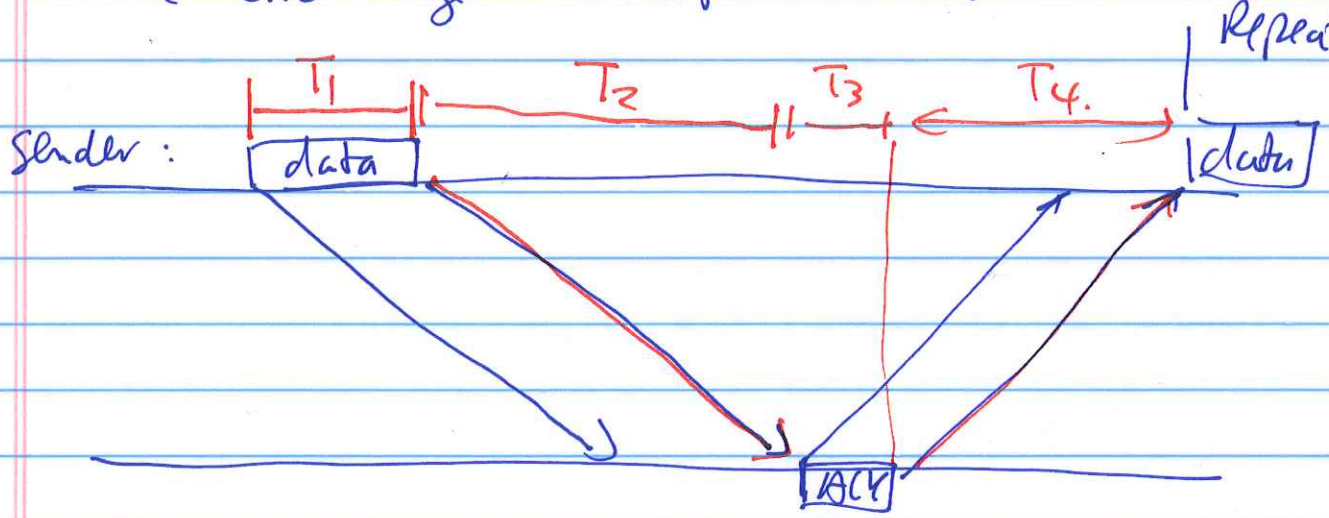


Receiver does NOTHING!

(Sender will then time out and retransmit the frame !!!)

Question 4:

Frame exchange in Stop-and-Wait:



T_1 = time to transmit a data frame

$$= \frac{8000 \text{ bits}}{64.000 \text{ bits per sec}}$$

$$= \frac{1}{8} \text{ sec} = 0.125 \text{ sec.}$$

T_2 = one-way propagation delay

$= 5.10^{-5}$ sec.

$= 0.00005$

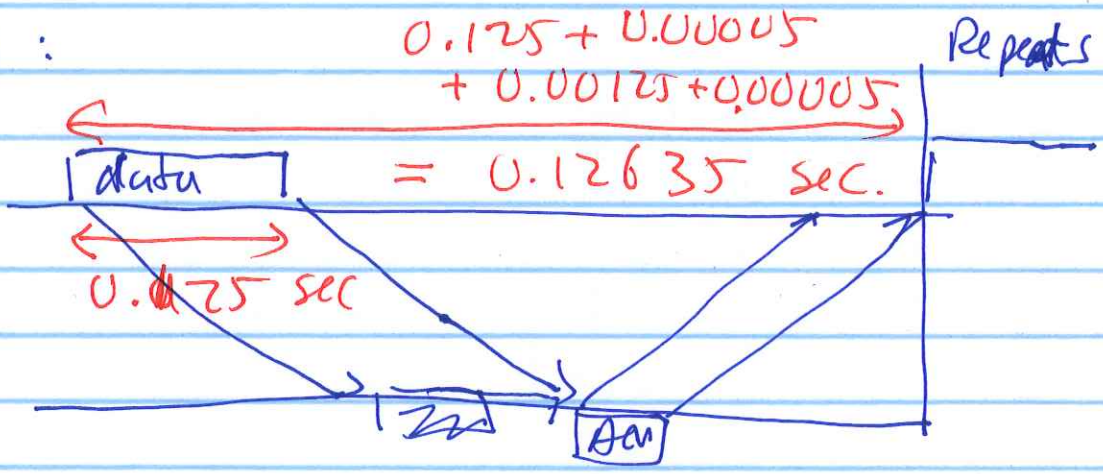
T_3 = time to transmit an ACK frame

$$= \frac{80 \text{ bits}}{64.000 \text{ bps}} = 0.00125 \text{ sec.}$$

T_L = one-way propagation delay

$= 5.10^{-5}$ sec $= 0.00005$ sec

SU:



Of the 0.12635 sec in the cycle, 0.125 sec is used to transmit data.

The fraction used to transmit data

$$= \frac{0.125}{0.12635} = 0.9893$$

Effective Bandwidth Util =

0.9893×64 kbps $= 63.3$ kbps

Part 2:

The end-to-end propagation delay does not change when bandwidth increases.

(End-to-end prop. delay delays at the speed of light only...)

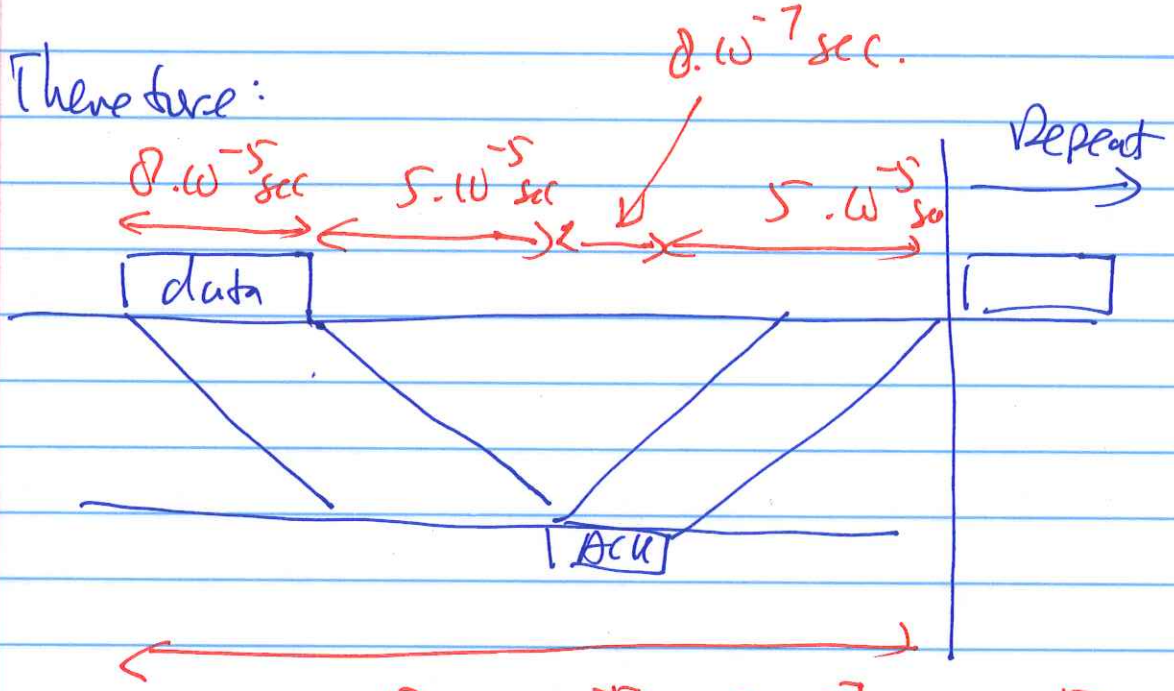
These changes:

$$T_1 = \frac{8000 \text{ bits}}{100.000.000 \text{ bps}} = 8 \cdot 10^{-5} \text{ sec}$$

$$= 0.00008$$

$$T_3 = \frac{80 \text{ bits}}{100.000.000 \text{ bps}} = 8 \cdot 10^{-7} \text{ sec.}$$

Therefore:



$$8.10^{-5} + 5.10^{-5} + 8.10^{-7} + 5.10^{-5}$$

$$= 18.10^{-5} + 8.10^{-7}$$

$$= 18.08 . 10^{-5} \text{ sec.}$$

Of the $18.08 . 10^{-5}$ sec in the cycle,

8.10^{-5} sec is use to transmit data.

Sv:

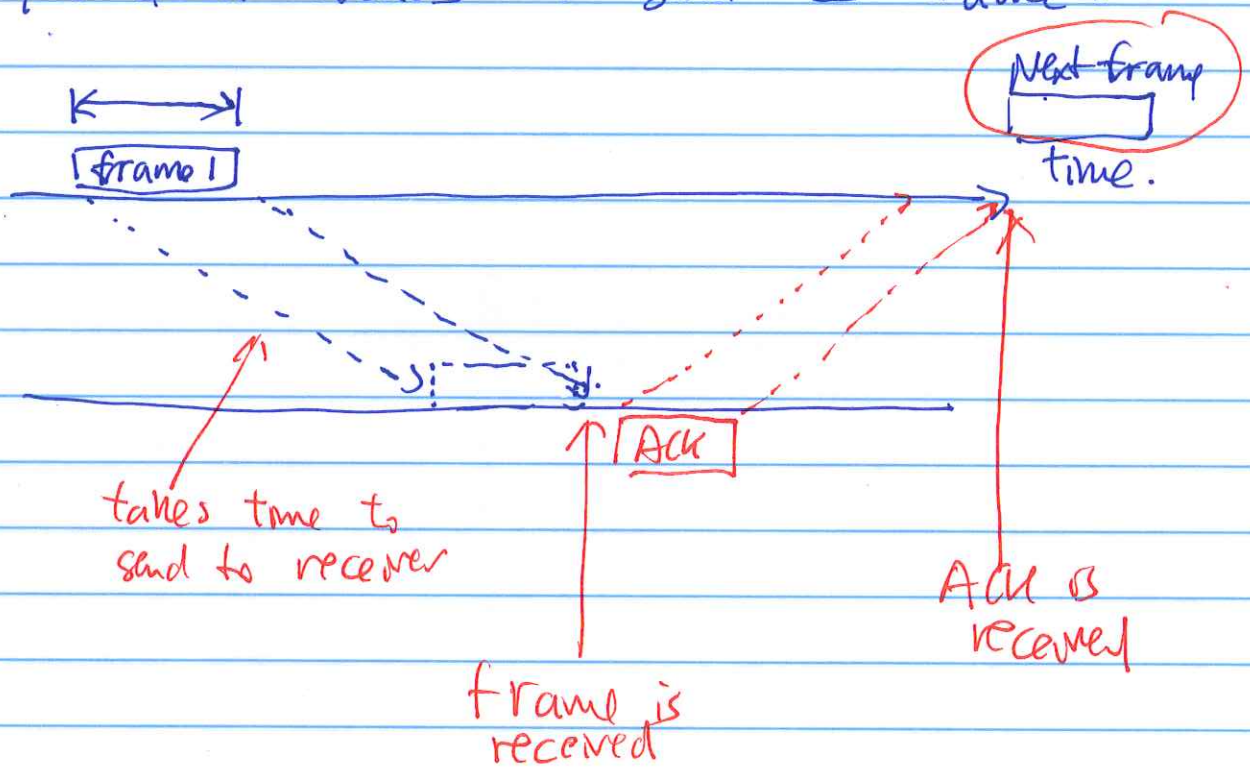
$$\frac{8.10^{-5}}{18.08 . 10^{-5}} = 0.44$$ is used for data

Eff. BW util = 0.44×64 kbps

$= 28.3$ kbps (over 50% is wasted!!!)

Question 5:

Sequence of events to send 1 frame:



Events:

(1) frame is sent

(2) frame needs to travel to receiver

(3) frame is received + checked (correct)

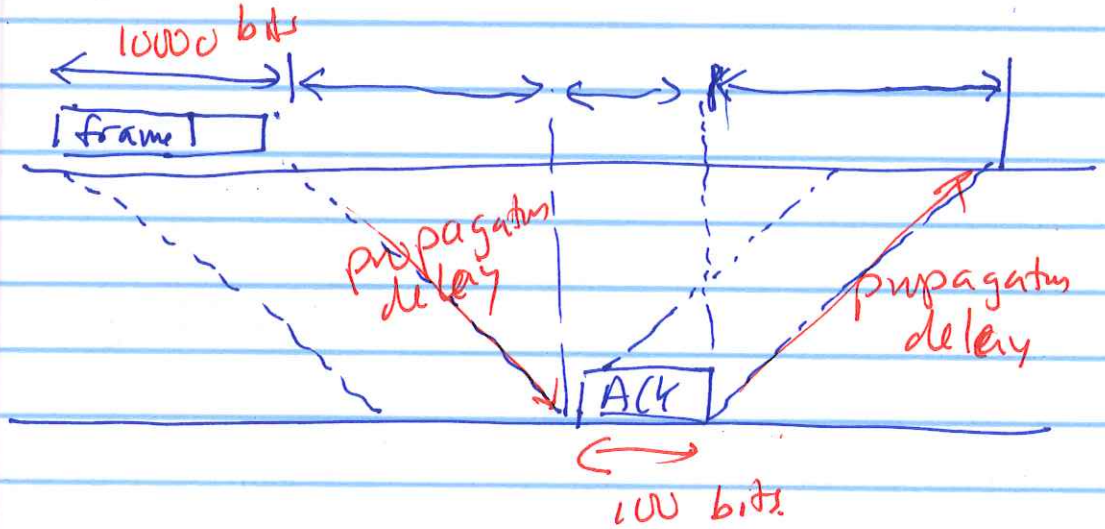
(4) Receiver send ACK frame

(5) ACK frame must travel to sender.

(6) ACK frame is received.

→ Then sender can send next frame!

Timing of the events:



(1) To send 10000 bits:

$$t_1 = \frac{10000}{10^9} \text{ sec} = 10^{-5} \text{ sec.}$$

(2) To travel to receiver:

$$t_2 = \text{prop. delay} = 1 \text{ msec} = 10^{-3} \text{ sec.}$$

(3) To send ACK (100 bits) frame:

$$t_3 = \frac{100}{10^9} \text{ sec} = 10^{-7} \text{ sec.}$$

(4) ACK travels to sender:

t_4 = propagation delay = 1 msec = 10^{-3} sec

Total time to send 1 frame (= 10000 bits)

$$= 10^{-5} + 10^{-3} + 10^{-7} + 10^{-3}$$

$$= 2.0101 \cdot 10^{-3} \text{ sec.}$$

This repeats until you sent all data:

1,000,000 bytes = 8,000,000 bits.

$$= 800 \times 10{,}000 \text{ bits}$$

$$= 800 \text{ frames.}$$

Total time to send the file of 1,000,000 bytes:

$$= 800 \times 2.0101 \text{ msec}$$

$$= 1.60808 \text{ sec}$$