Computer Networks

Part I - Tutorial 2

Question 1

A 64 kbps leased line connects two bank branches and is used for transferring secure bank information. A link layer protocol with 3-bit sequence number is deployed. Determine the minimum window size required to ensure that the throughput is at least 32 Kbps. Assume that the average packet size is 80 bytes, the signal propagation delay between the two sites is 10 ms, and the probability of error is negligible

Q1 answer

Given:

Tx_rate = 64 Kbps

Propagation delay (P_delay) = 10 millisecond

Packet size = 80 bytes = 640 bits

3 bit used for frame sequencing

Calculate Normalised propagation delay

a = Propagation delay /average frame transmission time

Ave frame tx_time = ave. frame size /Tx_rate

= 640 bit /64 K

= 10 msec.

a = 10 msec. /10 msec = 1

Q1 answer

The link utilisation for 32 Kbps is 32K/64K which is 0.5

Utilisation of the link is given by

$U = N/(1 + 2a)$ where N is the window size

$0.5 \leq N / (1 + 2*1)$

$N \geq 3/2 = 1.5$

Round up the window size , i.e., **2 ($< 2^3 = 8$)**

Question 2

In the figure below, frames are generated at node A and sent to node C through node B. Determine the minimum transmission rate required between nodes B and C so that the buffers of node B are not flooded, based on the following:

(a) The data rate between A and B is 100 *Kbps*.

(b) The propagation delay is 10 $\mu sec/km$ for both links.

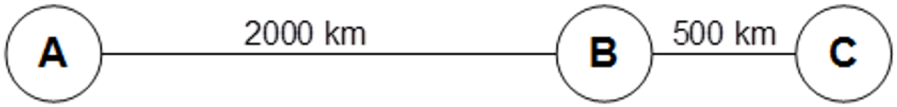
(c) The lines are full duplex between the nodes.

(d) All data frames are 1000 bit long; ACK frames are separate frames of negligible length.

(e) Between A and B, a sliding-window protocol with a window size of 3 is used, and each frame is acknowledged individually.

(f) Between B and C, a stop and wait is used.

(g) There is no error, and the processing delay at the nodes is negligible.



Question 2: Transmission Rate Calculation

A → B: Propagation Time = 2000 *10 μsec = 20 msec

Transmission Time = $1000/(100*10^3)$ = 10 msec

B → C: Propagation Time = 500 *10 μsec = 5 msec

Transmission Time = x = 1000/R msec

R = Data rate between B and C in kbps

Start sending 1st packet 00

Start sending 2nd packet 10

Start sending 3rd packet 20

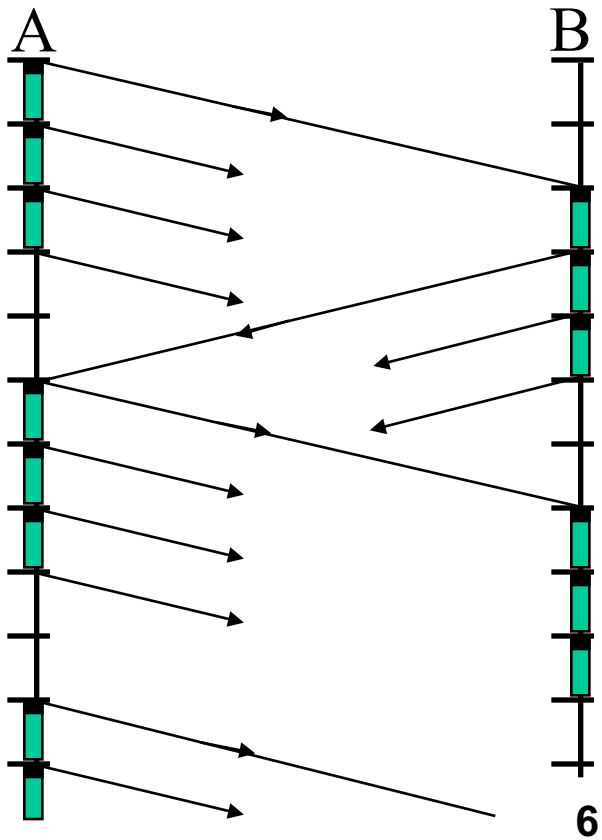
Ack recd for 1st packet, start sending 4th packet 50

Ack recd for 2nd packet, start sending 5th packet 60

Ack recd for 3rd packet, start sending 6th packet 70

Ack recd for 4th packet, start sending 7th packet 100

Ack recd for 5th packet, start sending 8th packet 110



Question 2: Transmission Rate Calculation

A → B: Takes 50 msec to transmit 3 frames.

B → C: Takes 10 + x msec to transmit one frame

Therefore,

$50 = 3\ (10 + x)$ ⊣ $x = 20/3$

$x = 1000/R$ ⊣ $R = 1000/x = 150$ kbps

Another approach to solve this question

The required condition:

(Link utilization from A to B) * (Full rate from A to B) ≤ (Link utilization from B to C) * (Full rate from B to C)

which means $\frac{3}{5} \times 100\ kbps \leq \frac{1}{1+2\times\frac{5}{x}} \times R\ kbps$

Because $\frac{3}{5} \times 100\ kbps = 60\ kbps$

and $\frac{1}{1+2\times\frac{5}{x}} \times R\ kbps = \frac{1}{1+2\times\frac{5}{1000/R}} \times R\ kbps = \frac{100R}{100+R}\ kbps$

the required condition becomes

$$60\ kbps \leq \frac{100R}{100+R}\ kbps$$

which leads to

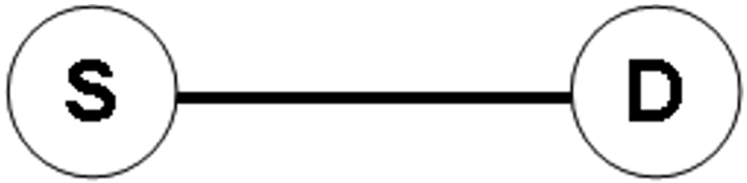
$$R \geq 150\ kbps.$$

Question 3

Consider a communication link between two cities of City *S* and City *D*. The frame transmission rate on the link is 100 *kbps* and the frame length is 25 bytes. The distance between City *S* and City *D* is 5 *km* and the propagation delay 3 *ms*/*km*. The communication link suffers from an average frame error probability of 0.2 and we adopt a Selective-Reject ARQ mechanism between City *S* and City *D* for reliable communication.

a) If the window size is 10, compute the link utilization from City S to City D.

a) Compute the minimum window size and the corresponding number of bits reserved for frame sequence in the header, in order to maximize the link utilization between City S and City D.



Q3(a): Selective-Reject ARQ Utilization

- Frame transmission time

$$T_f = 25bytes \times 8bits/bytes \div 100kbps = 2ms$$

- Propagation delay

$$T_p = 5km \times 3ms/km = 15ms$$

- Normalized propagation delay

$$a = {}^{T_p}\!/_{T_f} = 15/2 = 7.5$$

- Utilization of the ARQ

$$U = \frac{W(1-P)}{1+2a} = \frac{10(1-0.2)}{1+2\times 7.5} = \frac{8}{16} = 50\%$$

Q3(b): Minimum Window Size

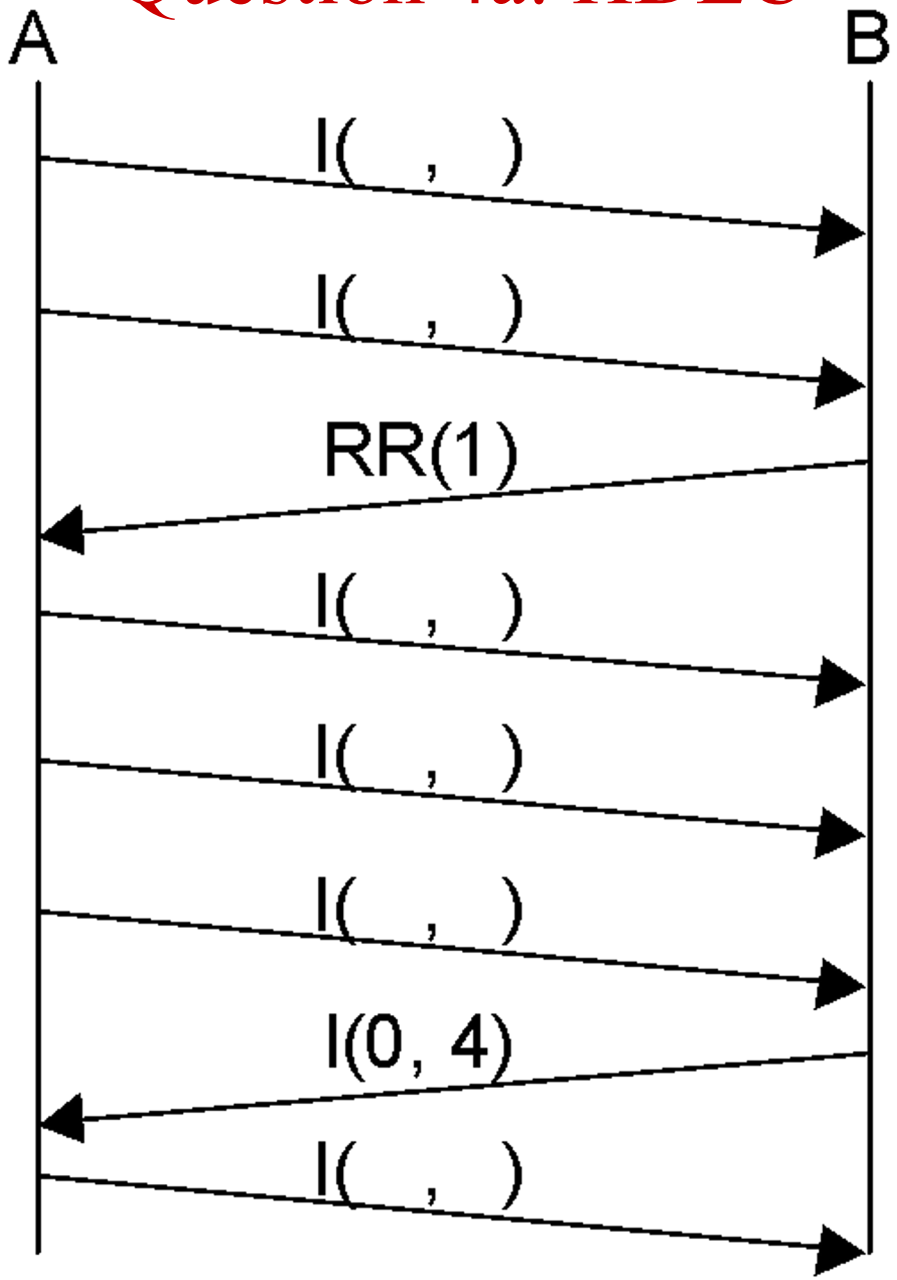
$$W \geq 1 + 2a = 1 + 2x7.5 = 16$$

- Minimum window size to maximize the throughput is **16**
- In Select-Repeat ARQ, for a k-bit sequence, the maximum window size is

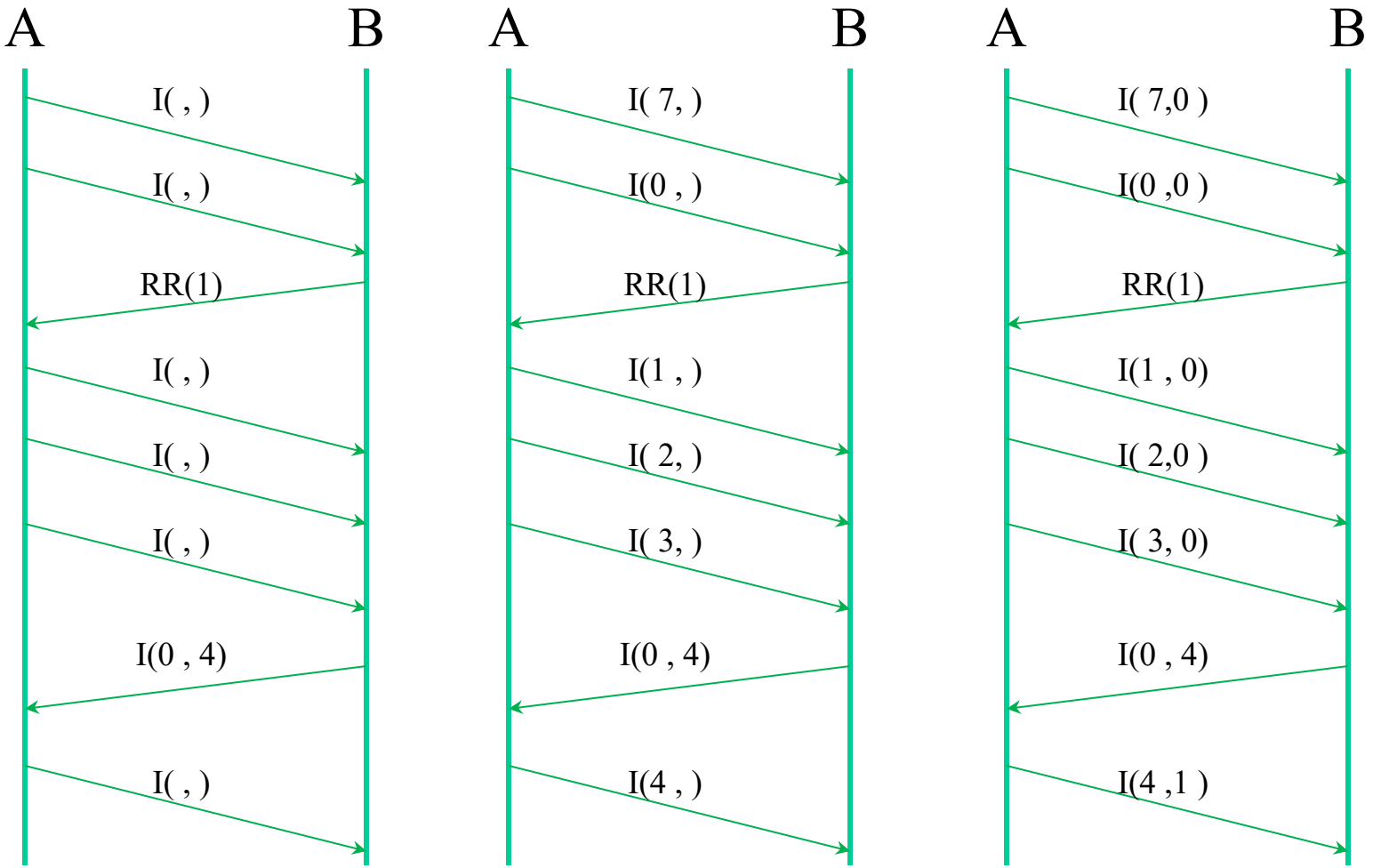
$$16 = W \leq 2^{k-1}$$

- Therefore, the minimum number of bit for sequencing is **5**

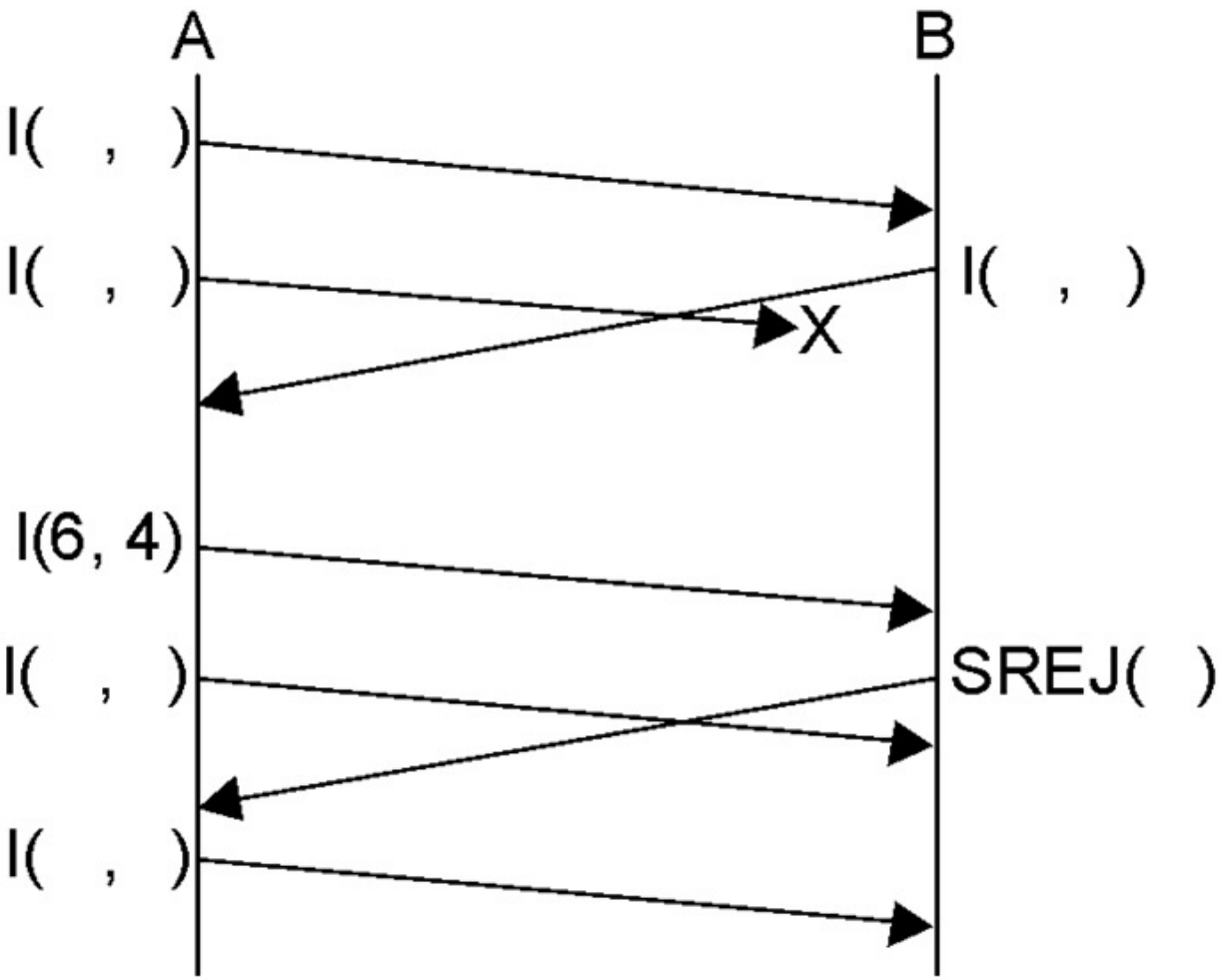
Question 4a: HDLC



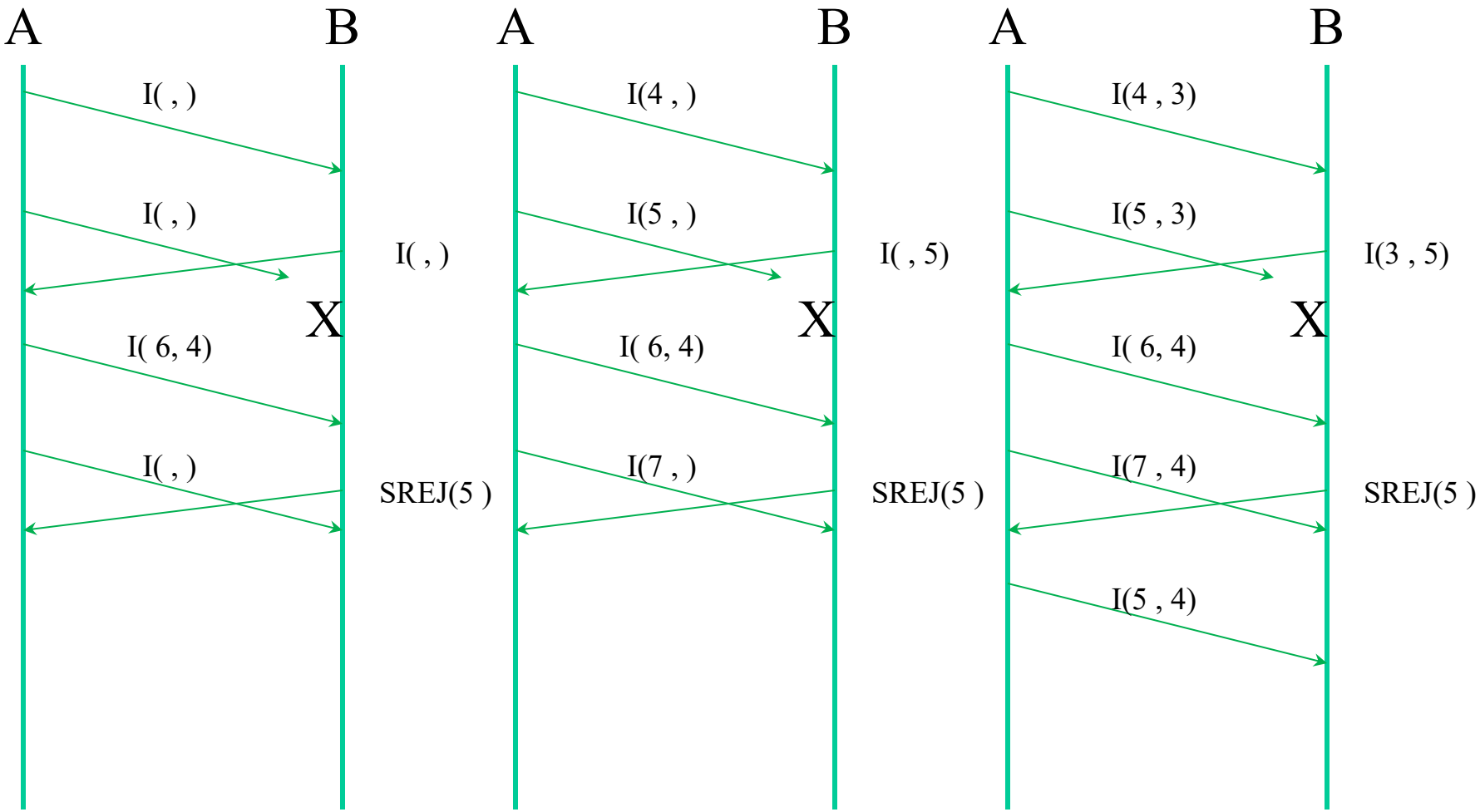
Question 4(a)


A
B
I(,)
I(,)
RR(1)
I(,)
I(,)
I(,)
I(0 , 4)
I(,)
A
B
I(7,)
I(0 ,)
RR(1)
I(1 ,)
I(2,)
I(3,)
I(0 , 4)
I(4 ,)
A
B
I(7,0)
I(0 ,0)
RR(1)
I(1 , 0)
I(2,0)
I(3, 0)
I(0 , 4)
I(4 ,1)

Question 4b: HDLC



Question 4(b)


A
B
I(,)
I(,)
I(,)
X
I(6, 4)
I(,)
SREJ(5)
A
B
I(4 ,)
I(5 ,)
I(, 5)
X
I(6, 4)
I(7 ,)
SREJ(5)
A
B
I(4 , 3)
I(5 , 3)
I(3 , 5)
X
I(6, 4)
I(7 , 4)
SREJ(5)
I(5 , 4)

In addition to the office hours listed in Lecture Note 1, please feel free to contact Assistant Professor Jun ZHAO as follows to schedule appointments to ask questions. Thanks!

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