COMP3331 - Network Assignment 2018s2
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NOTE: Program uses python2.7, arguments entered in same order as the spec

Report

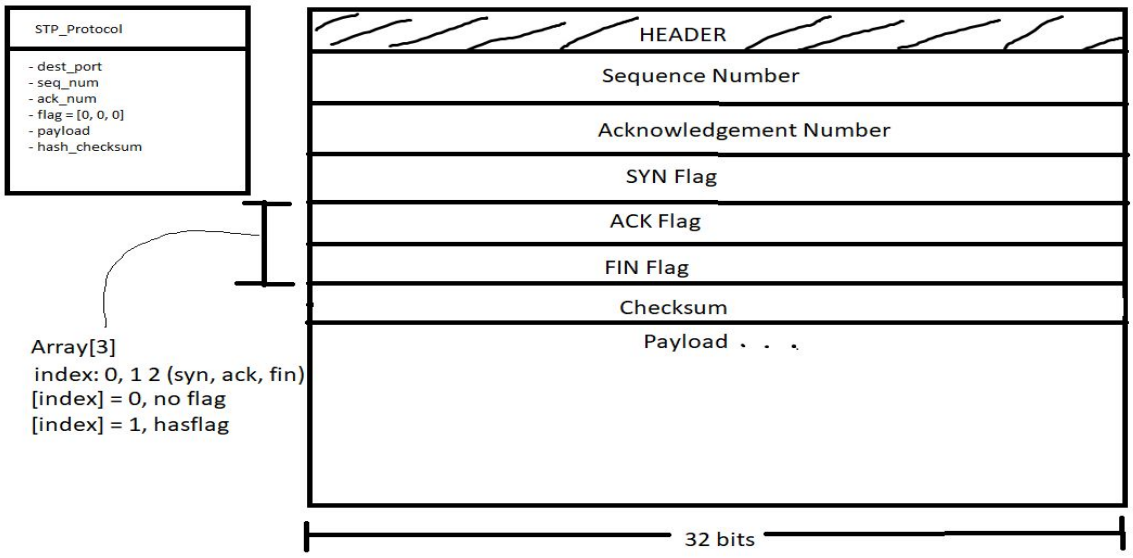
Q1.
List of successful implementation:

- Successfully create socket using UDP
- Working 3-Way Handshake (Sends SYN, Receives SYN, sends ACK)
- Initiate EstimatedRTT=500ms and DevRTT =250ms, then using the formula from textbook to calculate new EstimatedRTT and DevRTT
- Using new EstimatedRTT and DevRTT to calculate timeout interval
- SampleRTT is obtained per ACK except for retransmission timeout (not required)
- Timeout Interval gets doubled when it is doing retransmission - timeout (Figure 3.33)
- Re/calculate the next sequence number and next ack number, which is then stored into packet along with payload and send to the receiver
- Implemented timeout scenario, retransmitting a packet with the lastest unacked sequence number (sendbase) with payload corresponding to the seqnum
- Receives ACK and rebases the sendbase or last unacked, a packet is then sent back to the receiver
- Timer
- Receiver sends latest next ack when wrong packet is sent or corrupted (Cumulative ACK) (Fast Retransmission)
- Counts number of time ACK-value gets ACKed, when the ACK-value == 3, retransmit packet
- Window Size, follows rule LastByteRcvd - LastByteRead <= RcvBuffer
- Tear-down stage
- Logger
- PLD Module

After reading the spec and seeing Figure 2 from the spec, it gave me a starting point to how I was going to implement STP. Following the diagram, I created a stub for each entity in the diagram into classes in separate .py file. A good starting point was to create a socket for both sender and receiver and just to get something talking to each other (inspired by lab). STP_Protocol contains instance variable for seqnum, ack, checksum, array of flags(SYN, ACK, FIN) and payload. Sender and receiver are able to create object, replicating packets. The next stage was to somehow get the receiver to get the file the sender is sending, for now full file. This was done only using sockets and not any other classes i have created. Following on, the next thing that was implemented was the 3-way handshake. The sender initiate connection with receiver by sending SYN with a SEQ number and receiver sends back a SYNACK with its own initial SEQ number, a ACK is sent by sender and 3-way handshake is completed. STP_Segment is then implemented along continuation of Sender.py and Receiver.py, which allows the sender to split the files into segments depending on MSS and send in segments. STP_Segment also maintains corresponding seqnum. It was then time to

implement MWS and the way the program works is by using loops and calculating index number of the segment and sequence number maintained in the STP_Protocol class. The window resets to first segment when all are acked, or retransmission (shifting sendbase to first segment). PLD Module was where thing got complicated and trying to get STP to adapt to these scenarios. When pDrop occurs it continues through the window without sending packet. pCorrupt is implemented by adding 'c' character and uses checksum via SHA256 on both sender and receiver to check if corrupted data. pDuplicate sends packet twice, although it might be wrong dDup doesn't count for segment sent in window. pOrder utilises a list by appending and popping index 0 when length == MaxOrder. pDelay is implemented by using concept of threading so that other packets are still able to send while pDelay packet is waiting over time, the window however doesn't slide until acked. The teardown stage sends FIN flag to receiver when index is not found (file size sent). On the receiving end, if it detects FIN flag and for the receiving and initiate it teardown stage. After everything seemed to be working, the logger was then implemented and using those data tweaked the STP accordingly.

Q2.



Q3.

- Packets, if I had more fluent understanding of bits in programming the packets/header could of been better designed by masking bits, creating a more efficient and reduced size packet, especially for the flag.
- I would like to improve the way i shift my windows and implement it in a more efficient way. Currently to shift the window, I would have to wait for all acks from the segment sent in the window to be recognised then shifted, rather shifting as each packet is acked. (Go Back N or Selective Repeat)
- A better improvement for tear down state. This section was close to being hard coded and due to design. Before the fix there was an if statement that causes it to repeatedly send FIN due to delayed packets.

- Inconsistency of retransmission, my timeout retransmit one packet instead of whole window, while fast retransmission retransmit whole window.

Q4.

- James Kurose, Keith Ross -Computer Networking - Top Down Approach (ideas mainly from here)
- https://docs.python.org/3/library/socket.html
- https://realpython.com/python-sockets/
- https://www.tutorialspoint.com/python/python_multithreading.htm

5.A.

First of all it is obvious and concrete that the a higher pDrop takes longer for the file to send across causing the chance to have a timeout to be longer, both evident as first image finish time is 28 seconds and second image finish at 41.5seconds. In both cases drop of packet will cause retransmission, this is because of the behaviour of my STP. Assume that there is a window with 4 segments that is going to be sent and the last packet is dropped, my STP wait for a packet to arrive, but since it was lost the timer exceeds timeout interval and performs retransmission. Furthermore, the highlighted sequences in both images shows that we are getting return of multiple dup ack, causing further window size retransmission.

5.B. (NOTE: images 5B has incorrect handle PLD values, fixed after this but total transmitted should be the same)

i. Total transmitted = 430399
   Total time = 4362.5 seconds = 72.7 minutes
ii. Total transmitted = 436743
   Total time = 4958 seconds = 82.63 minutes
iii. Total transmitted = 436646
   Total time = 5924.5 seconds = 98.74 minutes

Lets first analyse the formula (TimeoutInterval = EstimatedRTT + Gamma *DevRTT) before moving onto the values. EstimatedRTT = (1- alpha) * EstimatedRTT + alpha * SampleRTT => What this formula does is it calculates the average of SampleRTT. Because EstimatedRTT is a weighted average new values that were entered are more relevant then the old. DevRTT defines the the variation of the sampleRTT and EstimatedRTT, calculated by DevRTT = (1 - B) * DevRTT + Beta * | SampleRTT - EstimatedRTT|. DevRTT value will bounce or fluctuate correspondingly to the different between SampleRTT and EstimatedRTT. Now, that we understand what the formulas are doing, we can apply it to understand the difference in received data values. The input data for each experiment are the same except for the gamma, hence resulting in the same probability for each test. Because of this, DevRTT value and EstimatedRTT will also have similar behaviour, performing same kind of fluctuation, which results the values between total time for each gamma value not being too far apart. The reason why there are an increase in total transmitted and total time is due to increase of TimeoutInterval which is in proportion to gamma, as gamma increase TimeoutInterval also

increases, hence the linear increase in total time. Total transmitted time should be similar and can vary depending on timeoutinterval. Longer timeoutinterval may affect number of number of transmission.

Q5c.

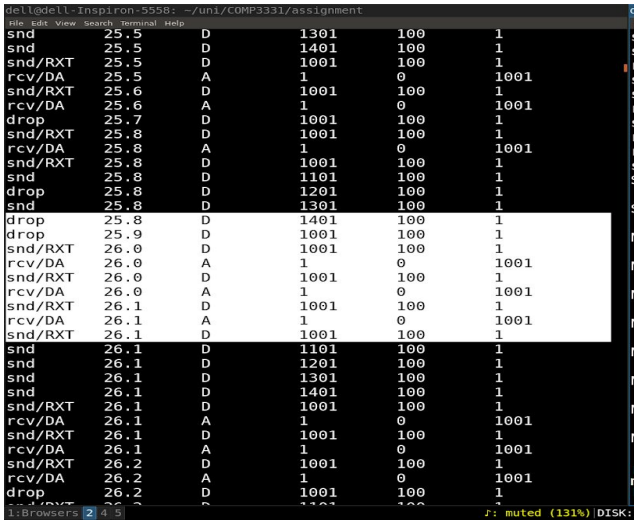
Yes the files both have been successfully transferred taking 9486.9 seconds (158.11minutes, 2.6hours). From my understanding the pDrop causes the biggest contribution on the overall time transfer. Suppose that the last packet from the window get dropped. For this particular STP, the window would have to wait for an acknowledgement for the last packet of window before shifting on to the next, and since it got dropped a timeout will occur and goes through a retransmission. Having consecutive timeouts will further affect the transfer time due to the timeout interval value doubling each retransmission. Base on the images of data we can see that there are are high number of retransmission which demonstrating this. pDuplicate, pCorrupt and pOrder also plays role but not as significant as pDrop because the sender still receives ACK values from the receiver and the window shift accordingly (or could also go through retransmission then window gets shifted).

APPENDIX

5. A.

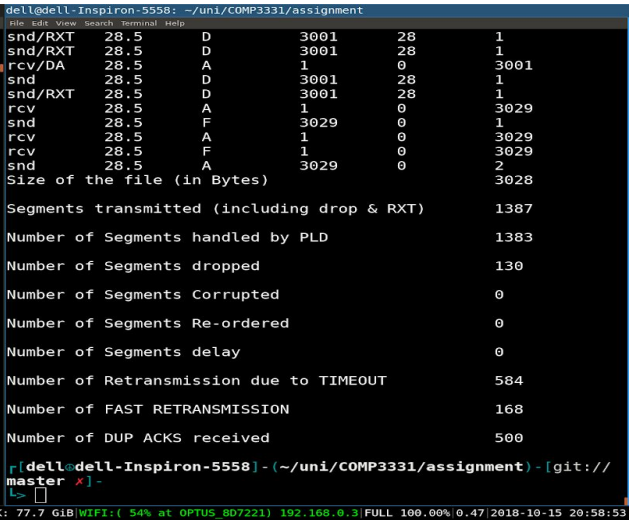
pDrop = 0.1, MWS = 500, MSS = 100, seed = 100, gamma = 4, pDuplicate, pCorrupt, pOrder, MaxOrder, pDelay, MaxDelay all set to 0

Sender



```
dell@dell-Inspiron-5558: ~/uni/COMP3331/assignment
File  Edit  View  Search  Terminal  Help
snd         25.5        D           1301        100         1
snd         25.5        D           1401        100         1
snd/RXT     25.5        D           1001        100         1
rcv/DA      25.5        A           1           0           1001
snd/RXT     25.6        D           1001        100         1
rcv/DA      25.6        A           1           0           1001
drop        25.7        D           1001        100         1
snd/RXT     25.8        D           1001        100         1
rcv/DA      25.8        A           1           0           1001
snd/RXT     25.8        D           1001        100         1
snd         25.8        D           1101        100         1
drop        25.8        D           1201        100         1
snd         25.8        D           1301        100         1
drop        25.8        D           1401        100         1
drop        25.9        D           1001        100         1
snd/RXT     26.0        D           1001        100         1
rcv/DA      26.0        A           1           0           1001
snd/RXT     26.0        D           1001        100         1
rcv/DA      26.0        A           1           0           1001
snd/RXT     26.1        D           1001        100         1
rcv/DA      26.1        A           1           0           1001
snd/RXT     26.1        D           1001        100         1
snd         26.1        D           1101        100         1
snd         26.1        D           1201        100         1
snd         26.1        D           1301        100         1
snd         26.1        D           1401        100         1
snd/RXT     26.1        D           1001        100         1
rcv/DA      26.1        A           1           0           1001
snd/RXT     26.1        D           1001        100         1
rcv/DA      26.1        A           1           0           1001
snd/RXT     26.2        D           1001        100         1
rcv/DA      26.2        A           1           0           1001
drop        26.2        D           1001        100         1
1:Browsers 2 4 5                                    ♪: muted (131%) DISK: 77.7 GiB WIFI:( 54% at OPTUS_8D7221) 192.168.0.3 FULL 100.00% 0.47 2018-10-15 20:58:53
```

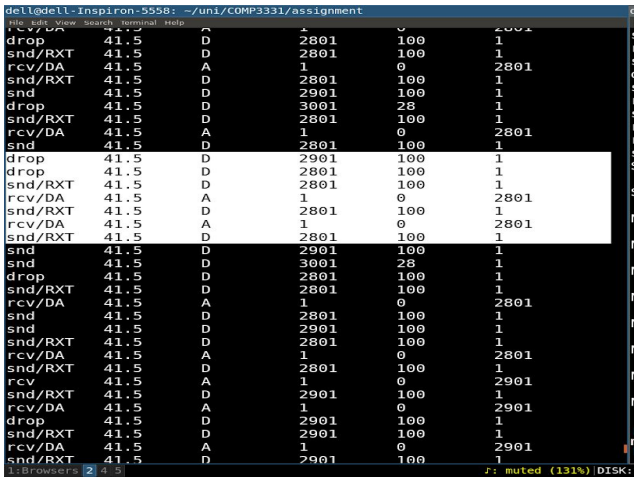
Sender



```
dell@dell-Inspiron-5558: ~/uni/COMP3331/assignment
File  Edit  View  Search  Terminal  Help
snd/RXT     28.5        D           3001        28          1
snd/RXT     28.5        D           3001        28          1
rcv/DA      28.5        A           1           0           3001
snd         28.5        D           3001        28          1
snd/RXT     28.5        D           3001        28          1
rcv         28.5        A           1           0           3029
snd         28.5        F           3029        0           1
rcv         28.5        A           1           0           3029
rcv         28.5        F           1           0           3029
snd         28.5        A           3029        0           2
Size of the file (in Bytes)                                 3028

Segments transmitted (including drop & RXT)                 1387

Number of Segments handled by PLD                           1383

Number of Segments dropped                                  130

Number of Segments Corrupted                                0

Number of Segments Re-ordered                               0

Number of Segments delay                                    0

Number of Retransmission due to TIMEOUT                     584

Number of FAST RETRANSMISSION                               168

Number of DUP ACKS received                                 500

┌[dell㉿dell-Inspiron-5558]-(~/uni/COMP3331/assignment)-[git://
master ✗]-
└─>
```

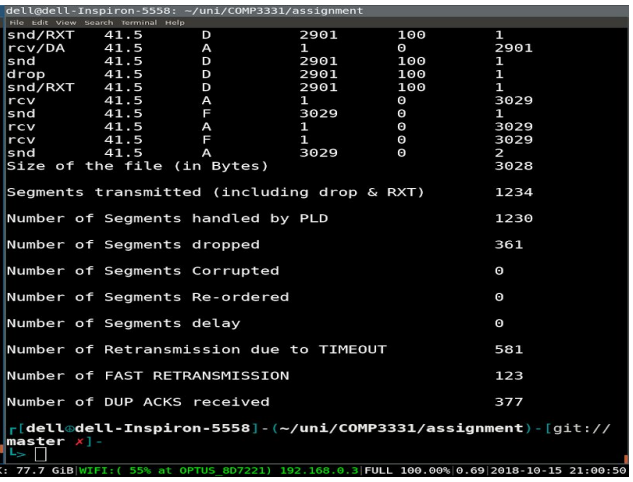
pDrop = 0.3

Sender



```
dell@dell-Inspiron-5558: ~/uni/COMP3331/assignment
File  Edit  View  Search  Terminal  Help
drop        41.5        D           2801        100         1
snd/RXT     41.5        D           2801        100         1
rcv/DA      41.5        A           1           0           2801
snd/RXT     41.5        D           2801        100         1
snd         41.5        D           2901        100         1
drop        41.5        D           3001        28          1
snd/RXT     41.5        D           2801        100         1
rcv/DA      41.5        A           1           0           2801
snd         41.5        D           2801        100         1
drop        41.5        D           2901        100         1
drop        41.5        D           2801        100         1
snd/RXT     41.5        D           2801        100         1
rcv/DA      41.5        A           1           0           2801
snd/RXT     41.5        D           2801        100         1
rcv/DA      41.5        A           1           0           2801
snd/RXT     41.5        D           2801        100         1
snd         41.5        D           2901        100         1
snd         41.5        D           3001        28          1
drop        41.5        D           2801        100         1
snd/RXT     41.5        D           2801        100         1
rcv/DA      41.5        A           1           0           2801
snd         41.5        D           2801        100         1
snd         41.5        D           2901        100         1
snd/RXT     41.5        D           2801        100         1
rcv/DA      41.5        A           1           0           2801
snd/RXT     41.5        D           2801        100         1
rcv         41.5        A           1           0           2901
snd/RXT     41.5        D           2901        100         1
rcv/DA      41.5        A           1           0           2901
drop        41.5        D           2901        100         1
snd/RXT     41.5        D           2901        100         1
rcv/DA      41.5        A           1           0           2901
snd/RXT     41.5        D           2901        100         1
1:Browsers 2 4 5                                    ♪: muted (131%) DISK: 77.7 GiB WIFI:( 55% at OPTUS_8D7221) 192.168.0.3 FULL 100.00% 0.69 2018-10-15 21:00:50
```

Sender



```
dell@dell-Inspiron-5558: ~/uni/COMP3331/assignment
File  Edit  View  Search  Terminal  Help
snd/RXT     41.5        D           2901        100         1
rcv/DA      41.5        A           1           0           2901
snd         41.5        D           2901        100         1
drop        41.5        D           2901        100         1
snd/RXT     41.5        D           2901        100         1
rcv         41.5        A           1           0           3029
snd         41.5        F           3029        0           1
rcv         41.5        A           1           0           3029
rcv         41.5        F           1           0           3029
snd         41.5        A           3029        0           2
Size of the file (in Bytes)                                 3028

Segments transmitted (including drop & RXT)                 1234

Number of Segments handled by PLD                           1230

Number of Segments dropped                                  361

Number of Segments Corrupted                                0

Number of Segments Re-ordered                               0

Number of Segments delay                                    0

Number of Retransmission due to TIMEOUT                     581

Number of FAST RETRANSMISSION                               123

Number of DUP ACKS received                                 377

┌[dell㉿dell-Inspiron-5558]-(~/uni/COMP3331/assignment)-[git://
master ✗]-
└─>
```

5.B.i

```
snd/RXT    4362.5     D          308201     3          1
rcv/DA     4362.5     A          1          0          308201
drop       4362.5     D          308201     3          1
drop       4362.5     D          308201     3          1
snd/RXT    4362.5     D          308201     3          1
rcv        4362.5     A          1          0          308204
snd        4362.5     F          308204     0          1
rcv        4362.5     A          1          0          308204
rcv        4362.5     F          1          0          308204
snd        4362.5     A          308204     0          2
Size of the file (in Bytes)                             308203

Segments transmitted (including drop & RXT)             430399

Number of Segments handled by PLD                       456781

Number of Segments dropped                              227408

Number of Segments Corrupted                            0

Number of Segments Re-ordered                           0

Number of Segments delay                                45622

Number of Retransmission due to TIMEOUT                 179749

Number of FAST RETRANSMISSION                           27708

Number of DUP ACKS received                             83115
```

5.B.ii

```
snd/dely   4958.1     D          308151     50         1
rcv/DA     4958.1     A          1          0          308151
snd/RXT    4958.1     D          308201     3          1
drop       4958.2     D          308151     50         1
snd/RXT    4958.2     D          308151     50         1
rcv        4958.2     A          1          0          308204
snd        4958.2     F          308204     0          1
rcv        4958.2     A          1          0          308204
rcv        4958.2     F          1          0          308204
snd        4958.2     A          308204     0          2
Size of the file (in Bytes)                             308203

Segments transmitted (including drop & RXT)             436743

Number of Segments handled by PLD                       462787

Number of Segments dropped                              230384

Number of Segments Corrupted                            0

Number of Segments Re-ordered                           0

Number of Segments delay                                46227

Number of Retransmission due to TIMEOUT                 179346

Number of FAST RETRANSMISSION                           28346

Number of DUP ACKS received                             84972
```

5.B.iii

```
dell@dell-Inspiron-5558: ~/uni/COMP3331/assignment
File  Edit  View  Search  Terminal  Help
snd/dely    5924.4      D           308151      50          1
rcv/DA      5924.4      A           1           0           308151
drop        5924.4      D           308201      3           1
drop        5924.4      D           308151      50          1
snd/RXT     5924.5      D           308151      50          1
rcv         5924.5      A           1           0           308204
snd         5924.5      F           308204      0           1
rcv         5924.5      A           1           0           308204
rcv         5924.5      F           1           0           308204
snd         5924.5      A           308204      0           2
Size of the file (in Bytes)                                 308203

Segments transmitted (including drop & RXT)                 436646

Number of Segments handled by PLD                           462603

Number of Segments dropped                                  230295

Number of Segments Corrupted                                0

Number of Segments Re-ordered                               0

Number of Segments delay                                    46212

Number of Retransmission due to TIMEOUT                     179233

Number of FAST RETRANSMISSION                               28343

Number of DUP ACKS received                                 84839
```

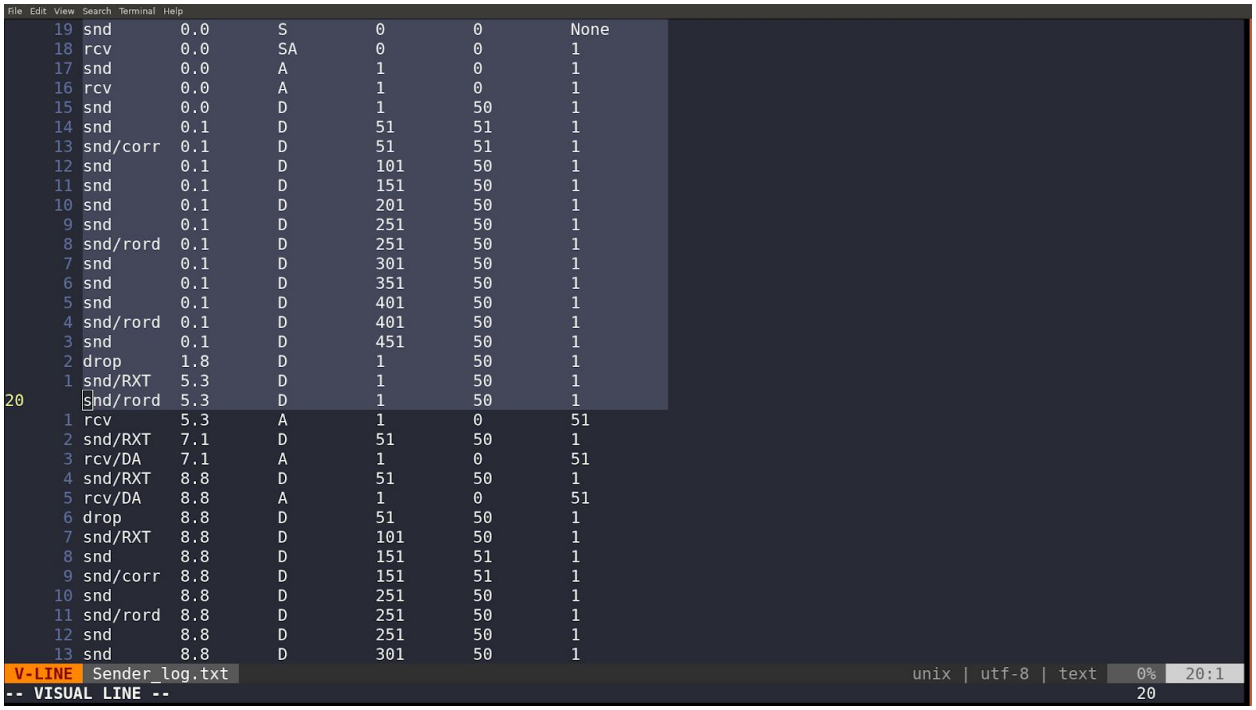
5.C.

Receiver:

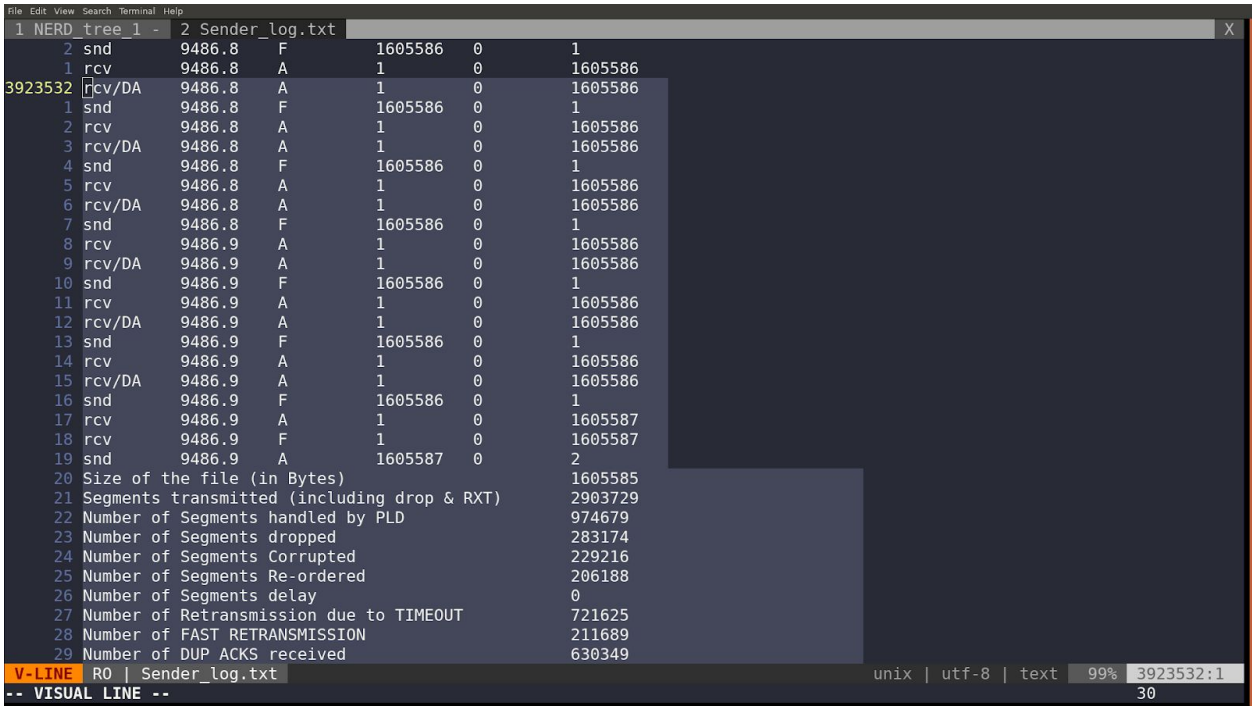
```
File  Edit  View  Search  Terminal  Help
    19 rcv       0.0      SYN      0        0        None
    18 snd       0.0      SA       0        0        1
    17 rcv       0.0      D        1        0        1
    16 snd       0.0      A        1        0        1
    15 rcv       0.0      D        1        50       1
    14 snd/DA    0.0      A        1        0        51
    13 rcv/corr  0.0      D        51       51       1
    12 snd/DA    0.0      A        1        0        51
    11 rcv       0.0      D        101      50       1
    10 snd       0.0      A        1        0        51
     9 rcv       0.0      D        151      50       1
     8 snd       0.0      A        1        0        51
     7 rcv       0.0      D        201      50       1
     6 snd       0.0      A        1        0        51
     5 rcv       0.0      D        201      50       1
     4 snd/DA    0.0      A        1        0        51
     3 rcv       0.0      D        251      50       1
     2 snd       0.0      A        1        0        51
     1 rcv       0.0      D        301      50       1
20   snd         0.0      A        1        0        51
     1 rcv       0.0      D        301      50       1
     2 snd/DA    0.0      A        1        0        51
     3 rcv       0.0      D        351      50       1
     4 snd       0.0      A        1        0        51
     5 rcv       0.0      D        401      50       1
     6 snd       0.0      A        1        0        51
     7 rcv       0.0      D        451      50       1
     8 snd       0.0      A        1        0        51
     9 rcv/DA    5.3      D        1        50       1
    10 snd       5.3      A        1        0        51
    11 rcv       7.0      D        51       50       1
    12 snd       7.0      A        1        0        101
    13 rcv/DA    8.7      D        51       50       1
 V-LINE  Receiver_log.txt                    unix | utf-8 | text   0%   20:1
-- VISUAL LINE --                                                   20
```

```
File  Edit  View  Search  Terminal  Help
    32 snd       9486.9   A        1        0        1605587
    31 snd       9486.9   F        1        0        1605587
    30 rcv       9486.9   F        1605586  0        1
    29 snd       9486.9   A        1        0        1605587
    28 snd       9486.9   F        1        0        1605587
    27 rcv       9486.9   F        1605586  0        1
    26 snd       9486.9   A        1        0        1605587
    25 snd       9486.9   F        1        0        1605587
    24 rcv       9486.9   F        1605586  0        1
    23 snd       9486.9   A        1        0        1605587
    22 snd       9486.9   F        1        0        1605587
    21 rcv       9486.9   F        1605586  0        1
    20 snd       9486.9   A        1        0        1605587
    19 snd       9486.9   F        1        0        1605587
    18 rcv       9486.9   F        1605586  0        1
    17 snd       9486.9   A        1        0        1605587
    16 snd       9486.9   F        1        0        1605587
    15 rcv       9486.9   F        1605586  0        1
    14 snd       9486.9   A        1        0        1605587
    13 snd       9486.9   F        1        0        1605587
    12 rcv       9486.9   F        1605586  0        1
    11 snd       9486.9   A        1        0        1605587
    10 snd       9486.9   F        1        0        1605587
     9 rcv       9486.9   F        1605586  0        1
     8 snd       9486.9   A        1        0        1605587
     7 snd       9486.9   F        1        0        1605587
```

Sender:



```
File  Edit  View  Search  Terminal  Help
     19 snd        0.0       S         0         0         None
     18 rcv        0.0       SA        0         0         1
     17 snd        0.0       A         1         0         1
     16 rcv        0.0       A         1         0         1
     15 snd        0.0       D         1         50        1
     14 snd        0.1       D         51        51        1
     13 snd/corr   0.1       D         51        51        1
     12 snd        0.1       D         101       50        1
     11 snd        0.1       D         151       50        1
     10 snd        0.1       D         201       50        1
      9 snd        0.1       D         251       50        1
      8 snd/rord   0.1       D         251       50        1
      7 snd        0.1       D         301       50        1
      6 snd        0.1       D         351       50        1
      5 snd        0.1       D         401       50        1
      4 snd/rord   0.1       D         401       50        1
      3 snd        0.1       D         451       50        1
      2 drop       1.8       D         1         50        1
      1 snd/RXT    5.3       D         1         50        1
20      snd/rord   5.3       D         1         50        1
      1 rcv        5.3       A         1         0         51
      2 snd/RXT    7.1       D         51        50        1
      3 rcv/DA     7.1       A         1         0         51
      4 snd/RXT    8.8       D         51        50        1
      5 rcv/DA     8.8       A         1         0         51
      6 drop       8.8       D         51        50        1
      7 snd/RXT    8.8       D         101       50        1
      8 snd        8.8       D         151       51        1
      9 snd/corr   8.8       D         151       51        1
     10 snd        8.8       D         251       50        1
     11 snd/rord   8.8       D         251       50        1
     12 snd        8.8       D         251       50        1
     13 snd        8.8       D         301       50        1
V-LINE  Sender_log.txt                                  unix | utf-8 | text   0%  20:1
-- VISUAL LINE --                                                            20
```



```
File  Edit  View  Search  Terminal  Help
1 NERD_tree_1 -  2 Sender_log.txt                                                X
      2 snd        9486.8    F         1605586   0         1
      1 rcv        9486.8    A         1         0         1605586
3923532 rcv/DA     9486.8    A         1         0         1605586
      1 snd        9486.8    F         1605586   0         1
      2 rcv        9486.8    A         1         0         1605586
      3 rcv/DA     9486.8    A         1         0         1605586
      4 snd        9486.8    F         1605586   0         1
      5 rcv        9486.8    A         1         0         1605586
      6 rcv/DA     9486.8    A         1         0         1605586
      7 snd        9486.8    F         1605586   0         1
      8 rcv        9486.9    A         1         0         1605586
      9 rcv/DA     9486.9    A         1         0         1605586
     10 snd        9486.9    F         1605586   0         1
     11 rcv        9486.9    A         1         0         1605586
     12 rcv/DA     9486.9    A         1         0         1605586
     13 snd        9486.9    F         1605586   0         1
     14 rcv        9486.9    A         1         0         1605586
     15 rcv/DA     9486.9    A         1         0         1605586
     16 snd        9486.9    F         1605586   0         1
     17 rcv        9486.9    A         1         0         1605587
     18 rcv        9486.9    F         1         0         1605587
     19 snd        9486.9    A         1605587   0         2
     20 Size of the file (in Bytes)                        1605585
     21 Segments transmitted (including drop & RXT)        2903729
     22 Number of Segments handled by PLD                  974679
     23 Number of Segments dropped                         283174
     24 Number of Segments Corrupted                       229216
     25 Number of Segments Re-ordered                      206188
     26 Number of Segments delay                           0
     27 Number of Retransmission due to TIMEOUT            721625
     28 Number of FAST RETRANSMISSION                      211689
     29 Number of DUP ACKS received                        630349
V-LINE  RO | Sender_log.txt                    unix | utf-8 | text  99%  3923532:1
-- VISUAL LINE --                                                            30
```