Report COMP3331

1. A brief discussion of how you have implemented the STP protocol. Provide a list of features that you have successfully implemented. In case you have not been able to get certain features of STP working, you should also mention that in your report.

I implemented my STP protocol using two java files. The arguments for running each of the program are stored and used to define how it functions. The main functions of the file are broken into stages of handshaking, closing the connection and sending data. The data sending section is further broken up to process segments that are received, determining what kind of errors have occurred and the responses required. A separate PLDmodule method is called in the data processing section, it takes in defining arguments to model errors occurring.

Several special classes were used to implement special functionality. The files use PrintStreams to write strings containing transfer metadata to generate the text logs. Writes were written after each call of socket.send and socket.receive. FileInputStreams and FileOutputStreams were used to read and write the files that were being transferred. ByteBuffers allowed for the header and file data to be placed inside a buffer to be transferred. Timeouts are measured using the Timer and TimerTasks classes, these handle timeouts by retransmitting the previous packet. Various getters were also added for ease of use.

Features Successfully implemented:

- Three way handshake

- Four segment tear down

- Header which contains relevant metatimer

- Single parallel thread timer that determines timeouts

- Proper sequence numbers and acknowledgement number calculations

- Log Files for sender and receiver

- Using random seed to allow rerun of tests

- Error generation and processing with PLDmodule implementation, including dropped packets, duplicated packets, corrupted packets and delayed packets. Reordered packets were not implemented as pipelining was not implemented

- Functioning checksum for flipped bits

- Correct transfer of file

1. A detailed diagram of your STP header and a quick explanation of all fields (similar to the diagrams that we have used in the lectures to understand TCP/UDP headers).

The ByteBuffer allowed different data types to be stored into the segment along with the data. Due to the fact that ByteBuffers were used, bits were unable to be used as only bytes and other primitive data could be stored within the ByteBuffer. The header contains the data as shown in the table.

|  |  |  |  |
| --- | --- | --- | --- |
| 32bits | | 32bits | |
| Sequence Number (32bits) | | Acknowledgement Number (32 bits) | |
| Flags (8 bits) | MWS (32 bits) | | MSS (24 bits) |
| MSS (8 bits) | Checksum (32 bits) | | Data (24 bits) |
| Data (up to MSS – 24 bits) | | | |

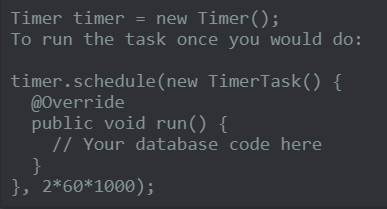
The sequence number and acknowledgement number function as defined in theory. The flags are SYN\_FLAG = 0x8 and ACK\_FLAG = 0x4 which can be bitwise OR’d to form the SYNACK\_FLAG.

1. Discuss any design trade-offs considered and made. Describe possible improvements and Extensions to your program and indicate how you could realise them.

Pipelining was not implemented which resulted in many advanced features of TCP. An obvious improvement would be to implement pipelining so that the maximum window size will become relevant through features such as fast transmission. This could be realised through the use of multithreading which I was unable to do because I am not familiar with how it worked and did not understand online tutorials.

1. Indicate any segments of code that you have borrowed from the Web or other books.

An example of how to run the timer scheduler was taken from stack overflow:



1. Answer the following questions: (include any output as an appendix to the main report.pdf, appendix is not included in the 5-page limit)
   1. Run your protocol using pDrop = 0.1, MWS = 500 bytes, MSS = 100 bytes, seed = 100, gamma = 4, and pDuplicate, pCorrupt, pOrder, MaxOrder, pDelay, MaxDelay all set to 0. Transfer the file test0.pdf (available on the assignment webpage). The file should be received correctly at the Receiver. Show the sequence of STP packets that are observed at the Receiver. It is sufficient to just indicate the sequence numbers of the STP packets that have arrived.
   2. Run an additional experiment with pdrop = 0.3, transferring the same file (test0.pdf). In your report, discuss the resulting packet sequences of both experiments indicating where dropping occurred. Also, in the appendix section show the packet sequences for both the experiments.

The packet sequences differ in transmission time from 0.11seconds to 7.50 seconds with pDrop = 0.3. The reason for this delay is due to timeouts occurring. It can be noted that the delayed time after each drop decreases, going from 1.2 seconds to only 0.3 seconds due to the timeoutInterval being recalculated.

(b) The timeout for STP is given by:

TimeoutInterval = EstimatedRTT + gamma \* DevRTT

where gamma will be supplied to the program as an input argument, see Section 4.5.

Set pdrop = 0.5, MWS = 500 bytes, MSS = 50 bytes, seed = 300, pdelay = 0.2, MaxDelay = 1000 and pDuplicate, pCorrupt, pOrder, MaxOrder all set to 0. Run three experiments with the following different gamma values:

i. gamma = 2

ii. gamma = 4

iii. gamma = 6

and transfer the file test1.pdf using STP. Show a table that indicates how many STP packets were transmitted in total and how long the overall transfer took. Discuss the results.

|  |  |  |
| --- | --- | --- |
| Gamma | STP Packets Transferred | Time of transfer (seconds) |
| 2 | 9579 | 1456.06 |
| 4 | 9408 | 2559.77 |
| 6 | 6292 | 308205 |

As the value of gamma increases, the time of transfer also increases. By increasing the value of gamma, the timeoutIntervals ends up increasing. Because timeoutintervals are increased and fast retransmit has not been implemented, more time is spent waiting when the packet has dropped which explains why the time of transfer increases.

(c) Use the following values and run STP to transfer test2.pdf.

MWS=500bytes MSS=50 gamma=4 pDrop=0.1 pDuplicate=0.1 pCorrupt=0.1 pOrder=0.1 maxOrder=4 pDelay=0 maxDelay=0 seed=300

Has the file been successfully transferred? How long the overall transfer took? For this experiment, which of the factor (out of pDrop, pDuplicate, pCorrupt and pOrder) is the most critical contributing most in the overall transfer time? How have you determined this? Provide the screen shot for the initial transfer (connection establishment + first 20 entries) and the last 20 entries plus the summary statistics table for the sender\_log.txt and receiver\_log.txt files in appendix. Do not attach the complete log files due to their sizes.

The file could not transfer successfully.

**Appendix**

Q5a) part i) pDrop = 0

rcv 0.00 S 0 0 0

snd 0.03 S 1 0 1

rcv 0.03 A 1 0 1

rcv 0.04 D 1 100 1

snd 0.04 A 1 0 101

rcv 0.04 D 101 100 1

snd 0.04 A 1 0 201

rcv 0.04 D 201 100 1

snd 0.04 A 1 0 301

rcv 0.04 D 301 100 1

snd 0.05 A 1 0 401

rcv 0.05 D 401 100 1

snd 0.05 A 1 0 501

rcv 0.05 D 501 100 1

snd 0.05 A 1 0 601

rcv 0.05 D 601 100 1

snd 0.05 A 1 0 701

rcv 0.06 D 701 100 1

snd 0.06 A 1 0 801

rcv 0.06 D 801 100 1

snd 0.06 A 1 0 901

rcv 0.06 D 901 100 1

snd 0.06 A 1 0 1001

rcv 0.06 D 1001 100 1

snd 0.06 A 1 0 1101

rcv 0.06 D 1101 100 1

snd 0.07 A 1 0 1201

rcv 0.07 D 1201 100 1

snd 0.07 A 1 0 1301

rcv 0.07 D 1301 100 1

snd 0.07 A 1 0 1401

rcv 0.07 D 1401 100 1

snd 0.07 A 1 0 1501

rcv 0.07 D 1501 100 1

snd 0.07 A 1 0 1601

rcv 0.08 D 1601 100 1

snd 0.08 A 1 0 1701

rcv 0.08 D 1701 100 1

snd 0.08 A 1 0 1801

rcv 0.08 D 1801 100 1

snd 0.08 A 1 0 1901

rcv 0.08 D 1901 100 1

snd 0.08 A 1 0 2001

rcv 0.09 D 2001 100 1

snd 0.09 A 1 0 2101

rcv 0.09 D 2101 100 1

snd 0.09 A 1 0 2201

rcv 0.09 D 2201 100 1

snd 0.09 A 1 0 2301

rcv 0.09 D 2301 100 1

snd 0.10 A 1 0 2401

rcv 0.10 D 2401 100 1

snd 0.10 A 1 0 2501

rcv 0.10 D 2501 100 1

snd 0.10 A 1 0 2601

rcv 0.10 D 2601 100 1

snd 0.10 A 1 0 2701

rcv 0.10 D 2701 100 1

snd 0.10 A 1 0 2801

rcv 0.10 D 2801 100 1

snd 0.10 A 1 0 2901

rcv 0.11 D 2901 100 1

snd 0.11 A 1 0 3001

rcv 0.11 D 3001 28 1

snd 0.11 A 1 0 3029

rcv 0.11 F 3029 0 2

snd 0.11 F 1 0 3030

snd 0.11 A 1 0 3030

rcv 0.11 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 0

==============================================

5a) part ii) pDrop = 0.3

rcv 0.00 S 0 0 0

snd 0.03 S 1 0 1

rcv 0.03 A 1 0 1

rcv 0.03 D 1 100 1

snd 0.03 A 1 0 101

rcv 0.03 D 101 100 1

snd 0.03 A 1 0 201

rcv 0.04 D 201 100 1

snd 0.04 A 1 0 301

rcv 1.78 D 301 100 1

snd 1.78 A 1 0 401

rcv 3.53 D 401 100 1

snd 3.53 A 1 0 501

rcv 3.53 D 501 100 1

snd 3.53 A 1 0 601

rcv 3.54 D 601 100 1

snd 3.54 A 1 0 701

rcv 3.54 D 701 100 1

snd 3.54 A 1 0 801

rcv 3.54 D 801 100 1

snd 3.54 A 1 0 901

rcv 3.54 D 901 100 1

snd 3.54 A 1 0 1001

rcv 3.55 D 1001 100 1

snd 3.55 A 1 0 1101

rcv 4.67 D 1101 100 1

snd 4.68 A 1 0 1201

rcv 5.80 D 1201 100 1

snd 5.80 A 1 0 1301

rcv 5.80 D 1301 100 1

snd 5.81 A 1 0 1401

rcv 5.81 D 1401 100 1

snd 5.81 A 1 0 1501

rcv 5.81 D 1501 100 1

snd 5.81 A 1 0 1601

rcv 6.62 D 1601 100 1

snd 6.62 A 1 0 1701

rcv 6.62 D 1701 100 1

snd 6.62 A 1 0 1801

rcv 6.62 D 1801 100 1

snd 6.62 A 1 0 1901

rcv 6.63 D 1901 100 1

snd 6.63 A 1 0 2001

rcv 6.63 D 2001 100 1

snd 6.63 A 1 0 2101

rcv 6.63 D 2101 100 1

snd 6.63 A 1 0 2201

rcv 6.63 D 2201 100 1

snd 6.63 A 1 0 2301

rcv 6.64 D 2301 100 1

snd 6.64 A 1 0 2401

rcv 6.98 D 2401 100 1

snd 6.98 A 1 0 2501

rcv 6.98 D 2501 100 1

snd 6.98 A 1 0 2601

rcv 7.29 D 2601 100 1

snd 7.29 A 1 0 2701

rcv 7.29 D 2701 100 1

snd 7.29 A 1 0 2801

rcv 7.29 D 2801 100 1

snd 7.29 A 1 0 2901

rcv 7.29 D 2901 100 1

snd 7.29 A 1 0 3001

rcv 7.50 D 3001 28 1

snd 7.50 A 1 0 3029

rcv 7.50 F 3029 0 2

snd 7.50 F 1 0 3030

snd 7.50 A 1 0 3030

rcv 7.50 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 0

==============================================

b) i)gamma = 0.2

Receiver\_log

rcv 0.00 S 0 0 0

snd 0.03 S 1 0 1

rcv 0.03 A 1 0 1

rcv 0.03 D 1 50 1

snd 0.03 A 1 0 51

rcv 0.04 D 51 50 1

snd 0.04 A 1 0 101

rcv 1.11 D 101 50 1

snd 1.11 A 1 0 151

rcv 1.11 D 151 50 1

snd 1.11 A 1 0 201

rcv 1.11 D 201 50 1

snd 1.11 A 1 0 251

rcv 1.12 D 251 50 1

snd 1.12 A 1 0 301

rcv 1.12 D 301 50 1

snd 1.12 A 1 0 351

rcv 1.12 D 351 50 1

snd 1.12 A 1 0 401

rcv 1.12 D 401 50 1

…

rcv 1455.59 D 307901 50 1

snd 1455.59 A 1 0 307951

rcv 1455.59 D 307951 50 1

snd 1455.59 A 1 0 308001

rcv 1455.75 D 308001 50 1

snd 1455.75 A 1 0 308051

rcv 1455.75 D 308051 50 1

snd 1455.75 A 1 0 308101

rcv 1455.90 D 308101 50 1

snd 1455.90 A 1 0 308151

rcv 1456.05 D 308151 50 1

snd 1456.05 A 1 0 308201

rcv 1456.05 D 308201 3 1

snd 1456.05 A 1 0 308204

rcv 1456.05 F 308204 0 2

snd 1456.05 F 1 0 308205

snd 1456.05 A 1 0 308205

rcv 1456.05 A 308205 0 2

==============================================

Amount of data received (bytes) 327503

Total Segments Received 6555

Data segments received 6551

Data segments with Bit Errors 0

Duplicate data segments received 386

Duplicate ACKs sent 386

==============================================

Sender\_log

Snd 0.01 S 0 0 0

rcv 0.04 SA 0 0 1

snd 0.04 A 1 0 1

snd 0.04 D 1 50 1

rcv 0.04 A 1 0 51

snd 0.04 D 51 50 1

rcv 0.04 A 1 0 101

drop 0.04 D 101 50 1

snd/RXT 1.11 D 101 50 1

rcv 1.12 A 1 0 151

snd 1.12 D 151 50 1

rcv 1.12 A 1 0 201

snd 1.12 D 201 50 1

rcv 1.12 A 1 0 251

snd 1.12 D 251 50 1

rcv 1.12 A 1 0 301

snd 1.12 D 301 50 1

rcv 1.13 A 1 0 351

snd 1.13 D 351 50 1

…

drop 1455.37 D 307851 50 1

snd/RXT 1455.60 D 307851 50 1

rcv 1455.60 A 1 0 307901

snd 1455.60 D 307901 50 1

rcv 1455.60 A 1 0 307951

snd 1455.60 D 307951 50 1

rcv 1455.60 A 1 0 308001

drop 1455.60 D 308001 50 1

snd/RXT 1455.76 D 308001 50 1

rcv 1455.76 A 1 0 308051

snd 1455.76 D 308051 50 1

rcv 1455.76 A 1 0 308101

drop 1455.76 D 308101 50 1

snd/RXT 1455.91 D 308101 50 1

rcv 1455.91 A 1 0 308151

drop 1455.91 D 308151 50 1

snd/RXT 1456.06 D 308151 50 1

rcv 1456.06 A 1 0 308201

snd 1456.06 D 308201 3 1

rcv 1456.06 A 1 0 308204

snd 1456.06 F 308204 0 2

rcv 1456.06 A 1 0 308205

rcv 1456.06 F 308204 0 2

snd 1456.06 A 308205 0 2

=============================================================

Size of the file (in Bytes) 308203

Segments transmitted (including drop & RXT) 9579

Number of Segments handled by PLD 9575

Number of Segments dropped 3024

Number of Segments Corrupted 0

Number of Segments Re-ordered 0

Number of Segments Duplicated 0

Number of Segments Delayed 623

Number of Retransmissions due to TIMEOUT 3410

Number of DUP ACKS received 386

=============================================================

ii) gamma = 4

Receiver\_log

rcv 0.00 S 0 0 0

snd 0.03 S 1 0 1

rcv 0.03 A 1 0 1

rcv 0.03 D 1 50 1

snd 0.03 A 1 0 51

rcv 0.04 D 51 50 1

snd 0.04 A 1 0 101

rcv 1.79 D 101 50 1

snd 1.79 A 1 0 151

rcv 1.79 D 151 50 1

snd 1.80 A 1 0 201

rcv 1.80 D 201 50 1

snd 1.80 A 1 0 251

rcv 1.80 D 251 50 1

snd 1.80 A 1 0 301

rcv 1.80 D 301 50 1

snd 1.80 A 1 0 351

rcv 1.81 D 351 50 1

snd 1.81 A 1 0 401

rcv 1.81 D 401 50 1

…

snd 2558.05 A 1 0 307751

rcv 2558.51 D 307751 50 1

snd 2558.51 A 1 0 307801

rcv 2558.51 D 307801 50 1

snd 2558.51 A 1 0 307851

rcv 2558.91 D 307851 50 1

snd 2558.91 A 1 0 307901

rcv 2558.91 D 307901 50 1

snd 2558.91 A 1 0 307951

rcv 2558.91 D 307951 50 1

snd 2558.91 A 1 0 308001

rcv 2559.21 D 308001 50 1

snd 2559.21 A 1 0 308051

rcv 2559.21 D 308051 50 1

snd 2559.21 A 1 0 308101

rcv 2559.48 D 308101 50 1

snd 2559.48 A 1 0 308151

rcv 2559.76 D 308151 50 1

snd 2559.76 A 1 0 308201

rcv 2559.76 D 308201 3 1

snd 2559.76 A 1 0 308204

rcv 2559.76 F 308204 0 2

snd 2559.76 F 1 0 308205

snd 2559.76 A 1 0 308205

rcv 2559.76 A 308205 0 2

==============================================

Amount of data received (bytes) 318953

Total Segments Received 6384

Data segments received 6380

Data segments with Bit Errors 0

Duplicate data segments received 215

Duplicate ACKs sent 215

==============================================

Sender\_log

snd 0.01 S 0 0 0

rcv 0.03 SA 0 0 1

snd 0.04 A 1 0 1

snd 0.04 D 1 50 1

rcv 0.04 A 1 0 51

snd 0.04 D 51 50 1

rcv 0.04 A 1 0 101

drop 0.04 D 101 50 1

snd/RXT 1.80 D 101 50 1

rcv 1.80 A 1 0 151

snd 1.80 D 151 50 1

rcv 1.80 A 1 0 201

snd 1.80 D 201 50 1

rcv 1.80 A 1 0 251

snd 1.81 D 251 50 1

rcv 1.81 A 1 0 301

snd 1.81 D 301 50 1

rcv 1.81 A 1 0 351

snd 1.81 D 351 50 1

rcv 1.81 A 1 0 401

…

drop 2558.51 D 307851 50 1

snd/RXT 2558.91 D 307851 50 1

rcv 2558.91 A 1 0 307901

snd 2558.91 D 307901 50 1

rcv 2558.91 A 1 0 307951

snd 2558.91 D 307951 50 1

rcv 2558.91 A 1 0 308001

drop 2558.91 D 308001 50 1

snd/RXT 2559.22 D 308001 50 1

rcv 2559.22 A 1 0 308051

snd 2559.22 D 308051 50 1

rcv 2559.22 A 1 0 308101

drop 2559.22 D 308101 50 1

snd/RXT 2559.49 D 308101 50 1

rcv 2559.49 A 1 0 308151

drop 2559.49 D 308151 50 1

snd/RXT 2559.77 D 308151 50 1

rcv 2559.77 A 1 0 308201

snd 2559.77 D 308201 3 1

rcv 2559.77 A 1 0 308204

snd 2559.77 F 308204 0 2

rcv 2559.77 A 1 0 308205

rcv 2559.77 F 308204 0 2

snd 2559.77 A 308205 0 2

=============================================================

Size of the file (in Bytes) 308203

Segments transmitted (including drop & RXT) 9408

Number of Segments handled by PLD 9404

Number of Segments dropped 3024

Number of Segments Corrupted 0

Number of Segments Re-ordered 0

Number of Segments Duplicated 0

Number of Segments Delayed 623

Number of Retransmissions due to TIMEOUT 3239

Number of DUP ACKS received 215

=============================================================

iii)

rcv 0.00 S 0 0 0

snd 0.03 S 1 0 1

rcv 0.03 A 1 0 1

rcv 0.03 D 1 50 1

snd 0.03 A 1 0 51

rcv 0.04 D 51 50 1

snd 0.04 A 1 0 101

rcv 2.48 D 101 50 1

snd 2.48 A 1 0 151

rcv 2.48 D 151 50 1

snd 2.48 A 1 0 201

rcv 2.48 D 201 50 1

snd 2.49 A 1 0 251

rcv 2.49 D 251 50 1

snd 2.49 A 1 0 301

rcv 2.49 D 301 50 1

snd 2.49 A 1 0 351

rcv 2.49 D 351 50 1

snd 2.49 A 1 0 401

rcv 2.50 D 401 50 1

…

rcv 3921.30 D 307801 50 1

snd 3921.30 A 1 0 307851

rcv 3922.65 D 307851 50 1

snd 3922.65 A 1 0 307901

rcv 3922.65 D 307901 50 1

snd 3922.65 A 1 0 307951

rcv 3922.65 D 307951 50 1

snd 3922.65 A 1 0 308001

rcv 3923.70 D 308001 50 1

snd 3923.70 A 1 0 308051

rcv 3923.70 D 308051 50 1

snd 3923.70 A 1 0 308101

rcv 3924.62 D 308101 50 1

snd 3924.62 A 1 0 308151

rcv 3925.56 D 308151 50 1

snd 3925.56 A 1 0 308201

rcv 3925.56 D 308201 3 1

snd 3925.56 A 1 0 308204

rcv 3925.56 F 308204 0 2

snd 3925.56 F 1 0 308205

snd 3925.56 A 1 0 308205

rcv 3925.56 A 308205 0 2

==============================================

Amount of data received (bytes) 314353

Total Segments Received 6292

Data segments received 6288

Data segments with Bit Errors 0

Duplicate data segments received 123

Duplicate ACKs sent 123

==============================================

Sender\_log

snd 0.01 S 0 0 0

rcv 0.04 SA 0 0 1

snd 0.04 A 1 0 1

snd 0.04 D 1 50 1

rcv 0.04 A 1 0 51

snd 0.04 D 51 50 1

rcv 0.04 A 1 0 101

drop 0.04 D 101 50 1

snd/RXT 2.49 D 101 50 1

rcv 2.49 A 1 0 151

snd 2.49 D 151 50 1

rcv 2.49 A 1 0 201

snd 2.49 D 201 50 1

rcv 2.49 A 1 0 251

snd 2.49 D 251 50 1

rcv 2.49 A 1 0 301

snd 2.50 D 301 50 1

rcv 2.50 A 1 0 351

snd 2.50 D 351 50 1

rcv 2.50 A 1 0 401

…

rcv 3918.26 A 1 0 307701

drop 3918.26 D 307701 50 1

snd/RXT 3919.78 D 307701 50 1

rcv 3919.78 A 1 0 307751

drop 3919.78 D 307751 50 1

snd/RXT 3921.31 D 307751 50 1

rcv 3921.31 A 1 0 307801

snd 3921.31 D 307801 50 1

rcv 3921.31 A 1 0 307851

drop 3921.31 D 307851 50 1

snd/RXT 3922.66 D 307851 50 1

rcv 3922.66 A 1 0 307901

snd 3922.66 D 307901 50 1

rcv 3922.66 A 1 0 307951

snd 3922.66 D 307951 50 1

rcv 3922.66 A 1 0 308001

drop 3922.66 D 308001 50 1

snd/RXT 3923.71 D 308001 50 1

rcv 3923.71 A 1 0 308051

snd 3923.71 D 308051 50 1

rcv 3923.71 A 1 0 308101

drop 3923.71 D 308101 50 1

snd/RXT 3924.62 D 308101 50 1

rcv 3924.62 A 1 0 308151

drop 3924.63 D 308151 50 1

snd/RXT 3925.56 D 308151 50 1

rcv 3925.56 A 1 0 308201

snd 3925.56 D 308201 3 1

rcv 3925.56 A 1 0 308204

snd 3925.56 F 308204 0 2

rcv 3925.56 A 1 0 308205

rcv 3925.56 F 308204 0 2

snd 3925.56 A 308205 0 2

=============================================================

Size of the file (in Bytes) 308203

Segments transmitted (including drop & RXT) 9316

Number of Segments handled by PLD 9312

Number of Segments dropped 3024

Number of Segments Corrupted 0

Number of Segments Re-ordered 0

Number of Segments Duplicated 0

Number of Segments Delayed 623

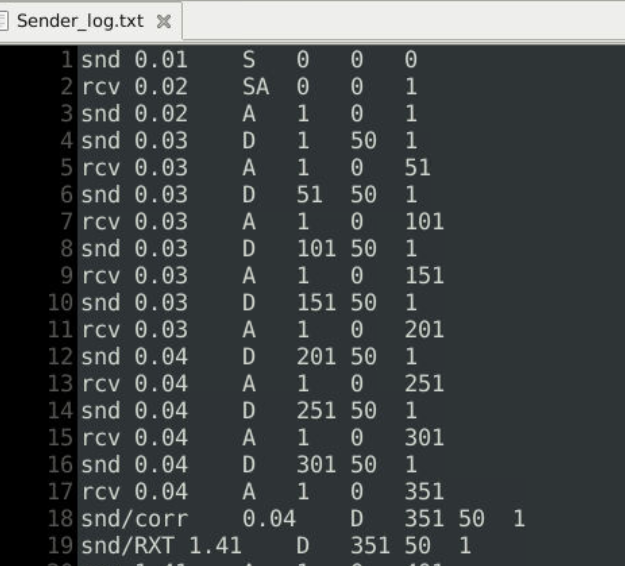
Number of Retransmissions due to TIMEOUT 3147

Number of DUP ACKS received 123

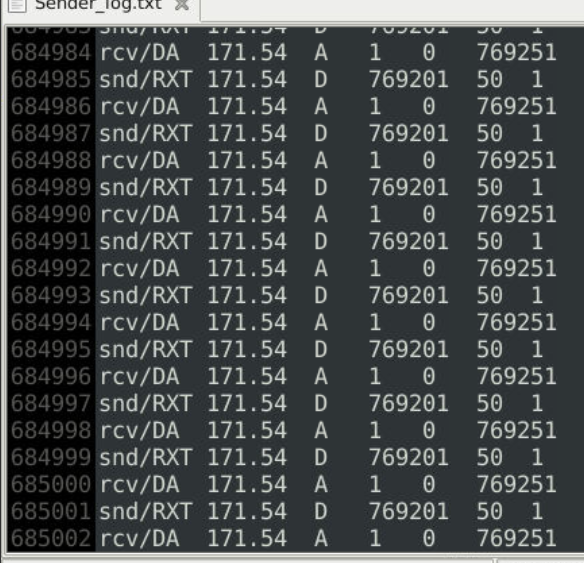
=============================================================

c) Sender\_log.txt

First 20 lines



Last lines when program was forcefully terminated



Receiver.txt

First 20 lines