Simple Transport Protocol

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1. Brief explanation

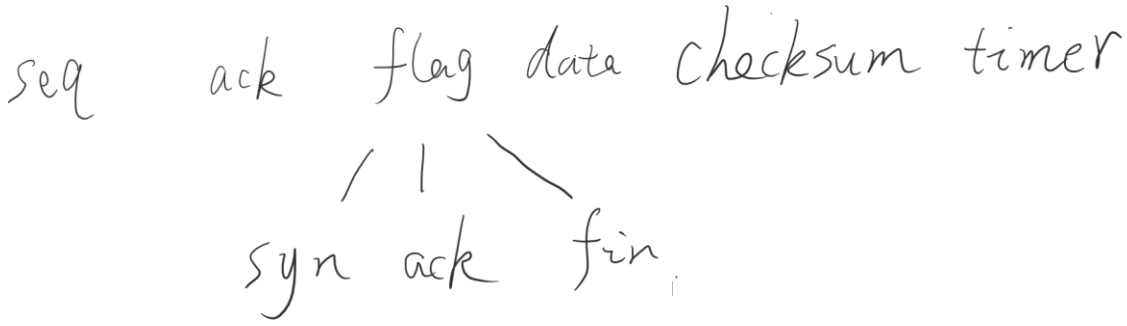
This assignment is asked to implement a reliable transport protocol over the UDP protocol. I use single thread to do this assignment and implement all features mentioned in assignment specification, including three-way handshake for the connection establishment, handling dropped, corrupted, duplicated, reordered and delayed packets by PLD and four-segment connection termination.

At the very beginning, I use the three-way handshake which is a method to create a connection between host and server. SYN, SYN-ACK, SYN

Next sender begins to transfer file, there is while loop in my send_file function, continue to check timeout event, send packets, receive packets and update timeout interval, and PLD will handle all packets.

Last sender and receiver will send FIN and ACK to each other to terminate the connection.

Explanation for header (packet):



Seq, ack

Flag includes three field, I setup 0b100 for syn, 0b010 for ack, 0b001 for fin

Checksum for check whether the packet is corrupted

Set timer for those packets which are the first packet of one window if this packet is not corrupted or drop, if it is dropped or corrupted, skip it.

2. List of features

Sender.py

Handshake:

1. Three – way handshake

During file transmission:

2. Check timeout event and retransmit packet if time out

3. Create a window to send packets

4. receive packets

5. Check whether need fast retransmit, and fast retransmit if needed

6. Calculate Sample RTT, Estimated RTT and update TimeoutInterval

PLD Handling:

7. Send the reordered packet

8. Send the delayed packet

9. Drop or duplicate or corrupt packets

10. Store one packet into reorder_window, and send the packet when counter equals maxOrder

11. Store one packet into delay_window, and send the packet in the future

12. If fast retransmit or retransmit after timeout, the message header in log file is snd/RXT, if not the message header is snd.

Termination:

15. Four segment connection termination

16. After termination, the two log files have the same format with the sample log files

Receiver.py

1. Three-way handshake

2. Receive packets, deal with duplicate packets (send DA messages)

3. Four segments connection termination

Packet.py

Store ack, syn, fin bits, seq, ack numbers and checksum and timer

3. Design Trade-offs and improvements

1. Because I use single thread, sometimes packets will be sent continuously until the window is full, then it receives packets or continuously receive packets then send.

2. And due to single thread, time elapsed may be longer

3. Receives will send 4 ACKs when sender needs fast retransmit, and due to this error, you will see sometimes there is a rcv/DA following after snd/RXT.

4. Segments of code borrowed

No idea on this assignment initially, so I look through this github and know what I will do.

https://github.com/viviSin/comp3331-assignments/blob/master/sender.py

5. Answers to following questions

a)

Run drop 0.1:

When the sender receives 3 ACKs, it fast retransmit, but the receiver receives this fast retransmit after the receiver sends 4 ACKs, I cannot correct this error, and I think after correct this error, there is little error in the program

The error is in log_file, but still can transfer file successfully.

Run drop 0.3:

Same error for drop 0.1, but can handle drop

Flow sequences of question a) are in very bottom of the report

b)

Gamma	# packets transmitted	Time elapsed
2	13473	6174s
4	13473	12335s
6	13360	12106s

In my statistics, the number of packets received decreased and the time elapsed increased with the value of gamma increased. The time elapsed from gamma 2 to gamma 4 is suitable, but from gamma 4 to gamma 6, there is no jump in time elapsed, hence there is something wrong in my timeout Interval implementation.

c)

The file has been successfully transmitted

The transfer overall took 6422s = 1.8h

Sender:

```
snd          0.00        S          0          0          0
rcv          0.00       SA          0          0          1
snd          0.00        A          1          0          1
snd/corr     0.00        D          1         50          1
snd          0.00        D         51         50          1
snd          0.00        D        101         50          1
snd          0.00        D        151         50          1
snd          0.00        D        201         50          1
snd          0.00        D        251         50          1
snd          0.00        D        251         50          1
snd          0.00        D        301         50          1
snd/corr     0.00        D        351         50          1
snd          0.00        D        401         50          1
snd          0.00        D        451         50          1
rcv          0.00        A          1          0          1
rcv/DA       0.00        A          1          0          1
rcv/DA       0.00        A          1          0          1
rcv/DA       0.00        A          1          0          1
snd/RXT      0.00        D          1         50          1
rcv/DA       0.00        A          1          0          1
```

```
89658  rcv/DA               6418.43         A              1            0            1604951
89659  snd/RXT              6418.43         D        1604951           50                  1
89660  rcv/DA               6418.43         A              1            0            1604951
89661  rcv/DA               6418.43         A              1            0            1604951
89662  rcv                  6418.43         A              1            0            1605401
89663  snd                  6418.43         D        1605451           50                  1
89664  snd                  6418.43         D        1605501           50                  1
89665  drop                 6418.43         D        1605551           35                  1
89666  rcv/DA               6418.43         A              1            0            1605401
89667  snd/RXT              6418.44         D        1605401           50                  1
89668  rcv/DA               6418.44         A              1            0            1605401
89669  rcv/DA               6418.44         A              1            0            1605401
89670  rcv                  6418.44         A              1            0            1605551
89671  snd/RXT/corr         6420.44         D        1605551           35                  1
89672  snd/RXT              6422.44         D        1605551           35                  1
89673  snd/RXT              6422.44         D        1605551           35                  1
89674  snd                  6422.44         F        1605586            0                  1
89675  rcv                  6422.44         A              1            0            1605586
89676  rcv                  6422.44         A              1            0            1605587
89677  rcv                  6422.44         F              1            0            1605587
89678  snd                  6422.44         A        1605587            0                  2
89679  ============================================================
89680  Size of the file (in Bytes)                      1605585
89681  Segments transmitted (including drop & RXT)        49726
89682  Number of Segments handled by PLD                  49722
89683  Number of Segments dropped                          4628
89684  Number of Segments Corrupted                        3698
89685  Number of Segments Re-ordered                       2506
89686  Number of Segments Duplicated                       4139
89687  Number of Segments Delayed                             0
89688  Number of Retransmissions due to TIMEOUT            3185
89689  Number of FAST RETRANSMISSION                      10286
89690  Number of DUP ACKs received                        30860
89691  ============================================================
```

Receiver:

```
 1  rcv                  0.00          S              0            0                  0
 2  snd                  0.00         SA              0            0                  1
 3  rcv                  0.00          A              1            0                  1
 4  rcv/corr             0.00          D              1           50                  1
 5  rcv                  0.00          D             51           50                  1
 6  snd                  0.00          A              1            0                  1
 7  rcv                  0.00          D            101           50                  1
 8  snd/DA               0.00          A              1            0                  1
 9  rcv                  0.00          D            151           50                  1
10  snd/DA               0.00          A              1            0                  1
11  rcv                  0.00          D            201           50                  1
12  snd/DA               0.00          A              1            0                  1
13  rcv                  0.00          D            251           50                  1
14  snd/DA               0.00          A              1            0                  1
15  rcv                  0.00          D            251           50                  1
16  snd/DA               0.00          A              1            0                  1
17  rcv                  0.00          D            301           50                  1
18  snd/DA               0.00          A              1            0                  1
19  rcv/corr             0.00          D            351           50                  1
20  rcv                  0.00          D            401           50                  1
```

```
85031  rcv                 6418.42         D          1605351          50               1
85032  snd/DA              6418.42         A                1           0         1604951
85033  rcv                 6418.43         D          1604951          50               1
85034  snd                 6418.43         A                1           0         1605401
85035  rcv                 6418.43         D          1604951          50               1
85036  snd/DA              6418.43         A                1           0         1605401
85037  rcv                 6418.43         D          1605451          50               1
85038  snd/DA              6418.43         A                1           0         1605401
85039  rcv                 6418.43         D          1605501          50               1
85040  snd/DA              6418.43         A                1           0         1605401
85041  rcv                 6418.43         D          1605401          50               1
85042  snd                 6418.44         A                1           0         1605551
85043  rcv/corr            6420.44         D          1605551          35               1
85044  rcv                 6422.44         D          1605551          35               1
85045  snd                 6422.44         A                1           0         1605586
85046  rcv                 6422.44         D          1605551          35               1
85047  snd/DA              6422.44         A                1           0         1605586
85048  rcv                 6422.44         F          1605586           0               1
85049  snd                 6422.44         A                1           0         1605587
85050  snd                 6422.44         F                1           0         1605587
85051  rcv                 6422.44         A          1605587           0               2
85052  ============================================
85053  Amount of data received (bytes)        1605585
85054  Total Segments Received                  40677
85055  Data segments received                   40673
85056  Data Segments with Bit Errors             3698
85057  Duplicate data segments received          6481
85058  Duplicate ACKs sent                      30861
85059  ============================================
```

Appendix

a)

When drop is 0.1:

Sender:

```
snd                     0.00          S                0              0                0
rcv                     0.00         SA                0              0                1
snd                     0.00          A                1              0                1
snd                     0.00          D                1            100                1
snd                     0.00          D              101            100                1
drop                    0.00          D              201            100                1
snd                     0.00          D              301            100                1
snd                     0.00          D              401            100                1
rcv                     0.00          A                1              0              101
snd                     0.00          D              501            100                1
rcv                     0.00          A                1              0              201
snd                     0.00          D              601            100                1
rcv/DA                  0.00          A                1              0              201
rcv/DA                  0.00          A                1              0              201
rcv/DA                  0.00          A                1              0              201
snd/RXT                 0.00          D              201            100                1
rcv/DA                  0.00          A                1              0              201
rcv                     0.01          A                1              0              701
snd                     0.01          D              701            100                1
snd                     0.01          D              801            100                1
snd                     0.01          D              901            100                1
snd                     0.01          D             1001            100                1
snd                     0.01          D             1101            100                1
rcv                     0.01          A                1              0              801
snd                     0.01          D             1201            100                1
rcv                     0.01          A                1              0              901
snd                     0.01          D             1301            100                1
rcv                     0.01          A                1              0             1001
snd                     0.01          D             1401            100                1
rcv                     0.01          A                1              0             1101
snd                     0.01          D             1501            100                1
rcv                     0.01          A                1              0             1201
snd                     0.01          D             1601            100                1
rcv                     0.01          A                1              0             1301
snd                     0.01          D             1701            100                1
rcv                     0.01          A                1              0             1401
snd                     0.01          D             1801            100                1
rcv                     0.01          A                1              0             1501
snd                     0.01          D             1901            100                1
rcv                     0.01          A                1              0             1601
drop                    0.01          D             2001            100                1
rcv                     0.01          A                1              0             1701
snd                     0.01          D             2101            100                1
rcv                     0.01          A                1              0             1801
snd                     0.01          D             2201            100                1
rcv                     0.01          A                1              0             1901
```

```
snd                     0.01          D             2301            100                1
rcv                     0.01          A                1              0             2001
snd                     0.01          D             2401            100                1
rcv/DA                  0.01          A                1              0             2001
rcv/DA                  0.01          A                1              0             2001
snd/RXT                 0.01          D             2001            100                1
rcv/DA                  0.01          A                1              0             2001
rcv/DA                  0.01          A                1              0             2001
rcv                     0.01          A                1              0             2501
snd                     0.01          D             2501            100                1
snd                     0.01          D             2601            100                1
drop                    0.01          D             2701            100                1
drop                    0.01          D             2801            100                1
snd                     0.01          D             2901            100                1
rcv                     0.02          A                1              0             2601
snd                     0.02          D             3001             28                1
rcv                     0.02          A                1              0             2701
rcv/DA                  0.02          A                1              0             2701
snd/RXT                 0.02          D             2701            100                1
rcv/DA                  0.02          A                1              0             2701
rcv                     0.02          A                1              0             2801
snd/RXT                 2.02          D             2801            100                1
snd                     2.02          F             3029              0                1
rcv                     2.02          A                1              0             3030
rcv                     2.02          F                1              0             3030
snd                     2.02          A             3030              0                2
============================================================
Size of the file (in Bytes)                         3028
Segments transmitted (including drop & RXT)           39
Number of Segments handled by PLD                     35
Number of Segments dropped                             4
Number of Segments Corrupted                           0
Number of Segments Re-ordered                          0
Number of Segments Duplicated                          0
Number of Segments Delayed                             0
Number of Retransmissions due to TIMEOUT               1
Number of FAST RETRANSMISSION                          3
Number of DUP ACKs received                           10
============================================================
```

Receiver:

```
rcv             0.00        S             0           0           0
snd             0.00       SA             0           0           1
rcv             0.00        A             1           0           1
rcv             0.00        D             1         100           1
snd             0.00        A             1           0         101
rcv             0.00        D           101         100           1
snd             0.00        A             1           0         201
rcv             0.00        D           301         100           1
snd/DA          0.00        A             1           0         201
rcv             0.00        D           401         100           1
snd/DA          0.00        A             1           0         201
rcv             0.00        D           501         100           1
snd/DA          0.00        A             1           0         201
rcv             0.00        D           601         100           1
snd/DA          0.00        A             1           0         201
rcv             0.00        D           201         100           1
snd             0.00        A             1           0         701
rcv             0.00        D           701         100           1
snd             0.01        A             1           0         801
rcv             0.01        D           801         100           1
snd             0.01        A             1           0         901
rcv             0.01        D           901         100           1
snd             0.01        A             1           0        1001
rcv             0.01        D          1001         100           1
snd             0.01        A             1           0        1101
rcv             0.01        D          1101         100           1
snd             0.01        A             1           0        1201
rcv             0.01        D          1201         100           1
snd             0.01        A             1           0        1301
rcv             0.01        D          1301         100           1
snd             0.01        A             1           0        1401
rcv             0.01        D          1401         100           1
snd             0.01        A             1           0        1501
rcv             0.01        D          1501         100           1
snd             0.01        A             1           0        1601
rcv             0.01        D          1601         100           1
snd             0.01        A             1           0        1701
rcv             0.01        D          1701         100           1
snd             0.01        A             1           0        1801
rcv             0.01        D          1801         100           1
snd             0.01        A             1           0        1901
rcv             0.01        D          1901         100           1
snd             0.01        A             1           0        2001
rcv             0.01        D          2101         100           1
snd/DA          0.01        A             1           0        2001
rcv             0.01        D          2201         100           1
snd/DA          0.01        A             1           0        2001
rcv             0.01        D          2301         100           1
snd/DA          0.01        A             1           0        2001
rcv             0.01        D          2401         100           1
snd/DA          0.01        A             1           0        2001
rcv             0.01        D          2001         100           1
snd             0.01        A             1           0        2501
rcv             0.01        D          2501         100           1
snd             0.01        A             1           0        2601
rcv             0.01        D          2601         100           1
snd             0.02        A             1           0        2701
rcv             0.02        D          2901         100           1
snd/DA          0.02        A             1           0        2701
rcv             0.02        D          3001          28           1
snd/DA          0.02        A             1           0        2701
rcv             0.02        D          2701         100           1
snd             0.02        A             1           0        2801
rcv             2.02        D          2801         100           1
snd             2.02        A             1           0        3029
rcv             2.02        F          3029           0           1
snd             2.02        A             1           0        3030
snd             2.02        F             1           0        3030
rcv             2.02        A          3030           0           2
============================================
Amount of data received (bytes)          3028
Total Segments Received                    35
Data segments received                     31
Data Segments with Bit Errors               0
Duplicate data segments received            0
Duplicate ACKs sent                        10
============================================
```

When drop is 0.3:

Sender:

1	snd	0.00	S	0	0	0
2	rcv	0.00	SA	0	0	1
3	snd	0.00	A	1	0	1
4	drop	0.00	D	1	100	1
5	snd	0.00	D	101	100	1
6	snd	0.00	D	201	100	1
7	snd	0.00	D	301	100	1
8	drop	0.00	D	401	100	1
9	rcv	0.00	A	1	0	1
10	rcv/DA	0.00	A	1	0	1
11	rcv/DA	0.00	A	1	0	1
12	drop	2.00	D	1	100	1
13	drop	4.00	D	1	100	1
14	snd/RXT	6.01	D	1	100	1
15	rcv	6.01	A	1	0	101
16	snd	6.01	D	501	100	1
17	rcv/DA	6.01	A	1	0	101
18	drop	6.01	D	101	100	1
19	drop	8.01	D	101	100	1
20	snd/RXT	10.01	D	101	100	1
21	rcv	10.01	A	1	0	401
22	snd	10.01	D	601	100	1
23	drop	10.01	D	701	100	1
24	snd	10.01	D	801	100	1
25	rcv/DA	10.01	A	1	0	401
26	rcv/DA	10.01	A	1	0	401
27	snd/RXT	12.02	D	401	100	1
28	rcv	12.02	A	1	0	701
29	snd	12.02	D	901	100	1
30	snd	12.02	D	1001	100	1
31	snd	12.02	D	1101	100	1
32	rcv/DA	12.02	A	1	0	701
33	drop	12.02	D	701	100	1
34	rcv/DA	12.02	A	1	0	701
35	rcv/DA	12.02	A	1	0	701
36	snd/RXT	14.02	D	701	100	1
37	rcv	14.02	A	1	0	1201
38	drop	14.02	D	1201	100	1
39	drop	14.02	D	1301	100	1
40	snd	14.02	D	1401	100	1
41	snd	14.02	D	1501	100	1
42	drop	14.02	D	1601	100	1
43	rcv/DA	14.02	A	1	0	1201
44	snd/RXT	14.02	D	1201	100	1
45	rcv/DA	14.02	A	1	0	1201
46	rcv	14.02	A	1	0	1301
47	snd	14.02	D	1701	100	1
48	rcv/DA	14.02	A	1	0	1301
49	snd/RXT	16.03	D	1301	100	1
50	rcv	16.03	A	1	0	1601
51	drop	16.03	D	1801	100	1
52	drop	16.03	D	1901	100	1
53	drop	16.03	D	2001	100	1
54	drop	18.03	D	1601	100	1
55	drop	20.03	D	1601	100	1

```
snd/RXT                 22.03         D              1601           100                 1
rcv                     22.04         A                 1             0              1801
snd                     22.04         D              2101           100                 1
snd                     22.04         D              2201           100                 1
rcv/DA                  22.04         A                 1             0              1801
snd/RXT                 22.04         D              1801           100                 1
rcv/DA                  22.04         A                 1             0              1801
rcv                     22.04         A                 1             0              1901
snd                     22.04         D              2301           100                 1
rcv/DA                  22.04         A                 1             0              1901
drop                    24.04         D              1901           100                 1
snd/RXT                 26.04         D              1901           100                 1
rcv                     26.04         A                 1             0              2001
drop                    26.04         D              2401           100                 1
drop                    28.04         D              2001           100                 1
drop                    30.04         D              2001           100                 1
snd/RXT                 32.05         D              2001           100                 1
rcv                     32.05         A                 1             0              2401
snd                     32.05         D              2501           100                 1
drop                    32.05         D              2601           100                 1
snd                     32.05         D              2701           100                 1
drop                    32.05         D              2801           100                 1
rcv/DA                  32.05         A                 1             0              2401
snd/RXT                 32.05         D              2401           100                 1
rcv/DA                  32.05         A                 1             0              2401
rcv                     32.05         A                 1             0              2601
snd                     32.05         D              2901           100                 1
drop                    32.05         D              3001            28                 1
rcv/DA                  32.05         A                 1             0              2601
snd/RXT                 34.05         D              2601           100                 1
rcv                     34.05         A                 1             0              2801
drop                    36.05         D              2801           100                 1
snd/RXT                 38.06         D              2801           100                 1
rcv                     38.06         A                 1             0              3001
snd/RXT                 40.06         D              3001            28                 1
snd                     40.06         F              3029             0                 1
rcv                     40.06         A                 1             0              3030
rcv                     40.06         F                 1             0              3030
snd                     40.06         A              3030             0                 2
============================================================
Size of the file (in Bytes)                          3028
Segments transmitted (including drop & RXT)            60
Number of Segments handled by PLD                      56
Number of Segments dropped                             24
Number of Segments Corrupted                            0
Number of Segments Re-ordered                           0
Number of Segments Duplicated                           0
Number of Segments Delayed                              0
Number of Retransmissions due to TIMEOUT               20
Number of FAST RETRANSMISSION                           5
Number of DUP ACKs received                            17
============================================================
```

Receiver:

1	rcv	0.00	S	0	0	0
2	snd	0.00	SA	0	0	1
3	rcv	0.00	A	1	0	1
4	rcv	0.00	D	101	100	1
5	snd	0.00	A	1	0	1
6	rcv	0.00	D	201	100	1
7	snd/DA	0.00	A	1	0	1
8	rcv	0.00	D	301	100	1
9	snd/DA	0.00	A	1	0	1
10	rcv	6.01	D	1	100	1
11	snd	6.01	A	1	0	101
12	rcv	6.01	D	501	100	1
13	snd/DA	6.01	A	1	0	101
14	rcv	10.01	D	101	100	1
15	snd	10.01	A	1	0	401
16	rcv	10.01	D	601	100	1
17	snd/DA	10.01	A	1	0	401
18	rcv	10.01	D	801	100	1
19	snd/DA	10.01	A	1	0	401
20	rcv	12.02	D	401	100	1
21	snd	12.02	A	1	0	701
22	rcv	12.02	D	901	100	1
23	snd/DA	12.02	A	1	0	701
24	rcv	12.02	D	1001	100	1
25	snd/DA	12.02	A	1	0	701
26	rcv	12.02	D	1101	100	1
27	snd/DA	12.02	A	1	0	701
28	rcv	14.02	D	701	100	1
29	snd	14.02	A	1	0	1201
30	rcv	14.02	D	1401	100	1
31	snd/DA	14.02	A	1	0	1201
32	rcv	14.02	D	1501	100	1
33	snd/DA	14.02	A	1	0	1201
34	rcv	14.02	D	1201	100	1
35	snd	14.02	A	1	0	1301
36	rcv	14.02	D	1701	100	1
37	snd/DA	14.02	A	1	0	1301
38	rcv	16.03	D	1301	100	1
39	snd	16.03	A	1	0	1601
40	rcv	22.03	D	1601	100	1
41	snd	22.03	A	1	0	1801
42	rcv	22.03	D	2101	100	1
43	snd/DA	22.03	A	1	0	1801
44	rcv	22.04	D	2201	100	1
45	snd/DA	22.04	A	1	0	1801
46	rcv	22.04	D	1801	100	1
47	snd	22.04	A	1	0	1901
48	rcv	22.04	D	2301	100	1
49	snd/DA	22.04	A	1	0	1901
50	rcv	26.04	D	1901	100	1
51	snd	26.04	A	1	0	2001
52	rcv	32.05	D	2001	100	1
53	snd	32.05	A	1	0	2401
54	rcv	32.05	D	2501	100	1
55	snd/DA	32.05	A	1	0	2401

```
rcv                    32.05          D              2701            100              1
snd/DA                 32.05          A                 1              0           2401
rcv                    32.05          D              2401            100              1
snd                    32.05          A                 1              0           2601
rcv                    32.05          D              2901            100              1
snd/DA                 32.05          A                 1              0           2601
rcv                    34.05          D              2601            100              1
snd                    34.05          A                 1              0           2801
rcv                    38.05          D              2801            100              1
snd                    38.06          A                 1              0           3001
rcv                    40.06          D              3001             28              1
snd                    40.06          A                 1              0           3029
rcv                    40.06          F              3029              0              1
snd                    40.06          A                 1              0           3030
snd                    40.06          F                 1              0           3030
rcv                    40.06          A              3030              0              2
================================================
Amount of data received (bytes)           3028
Total Segments Received                     36
Data segments received                      32
Data Segments with Bit Errors                0
Duplicate data segments received             0
Duplicate ACKs sent                         17
================================================
```

Appendix for question c