Assignment Report: PA 2 - A

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Design

My program is written in Java, and is basically designed as depicted in the diagram for rdt3.0 (page 215 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 the sections in the book that describe the alternating-bit protocol, then developed each stage of the protocol (1.0, 2.0, 2.1, 2.2, and finally 3.0).

I have noticed one situation in which my program behaves in a way that might be different than expected: When the logging level is high, my program drops about 2% of messages from layer 5 on side A because the previous message is still in transit. I decided to intentionally leave my program functioning this way (instead of increasing its timeout) because I think it provides a nice illustration of how debugging can affect program performance.

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

Following is the output of my program when 10 messages have been ACKed by the receiver with a loss probability of 0.1, a corruption probability of 0.1, and a log level of 2. My annotations for this report appear in the output enclosed in { red curly braces }:

```
rob @ ~/UofU/classes/CS-4480/PA 2/bin $ java Project
Network Simulator v1.0
Enter number of messages to simulate (> 0): [10] 10
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]
Enter trace level (>= 0): [0] 2
Enter random seed: [random]
SIDE A: Initializing sequence number to 0.
```

```
SIDE A: Initializing message in transit to false.
SIDE B: Initializing expected sequence number to 0.

EVENT time: 1300.980513423907  type: 1  entity: 0
SIDE A: Received message from layer 5 (aaaaaaaaaaaaaaaaaaaa)
SIDE A: Making packet destined for side B.

EVENT time: 1304.9891944851595  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (aaaaaaaaaaaaaaaaaaaa).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 1312.8324306509921  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 2685.466965515051  type: 1  entity: 0
SIDE A: Received message from layer 5 (bbbbbbbbbbbbbbbbbbbb)
SIDE A: Making packet destined for side B.
toLayer3: packet being lost
```

{ Here you can see that side A recovers from a lost packet by retransmitting after timeout. }

```
EVENT time: 2710.466965515051  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 2713.8404551462845  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (bbbbbbbbbbbbbbbbbbbb).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 2721.180968651743  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 4516.352753089735  type: 1  entity: 0
SIDE A: Received message from layer 5 (cccccccccccccccccccc)
SIDE A: Making packet destined for side B.

EVENT time: 4519.099107159598  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (cccccccccccccccccccc).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 4528.3225652264155  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 5080.110508881223  type: 1  entity: 0
SIDE A: Received message from layer 5 (ddddddddddddddddddddd)
SIDE A: Making packet destined for side B.

EVENT time: 5082.202100654711  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (ddddddddddddddddddddd).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 5089.235060070363  type: 2  entity: 0
```

```
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 6937.162015314139  type: 1  entity: 0
SIDE A: Received message from layer 5 (eeeeeeeeeeeeeeeeeeee)
SIDE A: Making packet destined for side B.
toLayer3: packet being lost

EVENT time: 6962.162015314139  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 6971.955996199901  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (eeeeeeeeeeeeeeeeeeee).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 6980.739579401438  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 8868.583238168414  type: 1  entity: 0
SIDE A: Received message from layer 5 (fffffffffffffffffff)
SIDE A: Making packet destined for side B.
toLayer3: packet being corrupted
```

{ Here you can see that side B recovers from packet corruption by sending a duplicate ACK. }

```
EVENT time: 8876.946773023532  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (?f).
SIDE B: Packet from side A is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 8884.870691152564  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet sent to side B was corrupt. Waiting for timeout.

EVENT time: 8893.583238168414  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 8902.200149059143  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (fffffffffffffffffff).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 8907.562473365773  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 9165.687600007086  type: 1  entity: 0
SIDE A: Received message from layer 5 (ggggggggggggggggggg)
SIDE A: Making packet destined for side B.
toLayer3: packet being lost
```

{ Again side A recovers from a lost packet by retransmitting after timeout. }

```
EVENT time: 9190.687600007086  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 9198.831655323107  type: 2  entity: 1
```

```
SIDE B: Received packet from side A via layer 3 (gggggggggggggggggggg).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.

EVENT time: 9203.08759545952  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 9381.571912470346  type: 1  entity: 0
SIDE A: Received message from layer 5 (hhhhhhhhhhhhhhhhhhhh)
SIDE A: Making packet destined for side B.

EVENT time: 9383.604943480917  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (hhhhhhhhhhhhhhhhhhhh).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.
toLayer3: packet being lost
```

{ Here side A recovers from a lost ACK by retransmitting after timeout. }

```
EVENT time: 9406.571912470346  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 9411.6738872169  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (hhhhhhhhhhhhhhhhhhhh).
SIDE B: Packet from side A is corrupt or duplicate. Sending duplicate ACK.
toLayer3: packet being corrupted
```

{ Here side A recovers from a corrupted ACK by retransmitting. }

```
EVENT time: 9414.640247911184  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: 9431.571912470346  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 9436.556039434361  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (hhhhhhhhhhhhhhhhhhhh).
SIDE B: Packet from side A is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 9442.209030123706  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 11253.035092057507  type: 1  entity: 0
SIDE A: Received message from layer 5 (iiiiiiiiiiiiiiiiiiii)
SIDE A: Making packet destined for side B.
```

{ Here side A recovers from a lost ACK followed immediately by a lost retransmission! }

```
EVENT time: 11258.297036834912  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (iiiiiiiiiiiiiiiiiiii).
SIDE B: Packet from side A is valid. Delivering to layer 5 and sending ACK.
SIDE B: Making packet destined for side A.
toLayer3: packet being lost
```

```
EVENT time: 11278.035092057507  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.
toLayer3: packet being lost

EVENT time: 11303.035092057507  type: 0  entity: 0
SIDE A: Timer interrupt. Retransmitting last packet.

EVENT time: 11309.852775783384  type: 2  entity: 1
SIDE B: Received packet from side A via layer 3 (iiiiiiiiiiiiiiiiiii).
SIDE B: Packet from side A is corrupt or duplicate. Sending duplicate ACK.

EVENT time: 11313.692351610529  type: 2  entity: 0
SIDE A: Received packet from side B via layer 3.
SIDE A: Last packet acknowledged from side B.

EVENT time: 11423.852013722497  type: 1  entity: 0
SIDE A: Received message from layer 5 (jjjjjjjjjjjjjjjjjjj)
SIDE A: Making packet destined for side B.

EVENT time: 11425.648340458562  type: 2  entity: 1

========== STATISTICS ==========

Number of original data packets transmitted:    10
Number of data packets retransmitted:           8
Number of ACK packets:                          13
Number of corrupt packets received:             2
Average RTT:                                    12.206113096187044
```

Following 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:    992
Number of data packets retransmitted:           682
Number of ACK packets:                          1499
Number of corrupt packets received:             437
Average RTT:                                    11.072440496693925
```

As you can see, the total number of packets transmitted was 3173 (992 original data + 682 retransmitted data + 1499 ACK = 3173). By subtracting the number of corrupt packets (437) from the number of packets retransmitted (682), we see that 245 packets, or approximately 8%, were lost. Of the remaining non-lost 2928 packets, about 14.9% were corrupted (437). It appears that my program is fairly accurately simulating the loss and corruption probabilities.