

# Assignment Report: PA 2 - B

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## ***Design***

My program is written in Java, and is basically designed as depicted in diagrams 3.20 and 3.21 (page 221) of the book. Naturally my program implements all the methods required by the assignment. Note that in order to display all my statistics at the *end* of program execution, I chose to override the `runSimulator()` method.

Fortunately I don't feel like I really had to make any design tradeoffs. I simply re-read section 3.4.3 in the book that describes the Go-Back-N protocol, then developed the protocol.

One area of my program known to produce mixed results is the loss/corruption statistics reporting. This may be due in part to the program completing execution before the timeout for a given lost packet has occurred.

## ***Testing***

I tested with different numbers of messages (10, 100, 1000, and even 10000), a variety of loss/corruption levels, and several timeout values. After executing a test, I always calculated my statistics to ensure that they were at the (approximately) correct levels.

## ***Output***

Below is the entire output of my program when 20 messages have been successfully transferred from sender to receiver with a loss probability of 0.1, a corruption probability of 0.1, an average time between messages of 10, and a log level of 2. My annotations for this report appear in the output enclosed in { red curly braces }:

```
Network Simulator v1.0
Enter number of messages to simulate (> 0): [10] 20
Enter the packet loss probability (0.0 for no loss): [0.0] 0.1
Enter the packet corruption probability (0.0 for no corruption): [0.0] 0.1
Enter the average time between messages from sender's layer 5 (> 0.0): [1000]
10
Enter trace level (>= 0): [0] 2
Enter random seed: [random]
SIDE A: Initializing base to 0.
SIDE A: Initializing next sequence number to 0.
SIDE A: Initializing window size to 8.
SIDE A: Initializing message buffer capacity to 50.
SIDE B: Initializing expected sequence number to 0.
```

EVENT time: 14.221234577788206 type: 1 entity: 0  
SIDE A: Received message from layer 5 (aaaaaaaaaaaaaaaaaaaaa)  
SIDE A: Sending packet 0 to side B.  
SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 18.354324506025154 type: 2 entity: 1  
SIDE B: Received packet 0 from side A via layer 3 (aaaaaaaaaaaaaaaaaaaaa).  
SIDE B: Packet 0 is valid. Delivering to layer 5 and sending ACK.  
toLayer3: packet being corrupted  
**{ Side B has failed to verify the very first packet. }**

EVENT time: 20.598331960789025 type: 1 entity: 0  
SIDE A: Received message from layer 5 (bbbbbbbbbbbbbbbbbbbbbb)  
SIDE A: Sending packet 1 to side B.  
toLayer3: packet being corrupted  
SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 21.28062605134601 type: 1 entity: 0  
SIDE A: Received message from layer 5 (cccccccccccccccccccc)  
SIDE A: Sending packet 2 to side B.  
SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 21.5818860555404 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet from side B is corrupt. Waiting for timeout.

EVENT time: 24.19282426233794 type: 2 entity: 1  
SIDE B: Received packet 1 from side A via layer 3 (?b).  
SIDE B: Packet 1 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 27.212002570656143 type: 2 entity: 1  
SIDE B: Received packet 2 from side A via layer 3 (cccccccccccccccccccc).  
SIDE B: Packet 2 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 29.625061048710368 type: 1 entity: 0  
SIDE A: Received message from layer 5 (dddddddddddddddddddd)  
SIDE A: Sending packet 3 to side B.  
toLayer3: packet being lost  
SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 32.496238042011015 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 0 acknowledged from side B.

EVENT time: 32.88499133871509 type: 1 entity: 0  
SIDE A: Received message from layer 5 (eeeeeeeeeeeeeeeeeeee)  
SIDE A: Sending packet 4 to side B.  
toLayer3: packet being lost  
SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 34.17222196296806 type: 1 entity: 0  
SIDE A: Received message from layer 5 (ffffffffffffffffffffff)  
SIDE A: Sending packet 5 to side B.  
SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 36.343606073456364 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 0 acknowledged from side B.

EVENT time: 37.6046359306143 type: 2 entity: 1  
SIDE B: Received packet 5 from side A via layer 3 (ffffffffffffffffffffff).  
SIDE B: Packet 5 is corrupt or duplicate. Sending duplicate ACK.  
toLayer3: packet being lost

EVENT time: 42.938179099441165 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (ggggggggggggggggggggg)  
 SIDE A: Sending packet 6 to side B.  
 SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 49.95342383935599 type: 2 entity: 1  
 SIDE B: Received packet 6 from side A via layer 3 (ggggggggggggggggggggg).  
 SIDE B: Packet 6 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 51.21152745657486 type: 2 entity: 0  
 SIDE A: Received packet from side B via layer 3.  
 SIDE A: Packet 0 acknowledged from side B.

EVENT time: 62.591890179762245 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (hhhhhhhhhhhhhhhhhhhh)  
 SIDE A: Sending packet 7 to side B.  
 SIDE A: Window and buffer are empty. No more packets to send.

EVENT time: 66.37866417072212 type: 2 entity: 1  
 SIDE B: Received packet 7 from side A via layer 3 (hhhhhhhhhhhhhhhhhhhh).  
 SIDE B: Packet 7 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 70.39852927072573 type: 2 entity: 0  
 SIDE A: Received packet from side B via layer 3.  
 SIDE A: Packet 0 acknowledged from side B.

EVENT time: 79.69809164351845 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (iiiiiiiiiiiiiiiiiiii)  
 SIDE A: Sending packet 8 to side B.

EVENT time: 84.51668708274875 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (jjjjjjjjjjjjjjjjjjjj)

EVENT time: 88.80482573152703 type: 2 entity: 1  
 SIDE B: Received packet 8 from side A via layer 3 (iiiiiiiiiiiiiiiiiiii).  
 SIDE B: Packet 8 is corrupt or duplicate. Sending duplicate ACK.  
 toLayer3: packet being lost

EVENT time: 97.04336682368624 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (kkkkkkkkkkkkkkkkkkkk)

EVENT time: 112.82481576457447 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (llllllllllllllllllllll)

EVENT time: 123.81170838342251 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (mmmmmmmmmmmmmmmmmmmm)

EVENT time: 138.8243946115705 type: 1 entity: 0  
 SIDE A: Received message from layer 5 (nnnnnnnnnnnnnnnnnnnn)

**{ Side A finally times out and retransmits starting at packet 1. }**

EVENT time: 144.2212345777882 type: 0 entity: 0  
 SIDE A: Timer interrupt.  
 SIDE A: Retransmitting unacknowledged packet 1.  
 SIDE A: Retransmitting unacknowledged packet 2.  
 SIDE A: Retransmitting unacknowledged packet 3.  
 toLayer3: packet being corrupted  
 SIDE A: Retransmitting unacknowledged packet 4.  
 SIDE A: Retransmitting unacknowledged packet 5.  
 toLayer3: packet being corrupted  
 SIDE A: Retransmitting unacknowledged packet 6.  
 SIDE A: Retransmitting unacknowledged packet 7.

SIDE A: Retransmitting unacknowledged packet 8.

EVENT time: 148.93833870980433 type: 1 entity: 0  
SIDE A: Received message from layer 5 (oooooooooooooooooooo)

EVENT time: 151.9004793886454 type: 2 entity: 1  
SIDE B: Received packet 1 from side A via layer 3 (bbbbbbbbbbbbbbbbbbbb).  
SIDE B: Packet 1 is valid. Delivering to layer 5 and sending ACK.

EVENT time: 156.85837448220252 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 1 acknowledged from side B.

EVENT time: 160.1380497887481 type: 2 entity: 1  
SIDE B: Received packet 2 from side A via layer 3 (cccccccccccccccccccc).  
SIDE B: Packet 2 is valid. Delivering to layer 5 and sending ACK.

EVENT time: 164.7075960759307 type: 1 entity: 0  
SIDE A: Received message from layer 5 (ppppppppppppppppppppp)  
SIDE A: Sending packet 9 to side B.

EVENT time: 165.45147243234365 type: 2 entity: 1  
SIDE B: Received packet 1008633697 from side A via layer 3  
(dddddddddddddddddddd).  
SIDE B: Packet 1008633697 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 169.39202424129135 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 2 acknowledged from side B.

EVENT time: 170.89016128177116 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 2 acknowledged from side B.

EVENT time: 171.44345065424358 type: 2 entity: 1  
SIDE B: Received packet 4 from side A via layer 3 (eeeeeeeeeeeeeeeeeeee).  
SIDE B: Packet 4 is corrupt or duplicate. Sending duplicate ACK.  
toLayer3: packet being corrupted

EVENT time: 172.93131758905398 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet from side B is corrupt. Waiting for timeout.

EVENT time: 176.7053575367576 type: 2 entity: 1  
SIDE B: Received packet 5 from side A via layer 3 (ffffffffffffffffffff).  
SIDE B: Packet 5 is corrupt or duplicate. Sending duplicate ACK.  
toLayer3: packet being lost

EVENT time: 181.87458108190262 type: 2 entity: 1  
SIDE B: Received packet 6 from side A via layer 3 (gggggggggggggggggggg).  
SIDE B: Packet 6 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 183.4571110875115 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 2 acknowledged from side B.

EVENT time: 183.62168128730414 type: 1 entity: 0  
SIDE A: Received message from layer 5 (qqqqqqqqqqqqqqqqqqqq)  
SIDE A: Sending packet 10 to side B.

EVENT time: 184.80153872055425 type: 1 entity: 0  
SIDE A: Received message from layer 5 (rrrrrrrrrrrrrrrrrrrrr)

EVENT time: 185.34339917829018 type: 2 entity: 1  
SIDE B: Received packet 7 from side A via layer 3 (hhhhhhhhhhhhhhhhhh).  
SIDE B: Packet 7 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 187.8406086833059 type: 2 entity: 1  
SIDE B: Received packet 8 from side A via layer 3 (iiiiiiiiiiiiiiiiiii).  
SIDE B: Packet 8 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 188.85544682398387 type: 1 entity: 0  
SIDE A: Received message from layer 5 (ssssssssssssssssssss)

EVENT time: 191.30870953815318 type: 2 entity: 1  
SIDE B: Received packet 9 from side A via layer 3 (jjjjjjjjjjjjjjjjjj).  
SIDE B: Packet 9 is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 191.36567159406565 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 2 acknowledged from side B.

EVENT time: 193.2771730596909 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 2 acknowledged from side B.

EVENT time: 193.40537932428253 type: 2 entity: 1  
SIDE B: Received packet 10 from side A via layer 3 (kkkkkkkkkkkkkkkkkkk).  
SIDE B: Packet 10 is corrupt or duplicate. Sending duplicate ACK.  
toLayer3: packet being lost

EVENT time: 195.31161131184317 type: 2 entity: 0  
SIDE A: Received packet from side B via layer 3.  
SIDE A: Packet 2 acknowledged from side B.

EVENT time: 204.06199732088265 type: 1 entity: 0  
SIDE A: Received message from layer 5 (tttttttttttttttttttt)

EVENT time: 207.30638574866666 type: 1 entity: 0

===== STATISTICS =====

Number of original data packets transmitted:	20
Number of data packets retransmitted:	8
Number of ACK packets:	17
Number of corrupt packets received:	5
Number of packets lost:	6
Average RTT:	37.826565763340994

Below are the statistics output by my program after transmitting 1000 messages, with a loss probability of 0.1 (10%) and a corruption probability of 0.15 (15%). Note that the number of original packets transmitted by side A is less than 1000 because my logging delays (mentioned previously) led to about 0.8% of packets from layer 5 being dropped because the previous message was still in transit:

===== STATISTICS =====

Number of original data packets transmitted:	262
Number of data packets retransmitted:	600
Number of ACK packets:	706
Number of corrupt packets received:	210
Number of packets lost:	179
Average RTT:	41.26886384278235

As you can see, the total number of packets transmitted was 1568 (262 original data + 600 retransmitted data + 706 ACK = 1568). The number of lost packets (179) divided by the total (1568) is approximately 11%. The number of non-lost packets (1568 - 179 = 1389) divided by the number of corrupt packets (210) is approximately 15%. Thus it appears that my program is fairly accurately simulating the loss and corruption probabilities.