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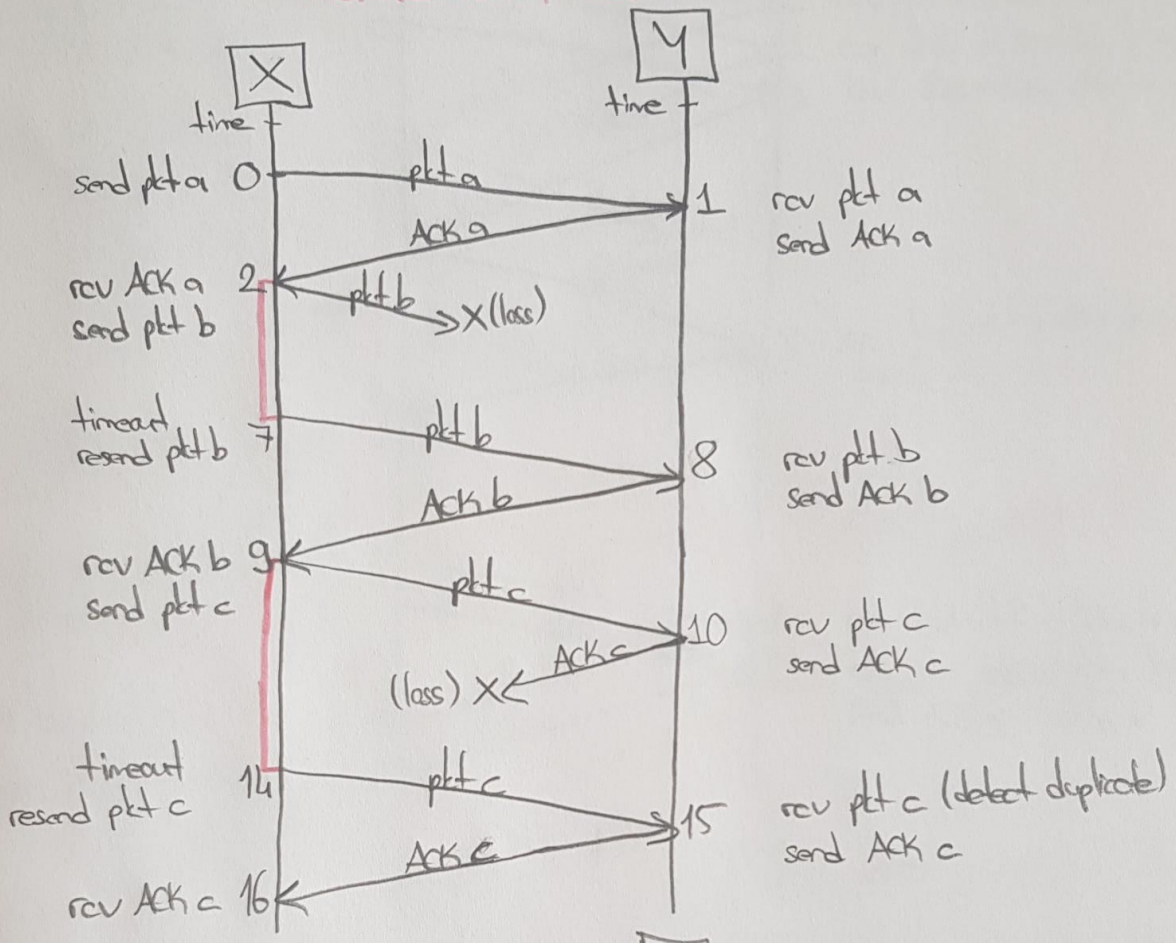
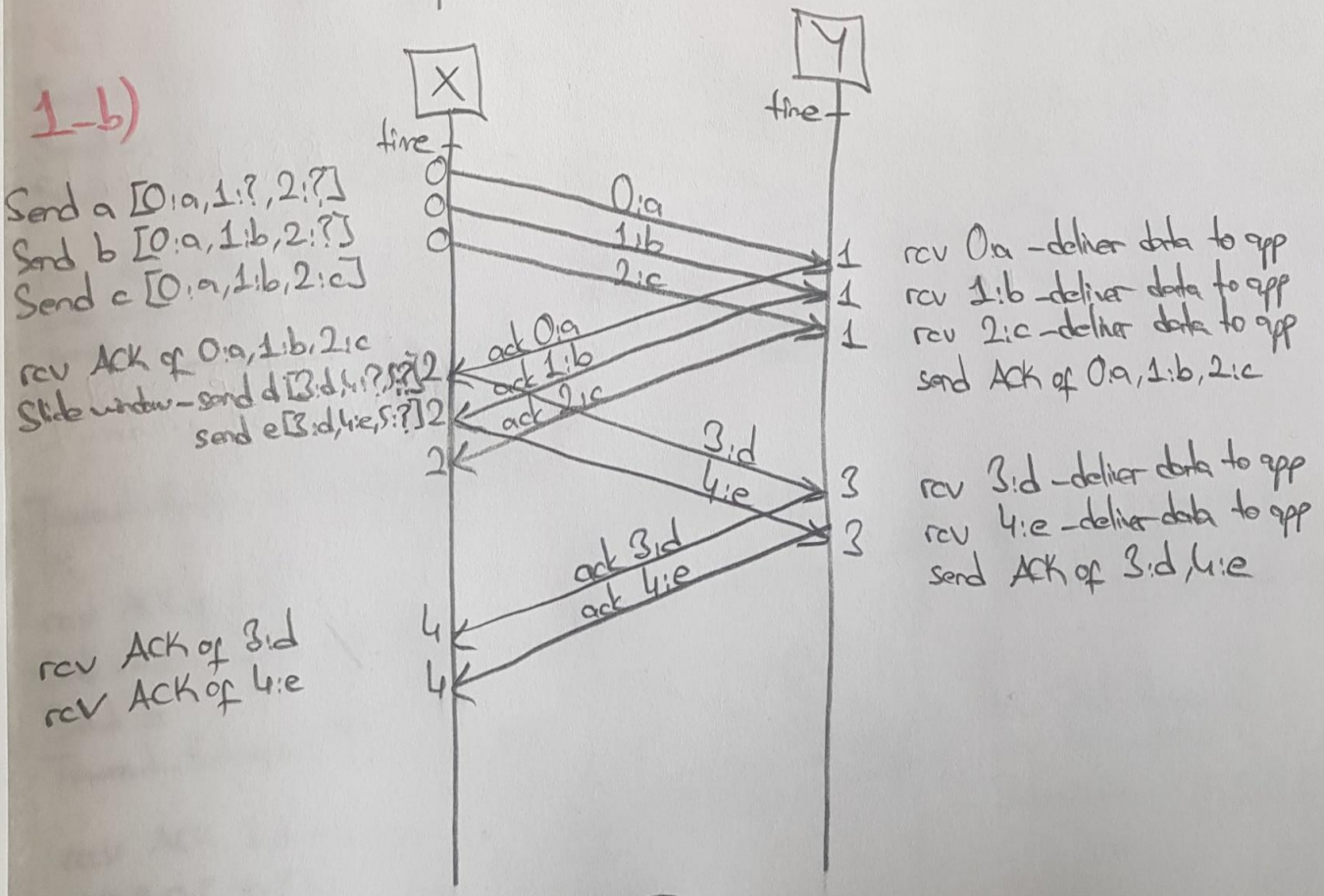
HOMEWORK 2

1- a)



1-b)



1-c) i.

Send a [0:a, 1:?, 2:?]
Send b [0:a, 1:b, 2:?]
Send c [0:a, 1:b, 2:c]

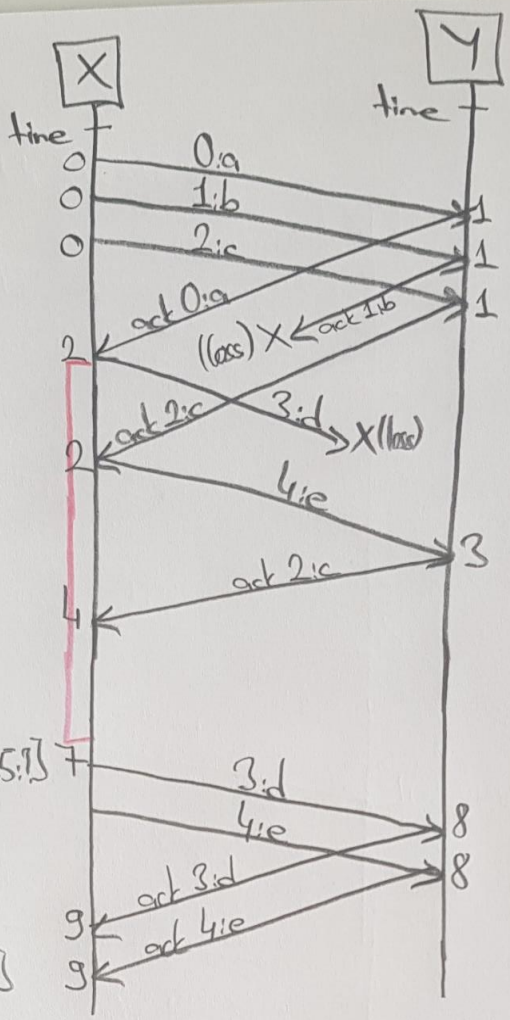
rcv ACK of 0:a and 2:c
Send d [3:d, 4:?, 5:?]

Send e [3:d, 4:e, 5:?]

rcv ACK 2:c
Ignore duplicate ACK
[3:d, 4:e, 5:?]

Timeout - Retransmit d [3:d, 4:e, 5:?]
Retransmit e

rcv ACK 3:d and 4:e
Slide window - [5:?, 0:?, 1:?]



rcv 0:a - deliver data to app
rcv 1:b - deliver data to app
rcv 2:c - deliver data to app

rcv 4:e - out of order, discard
resend ACK 2:c

rcv 3:d - deliver data to app
rcv 4:e - deliver data to app
Send ACK of 3:d, 4:e

c) ii.

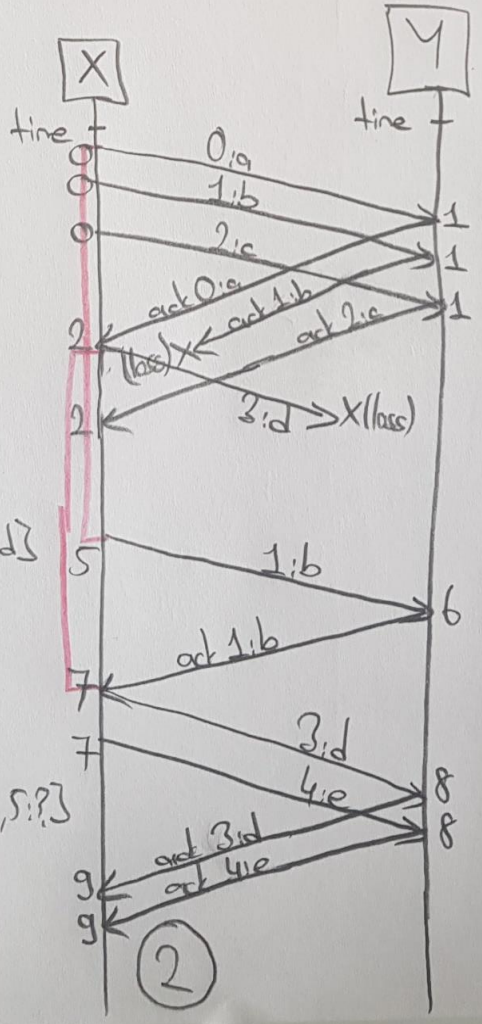
Send a [0:a, 1:?, 2:?]
Send b [0:a, 1:b, 2:?]
Send c [0:a, 1:b, 2:c]

rcv ACK of 0:a and 2:c
Slide window [1:b, 2:c, 3:d]
send d

Timeout - Retransmit b [1:b, 2:c, 3:d]

rcv ACK of 1:b
Slide window [3:d, 4:e, 5:?]
Send e
Timeout - Retransmit d [3:d, 4:e, 5:?]

rcv ACK 3:d and 4:e
[5:?, 0:?, 1:?]



[0:?, 1:?, 2:?]

rcv 0:a [1:?, 2:?, 3:?] slide window
deliver a
rcv 1:b [2:?, 3:?, 4:?] slide window
deliver b
rcv 2:c [3:?, 4:?, 5:?] slide window
deliver c

rcv 1:b [3:?, 4:?, 5:?] duplicate
discard and send ACK 1:b

rcv 3:d - deliver d
rcv 4:e - deliver e
Slide window [5:?, 0:?, 1:?]

2- $x = 10^5$ m (Distance between A and B

$R = 10^6$ bits/sec

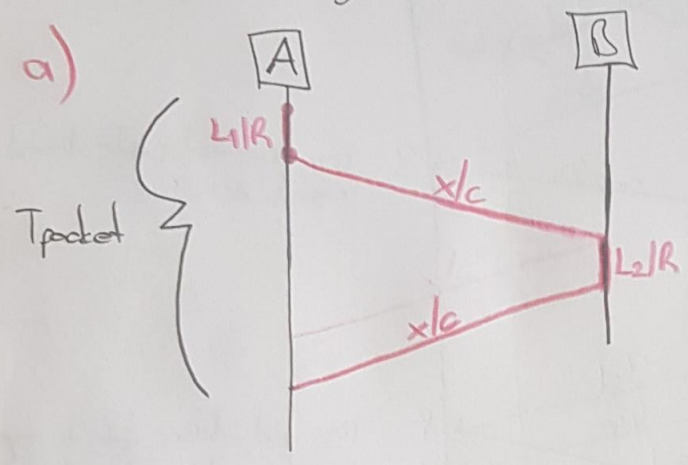
$c = 2 \times 10^8$ m/sec

# of data packets = 10000

$L_1 = 100$ bytes $= 800$ bits (length of data in each packet sent by A)

$L_2 = 25$ bytes $= 200$ bits (length of data in each packet sent by B)

a)



$$T_{packet} = \frac{L_1}{R} + \frac{L_2}{R} + \frac{2x}{c}$$

$$= \frac{1000 \text{ bits}}{10^6 \text{ bits/sec}} + \frac{2 \times 10^5 \text{ m}}{2 \times 10^8 \text{ m/sec}} = 1000 \times 10^{-6} \text{ sec} + 10^{-3} \text{ sec}$$

$$= 1 \times 10^{-3} \text{ sec} + 1 \times 10^{-3} \text{ sec} = 2 \times 10^{-3} \text{ sec} = 2 \text{ msec}$$

Total time to transfer 10000 packets via Stop-and-Wait

$= n \cdot T_{packet} = 10000 \times 2 \text{ msec} = 20000 \text{ msec} = 20 \text{ sec}$

b) for 100% utilization, minimum window size for sender should be

1st way

$$W_{min} = \left\lceil \frac{T_{packet}}{d_{trans}} \right\rceil = \left\lceil \frac{2 \text{ msec}}{800 \times 10^{-3} \text{ msec}} \right\rceil = 3$$

2nd way

$$W_{min} = \left\lceil 1 + 2 \times \frac{T_p}{T_t} \right\rceil = \left\lceil 1 + \frac{2 \times 0.5 \times 10^{-3} \text{ sec}}{0.8 \times 10^{-3} \text{ sec}} \right\rceil = \left\lceil 2.25 \right\rceil = 3$$

Transmission delay $= T_t = \frac{800 \text{ bits}}{10^6 \text{ bits/sec}} = 0.8 \times 10^{-3}$ sec, Propagation delay $= T_p = \frac{10^5 \text{ m}}{2 \times 10^8 \text{ m/sec}} = 0.5 \times 10^{-3}$ sec