**CS422 Lab 2: Reliable Transport Protocol**

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**Part A: Implementation**

I implemented the RDT 3.0 protocol (alternating-bit) in prog\_rdt.c. Key features:

* Sender (A) uses a queue to buffer messages from layer 5 while waiting for ACKs.
* Sequence numbers alternate between 0 and 1.
* Checksum is the sum of seqnum, acknum, and payload bytes (as unsigned char).
* Timeout set to 15.0 time units.
* Receiver (B) delivers only in-order, non-corrupt packets to layer 5 and sends ACKs (acknum = received seqnum for good packets, or last good for duplicates).
* No NAKs; discards corrupt packets.
* Debug prints added for TRACE >= 2 to show actions.
* Added A\_sent counter for Part C.

The code handles losses and corruptions via timeouts and retransmissions, as seen in the sample outputs.

**Part B: Sample Outputs**

1. No loss, no corruption

➜ lab2-code-c 👾 make

gcc -Wall -Wextra -g prog\_rdt.c -o prog\_rdt

➜ lab2-code-c 👾 ./prog\_rdt

----- Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 5

Enter packet loss probability [enter 0.0 for no loss]:0

Enter packet corruption probability [0.0 for no corruption]:0

Enter average time between messages from sender's layer5 [ > 0.0]:100

Enter TRACE:2

EVENT time: 69.657104, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: aaaaaaaaaaaaaaaaaaaa

EVENT time: 72.548187, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

B\_input: correct seq=0, delivering to layer5: aaaaaaaaaaaaaaaaaaaa, sending ACK 0

EVENT time: 77.306335, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

EVENT time: 143.395233, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: bbbbbbbbbbbbbbbbbbbb

EVENT time: 151.621658, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

B\_input: correct seq=1, delivering to layer5: bbbbbbbbbbbbbbbbbbbb, sending ACK 1

EVENT time: 158.395233, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

EVENT time: 161.324890, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: correct ACK for seq=1, stopping timer, flipping seq to 0

EVENT time: 163.015137, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

B\_input: wrong seq (expected 0), sending duplicate ACK 1

EVENT time: 164.169830, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: wrong ACK (expected 0), ignored

EVENT time: 305.496277, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: cccccccccccccccccccc

EVENT time: 305.800812, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: dddddddddddddddddddd

A\_output: sender busy, queued the message

EVENT time: 311.665894, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1980 payload=cccccccccccccccccccc

B\_input: correct seq=0, delivering to layer5: cccccccccccccccccccc, sending ACK 0

EVENT time: 317.508850, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

EVENT time: 325.657684, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

B\_input: correct seq=1, delivering to layer5: dddddddddddddddddddd, sending ACK 1

EVENT time: 331.609467, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: correct ACK for seq=1, stopping timer, flipping seq to 0

EVENT time: 424.283875, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: eeeeeeeeeeeeeeeeeeee

EVENT time: 425.307770, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=2020 payload=eeeeeeeeeeeeeeeeeeee

B\_input: correct seq=0, delivering to layer5: eeeeeeeeeeeeeeeeeeee, sending ACK 0

EVENT time: 433.774841, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

Simulator terminated at time 433.774841

after sending 5 msgs from layer5

A sent 6 packets from layer 3

2. Loss probability 0.3, no corruption.

➜ lab2-code-c 👾 ./prog\_rdt

----- Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 5

Enter packet loss probability [enter 0.0 for no loss]:0.3

Enter packet corruption probability [0.0 for no corruption]:0

Enter average time between messages from sender's layer5 [ > 0.0]:100

Enter TRACE:2

EVENT time: 69.657104, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: aaaaaaaaaaaaaaaaaaaa

EVENT time: 72.548187, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

B\_input: correct seq=0, delivering to layer5: aaaaaaaaaaaaaaaaaaaa, sending ACK 0

EVENT time: 77.306335, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

EVENT time: 143.395233, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: bbbbbbbbbbbbbbbbbbbb

EVENT time: 151.621658, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

B\_input: correct seq=1, delivering to layer5: bbbbbbbbbbbbbbbbbbbb, sending ACK 1

TOLAYER3: packet being lost

EVENT time: 158.395233, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

EVENT time: 166.697159, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

B\_input: wrong seq (expected 0), sending duplicate ACK 1

EVENT time: 173.395233, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

TOLAYER3: packet being lost

EVENT time: 176.485580, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: correct ACK for seq=1, stopping timer, flipping seq to 0

EVENT time: 305.496277, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: cccccccccccccccccccc

EVENT time: 312.449646, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1980 payload=cccccccccccccccccccc

B\_input: correct seq=0, delivering to layer5: cccccccccccccccccccc, sending ACK 0

TOLAYER3: packet being lost

EVENT time: 320.496277, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=0 ack=0 checksum=1980 payload=cccccccccccccccccccc

EVENT time: 328.013489, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1980 payload=cccccccccccccccccccc

B\_input: wrong seq (expected 1), sending duplicate ACK 0

EVENT time: 334.888245, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

EVENT time: 499.391693, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: dddddddddddddddddddd

TOLAYER3: packet being lost

EVENT time: 514.391724, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

EVENT time: 517.212952, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

B\_input: correct seq=1, delivering to layer5: dddddddddddddddddddd, sending ACK 1

TOLAYER3: packet being lost

EVENT time: 529.391724, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

EVENT time: 536.072144, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

B\_input: wrong seq (expected 0), sending duplicate ACK 1

EVENT time: 542.413818, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: correct ACK for seq=1, stopping timer, flipping seq to 0

EVENT time: 682.774231, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: eeeeeeeeeeeeeeeeeeee

EVENT time: 690.262329, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=2020 payload=eeeeeeeeeeeeeeeeeeee

B\_input: correct seq=0, delivering to layer5: eeeeeeeeeeeeeeeeeeee, sending ACK 0

TOLAYER3: packet being lost

EVENT time: 697.774231, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=0 ack=0 checksum=2020 payload=eeeeeeeeeeeeeeeeeeee

EVENT time: 704.788330, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=2020 payload=eeeeeeeeeeeeeeeeeeee

B\_input: wrong seq (expected 1), sending duplicate ACK 0

EVENT time: 709.387756, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

Simulator terminated at time 709.387756

after sending 5 msgs from layer5

A sent 11 packets from layer 3

3. Corruption probability 0.3, no loss.

➜ lab2-code-c 👾 ./prog\_rdt

----- Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 5

Enter packet loss probability [enter 0.0 for no loss]:0

Enter packet corruption probability [0.0 for no corruption]:0.3

Enter average time between messages from sender's layer5 [ > 0.0]:100

Enter TRACE:2

EVENT time: 69.657104, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: aaaaaaaaaaaaaaaaaaaa

EVENT time: 72.548187, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

B\_input: correct seq=0, delivering to layer5: aaaaaaaaaaaaaaaaaaaa, sending ACK 0

TOLAYER3: packet being corrupted

EVENT time: 77.306335, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=Z

A\_input: packet corrupt, ignored

EVENT time: 84.657104, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

EVENT time: 94.185234, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

B\_input: wrong seq (expected 1), sending duplicate ACK 0

EVENT time: 99.657104, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

EVENT time: 103.888474, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

EVENT time: 104.277016, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1940 payload=aaaaaaaaaaaaaaaaaaaa

B\_input: wrong seq (expected 1), sending duplicate ACK 0

EVENT time: 105.431709, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: wrong ACK (expected 1), ignored

EVENT time: 143.395233, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: bbbbbbbbbbbbbbbbbbbb

EVENT time: 143.699783, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: cccccccccccccccccccc

A\_output: sender busy, queued the message

EVENT time: 149.564850, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=1961 payload=bbbbbbbbbbbbbbbbbbbb

B\_input: correct seq=1, delivering to layer5: bbbbbbbbbbbbbbbbbbbb, sending ACK 1

EVENT time: 155.407806, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: correct ACK for seq=1, stopping timer, flipping seq to 0

TOLAYER3: packet being corrupted

EVENT time: 163.556625, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=999999 checksum=1980 payload=cccccccccccccccccccc

B\_input: packet corrupt, discarded

EVENT time: 170.407806, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=0 ack=0 checksum=1980 payload=cccccccccccccccccccc

EVENT time: 173.229004, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=1980 payload=cccccccccccccccccccc

B\_input: correct seq=0, delivering to layer5: cccccccccccccccccccc, sending ACK 0

EVENT time: 179.853607, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

EVENT time: 262.182861, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: dddddddddddddddddddd

EVENT time: 266.287964, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

B\_input: correct seq=1, delivering to layer5: dddddddddddddddddddd, sending ACK 1

TOLAYER3: packet being corrupted

EVENT time: 273.776062, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=Z

A\_input: packet corrupt, ignored

EVENT time: 277.182861, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

TOLAYER3: packet being corrupted

EVENT time: 284.196991, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=Zddddddddddddddddddd

B\_input: packet corrupt, discarded

EVENT time: 292.182861, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

EVENT time: 299.489807, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

B\_input: wrong seq (expected 0), sending duplicate ACK 1

EVENT time: 307.182861, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

EVENT time: 309.073608, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=1 ack=0 checksum=2001 payload=dddddddddddddddddddd

B\_input: wrong seq (expected 0), sending duplicate ACK 1

EVENT time: 309.160431, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: correct ACK for seq=1, stopping timer, flipping seq to 0

EVENT time: 312.863281, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=1 checksum=1 payload=

A\_input: wrong ACK (expected 0), ignored

EVENT time: 312.916260, type: 1, fromlayer5 entity: 0

A\_output: received message from layer5: eeeeeeeeeeeeeeeeeeee

TOLAYER3: packet being corrupted

EVENT time: 315.908875, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=2020 payload=Zeeeeeeeeeeeeeeeeeee

B\_input: packet corrupt, discarded

EVENT time: 327.916260, type: 0, timerinterrupt entity: 0

A\_timerinterrupt: timeout, retransmitting packet seq=0 ack=0 checksum=2020 payload=eeeeeeeeeeeeeeeeeeee

EVENT time: 334.864685, type: 2, fromlayer3 entity: 1

B\_input: received packet seq=0 ack=0 checksum=2020 payload=eeeeeeeeeeeeeeeeeeee

B\_input: correct seq=0, delivering to layer5: eeeeeeeeeeeeeeeeeeee, sending ACK 0

EVENT time: 342.051514, type: 2, fromlayer3 entity: 0

A\_input: received packet seq=0 ack=0 checksum=0 payload=

A\_input: correct ACK for seq=0, stopping timer, flipping seq to 1

Simulator terminated at time 342.051514

after sending 5 msgs from layer5

A sent 12 packets from layer 3

**Part C: Experiments**

1. Varying Packet Loss Probability (corruptprob=0, lambda=1000, nsimmax=10):

lossprob=0: 10.0

lossprob=0.2: 14.9

lossprob=0.4: 26.5

lossprob=0.6: 64.2

A graph with blue squares

AI-generated content may be incorrect.

2. Varying Packet Corruption Probability (lossprob=0, lambda=1000, nsimmax=10):

corruptprob=0: 10.0

corruptprob=0.2: 15.4

corruptprob=0.4: 32.4

corruptprob=0.6: 66.3

A graph with red squares

AI-generated content may be incorrect.

3. Impact Comparison:

Packet loss and corruption have very similar impacts on the number of packets sent from layer 3. In RDT 3.0, both lead to the same outcome: no valid ACK reaches the sender, triggering a timeout and retransmission. Loss prevents packet arrival, while corruption causes the receiver/sender to discard it. Thus, the protocol handles them equivalently, resulting in comparable average transmission counts for the same probability values. The slight differences in averages are due to random simulation variability.