Project 2: Transmission Control Protocol

Computer Networks (CS-UH 3012) - Summer 2022

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In this project, we used Go Back N pipelining strategy to send multiple packets. The window size is 10, but can be changed, as it is defined as a global variable. The sender starts by sending 10 packets at first. Upon receiving acknowledgement, it immediately sends a packet thus ensuing that there are always 10 packets in the pipeline. When there is a timeout due to packet loss, sender sends all the packets in the current window. On the receiver's end, it only accepts in order packets and discards out of order packets. While it sends acknowledgement for every packet received, it only writes the data packets to file which arrive in order. As a buffer was not a requirement for the project, we simply discarded the out of order packets. Sender transfer window moves only if it receives correct acknowledgement for the last packet sent.

Following screenshots show the sender and receiver in action:

Test 1: small file: low delay and low losses

```
user@ubuntu:~/Desktop/NWagain/obj$ ./rdt_receiver 5001 recv.t       [delay 100 ms] [loss up=0.3] [loss down=0.2] user@ubuntu:~/Desktop/NWagain/o
xt                                                                  bj$ ./rdt_sender $MAHIMAHI_BASE 5001 smallfile.txt
Epoch time, Bytes received, Sequence number(PackNum)               Sending packet 0 (0) to 100.64.0.3
                                                                   Sending packet 1456 (1) to 100.64.0.3
Writing in file: 1657301109, 1456, 0 (0)                           Sending packet 2912 (2) to 100.64.0.3
Writing in file: 1657301109, 1456, 1456 (1)                        End Of File has been reached
Writing in file: 1657301109, 907, 2912 (2)                         Timeout.
                                                                   Resending pack 0, (0)
EOF packet received.                                               Resending pack 1456, (1)
user@ubuntu:~/Desktop/NWagain/obj$ []                              Resending pack 2912, (2)
                                                                   0, Ack Num: 1456, for (0)
                                                                   Timeout.
                                                                   Resending pack 1456, (1)
                                                                   Resending pack 2912, (2)
                                                                   Timeout.
                                                                   Resending pack 1456, (1)
                                                                   Resending pack 2912, (2)
                                                                   Timeout.
                                                                   Resending pack 1456, (1)
                                                                   Resending pack 2912, (2)
                                                                   0, Ack Num: 2912, for (1)
                                                                   0, Ack Num: 3819, for (2)

                                                                   Sending EOF packet and exiting.
                                                                   [delay 100 ms] [loss up=0.3] [loss down=0.2] user@ubuntu:~/Desktop/NWagain/o
                                                                   $ []
```

Test 2: medium size file: low delay and low losses

```
user@ubuntu:~/Desktop/NWagain/obj$ ./rdt_recei
ver 5001 recv.txt
Epoch time, Bytes received, Sequence number(Pa
ckNum)

Writing in file: 1657301462, 1456, 0 (0)
Writing in file: 1657301462, 1456, 1456 (1)
Writing in file: 1657301462, 1456, 2912 (2)
Writing in file: 1657301462, 1456, 4368 (3)
Writing in file: 1657301462, 1456, 5824 (4)
Writing in file: 1657301463, 1456, 7280 (5)
Writing in file: 1657301463, 1456, 8736 (6)
Writing in file: 1657301463, 1456, 10192 (7)
Writing in file: 1657301463, 1456, 11648 (8)
Writing in file: 1657301463, 1456, 13104 (9)
Writing in file: 1657301463, 1456, 14560 (10)
Writing in file: 1657301463, 1456, 16016 (11)
Writing in file: 1657301463, 1456, 17472 (12)
Writing in file: 1657301463, 1456, 18928 (13)
Writing in file: 1657301463, 1456, 20384 (14)
Writing in file: 1657301463, 1456, 21840 (15)
Writing in file: 1657301463, 1456, 23296 (16)
Writing in file: 1657301463, 1456, 24752 (17)
Writing in file: 1657301463, 419, 26208 (18)

EOF packet received.
user@ubuntu:~/Desktop/NWagain/obj$ 
```

```
[delay 80 ms] [loss up=0.1] [loss down=0.25] us
er@ubuntu:~/Desktop/NWagain/obj$ ./rdt_sender $
MAHIMAHI_BASE 5001 sendfile.txt
Sending packet 0 (0) to 100.64.0.3
Sending packet 1456 (1) to 100.64.0.3
Sending packet 2912 (2) to 100.64.0.3
Sending packet 4368 (3) to 100.64.0.3
Sending packet 5824 (4) to 100.64.0.3
Sending packet 7280 (5) to 100.64.0.3
Sending packet 8736 (6) to 100.64.0.3
Sending packet 10192 (7) to 100.64.0.3
Sending packet 11648 (8) to 100.64.0.3
Sending packet 13104 (9) to 100.64.0.3
Timeout.
Resending pack 0, (0)
Resending pack 1456, (1)
Resending pack 2912, (2)
Resending pack 4368, (3)
Resending pack 5824, (4)
Resending pack 7280, (5)
Resending pack 8736, (6)
Resending pack 10192, (7)
Resending pack 11648, (8)
Resending pack 13104, (9)
0, Ack Num: 1456, for (0)
Sending packet 14560 (10) to 100.64.0.3
0, Ack Num: 2912, for (1)
Sending packet 16016 (11) to 100.64.0.3
Timeout.
Resending pack 2912, (2)
Resending pack 4368, (3)
Resending pack 5824, (4)
Resending pack 7280, (5)
Resending pack 8736, (6)
Resending pack 10192, (7)
Resending pack 11648, (8)
Resending pack 13104, (9)
Resending pack 14560, (10)
Resending pack 16016, (11)
0, Ack Num: 4368, for (2)
Sending packet 17472 (12) to 100.64.0.3
0, Ack Num: 5824, for (3)
Sending packet 18928 (13) to 100.64.0.3
Timeout.
Resending pack 5824, (4)
Resending pack 7280, (5)
Resending pack 8736, (6)
Resending pack 10192, (7)
Resending pack 11648, (8)
Resending pack 13104, (9)
Resending pack 14560, (10)
Resending pack 16016, (11)
Resending pack 17472, (12)
```

```
Resending pack 11648, (8)
Resending pack 13104, (9)
Resending pack 14560, (10)
Resending pack 16016, (11)
Resending pack 17472, (12)
Resending pack 18928, (13)
Resending pack 20384, (14)
Resending pack 21840, (15)
Resending pack 23296, (16)
0, Ack Num: 11648, for (7)
Sending packet 24752 (17) to 100.64.0.3
0, Ack Num: 13104, for (8)
Sending packet 26208 (18) to 100.64.0.3
0, Ack Num: 14560, for (9)
End Of File has been reached
0, Ack Num: 16016, for (10)
0, Ack Num: 17472, for (11)
Timeout.
Resending pack 17472, (12)
Resending pack 18928, (13)
Resending pack 20384, (14)
Resending pack 21840, (15)
Resending pack 23296, (16)
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 17472, (12)
Resending pack 18928, (13)
Resending pack 20384, (14)
Resending pack 21840, (15)
Resending pack 23296, (16)
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 17472, (12)
Resending pack 18928, (13)
Resending pack 20384, (14)
Resending pack 21840, (15)
Resending pack 23296, (16)
Resending pack 24752, (17)
Resending pack 26208, (18)
0, Ack Num: 18928, for (12)
0, Ack Num: 20384, for (13)
0, Ack Num: 21840, for (14)
0, Ack Num: 23296, for (15)
0, Ack Num: 24752, for (16)
0, Ack Num: 26208, for (17)
0, Ack Num: 26627, for (18)

Sending EOF packet and exiting.
[delay 80 ms] [loss up=0.1] [loss down=0.25] us
m:~/Desktop/NWagain/obj$ 
```

Test 3: large size file: low delay and low losses

```
Writing in file: 1657301693, 1456, 61152 (42)      Resending pack 116480, (80)
Writing in file: 1657301693, 1456, 62608 (43)      Resending pack 117936, (81)
Writing in file: 1657301693, 1456, 64064 (44)      Resending pack 119392, (82)
Writing in file: 1657301693, 1456, 65520 (45)      Resending pack 120848, (83)
Writing in file: 1657301693, 1456, 66976 (46)      Resending pack 122304, (84)
Writing in file: 1657301694, 1456, 68432 (47)      Resending pack 123760, (85)
Writing in file: 1657301695, 1456, 69888 (48)      Resending pack 125216, (86)
Writing in file: 1657301695, 1456, 71344 (49)      Resending pack 126672, (87)
Writing in file: 1657301695, 1456, 72800 (50)      Resending pack 128128, (88)
Writing in file: 1657301695, 1456, 74256 (51)      0, Ack Num: 116480, for (79)
Writing in file: 1657301695, 1456, 75712 (52)      Sending packet 129584 (89) to 100.64.0.3
Writing in file: 1657301695, 1456, 77168 (53)      Timeout.
Writing in file: 1657301695, 1456, 78624 (54)      Resending pack 116480, (80)
Writing in file: 1657301695, 1456, 80080 (55)      Resending pack 117936, (81)
Writing in file: 1657301695, 1456, 81536 (56)      Resending pack 119392, (82)
Writing in file: 1657301695, 1456, 82992 (57)      Resending pack 120848, (83)
Writing in file: 1657301695, 1456, 84448 (58)      Resending pack 122304, (84)
Writing in file: 1657301695, 1456, 85904 (59)      Resending pack 123760, (85)
Writing in file: 1657301695, 1456, 87360 (60)      Resending pack 125216, (86)
Writing in file: 1657301695, 1456, 88816 (61)      Resending pack 126672, (87)
Writing in file: 1657301695, 1456, 90272 (62)      Resending pack 128128, (88)
Writing in file: 1657301695, 1456, 91728 (63)      Resending pack 129584, (89)
Writing in file: 1657301695, 1456, 93184 (64)      0, Ack Num: 117936, for (80)
Writing in file: 1657301695, 1456, 94640 (65)      Sending packet 131040 (90) to 100.64.0.3
Writing in file: 1657301696, 1456, 96096 (66)      0, Ack Num: 119392, for (81)
Writing in file: 1657301696, 1456, 97552 (67)      Sending packet 132496 (91) to 100.64.0.3
Writing in file: 1657301696, 1456, 99008 (68)      0, Ack Num: 120848, for (82)
Writing in file: 1657301696, 1456, 100464 (69)     End Of File has been reached
Writing in file: 1657301696, 1456, 101920 (70)     0, Ack Num: 122304, for (83)
Writing in file: 1657301696, 1456, 103376 (71)     Timeout.
Writing in file: 1657301696, 1456, 104832 (72)     Resending pack 122304, (84)
Writing in file: 1657301696, 1456, 106288 (73)     Resending pack 123760, (85)
Writing in file: 1657301696, 1456, 107744 (74)     Resending pack 125216, (86)
Writing in file: 1657301696, 1456, 109200 (75)     Resending pack 126672, (87)
Writing in file: 1657301696, 1456, 110656 (76)     Resending pack 128128, (88)
Writing in file: 1657301696, 1456, 112112 (77)     Resending pack 129584, (89)
Writing in file: 1657301697, 1456, 113568 (78)     Resending pack 131040, (90)
Writing in file: 1657301697, 1456, 115024 (79)     Resending pack 132496, (91)
Writing in file: 1657301697, 1456, 116480 (80)     0, Ack Num: 123760, for (84)
Writing in file: 1657301697, 1456, 117936 (81)     0, Ack Num: 125216, for (85)
Writing in file: 1657301697, 1456, 119392 (82)     0, Ack Num: 126672, for (86)
Writing in file: 1657301698, 1456, 120848 (83)     0, Ack Num: 128128, for (87)
Writing in file: 1657301698, 1456, 122304 (84)     0, Ack Num: 129584, for (88)
Writing in file: 1657301698, 1456, 123760 (85)     0, Ack Num: 131040, for (89)
Writing in file: 1657301698, 1456, 125216 (86)     Timeout.
Writing in file: 1657301698, 1456, 126672 (87)     Resending pack 131040, (90)
Writing in file: 1657301698, 1456, 128128 (88)     Resending pack 132496, (91)
Writing in file: 1657301699, 1456, 129584 (89)     0, Ack Num: 132496, for (90)
Writing in file: 1657301699, 1456, 131040 (90)     0, Ack Num: 133027, for (91)
Writing in file: 1657301699, 531, 132496 (91)
                                                   Sending EOF packet and exiting.
EOF packet received.                               [delay 80 ms] [loss up=0.1] [loss_down=0.25] us
user@ubuntu:~/Desktop/NWagain/obj$ []             er@ubuntu:~/Desktop/NWagain/obj$ █
```

Test 4: small file: high delay and high losses

```
user@ubuntu:~/Desktop/NWagain/obj$ ./rdt_recei
ver 5001 recv.txt
Epoch time, Bytes received, Sequence number(Pa
ckNum)

Writing in file: 1657301823, 1456, 0 (0)
Writing in file: 1657301823, 1456, 1456 (1)
Writing in file: 1657301824, 907, 2912 (2)

EOF packet received.
user@ubuntu:~/Desktop/NWagain/obj$ 
```

```
[delay 120 ms] [loss up=0.6] [loss down=0.7] us
er@ubuntu:~/Desktop/NWagain/obj$ ./rdt_sender $
MAHIMAHI_BASE 5001 smallfile.txt
Sending packet 0 (0) to 100.64.0.3
Sending packet 1456 (1) to 100.64.0.3
Sending packet 2912 (2) to 100.64.0.3
End Of File has been reached
Timeout.
Resending pack 0, (0)
Resending pack 1456, (1)
Resending pack 2912, (2)
Timeout.
Resending pack 0, (0)
Resending pack 1456, (1)
Resending pack 2912, (2)
Timeout.
Resending pack 0, (0)
Resending pack 1456, (1)
Resending pack 2912, (2)
0, Ack Num: 1456, for (0)
0, Ack Num: 2912, for (1)
Timeout.
Resending pack 2912, (2)
Timeout.
Resending pack 2912, (2)
Timeout.
Resending pack 2912, (2)
0, Ack Num: 3819, for (2)

Sending EOF packet and exiting.
[delay 120 ms] [loss up=0.6] [loss down=0.7] us
er@ubuntu:~/Desktop/NWagain/obj$ 
```

Test 5: medium size file: high delay and high losses

```
user@ubuntu:~/Desktop/NWagain/obj$ ./rdt_recei
ver 5001 recv.txt
Epoch time, Bytes received, Sequence number(Pa
ckNum)

Writing in file: 1657301879, 1456, 0 (0)
Writing in file: 1657301879, 1456, 1456 (1)
Writing in file: 1657301880, 1456, 2912 (2)
Writing in file: 1657301880, 1456, 4368 (3)
Writing in file: 1657301880, 1456, 5824 (4)
Writing in file: 1657301880, 1456, 7280 (5)
Writing in file: 1657301880, 1456, 8736 (6)
Writing in file: 1657301881, 1456, 10192 (7)
Writing in file: 1657301881, 1456, 11648 (8)
Writing in file: 1657301881, 1456, 13104 (9)
Writing in file: 1657301881, 1456, 14560 (10)
Writing in file: 1657301881, 1456, 16016 (11)
Writing in file: 1657301881, 1456, 17472 (12)
Writing in file: 1657301882, 1456, 18928 (13)
Writing in file: 1657301883, 1456, 20384 (14)
Writing in file: 1657301885, 1456, 21840 (15)
Writing in file: 1657301886, 1456, 23296 (16)
Writing in file: 1657301886, 1456, 24752 (17)
Writing in file: 1657301886, 419, 26208 (18)

EOF packet received.
user@ubuntu:~/Desktop/NWagain/obj$
```

```
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
Timeout.
Resending pack 24752, (17)
Resending pack 26208, (18)
0, Ack Num: 26208, for (17)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
Timeout.
Resending pack 26208, (18)
0, Ack Num: 26627, for (18)

Sending EOF packet and exiting.
[delay 120 ms] [loss up=0.6] [loss down=0.7] us
er@ubuntu:~/Desktop/NWagain/obj$
```

Test 6: large size file: high delay and high losses

```
Writing in file: 1657302166, 1456, 61152 (42)      Resending pack 131040, (90)
Writing in file: 1657302168, 1456, 62608 (43)      Resending pack 132496, (91)
Writing in file: 1657302170, 1456, 64064 (44)      Timeout.
Writing in file: 1657302171, 1456, 65520 (45)      Resending pack 129584, (89)
Writing in file: 1657302171, 1456, 66976 (46)      Resending pack 131040, (90)
Writing in file: 1657302172, 1456, 68432 (47)      Resending pack 132496, (91)
Writing in file: 1657302172, 1456, 69888 (48)      0, Ack Num: 131040, for (89)
Writing in file: 1657302172, 1456, 71344 (49)      Timeout.
Writing in file: 1657302173, 1456, 72800 (50)      Resending pack 131040, (90)
Writing in file: 1657302174, 1456, 74256 (51)      Resending pack 132496, (91)
Writing in file: 1657302175, 1456, 75712 (52)      Timeout.
Writing in file: 1657302177, 1456, 77168 (53)      Resending pack 131040, (90)
Writing in file: 1657302178, 1456, 78624 (54)      Resending pack 132496, (91)
Writing in file: 1657302179, 1456, 80080 (55)      Timeout.
Writing in file: 1657302180, 1456, 81536 (56)      Resending pack 131040, (90)
Writing in file: 1657302181, 1456, 82992 (57)      Resending pack 132496, (91)
Writing in file: 1657302183, 1456, 84448 (58)      Timeout.
Writing in file: 1657302183, 1456, 85904 (59)      Resending pack 131040, (90)
Writing in file: 1657302183, 1456, 87360 (60)      Resending pack 132496, (91)
Writing in file: 1657302186, 1456, 88816 (61)      0, Ack Num: 132496, for (90)
Writing in file: 1657302188, 1456, 90272 (62)      Timeout.
Writing in file: 1657302191, 1456, 91728 (63)      Resending pack 132496, (91)
Writing in file: 1657302191, 1456, 93184 (64)      Timeout.
Writing in file: 1657302192, 1456, 94640 (65)      Resending pack 132496, (91)
Writing in file: 1657302192, 1456, 96096 (66)      Timeout.
Writing in file: 1657302194, 1456, 97552 (67)      Resending pack 132496, (91)
Writing in file: 1657302194, 1456, 99008 (68)      Timeout.
Writing in file: 1657302197, 1456, 100464 (69)     Resending pack 132496, (91)
Writing in file: 1657302198, 1456, 101920 (70)     Timeout.
Writing in file: 1657302198, 1456, 103376 (71)     Resending pack 132496, (91)
Writing in file: 1657302199, 1456, 104832 (72)     Timeout.
Writing in file: 1657302199, 1456, 106288 (73)     Resending pack 132496, (91)
Writing in file: 1657302201, 1456, 107744 (74)     Timeout.
Writing in file: 1657302201, 1456, 109200 (75)     Resending pack 132496, (91)
Writing in file: 1657302202, 1456, 110656 (76)     Timeout.
Writing in file: 1657302202, 1456, 112112 (77)     Resending pack 132496, (91)
Writing in file: 1657302202, 1456, 113568 (78)     Timeout.
Writing in file: 1657302202, 1456, 115024 (79)     Resending pack 132496, (91)
Writing in file: 1657302203, 1456, 116480 (80)     Timeout.
Writing in file: 1657302205, 1456, 117936 (81)     Resending pack 132496, (91)
Writing in file: 1657302206, 1456, 119392 (82)     Timeout.
Writing in file: 1657302207, 1456, 120848 (83)     Resending pack 132496, (91)
Writing in file: 1657302207, 1456, 122304 (84)     Timeout.
Writing in file: 1657302207, 1456, 123760 (85)     Resending pack 132496, (91)
Writing in file: 1657302209, 1456, 125216 (86)     Timeout.
Writing in file: 1657302209, 1456, 126672 (87)     Resending pack 132496, (91)
Writing in file: 1657302211, 1456, 128128 (88)     Timeout.
Writing in file: 1657302212, 1456, 129584 (89)     Resending pack 132496, (91)
Writing in file: 1657302215, 1456, 131040 (90)     0, Ack Num: 133027, for (91)
Writing in file: 1657302218, 531, 132496 (91)

                                                   Sending EOF packet and exiting.
EOF packet received.                               [delay 120 ms] [loss up=0.6] [loss down=0.7] us
user@ubuntu:~/Desktop/NWagain/obj$                 er@ubuntu:~/Desktop/NWagain/obj$
```