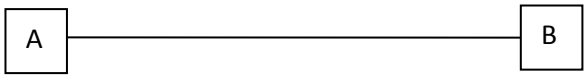
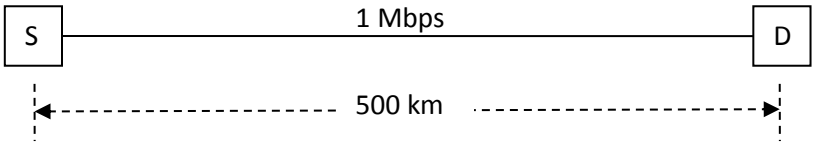
IS 504 – Exercise #3

1. Consider the following network. the round trip time (RTT) between A and B is 1 second and host A wants to send 4 packets (namely a,b,c,d) to host B. Assume that the network loses 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th}, … data packets sent by host A, and 3^{rd}, 6^{th}, 9^{th}, 12^{th}, … acknowledgements sent by host B, and no other error occurs. Also assume that packet transmission and processing delays are negligibly small and no other traffic is present in the network.



   For each of the following cases show the sequence of packets exchanged by A and B (indicate sequence number and content of each data/acknowledgement packet and indicate noteworthy events such as timeout, deliver content to application, duplicate packet, etc.) and find the minimum amount of time required to reliably deliver all packets to host B.
   a. Suppose that the Go-Back-N protocol is used with window size N=3 and timer timeout is 3 seconds.
   b. Suppose that the Selective-Repeat protocol is used with window size N=3 and timeout for individual packets is 3 seconds.
2. Consider the following network. Suppose host S wants to send a 12 Kbyte ($12*10^3$ bytes) file to host D. S breaks the file into 120 byte chunks and each chunk is sent in a separate data packet with 5 byte header. The link between the hosts is bidirectional and runs at 1 Mbps ($1*10^6$ bits/sec) in each direction. Propagation speed in the medium is $2*10^8$ m/sec and length of the link is 500 km. Assume that no error occurs in the network, acknowledgement packets are negligibly small, and processing delays are negligibly small, and no other traffic is present in the network.

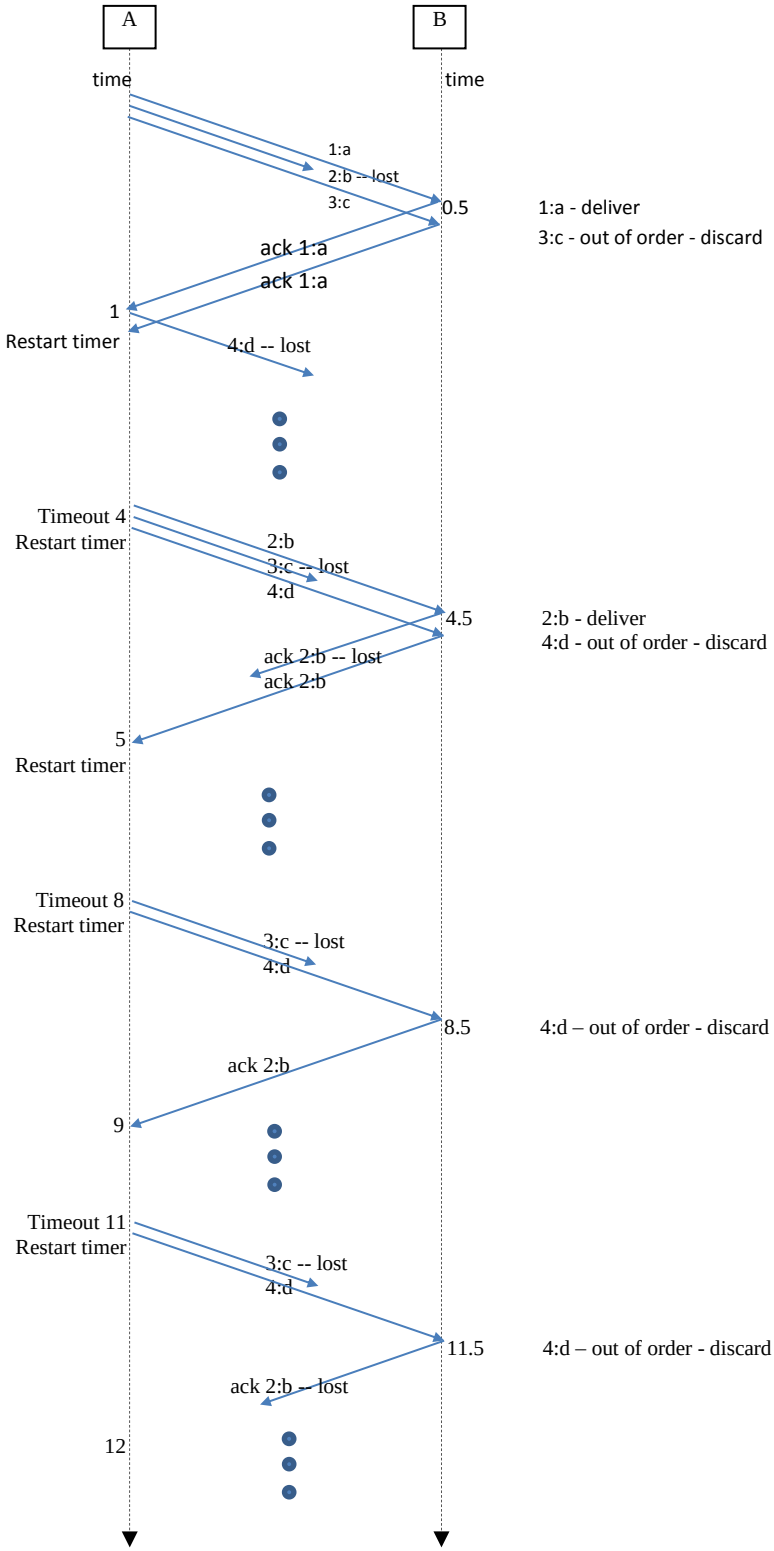


   a. Suppose that the Go-Back-N protocol is used with window size N=3 and timeout=1 second. How long does it take to deliver entire file to host D?
   b. Suppose that the Go-Back-N protocol is used. What is the minimum window size to have 100% utilization on the link when source S has data to send?
   c. Suppose that the Go-Back-N protocol is used with the window size found in part (c) and timeout=1 second. How long does it take to deliver entire file to host D?

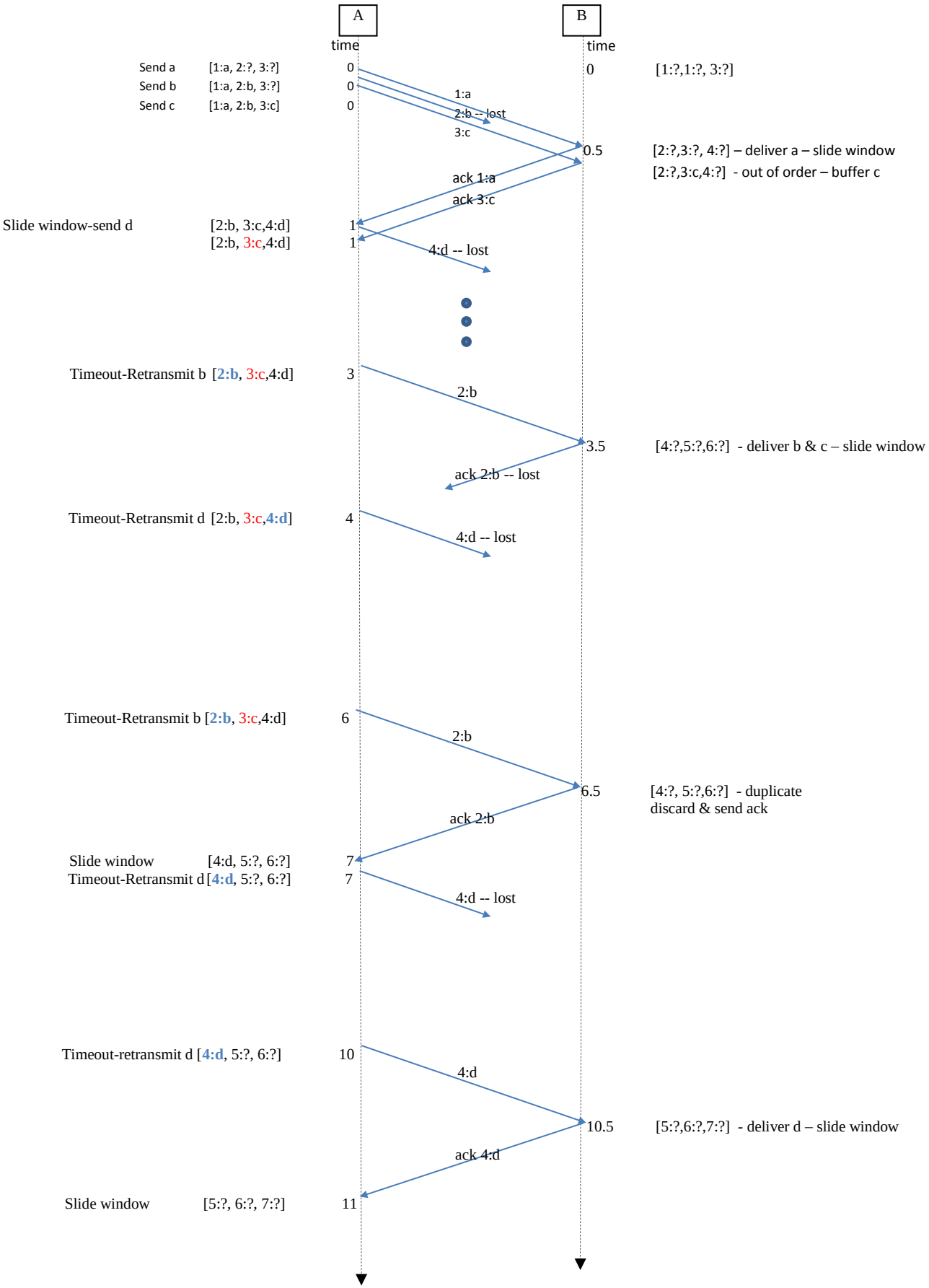
Solutions

1-a)

The packets c & d will never be delivered to the destination B because after a,b delivered to B, sender will send c,d and c will be lost, after timeout sender will retransmit c,d and c will be lost again, after timeout sender will retransmit c,d and c will be lost, so on.



1-b)


A
B
time
time
Send a [1:a, 2:?, 3:?]
Send b [1:a, 2:b, 3:?]
Send c [1:a, 2:b, 3:c]
0
0
0
0
[1:?,1:?, 3:?]
1:a
2:b -- lost
3:c
0.5
[2:?,3:?, 4:?] – deliver a – slide window
[2:?,3:c,4:?] - out of order – buffer c
ack 1:a
ack 3:c
Slide window-send d [2:b, 3:c,4:d]
[2:b, 3:c,4:d]
1
1
4:d -- lost
Timeout-Retransmit b [2:b, 3:c,4:d]
3
2:b
3.5
[4:?,5:?,6:?] - deliver b & c – slide window
ack 2:b -- lost
Timeout-Retransmit d [2:b, 3:c,4:d]
4
4:d -- lost
Timeout-Retransmit b [2:b, 3:c,4:d]
6
2:b
6.5
[4:?, 5:?,6:?] - duplicate
discard & send ack
ack 2:b
Slide window [4:d, 5:?, 6:?]
Timeout-Retransmit d [4:d, 5:?, 6:?]
7
7
4:d -- lost
Timeout-retransmit d [4:d, 5:?, 6:?]
10
4:d
10.5
[5:?,6:?,7:?] - deliver d – slide window
ack 4:d
Slide window [5:?, 6:?, 7:?]
11

2-a)

Number of packets to send = n = 12 * 10^3 byte/120 bytes = 100 packets

Length of data in each packet = m=120 bytes = 120*8 bits = 960 bits

Length of header in each packet = h = 5 bytes = 5 * 8 bits = 40 bits

Transmission rate = r = 1 Mbps = 1 * 10^6 bits/sec

Packet transmission delay = d_{trans} = (h+m)/r = (960+40) / 1*10^6 = 1*10^{-3} sec = 1 msec

Distance between A and B = x = 500 km = 500 * 10^3 m

Signal propagation speed = c = 2 * 10^8 m/sec

Propagation delay = d_{prop} = x/c = 2.5 * 10^{-3} sec = 2.5 msec

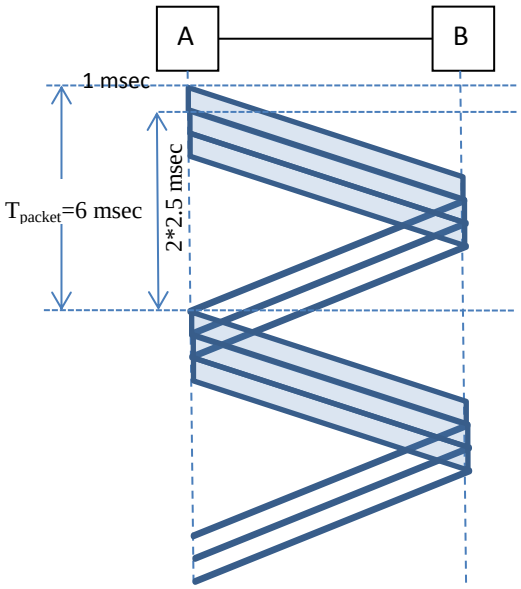
According to the following time-space diagram, 3 packets can be sent in every T_{packet}=d_{trans}+RTT=1+2*2.5 msec=6 msec

Therefore, 99 packets can be delivered in 6*(99/3) msec = 198 msec

The last packet can be delivered in 1+2.5 msec = 3.5 msec

Finally, the file can be delivered in 198+3.5 = 201.5 msec.

Note: Since timeout=1 sec >> T_{packet}=0.006 sec and there is no error in the network, there will be no retransmissions.



2-b)

Since T_{packet}=1+2*2.5 seconds=6 seconds, for 100% utilization minimum window size should be

$$W_{min} = \left\lceil \frac{T_{packet}}{d_{trans}} \right\rceil = \frac{6}{1} = 6$$

2-c)

When window size is 6, A will continue to send packets until all packets are transmitted. Therefore, the file can be delivered in

d = d_{prop} + n * d_{trans} = 2.5 + 100 * 1 = 102.5 msec