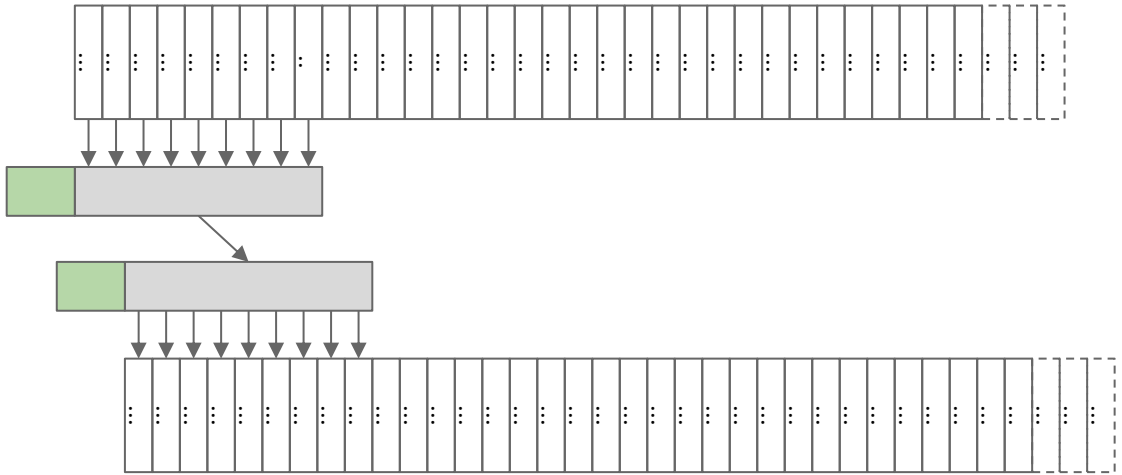


Lecture 11 (Transport 2)

TCP Implementation Exercises ANS

Question 1: TCP in Action

Consider a sender sending 1000B of data to a receiver over TCP. The sender sends packets of 100B, the window size is 300B, and the ISN is 99 (so D100 is the first packet sent, then D200, and so on).

Remember, TCP uses a sliding window and retransmits the packet containing the next expected byte on a timeout or, if TCP Fast Retransmit is enabled, when three duplicate acks are received. Assume here that TCP Fast Retransmit is not enabled. The initial transmission of packets D200 and D700 get dropped.

1.1 Fill in the below table with all packets sent by the sender until the receiver has received all packets and the sender knows that. For simplicity, assume that packets (data and ACKs) arrive in order. You may or may not need to fill in all lines.

Ind.	Packet Data Offset	Sent on Timeout	Dropped?	Cumulative ACK
1	D100			A200
2	D200		X	
3	D300			A200
4				
5				
6				
7				
8				
9				
10				
11				
12				

- 1.2 If the RTT of the link is 10ms and the timeout is initially 3 seconds, what is the total time needed for the receiver to receive all packets and for the sender to know that?
- Assume small packets (negligible transmission delay) and negligible processing time, and that the estimates that go into the Retransmission Timeout (RTO) remain constant during the events below.
- 2*RTO + 5 RTT = 6.05 s
- 1*RTT for 1, 1*RTO before 5, 2*RTT for 5-7, 1*RTO before 11, 2*RTT for 11-12
- Note that we have 2*RTT for 5-7 – not 3*RTT. Because D500 and D600 are sent at practically the same time, it takes 1 RTT from when we send D500 until we receive A700.

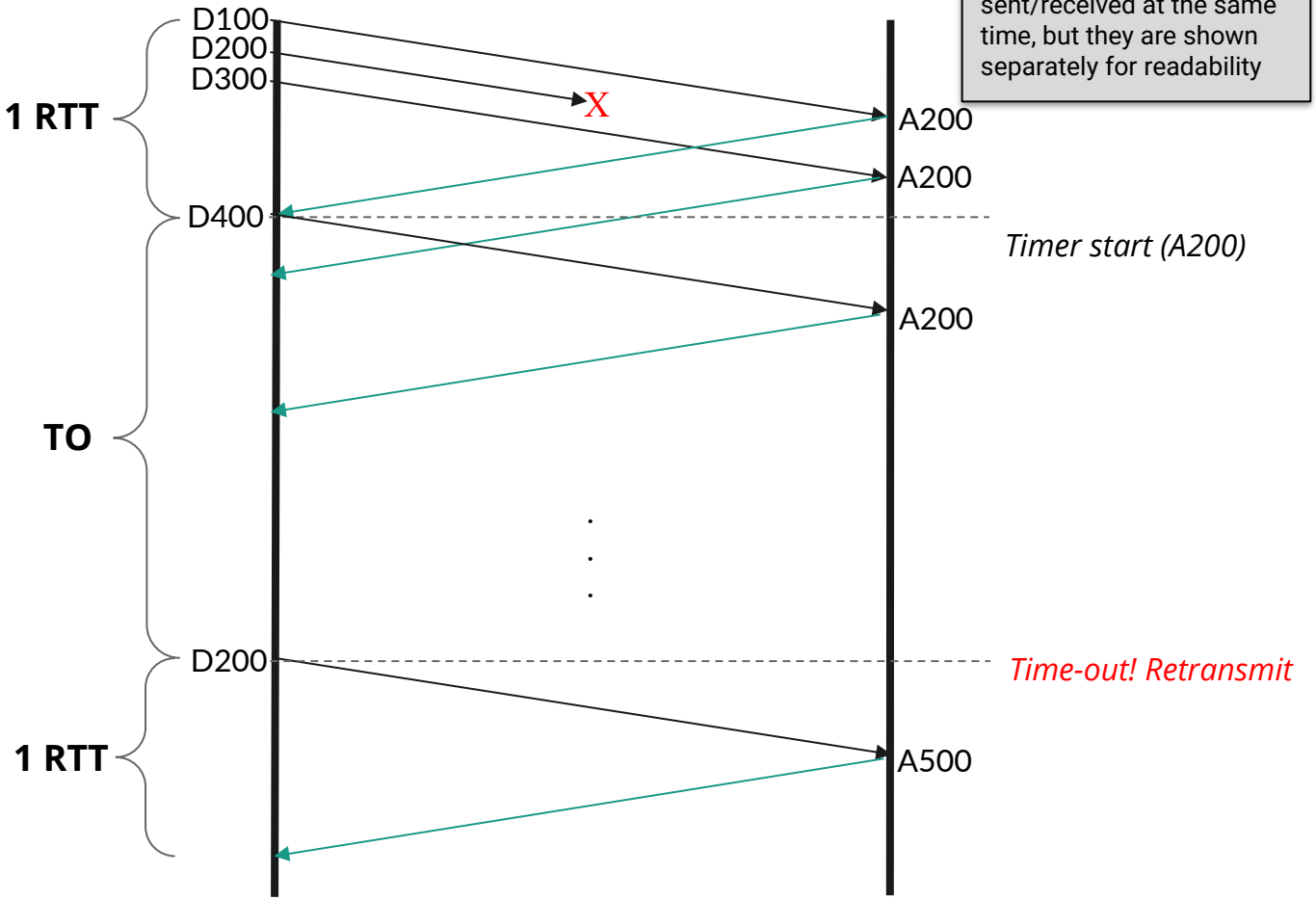
Consider a sender sending 1000B of data to a receiver over TCP. The sender sends packets of 100B, the window size is 300B, and the ISN is 99 (so D100 is the first packet sent, then D200, and so on).

Remember, TCP uses a sliding window and retransmits the packet containing the next expected byte on a timeout or, if TCP Fast Retransmit is enabled, when three duplicate acks are received. Assume here that TCP Fast Retransmit is not enabled. The initial transmission of packets D200 and D700 get dropped.

1.1 Fill in the below table with all packets sent by the sender until the receiver has received all packets and the sender knows that. For simplicity, assume that packets (data and ACKs) arrive in order. You may or may not need to fill in all lines.

Question 1 ANS

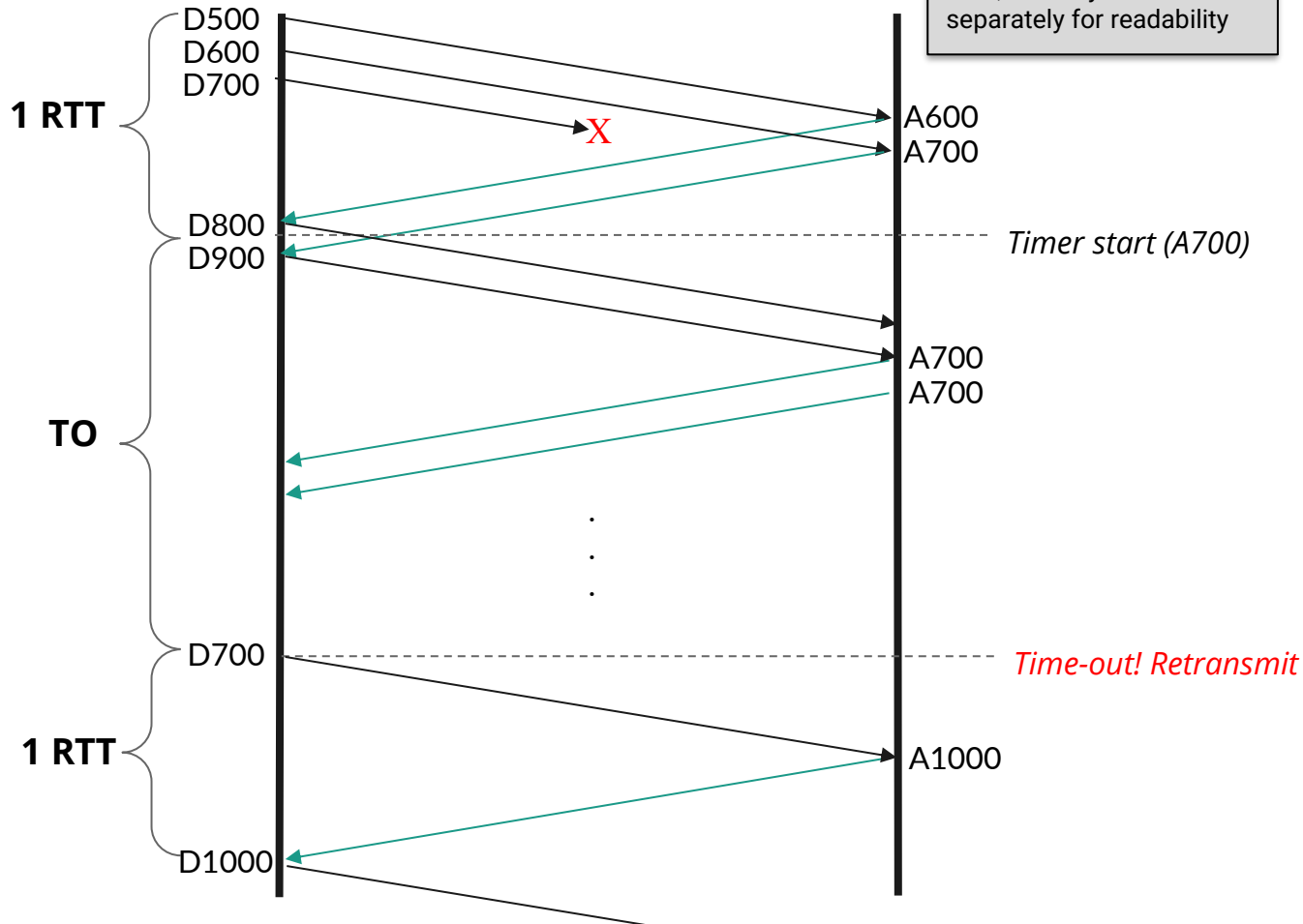
Note: Each batch (D100, D200, D300) is sent/received at the same time, but they are shown separately for readability



Index	Packet Data Offset	Sent on TO	Dropped?	Cumulative ACK
1	D100			A200
2	D200		X	
3	D300			A200
4	D400			A200
5	D200	X		A500
6	D500			A600
7	D600			A700
8	D700		X	
9	D800			A700
10	D900			A700
11	D700	X		A1000
12	D1000			A1100

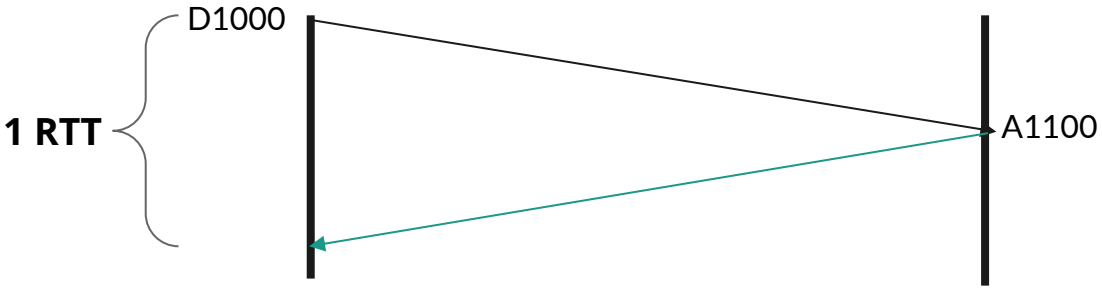
Question 1 ANS

Note: Each batch is sent/received at the same time, but they are shown separately for readability



Index	Packet Data Offset	Sent on TO	Dropped?	Cumulative ACK
1	D100			A200
2	D200		X	
3	D300			A200
4	D400			A200
5	D200	X		A500
6	D500			A600
7	D600			A700
8	D700		X	
9	D800			A700
10	D900			A700
11	D700	X		A1000
12	D1000			A1100

Question 1 ANS



1.2 If the RTT of the link is 10ms and the timeout is initially 3 seconds, what is the total time needed for the receiver to receive all packets and for the sender to know that? Assume small packets (negligible transmission delay) and negligible processing time, and that the estimates that go into the Retransmission Timeout (RTO) remain constant during the events below.

ANS: ACK progression: A200 → A500 → A700 → A1000 → A1100

- First loss (D200) → wait 1 RTO = 3 s
- Second loss (D700) → another 1 RTO = 3 s
- Normal ACK progress → 5 RTT = 50 ms
- Total Time = 2 * TO + 5 * RTT = 6.05 seconds
- Note: Each batch is sent/received at the same time, but they are shown separately for readability. Because D500 and D600 are sent at the same time, it takes 1 RTT from when we send D500 until we receive A700.

Question 2 TCP Calculations

2.1 Suppose two hosts are about to open a TCP connection. The TCP headers used in the communication are only 20 bytes long and regular (no-options) IPv4 is being used for Layer 3. If the MTU of the link is 1260 bytes, what is the MSS?

- ANS: 1220 bytes (payload) = 1260 bytes - 20 bytes (TCP header) - 20 bytes (IP header)

2.2 When this connection starts, the sender starts with an ISN 19. The initial window for the sender is set to 10 packets. Given the previously calculated MSS, what ACK does the sender receive as part of the TCP handshake? After that, what is the first and last ACK the sender receives for this initial window? (Assume no packets were lost or reordered).

- ANS: The ACK as part of the TCP handshake will be 20, because the receiver is ACKing having received the ISN. After that, the first ACK for real data sent by the sender will be 1240, which is the MSS (1220, calculated in the last problem) + the current sequence number, which is 20. The last ACK will be 12220, which is the next sequence number after all data is sent, 20+10×1220=12220.

2.3 What is the maximum theoretical throughput for this window size if: Window size:12200 bytes; RTT:40 ms?

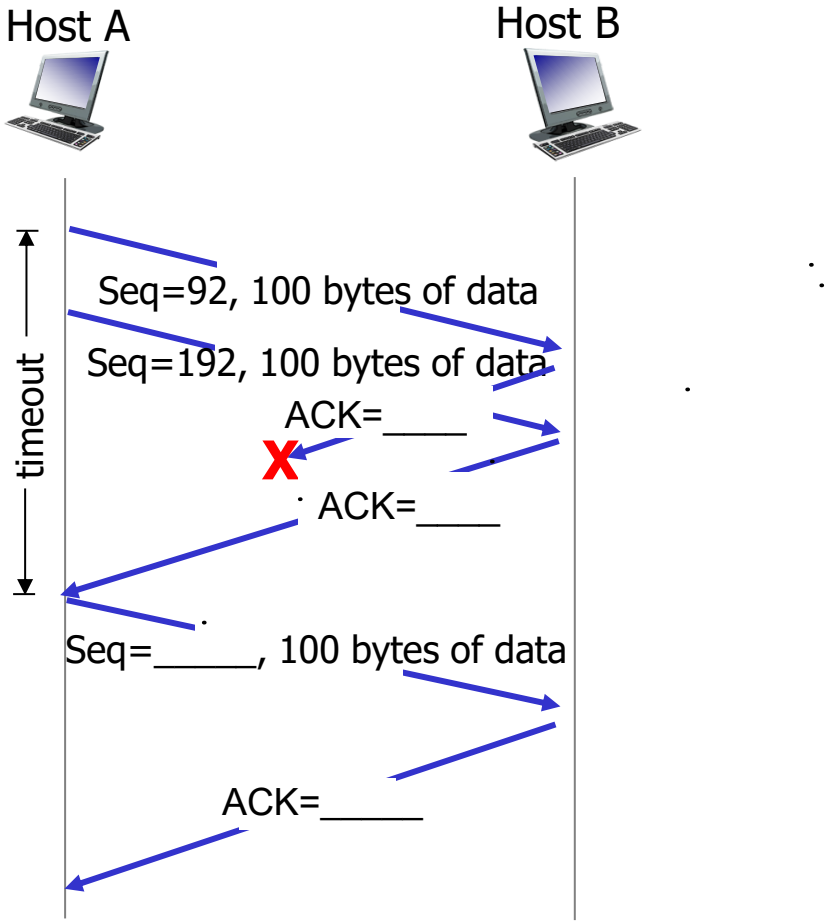
- ANS: Window (BDP) = 12200 bytes, RTT = 0.04 s
- Throughput (bandwidth) = 12200 / 0.04 = 305000 B/s = 305 KB/s

2.5 Assume 40msec is the Estimated_RTT. If the lowest bandwidth across this connection is 76.25 MB/s, what is the smallest window that optimizes the question?

- ANS: Bandwidth = 76.25 MB/s, RTT = 0.04 s
- Minimum window (BDP) = 76.25 × 0.04 = 3.05 MB

Q. Lost ACK

- Fill in the byte numbers



Q. Lost ACK ANS