

Assignment

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Notes: Please use python3 instead of python to test my program

Question 1: A brief discussion of how you have implemented the STP protocol.

Packet encapsulation:

First, construct a STP entity class, which stores the specific parameters needed for STP transmission, such as sequence number, acknowledgment number, ACK, SYN, FIN, DATA. Each time a STP packet is sent, parameters are passed to this entity class to encapsulate the data.

Three-way handshake:

The connection between the sender and the receiver is initiated by the sender through a three-way handshake. The sender sets the SYN flag to True, which means that the sender sends a request and wants the receiver to open the channel. This packet does not contain any data, and the packet is sent to the receiver's port.

If the receiver IP address and port are available, the receiver will read the SYN flag to determine if the SYN flag is True. If True, set the header ACK flag and SYN flag to True and update the sequence number to the next expected sequence number that the receiver expects to view. The packet is encapsulated and sent to the sender's address and port.

After receiving the data packet, the sender parses the data packet and reads the ACK and SYN flag bits. If both ACK and SYN are true, the sender will send a data packet with the ACK as True, telling the receiver that the channel is already open. Data will be transmitted soon

File processing:

The file is read in binary format. After reading, the data is stored in a variable, and each time a specific length of data is read from it.

Data transmission methodology

● **Calculate and update the window size:**

Before each data packet is sent, the current window size and the value of the MWS are compared. If the MWS is greater than the current window size, the data packet is sent after reading the specific length data, and the size of the current window is updated and the sequence number of the transmitted data packet is updated. If the current window size is equal to MWS, the process proceeds to receive data packets.

Sender sends packets:

Determine the size of the current window before sending the data packet. If the window size is less than MWS, load the data, then package the STP packet, and then transfer the packet.

- **Sender receives packets:**

When the sender receives a packet acknowledgment number, the program will parse the packet and check the received acknowledgment number and the current location of the window. If the confirmation number is greater than the window current location. The sender will iteratively confirm that all received packets in the window have an acknowledgment number greater than the sequence number. Otherwise, this packet is considered to be a duplicate received packet.

- **Timer: implementation**

During the packet transmission process, the entire program uses only one timer, and the timer is only turned on before the first packet is sent. When the sender receives the data packet, determines the acknowledge number of the data packet and the current window position. If the acknowledge number is greater than the current window position, it indicates that a data packet is successfully received, the timer reset and updates the current SampleRTT, timeout and current window position. If the received envelope number is smaller than the current window position, it indicates that the received data packet is a duplicate data packet. In this case, the SampleRTT, timeout and the current window position are not updated. The timer continues to be in a timed state.

When the timer expires, the method of retransmitting the packet is triggered, and the packet with the current window in the first place is sent. Reset the timer.

- **Retransmit protocol:**

Delay, drop, and corruption will trigger the retransmission mechanism of the timer. Delay, drop, and corrupt will also trigger three times to transmit the same acknowledge number, which will also cause the packet to be retransmitted.

- **Four-segment connection termination**

Once the current remaining file length is less than 0 and there are currently no unacked data packets, the sender actively sends a data packet with FIN flag. This data packet does not contain any data. The receiver receives the data packet and knows the value of the FIN flag. If the FIN flag is True, the receiver immediately sends the packet which FIN flag is also True after receiving the data packet. When the sender receives the FIN flag from the receiver, it stops sending packets.

PLD Model:

The PLD module is designed and implemented between the transmitter and receiver. Based on user-defined random number seed generator. If the number of random seeds is greater than pDrop, the packet is successfully transmitted to the receiver, otherwise the packet is dropped. If the number of random seeds is greater than pduplicate, the

packet is successfully transmitted to the receiver, otherwise two identical packets are sent consecutively. If the random number seed is greater than pcorrupt, the packet is successfully transmitted to the receiver, otherwise the data in the packet is changed and then sent to the receiver. If the number of random seeds is greater than the order, the packet is successfully transmitted to the receiver, otherwise the packet is recorded, and the packet is sent after the four packets are sent. If the number of random seeds is greater than pDelay, the packet is successfully transmitted to the receiver, otherwise it starts timing, and after a certain period of time, the packet is sent.

The following features are successfully implemented

- Three-way handshake
- Encapsulate STP packet
- Calculate dynamic SampleRTT and timeout
- Retransmission protocol
- Cumulative Acknowledgment
- Sequence and Acknowledgment numbers based on payload size
- Recording log file both sender and receiver
- Current window size
- Four-way termination
- pDrop function
- pDelay function
- pCorrupt function
- pDuplicate function
- pOrder function

Question 2: A detailed diagram of your STP header and explanation of all fields

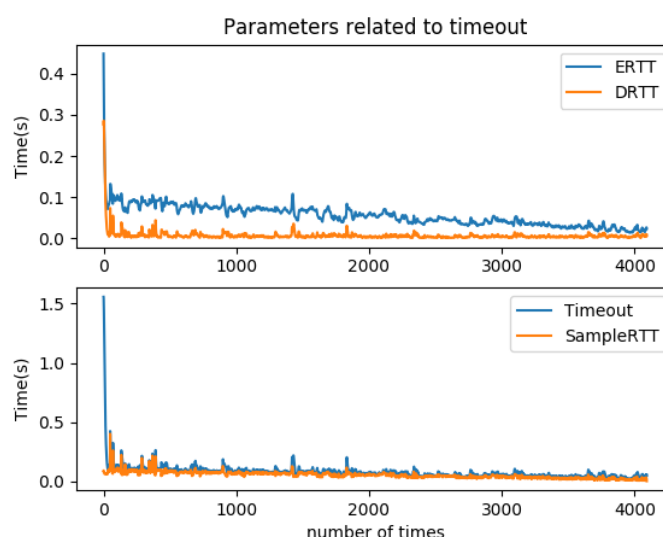
| | | | |
|-----------------|----------|------------|--|
| Sequence number | | ACK number | |
| SYN flag | ACK flag | FIN flag | |
| Data | | | |

| Header | Description |
|--------------------|--|
| Sequence number | This is used to indicate the first byte of data contained in the packet. Both the sender and the receiver use this number to identify the packets they send and confirm, respectively. |
| Acknowledge number | This is used to indicates the last bytes that confirmed by receiver. This number will be increased by sequence number. |
| SYN flag | SYN flag is use in initiating connection through three-way handshake |

| | |
|----------|--|
| ACK flag | ACK flag is use in initiating three-way handshake and acknowledging four-way termination |
| FIN flag | Fin flag is used to terminate the connection |
| Data | Data transmitted by each packet |

Question 3:

- There is an error when the timer calculates SampleRTT. Due to the principle of go back n transmission, when the receiver receives the data packet, the timer starts again, which makes the error calculate the real SampleRTT of the already sent data packet.
- The design of the timer can be further optimized. The timer in the program will update the current SampleRTT value after successfully receiving a packet. Because the timer has an error in calculating the SampleRTT. Therefore the value of simpleRTT will become smaller. The optimization scheme is that each MWS only calculates one SampleRTT, but this method also has disadvantages, which will result in a long timeout.



This picture is the result of transmitting test2.pdf. You can see that DevRTT, EstimateRTT, timeout and SampleRTT are all decreasing, which is the factor that affects the file transfer time. Due to the difference in the calculation of the timeout, it will lead to time differences.

Question 4:

Answer: I refer to the framework of STP transmission and the structure of STP packets from the Internet. The rest parts of the assignment are finished by myself.

Question (a):

- $pDrop = 0.1$, MWS = 500 bytes, MSS = 100 bytes, seed = 100, gamma = 4
- In my experiment, when $pDrop$ is equal to 0.1, the sequence number of the dropped packet are 201, 2001, 2701, 2801. There are total 4 dropped packets.

- $pDrop = 0.3$, $MWS = 500$ bytes, $MSS = 100$ bytes, $seed = 100$, $gamma = 4$
In my experiment, when $pDrop$ is equal to 0.3, the sequence number of the dropped packet are 1, 401, 601, 701, 901, 1301, 1401, 1501, 1901, 2401, 2501, 2601, 2901. There are total 24 dropped packets.

| pDrop value | dropped packets |
|-------------|-----------------|
| 0.1 | 4 |
| 0.3 | 24 |

Question(b):

| | Number of STP packets | Overall transfer time |
|-------------|-----------------------|-----------------------|
| $gamma = 2$ | 12584 | 83 minutes |
| $gamma = 4$ | 12450 | 135 minutes |
| $gamma = 6$ | 12450 | 183 minutes |

The transmission time becomes larger as the gamma value becomes larger, because the value of gamma determines the length of time for SampleRTT and timeout. In the case where the other parameters are unchanged, the only change to gamma is timeout. The number of sent packets does not change with gamma changes, because the length of the file is fixed, and both MWS and MSS are fixed. Since these variables are not changed, the number of packets does not change.

Question(c):**Has the file been successfully transferred?**

Answer: Yes, the file has been successfully transferred

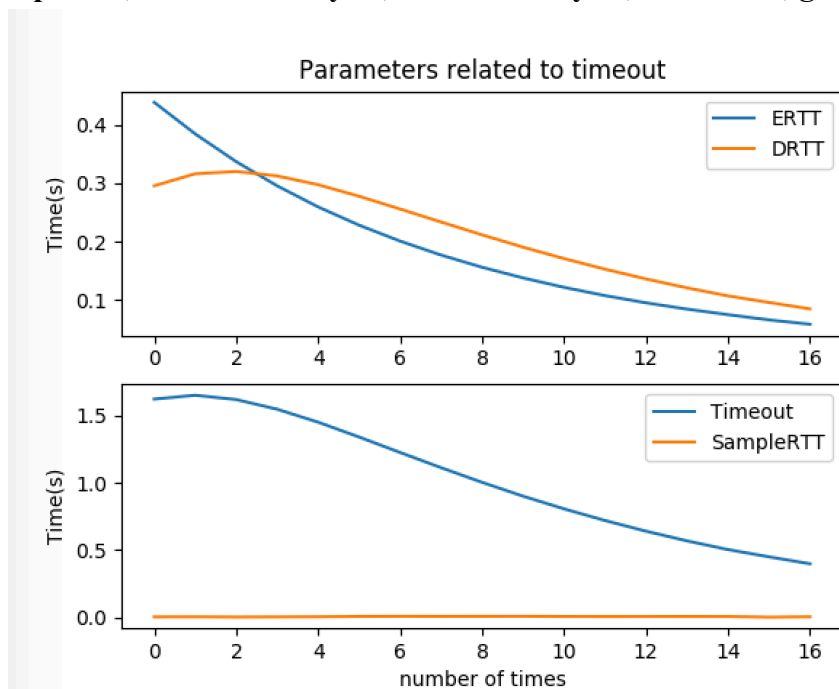
How long the overall transfer took?

Answer: It takes me about 8 minutes to transfer the whole PDF file.

Which of the factors is the most critical in the overall transfer time?

- According to the question $MWS=500$ bytes $MSS=50$ $gamma=4$ $pDrop=0.1$ $pDuplicate=0.1$ $pCorrupt=0.1$ $pOrder=0.1$ $maxOrder=4$ $pDelay=0$ $maxDelay=0$ $seed=300$, it takes about **8 minutes** to transfer the test2.pdf file.
- Change the value of $pDrop$ to 0 to keep the other variables unchanged, it takes about **4 minutes** to transfer the whole test2.pdf file
- Change the value of $pDuplicate$ to 0 to keep the other variables unchanged, it takes about **8 minutes** to transfer the whole test2.pdf file
- Change the value of $pCorrupt$ to 0 to keep the other variables unchanged, it takes about **5 minutes** to transfer the whole test2.pdf file
- Change the value of $pOrder$ to 0 to keep the other variables unchanged, it takes about **7 minutes** to transfer the whole test2.pdf file

By using the control variable method, we can see that when $pDrop$ is 0, the transmission time drop a lot, but when the other variables are changed, the transmission time does not change substantially or transmission time change is small. Therefore, **pDrop** is the most critical factor contributing to overall transfer time.

Appendix:**(a) pDrop = 0.1, MWS = 500 bytes, MSS = 100 bytes, seed = 100, gamma = 4**

Timeout.png

Sender_log.txt

| | | | | |
|---------|--------|------|-----|------|
| snd | 0.00 S | 0 | 0 | 0 |
| rcv | 0.00 A | 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 | 0.01 D | 201 | 100 | 1 |
| snd | 0.01 D | 301 | 100 | 1 |
| snd | 0.01 D | 401 | 100 | 1 |
| rcv | 0.01 A | 1 | 0 | 101 |
| snd | 0.01 D | 501 | 100 | 1 |
| rcv | 0.01 A | 1 | 0 | 201 |
| snd | 0.01 D | 601 | 100 | 1 |
| rcv/DA | 0.01 A | 1 | 0 | 201 |
| rcv/DA | 0.01 A | 1 | 0 | 201 |
| rcv/DA | 0.01 A | 1 | 0 | 201 |
| snd/RXT | 0.02 D | 201 | 100 | 1 |
| rcv/DA | 0.02 A | 1 | 0 | 201 |
| rcv | 0.02 A | 1 | 0 | 701 |
| snd | 0.02 D | 701 | 100 | 1 |
| snd | 0.02 D | 801 | 100 | 1 |
| snd | 0.02 D | 901 | 100 | 1 |
| snd | 0.02 D | 1001 | 100 | 1 |
| snd | 0.02 D | 1101 | 100 | 1 |
| rcv | 0.02 A | 1 | 0 | 801 |
| snd | 0.02 D | 1201 | 100 | 1 |
| rcv | 0.03 A | 1 | 0 | 901 |
| snd | 0.03 D | 1301 | 100 | 1 |
| rcv | 0.03 A | 1 | 0 | 1001 |

| | | | | |
|---|--------|------|-----|------|
| snd | 0.03 D | 1401 | 100 | 1 |
| rcv | 0.03 A | 1 | 0 | 1101 |
| snd | 0.03 D | 1501 | 100 | 1 |
| rcv | 0.03 A | 1 | 0 | 1201 |
| snd | 0.03 D | 1601 | 100 | 1 |
| rcv | 0.03 A | 1 | 0 | 1301 |
| snd | 0.04 D | 1701 | 100 | 1 |
| rcv | 0.04 A | 1 | 0 | 1401 |
| snd | 0.04 D | 1801 | 100 | 1 |
| rcv | 0.04 A | 1 | 0 | 1501 |
| snd | 0.04 D | 1901 | 100 | 1 |
| rcv | 0.04 A | 1 | 0 | 1601 |
| drop | 0.04 D | 2001 | 100 | 1 |
| rcv | 0.04 A | 1 | 0 | 1701 |
| snd | 0.04 D | 2101 | 100 | 1 |
| rcv | 0.04 A | 1 | 0 | 1801 |
| snd | 0.05 D | 2201 | 100 | 1 |
| rcv | 0.05 A | 1 | 0 | 1901 |
| snd | 0.05 D | 2301 | 100 | 1 |
| rcv | 0.05 A | 1 | 0 | 2001 |
| snd | 0.05 D | 2401 | 100 | 1 |
| rcv/DA | 0.05 A | 1 | 0 | 2001 |
| rcv/DA | 0.05 A | 1 | 0 | 2001 |
| rcv/DA | 0.05 A | 1 | 0 | 2001 |
| snd/RXT | 0.05 D | 2001 | 100 | 1 |
| rcv/DA | 0.05 A | 1 | 0 | 2001 |
| rcv | 0.06 A | 1 | 0 | 2501 |
| snd | 0.06 D | 2501 | 100 | 1 |
| snd | 0.06 D | 2601 | 100 | 1 |
| drop | 0.06 D | 2701 | 100 | 1 |
| drop | 0.06 D | 2801 | 100 | 1 |
| snd | 0.06 D | 2901 | 100 | 1 |
| rcv | 0.06 A | 1 | 0 | 2601 |
| snd | 0.06 D | 3001 | 28 | 1 |
| rcv | 0.06 A | 1 | 0 | 2701 |
| rcv/DA | 0.06 A | 1 | 0 | 2701 |
| rcv/DA | 0.07 A | 1 | 0 | 2701 |
| snd/RXT | 0.47 D | 2701 | 100 | 1 |
| rcv | 0.47 A | 1 | 0 | 2801 |
| snd/RXT | 0.87 D | 2801 | 100 | 1 |
| rcv | 0.87 A | 1 | 0 | 3029 |
| snd | 0.87 F | 3029 | 0 | 1 |
| rcv | 0.87 A | 1 | 0 | 3030 |
| rcv | 0.87 F | 1 | 0 | 3030 |
| snd | 0.87 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 Delay | | | | 0 |
| Number of Segments Retransmissions due to TIMEOUT | | | | 2 |
| Number of Segments FAST RETRANSMISSION | | | | 2 |
| Number of Segments DUP ACKS received | | | | 10 |

Receiver_log.txt

| | | | | |
|--------|---------|------|-----|------|
| 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 | 0.01 A | 1 | 0 | 201 |
| rcv | 0.01 D | 301 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 201 |
| rcv | 0.01 D | 401 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 201 |
| rcv | 0.01 D | 501 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 201 |
| rcv | 0.01 D | 601 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 201 |
| rcv | 0.02 D | 201 | 100 | 1 |
| snd | 0.02 A | 1 | 0 | 701 |
| rcv | 0.02 D | 701 | 100 | 1 |
| snd | 0.02 A | 1 | 0 | 801 |
| rcv | 0.02 D | 801 | 100 | 1 |
| snd | 0.02 A | 1 | 0 | 901 |
| rcv | 0.02 D | 901 | 100 | 1 |
| snd | 0.02 A | 1 | 0 | 1001 |
| rcv | 0.02 D | 1001 | 100 | 1 |
| snd | 0.02 A | 1 | 0 | 1101 |
| rcv | 0.02 D | 1101 | 100 | 1 |
| snd | 0.02 A | 1 | 0 | 1201 |
| rcv | 0.02 D | 1201 | 100 | 1 |
| snd | 0.03 A | 1 | 0 | 1301 |
| rcv | 0.03 D | 1301 | 100 | 1 |
| snd | 0.03 A | 1 | 0 | 1401 |
| rcv | 0.03 D | 1401 | 100 | 1 |
| snd | 0.03 A | 1 | 0 | 1501 |
| rcv | 0.03 D | 1501 | 100 | 1 |
| snd | 0.03 A | 1 | 0 | 1601 |
| rcv | 0.03 D | 1601 | 100 | 1 |
| snd | 0.03 A | 1 | 0 | 1701 |
| rcv | 0.03 D | 1701 | 100 | 1 |
| snd | 0.04 A | 1 | 0 | 1801 |
| rcv | 0.04 D | 1801 | 100 | 1 |
| snd | 0.04 A | 1 | 0 | 1901 |
| rcv | 0.04 D | 1901 | 100 | 1 |
| snd | 0.04 A | 1 | 0 | 2001 |
| rcv | 0.04 D | 2101 | 100 | 1 |
| snd/DA | 0.04 A | 1 | 0 | 2001 |
| rcv | 0.05 D | 2201 | 100 | 1 |
| snd/DA | 0.05 A | 1 | 0 | 2001 |
| rcv | 0.05 D | 2301 | 100 | 1 |
| snd/DA | 0.05 A | 1 | 0 | 2001 |
| rcv | 0.05 D | 2401 | 100 | 1 |
| snd/DA | 0.05 A | 1 | 0 | 2001 |
| rcv | 0.05 D | 2001 | 100 | 1 |
| snd | 0.05 A | 1 | 0 | 2501 |
| rcv | 0.06 D | 2501 | 100 | 1 |
| snd | 0.06 A | 1 | 0 | 2601 |
| rcv | 0.06 D | 2601 | 100 | 1 |

| | | | | |
|--------|--------|------|-----|------|
| snd | 0.06 A | 1 | 0 | 2701 |
| rcv | 0.06 D | 2901 | 100 | 1 |
| snd/DA | 0.06 A | 1 | 0 | 2701 |
| rcv | 0.06 D | 3001 | 28 | 1 |
| snd/DA | 0.06 A | 1 | 0 | 2701 |
| rcv | 0.47 D | 2701 | 100 | 1 |
| snd | 0.47 A | 1 | 0 | 2801 |
| rcv | 0.87 D | 2801 | 100 | 1 |
| snd | 0.87 A | 1 | 0 | 3029 |
| rcv | 0.87 F | 3029 | 0 | 1 |
| snd | 0.87 A | 1 | 0 | 3030 |
| snd | 0.87 F | 1 | 0 | 3030 |
| rcv | 0.87 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 |

(a) pDrop = 0.3, MWS = 500 bytes, MSS = 100 bytes, seed = 100, gamma = 4

Sender_log.txt

| | | | | |
|---------|--------|------|-----|-----|
| snd | 0.00 S | 0 | 0 | 0 |
| rcv | 0.00 A | 0 | 0 | 1 |
| snd | 0.00 A | 1 | 0 | 1 |
| drop | 0.00 D | 1 | 100 | 1 |
| snd | 0.00 D | 101 | 100 | 1 |
| snd | 0.01 D | 201 | 100 | 1 |
| snd | 0.01 D | 301 | 100 | 1 |
| drop | 0.01 D | 401 | 100 | 1 |
| rcv/DA | 0.01 A | 1 | 0 | 1 |
| rcv/DA | 0.01 A | 1 | 0 | 1 |
| rcv/DA | 0.01 A | 1 | 0 | 1 |
| drop | 0.01 D | 1 | 100 | 1 |
| drop | 1.51 D | 1 | 100 | 1 |
| snd/RXT | 3.01 D | 1 | 100 | 1 |
| rcv | 3.02 A | 1 | 0 | 401 |
| snd | 3.02 D | 501 | 100 | 1 |
| drop | 3.02 D | 601 | 100 | 1 |
| drop | 3.02 D | 701 | 100 | 1 |
| snd | 3.02 D | 801 | 100 | 1 |
| rcv/DA | 3.02 A | 1 | 0 | 401 |
| rcv/DA | 3.02 A | 1 | 0 | 401 |
| snd/RXT | 4.52 D | 401 | 100 | 1 |
| rcv | 4.52 A | 1 | 0 | 601 |
| drop | 4.52 D | 901 | 100 | 1 |
| snd | 4.53 D | 1001 | 100 | 1 |
| rcv/DA | 4.53 A | 1 | 0 | 601 |
| snd/RXT | 6.03 D | 601 | 100 | 1 |
| rcv | 6.03 A | 1 | 0 | 701 |
| snd | 6.03 D | 1101 | 100 | 1 |
| rcv/DA | 6.03 A | 1 | 0 | 701 |

| | | | | |
|---------|---------|------|-----|------|
| snd/RXT | 7.53 D | 701 | 100 | 1 |
| rcv | 7.53 A | 1 | 0 | 901 |
| snd | 7.54 D | 1201 | 100 | 1 |
| drop | 7.54 D | 1301 | 100 | 1 |
| rcv/DA | 7.54 A | 1 | 0 | 901 |
| snd/RXT | 9.04 D | 901 | 100 | 1 |
| rcv | 9.04 A | 1 | 0 | 1301 |
| drop | 9.04 D | 1401 | 100 | 1 |
| drop | 9.04 D | 1501 | 100 | 1 |
| snd | 9.04 D | 1601 | 100 | 1 |
| snd | 9.04 D | 1701 | 100 | 1 |
| rcv/DA | 9.04 A | 1 | 0 | 1301 |
| rcv/DA | 9.05 A | 1 | 0 | 1301 |
| drop | 10.55 D | 1301 | 100 | 1 |
| snd/RXT | 12.05 D | 1301 | 100 | 1 |
| rcv | 12.05 A | 1 | 0 | 1401 |
| snd | 12.05 D | 1801 | 100 | 1 |
| rcv/DA | 12.06 A | 1 | 0 | 1401 |
| snd/RXT | 13.56 D | 1401 | 100 | 1 |
| rcv | 13.56 A | 1 | 0 | 1501 |
| drop | 13.56 D | 1901 | 100 | 1 |
| drop | 15.06 D | 1501 | 100 | 1 |
| drop | 16.56 D | 1501 | 100 | 1 |
| drop | 18.07 D | 1501 | 100 | 1 |
| drop | 19.57 D | 1501 | 100 | 1 |
| snd/RXT | 21.07 D | 1501 | 100 | 1 |
| rcv | 21.07 A | 1 | 0 | 1901 |
| snd | 21.07 D | 2001 | 100 | 1 |
| snd | 21.07 D | 2101 | 100 | 1 |
| snd | 21.07 D | 2201 | 100 | 1 |
| snd | 21.07 D | 2301 | 100 | 1 |
| rcv/DA | 21.07 A | 1 | 0 | 1901 |
| rcv/DA | 21.08 A | 1 | 0 | 1901 |
| rcv/DA | 21.08 A | 1 | 0 | 1901 |
| drop | 21.08 D | 1901 | 100 | 1 |
| rcv/DA | 21.08 A | 1 | 0 | 1901 |
| snd/RXT | 22.59 D | 1901 | 100 | 1 |
| rcv | 22.59 A | 1 | 0 | 2401 |
| drop | 22.59 D | 2401 | 100 | 1 |
| drop | 22.59 D | 2501 | 100 | 1 |
| drop | 22.60 D | 2601 | 100 | 1 |
| snd | 22.60 D | 2701 | 100 | 1 |
| snd | 22.60 D | 2801 | 100 | 1 |
| rcv/DA | 22.61 A | 1 | 0 | 2401 |
| rcv/DA | 22.62 A | 1 | 0 | 2401 |
| drop | 24.12 D | 2401 | 100 | 1 |
| snd/RXT | 25.62 D | 2401 | 100 | 1 |
| rcv | 25.63 A | 1 | 0 | 2501 |
| drop | 25.63 D | 2901 | 100 | 1 |
| snd/RXT | 27.13 D | 2501 | 100 | 1 |
| rcv | 27.13 A | 1 | 0 | 2601 |
| snd | 27.13 D | 3001 | 28 | 1 |
| rcv/DA | 27.13 A | 1 | 0 | 2601 |
| drop | 28.63 D | 2601 | 100 | 1 |
| snd/RXT | 30.13 D | 2601 | 100 | 1 |
| rcv | 30.14 A | 1 | 0 | 2901 |
| drop | 31.64 D | 2901 | 100 | 1 |
| snd/RXT | 33.14 D | 2901 | 100 | 1 |

| | | | | |
|-----|---------|------|---|------|
| rcv | 33.14 A | 1 | 0 | 3029 |
| snd | 33.14 F | 3029 | 0 | 1 |
| rcv | 33.14 A | 1 | 0 | 3030 |
| rcv | 33.14 F | 1 | 0 | 3030 |
| snd | 33.14 A | 3030 | 0 | 2 |

| | |
|---|------|
| Size of the file (in Bytes) | 3028 |
| Segments transmitted (including drop & RXT) | 59 |
| Number of Segments handled by PLD | 55 |
| Number of Segments dropped | 24 |
| Number of Segments Corrupted | 0 |
| Number of Segments Re-ordered | 0 |
| Number of Segments Duplicated | 0 |
| Number of Segments Delay | 0 |
| Number of Segments Retransmissions due to TIMEOUT | 22 |
| Number of Segments FAST RETRANSMISSION | 0 |
| Number of Segments DUP ACKS received | 18 |

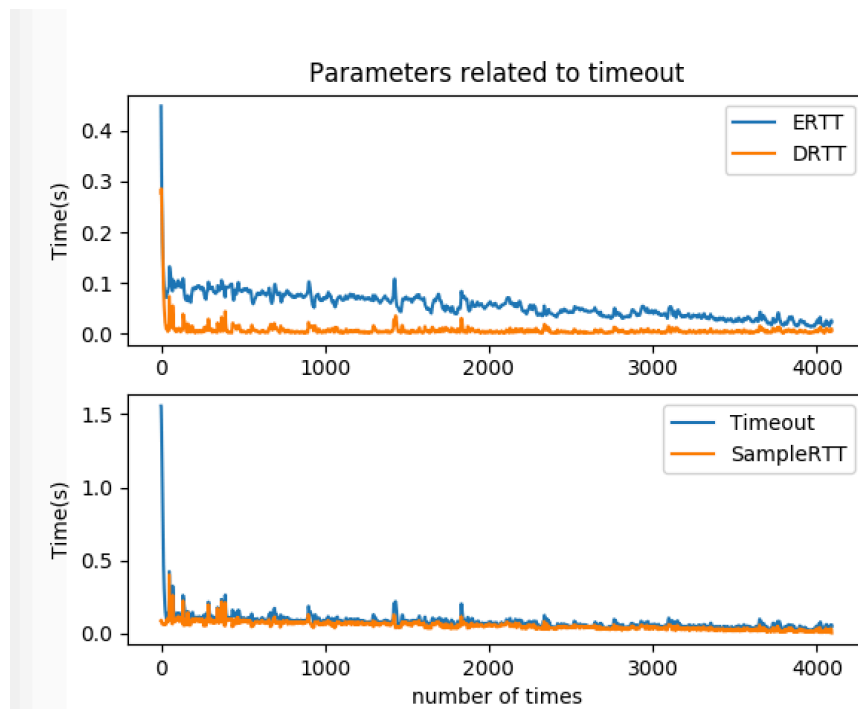
Receiver_log.txt

| | | | | |
|--------|---------|------|-----|------|
| 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 | 101 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 1 |
| rcv | 0.01 D | 201 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 1 |
| rcv | 0.01 D | 301 | 100 | 1 |
| snd/DA | 0.01 A | 1 | 0 | 1 |
| rcv | 3.01 D | 1 | 100 | 1 |
| snd | 3.02 A | 1 | 0 | 401 |
| rcv | 3.02 D | 501 | 100 | 1 |
| snd/DA | 3.02 A | 1 | 0 | 401 |
| rcv | 3.02 D | 801 | 100 | 1 |
| snd/DA | 3.02 A | 1 | 0 | 401 |
| rcv | 4.52 D | 401 | 100 | 1 |
| snd | 4.52 A | 1 | 0 | 601 |
| rcv | 4.53 D | 1001 | 100 | 1 |
| snd/DA | 4.53 A | 1 | 0 | 601 |
| rcv | 6.03 D | 601 | 100 | 1 |
| snd | 6.03 A | 1 | 0 | 701 |
| rcv | 6.03 D | 1101 | 100 | 1 |
| snd/DA | 6.03 A | 1 | 0 | 701 |
| rcv | 7.53 D | 701 | 100 | 1 |
| snd | 7.53 A | 1 | 0 | 901 |
| rcv | 7.54 D | 1201 | 100 | 1 |
| snd/DA | 7.54 A | 1 | 0 | 901 |
| rcv | 9.04 D | 901 | 100 | 1 |
| snd | 9.04 A | 1 | 0 | 1301 |
| rcv | 9.04 D | 1601 | 100 | 1 |
| snd/DA | 9.04 A | 1 | 0 | 1301 |
| rcv | 9.04 D | 1701 | 100 | 1 |
| snd/DA | 9.05 A | 1 | 0 | 1301 |
| rcv | 12.05 D | 1301 | 100 | 1 |
| snd | 12.05 A | 1 | 0 | 1401 |
| rcv | 12.05 D | 1801 | 100 | 1 |
| snd/DA | 12.06 A | 1 | 0 | 1401 |
| rcv | 13.56 D | 1401 | 100 | 1 |

| | | | | |
|--------|---------|------|-----|------|
| snd | 13.56 A | 1 | 0 | 1501 |
| rcv | 21.07 D | 1501 | 100 | 1 |
| snd | 21.07 A | 1 | 0 | 1901 |
| rcv | 21.07 D | 2001 | 100 | 1 |
| snd/DA | 21.07 A | 1 | 0 | 1901 |
| rcv | 21.07 D | 2101 | 100 | 1 |
| snd/DA | 21.07 A | 1 | 0 | 1901 |
| rcv | 21.07 D | 2201 | 100 | 1 |
| snd/DA | 21.08 A | 1 | 0 | 1901 |
| rcv | 21.08 D | 2301 | 100 | 1 |
| snd/DA | 21.08 A | 1 | 0 | 1901 |
| rcv | 22.59 D | 1901 | 100 | 1 |
| snd | 22.59 A | 1 | 0 | 2401 |
| rcv | 22.60 D | 2701 | 100 | 1 |
| snd/DA | 22.60 A | 1 | 0 | 2401 |
| rcv | 22.60 D | 2801 | 100 | 1 |
| snd/DA | 22.60 A | 1 | 0 | 2401 |
| rcv | 25.62 D | 2401 | 100 | 1 |
| snd | 25.63 A | 1 | 0 | 2501 |
| rcv | 27.13 D | 2501 | 100 | 1 |
| snd | 27.13 A | 1 | 0 | 2601 |
| rcv | 27.13 D | 3001 | 28 | 1 |
| snd/DA | 27.13 A | 1 | 0 | 2601 |
| rcv | 30.13 D | 2601 | 100 | 1 |
| snd | 30.13 A | 1 | 0 | 2901 |
| rcv | 33.14 D | 2901 | 100 | 1 |
| snd | 33.14 A | 1 | 0 | 3029 |
| rcv | 33.14 F | 3029 | 0 | 1 |
| snd | 33.14 A | 1 | 0 | 3030 |
| snd | 33.14 F | 1 | 0 | 3030 |
| rcv | 33.14 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 | 18 |

**(c) MWS=500bytes MSS=50 gamma=4 pDrop=0.1 pDuplicate=0 pOrder=0.1
maxOrder=4 maxDelay=0 seed=300**



Timeout.png

Sender_log.txt

| Sender_log.txt | | | | |
|----------------|------|---|-----|-----|
| snd | 0.00 | S | 0 | 0 |
| rcv | 0.00 | A | 0 | 1 |
| snd | 0.00 | A | 1 | 1 |
| snd/corr | 0.01 | D | 1 | 1 |
| snd | 0.02 | D | 51 | 1 |
| snd | 0.03 | D | 101 | 1 |
| snd | 0.04 | D | 151 | 1 |
| snd | 0.05 | D | 201 | 1 |
| snd | 0.06 | D | 251 | 1 |
| snd/dup | 0.06 | D | 251 | 1 |
| snd | 0.08 | D | 301 | 1 |
| snd/corr | 0.09 | D | 351 | 1 |
| snd | 0.10 | D | 401 | 1 |
| snd | 0.11 | D | 451 | 1 |
| rcv/DA | 0.11 | A | 1 | 1 |
| rcv/DA | 0.11 | A | 1 | 1 |
| rcv/DA | 0.11 | A | 1 | 1 |
| snd/RXT | 0.12 | D | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| snd/RXT | 0.12 | D | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| rcv/DA | 0.12 | A | 1 | 1 |
| snd/corr | 0.12 | D | 1 | 1 |
| rcv | 0.12 | A | 1 | 351 |
| snd | 0.14 | D | 501 | 1 |
| snd | 0.15 | D | 551 | 1 |
| snd | 0.16 | D | 601 | 1 |

| | | | | | |
|----------|--------|---|---------|----|---------|
| drop | 448.04 | D | 1604951 | 50 | 1 |
| snd | 448.04 | D | 1605001 | 50 | 1 |
| snd | 448.04 | D | 1605051 | 50 | 1 |
| snd | 448.04 | D | 1605101 | 50 | 1 |
| snd | 448.04 | D | 1605151 | 50 | 1 |
| snd | 448.04 | D | 1605201 | 50 | 1 |
| snd | 448.04 | D | 1605251 | 50 | 1 |
| rcv/DA | 448.05 | A | 1 | 0 | 1604801 |
| rcv/DA | 448.05 | A | 1 | 0 | 1604801 |
| rcv/DA | 448.05 | A | 1 | 0 | 1604801 |
| snd/RXT | 448.05 | D | 1604801 | 50 | 1 |
| rcv/DA | 448.05 | A | 1 | 0 | 1604801 |
| rcv/DA | 448.05 | A | 1 | 0 | 1604801 |
| rcv/DA | 448.05 | A | 1 | 0 | 1604801 |
| drop | 448.06 | D | 1604801 | 50 | 1 |
| rcv/DA | 448.06 | A | 1 | 0 | 1604801 |
| rcv/DA | 448.06 | A | 1 | 0 | 1604801 |
| rcv | 448.06 | A | 1 | 0 | 1604951 |
| snd | 448.06 | D | 1605301 | 50 | 1 |
| snd | 448.06 | D | 1605351 | 50 | 1 |
| snd | 448.06 | D | 1605401 | 50 | 1 |
| rcv/DA | 448.06 | A | 1 | 0 | 1604951 |
| rcv/DA | 448.06 | A | 1 | 0 | 1604951 |
| rcv/DA | 448.06 | A | 1 | 0 | 1604951 |
| snd/RXT | 448.06 | D | 1604951 | 50 | 1 |
| rcv | 448.08 | A | 1 | 0 | 1605451 |
| snd | 448.08 | D | 1605451 | 50 | 1 |
| drop | 448.08 | D | 1605501 | 50 | 1 |
| snd/corr | 448.08 | D | 1605551 | 35 | 1 |
| rcv | 448.08 | A | 1 | 0 | 1605501 |
| snd/RXT | 448.14 | D | 1605501 | 50 | 1 |
| rcv | 448.14 | A | 1 | 0 | 1605551 |
| snd/RXT | 448.20 | D | 1605551 | 35 | 1 |
| rcv | 448.20 | A | 1 | 0 | 1605586 |
| snd | 448.20 | F | 1605586 | 0 | 1 |
| rcv | 448.20 | A | 1 | 0 | 1605587 |
| rcv | 448.20 | F | 1 | 0 | 1605587 |
| snd | 448.20 | A | 1605587 | 0 | 2 |

| | |
|---|---------|
| ===== | |
| Size of the file (in Bytes) | 1605585 |
| Segments transmitted (including drop & RXT) | 45674 |
| Number of Segments handled by PLD | 45670 |
| Number of Segments dropped | 4252 |
| Number of Segments Corrupted | 3411 |
| Number of Segments Re-ordered | 2990 |
| Number of Segments Duplicated | 3785 |
| Number of Segments Delay | 0 |
| Number of Segments Retransmissions due to TIMEOUT | 2748 |
| Number of Segments FAST RETRANSMISSION | 4618 |
| Number of Segments DUP ACKS received | 28012 |
| ===== | |

Receiver_log.txt

| Receiver_log.txt | | | | | |
|----------------------------------|----------|---------|----|---------|--|
| rcv | 0.00 S | 0 | 0 | 0 | |
| snd | 0.00 SA | 0 | 0 | 1 | |
| rcv | 0.00 A | 1 | 0 | 1 | |
| rcv | 0.02 D | 51 | 50 | 1 | |
| snd/DA | 0.02 A | 1 | 0 | 1 | |
| rcv | 0.03 D | 101 | 50 | 1 | |
| snd/DA | 0.03 A | 1 | 0 | 1 | |
| rcv | 0.04 D | 151 | 50 | 1 | |
| snd/DA | 0.04 A | 1 | 0 | 1 | |
| rcv | 0.05 D | 201 | 50 | 1 | |
| snd/DA | 0.05 A | 1 | 0 | 1 | |
| rcv | 0.06 D | 251 | 50 | 1 | |
| snd/DA | 0.06 A | 1 | 0 | 1 | |
| rcv | 0.06 D | 251 | 50 | 1 | |
| snd/DA | 0.06 A | 1 | 0 | 1 | |
| rcv | 0.08 D | 301 | 50 | 1 | |
| snd/DA | 0.08 A | 1 | 0 | 1 | |
| rcv | 0.10 D | 401 | 50 | 1 | |
| snd/DA | 0.10 A | 1 | 0 | 1 | |
| rcv | 0.11 D | 451 | 50 | 1 | |
| snd/DA | 0.11 A | 1 | 0 | 1 | |
| rcv | 0.12 D | 1 | 50 | 1 | |
| snd | 0.12 A | 1 | 0 | 351 | |
| rcv | 0.12 D | 1 | 50 | 1 | |
| snd/DA | 0.12 A | 1 | 0 | 351 | |
| rcv | 0.14 D | 501 | 50 | 1 | |
| snd/DA | 0.14 A | 1 | 0 | 351 | |
| rcv | 0.15 D | 551 | 50 | 1 | |
| snd/DA | 0.15 A | 1 | 0 | 351 | |
| rcv | 0.16 D | 601 | 50 | 1 | |
| | | | | | |
| snd/DA | 447.97 A | 1 | 0 | 1604301 | |
| rcv | 447.97 D | 1604701 | 50 | 1 | |
| snd/DA | 447.97 A | 1 | 0 | 1604301 | |
| rcv | 447.97 D | 1604751 | 50 | 1 | |
| snd/DA | 447.97 A | 1 | 0 | 1604301 | |
| rcv | 447.98 D | 1604301 | 50 | 1 | |
| snd | 447.98 A | 1 | 0 | 1604351 | |
| rcv | 447.98 D | 1604301 | 50 | 1 | |
| snd/DA | 447.98 A | 1 | 0 | 1604351 | |
| rcv | 448.04 D | 1604351 | 50 | 1 | |
| snd | 448.04 A | 1 | 0 | 1604801 | |
| rcv | 448.04 D | 1604851 | 50 | 1 | |
| snd/DA | 448.04 A | 1 | 0 | 1604801 | |
| rcv | 448.04 D | 1604901 | 50 | 1 | |
| snd/DA | 448.04 A | 1 | 0 | 1604801 | |
| rcv | 448.04 D | 1605001 | 50 | 1 | |
| snd/DA | 448.04 A | 1 | 0 | 1604801 | |
| rcv | 448.04 D | 1605051 | 50 | 1 | |
| snd/DA | 448.04 A | 1 | 0 | 1604801 | |
| rcv | 448.04 D | 1605101 | 50 | 1 | |
| snd/DA | 448.05 A | 1 | 0 | 1604801 | |
| rcv | 448.05 D | 1605151 | 50 | 1 | |
| snd/DA | 448.05 A | 1 | 0 | 1604801 | |
| rcv | 448.05 D | 1605201 | 50 | 1 | |
| snd/DA | 448.05 A | 1 | 0 | 1604801 | |
| rcv | 448.05 D | 1605251 | 50 | 1 | |
| snd/DA | 448.05 A | 1 | 0 | 1604801 | |
| rcv | 448.05 D | 1604801 | 50 | 1 | |
| snd | 448.05 A | 1 | 0 | 1604951 | |
| rcv | 448.06 D | 1605301 | 50 | 1 | |
| snd/DA | 448.06 A | 1 | 0 | 1604951 | |
| rcv | 448.06 D | 1605351 | 50 | 1 | |
| snd/DA | 448.06 A | 1 | 0 | 1604951 | |
| rcv | 448.06 D | 1605401 | 50 | 1 | |
| snd/DA | 448.06 A | 1 | 0 | 1604951 | |
| rcv | 448.08 D | 1604951 | 50 | 1 | |
| snd | 448.08 A | 1 | 0 | 1605451 | |
| rcv | 448.08 D | 1605451 | 50 | 1 | |
| snd | 448.08 A | 1 | 0 | 1605501 | |
| rcv | 448.14 D | 1605501 | 50 | 1 | |
| snd | 448.14 A | 1 | 0 | 1605551 | |
| rcv | 448.20 D | 1605551 | 35 | 1 | |
| snd | 448.20 A | 1 | 0 | 1605586 | |
| rcv | 448.20 F | 1605586 | 0 | 1 | |
| snd | 448.20 A | 1 | 0 | 1605587 | |
| snd | 448.20 F | 1 | 0 | 1605587 | |
| rcv | 448.20 A | 1605587 | 0 | 2 | |
| ===== | | | | | |
| Amount of data received (bytes) | | | | 1981070 | |
| Total Segments Received | | | | 41421 | |
| Data segments received | | | | 41417 | |
| Data segments with Bit Errors | | | | 3412 | |
| Duplicate data segments received | | | | 4098 | |
| Duplicate ACKs sent | | | | 28012 | |
| ===== | | | | | |