

Report:

1. List of features implemented:

(a) 3- way handshake

To initiate the connection, the STP protocol receiver first starts by the 3- way handshake:

- i. receiver send SYN packet with SYN= 1, a chosen “client_isn” and send the packet to sender
- ii. sender receive SYN segment and proceed to allocate buffer and variables for connection. After that, it sends a connection granted segment back with no app data, containing info: SYN = 1, ACK field = “client_isn+1”, seq = server_isn. Basically a SYNACK packet
- iii. After receiving SYNACK confirmation, receiver allocates its own buffer and variables, then sends sender another segment: seq= “client_isn”+1 , ACK= “server_isn”+1, SYN = 0

(b) Time Out Interval

The time out interval is calculated by first finding out the difference between sent and received time between the first SYN packet is sent and the SYNACK received. This difference is used as SampleRTT . Given starting value of Estimated RTT and Dev RTT, the following values are calculated every time a response from a packet sent is received, updating SampleRTT constantly.

EstimatedRTT = $(1-\alpha) * \text{EstimatedRTT_prev} + \alpha * \text{SampleRTT}$

DevRTT = $(1-\beta) * \text{DevRTT_prev} + \beta * |\text{SampleRTT} - \text{EstimatedRTT}|$

Time Out Interval = $\text{EstimatedRTT} - 4 * \text{DevRTT}$

$\beta = 0.25$

$\alpha = 0.125$

(c) Header and Sliding windows

After the connection is established, sender starts sending segments of the file under the limitation of MWS/MSS which is number of segments allowed on the fly at one time. These packets are generated with header and stored in list “pkts_waiting”.

A while loop is used to send packets from the waiting queue by popping of and send them one by one. These pkts sent but unacked is stored in list “pkts_on_the_fly”. The reordering of packets sent are prioritised before the queue. The packets to be sent goes through PLD handle to mimic real life losses.

When a data packet is received by Receiver, it will send the ACK segments where ACK = (sequence number of pkt + size of data). An expected ACK number is recorded to check if data packets are arriving in order, if not, the packet is recorded in a list “pkts_buffer” for future appending file purposes. The ACK sent by Receiver can be in order or an accumulated ACK number if there are packets out of order.

(d) 4 -segment hand shake

Finally when the file has been transferred completely, Sender will send a FIN packet. Receiver receiving it will return a FINACK packet and quit itself. Sender receiving the FINACK will send an ACK packet and exit as well.

2. Header: (as a list)

SEQ = index 0 : stores sequence number (first byte in segment sent by sender)
ACK = index 1 : store ACK number (next byte Receiver is expecting)
FLAG = index 2 : store type of pkt, SYN/ACK/DATA/FIN/SYNACK/FINACK
MSG = index 3 : data segments from file (at most MSS)
CHSUM = index 4: checksum from md5 hashing

3.

To prevent data corruption, considerations is made: instead of splicing the data by bytes, pickle dumping strings are used for more precision. Structure of a list is used for easy access to information and comparison. Possible improvements include having bit wise operation on FLAG might be desirable because combination of flags might vary other than the 6 major flags listed above. Other than that, using bits to represent might be time and memory efficient as flags can be easily represented in less bits than strings above.

4.

Referencing have been made from textbook section 3.5

5.

(a)pDrop 0.3 has significant more dropping than pDrop 0.1, this results in more duplicate acks recorded. (Refer to Appendix for sequences)

(b) With increasing gamma, the time out interval increases as well. This shows its impact of total time it took to transmit the whole file. Size of file: 308203 Bytes

Gamma	Number of packets transmitted (bytes)	Time taken overall
2	19876	36 min
4	20045	37 min
6	20304	47 min

Sender Log start time vs last segment ACKed:

Gamma = 2

Sender log file for transmission at 2018-10-20 21:08:06.016718

```
snd      | 2018-10-20 21:44:39.093816 | 0      | A      | 0      | 120      |
```

***** !END OF TRANSMISSION! *****

SENDER STATS: -----

1. Size of the file (in Bytes): 308203
2. Segments transmitted (including drop & RXT): 19876

Gamma = 4

Sender log file for transmission at 2018-10-20 21:09:14.913924

```
snd      | 2018-10-20 21:46:50.016048 | 0      | A      | 0      | 120      |
```

***** !END OF TRANSMISSION! *****

SENDER STATS: -----

1. Size of the file (in Bytes): 308203
2. Segments transmitted (including drop & RXT): 20045

Gamma = 6

```
snd      | 2018-10-20 21:57:52.098626 | 0      | A      | 0      | 120      |
```

***** !END OF TRANSMISSION! *****

SENDER STATS: -----

1. Size of the file (in Bytes): 308203
2. Segments transmitted (including drop & RXT): 20304

(c)

File successfully transferred, judging from statistics, pDrop is more influential and critical compared to others. This can be observed from the large number of packets dropped although they all share the same probabilities. This is mostly due to flooding of duplicate ACKs and the lost re-transmissions by sender.

Appendix:

(a) pDrop: 0.1 Receiver Stats

Receiver log file for transmission at 2018-10-20 17:54:44.094519

<event>	<time>	<ack-number>	<type-of-packet>	<seq-number>	<number-of-bytes-data>
rcv	2018-10-20 17:54:45.214142	0	S	0	136
snd	2018-10-20 17:54:45.214239	1	SA	0	136
rcv	2018-10-20 17:54:45.215682	0	D	0	136
snd	2018-10-20 17:54:45.215860	100	A	0	136
rcv	2018-10-20 17:54:45.216404	0	D	100	136
snd	2018-10-20 17:54:45.216562	200	A	100	136
rcv	2018-10-20 17:54:45.217101	0	D	200	136
snd	2018-10-20 17:54:45.217246	300	A	200	136
rcv	2018-10-20 17:54:45.217823	0	D	300	136
snd	2018-10-20 17:54:45.217959	400	A	300	136
rcv	2018-10-20 17:54:45.218500	0	D	400	136
snd	2018-10-20 17:54:45.218627	500	A	400	136
rcv	2018-10-20 17:54:45.219407	0	D	500	136
snd	2018-10-20 17:54:45.219533	600	A	500	136
rcv	2018-10-20 17:54:45.220354	0	D	600	136
snd	2018-10-20 17:54:45.220454	700	A	600	136
rcv	2018-10-20 17:54:45.221197	0	D	700	136
snd	2018-10-20 17:54:45.221314	800	A	700	136
rcv	2018-10-20 17:54:45.222051	0	D	800	136
snd	2018-10-20 17:54:45.222176	900	A	800	136
rcv	2018-10-20 17:54:45.222856	0	D	900	136
snd	2018-10-20 17:54:45.222986	1000	A	900	136
rcv	2018-10-20 17:54:45.223671	0	D	1000	136
snd	2018-10-20 17:54:45.223798	1100	A	1000	136
rcv	2018-10-20 17:54:45.224504	0	D	1100	136
snd	2018-10-20 17:54:45.224630	1200	A	1100	136
rcv	2018-10-20 17:54:45.225306	0	D	1200	136
snd	2018-10-20 17:54:45.225429	1300	A	1200	136
rcv	2018-10-20 17:54:45.226161	0	D	1300	136
snd	2018-10-20 17:54:45.226287	1400	A	1300	136
rcv	2018-10-20 17:54:45.226979	0	D	1400	136
snd	2018-10-20 17:54:45.227100	1500	A	1400	136
rcv	2018-10-20 17:54:45.227920	0	D	1500	136
snd	2018-10-20 17:54:45.228039	1600	A	1500	136
rcv	2018-10-20 17:54:45.228700	0	D	1600	136
snd	2018-10-20 17:54:45.228826	1700	A	1600	136
rcv	2018-10-20 17:54:45.230196	0	D	1800	136
snd	2018-10-20 17:54:45.230291	1700	A	0	120
rcv	2018-10-20 17:54:45.230966	0	D	1900	136
snd	2018-10-20 17:54:45.231053	1700	A	0	120
rcv	2018-10-20 17:54:45.231807	0	D	2000	136
snd	2018-10-20 17:54:45.231891	1700	A	0	120
rcv	2018-10-20 17:54:45.232601	0	D	2100	136

rcv		2018-10-20 17:54:45.232601		0		D		2100		136	
snd		2018-10-20 17:54:45.232710		1700		A		0		120	
rcv		2018-10-20 17:54:45.233442		0		D		1700		136	
snd		2018-10-20 17:54:45.233647		2200		A		0		120	
rcv		2018-10-20 17:54:45.234563		0		D		2200		136	
snd		2018-10-20 17:54:45.234711		2300		A		2200		136	
rcv		2018-10-20 17:54:45.235225		0		D		2300		136	
snd		2018-10-20 17:54:45.235352		2400		A		2300		136	
rcv		2018-10-20 17:54:45.236669		0		D		2500		136	
snd		2018-10-20 17:54:45.236766		2400		A		0		120	
rcv		2018-10-20 17:54:45.237447		0		D		2600		136	
snd		2018-10-20 17:54:45.237572		2400		A		0		120	
rcv		2018-10-20 17:54:45.238243		0		D		2700		136	
snd		2018-10-20 17:54:45.238327		2400		A		0		120	
rcv		2018-10-20 17:54:45.238979		0		D		2800		136	
snd		2018-10-20 17:54:45.239060		2400		A		0		120	
rcv		2018-10-20 17:54:45.239784		0		D		2400		136	
snd		2018-10-20 17:54:45.239969		2900		A		0		120	
rcv		2018-10-20 17:54:45.240798		0		D		2900		136	
snd		2018-10-20 17:54:45.240906		3000		A		2900		136	
rcv		2018-10-20 17:54:45.241412		0		D		3000		136	
snd		2018-10-20 17:54:45.241515		3028		A		3000		136	
rcv		2018-10-20 17:54:45.241603		0		F		0		136	
snd		2018-10-20 17:54:45.241714		0		FA		0		136	

***** !END OF TRANSMISSION! *****

RECEIVER STATS: -----

1. Amount of Data Received (bytes): 3028
2. Total segments received: 66
3. Data segments received: 37
4. Data Segments with bit errors: 0
5. Duplicate data segments received: 0
6. Duplicate Acks sent: 8

(a) pDrop: 0.3 Receiver Stats

Receiver log file for transmission at 2018-10-20 17:57:23.609910

<event>	<time>	<ack-number>	<type-of-packet>	<seq-number>	<number-of-bytes-data>
rcv	2018-10-20 17:57:36.786941	0	S	0	136
snd	2018-10-20 17:57:36.787020	1	SA	0	136
rcv	2018-10-20 17:57:36.788517	0	D	0	136
snd	2018-10-20 17:57:36.788647	100	A	0	136
rcv	2018-10-20 17:57:36.789947	0	D	200	136
snd	2018-10-20 17:57:36.790060	100	A	0	120
rcv	2018-10-20 17:57:36.791548	0	D	400	136
snd	2018-10-20 17:57:36.791666	100	A	0	120
rcv	2018-10-20 17:57:36.792712	0	D	500	136
snd	2018-10-20 17:57:36.792826	100	A	0	120
rcv	2018-10-20 17:57:36.793758	0	D	100	136
snd	2018-10-20 17:57:36.793957	300	A	0	120
rcv	2018-10-20 17:57:36.794896	0	D	600	136
snd	2018-10-20 17:57:36.794983	300	A	0	120
rcv	2018-10-20 17:57:36.795652	0	D	700	136
snd	2018-10-20 17:57:36.795727	300	A	0	120
rcv	2018-10-20 17:57:36.796514	0	D	300	136
snd	2018-10-20 17:57:36.796696	800	A	0	120
rcv	2018-10-20 17:57:36.797611	0	D	800	136
snd	2018-10-20 17:57:36.797731	900	A	800	136
rcv	2018-10-20 17:57:36.798417	0	D	900	136
snd	2018-10-20 17:57:36.798541	1000	A	900	136
rcv	2018-10-20 17:57:36.799649	0	D	1000	136
snd	2018-10-20 17:57:36.800101	1100	A	1000	136
rcv	2018-10-20 17:57:36.803682	0	D	1300	136
snd	2018-10-20 17:57:36.803805	1100	A	0	120
rcv	2018-10-20 17:57:36.804556	0	D	1400	136
snd	2018-10-20 17:57:36.804647	1100	A	0	120
rcv	2018-10-20 17:57:36.805457	0	D	1500	136
snd	2018-10-20 17:57:36.805573	1100	A	0	120
rcv	2018-10-20 17:57:38.410429	0	D	1100	136
snd	2018-10-20 17:57:38.410934	1200	A	0	120
rcv	2018-10-20 17:57:38.412512	0	D	1200	136
snd	2018-10-20 17:57:38.413161	1600	A	0	120
rcv	2018-10-20 17:57:38.415232	0	D	1300	136
snd	2018-10-20 17:57:38.415497	1600	A	0	120
rcv	2018-10-20 17:57:38.417895	0	D	1400	136
snd	2018-10-20 17:57:38.418177	1600	A	0	120
rcv	2018-10-20 17:57:38.420391	0	D	1500	136
snd	2018-10-20 17:57:38.420644	1600	A	0	120
rcv	2018-10-20 17:57:38.422963	0	D	1600	136
snd	2018-10-20 17:57:38.423397	1700	A	1600	136
rcv	2018-10-20 17:57:38.432086	0	D	2000	136

rcv	2018-10-20 17:57:38.432086	0	D	2000	136
snd	2018-10-20 17:57:38.432415	1700	A	0	120
rcv	2018-10-20 17:57:40.046280	0	D	2000	136
snd	2018-10-20 17:57:40.046390	1700	A	0	120
rcv	2018-10-20 17:57:40.046869	0	D	2100	136
snd	2018-10-20 17:57:40.046967	1700	A	0	120
rcv	2018-10-20 17:57:40.047737	0	D	1700	136
snd	2018-10-20 17:57:40.047863	1800	A	0	120
rcv	2018-10-20 17:57:41.651133	0	D	1800	136
snd	2018-10-20 17:57:41.651268	1900	A	0	120
rcv	2018-10-20 17:57:41.651734	0	D	1900	136
snd	2018-10-20 17:57:41.651856	2200	A	0	120
rcv	2018-10-20 17:57:41.652796	0	D	2100	136
snd	2018-10-20 17:57:41.652853	2200	A	0	120
rcv	2018-10-20 17:57:41.653320	0	D	2200	136
snd	2018-10-20 17:57:41.653421	2300	A	2200	136
rcv	2018-10-20 17:57:41.654009	0	D	2300	136
snd	2018-10-20 17:57:41.654112	2400	A	2300	136
rcv	2018-10-20 17:57:41.655702	0	D	2600	136
snd	2018-10-20 17:57:41.655766	2400	A	0	120
rcv	2018-10-20 17:57:41.656403	0	D	2700	136
snd	2018-10-20 17:57:41.656470	2400	A	0	120
rcv	2018-10-20 17:57:41.657663	0	D	2400	136
snd	2018-10-20 17:57:41.657749	2500	A	0	120
rcv	2018-10-20 17:57:41.658430	0	D	2900	136
snd	2018-10-20 17:57:41.658492	2500	A	0	120
rcv	2018-10-20 17:57:43.262896	0	D	2500	136
snd	2018-10-20 17:57:43.263554	2800	A	0	120
rcv	2018-10-20 17:57:43.264824	0	D	2600	136
snd	2018-10-20 17:57:43.264926	2800	A	0	120
rcv	2018-10-20 17:57:43.267200	0	D	2900	136
snd	2018-10-20 17:57:43.267295	2800	A	0	120
rcv	2018-10-20 17:57:43.268261	0	D	3000	136
snd	2018-10-20 17:57:43.268363	2800	A	0	120
rcv	2018-10-20 17:57:43.269307	0	D	2800	136
snd	2018-10-20 17:57:43.269465	3028	A	0	120
rcv	2018-10-20 17:57:43.269856	0	F	0	136
snd	2018-10-20 17:57:43.270021	0	FA	0	136

***** !END OF TRANSMISSION! *****

RECEIVER STATS: -----

1. Amount of Data Received (bytes): 3028
2. Total segments received: 80
3. Data segments received: 38
4. Data Segments with bit errors: 0
5. Duplicate data segments received: 0
6. Duplicate Acks sent: 21

(c)

first 20 segments for sender:

1 Sender log file for transmission at 2018-10-20 21:11:42.972580

2					
3 <event>	<time>	<ack-number>	<type-of-packet>	<seq-number>	<number-of-bytes-data>
4 -----	-----	-----	-----	-----	-----
5 snd	2018-10-20 21:11:42.972810	0	S	0	120
6 rcv	2018-10-20 21:11:42.973232	1	SA	0	136
7 snd	2018-10-20 21:11:42.973354	1	A	1	120
8 corr	2018-10-20 21:11:43.147806	0	D	0	120
9 snd	2018-10-20 21:11:43.149894	0	D	50	120
10 snd	2018-10-20 21:11:43.152687	0	D	100	120
11 corr	2018-10-20 21:11:43.153582	0	D	150	120
12 snd	2018-10-20 21:11:43.154455	0	D	200	120
13 snd	2018-10-20 21:11:43.155981	0	D	250	120
14 drop	2018-10-20 21:11:43.156699	0	D	300	120
15 drop	2018-10-20 21:11:43.158034	0	D	350	120
16 rord	2018-10-20 21:11:43.158614	0	D	450	120
17 snd	2018-10-20 21:11:43.159281	0	D	500	120
18 snd	2018-10-20 21:11:43.160319	0	D	550	120
19 snd	2018-10-20 21:11:43.161314	0	D	600	120
20 snd	2018-10-20 21:11:43.162307	0	D	650	120
21 snd	2018-10-20 21:11:43.163867	0	D	700	120
22 snd	2018-10-20 21:11:43.164861	0	D	750	120
23 snd	2018-10-20 21:11:43.166518	0	D	300	120
24 snd	2018-10-20 21:11:43.168425	0	D	300	120
25 snd	2018-10-20 21:11:43.169888	0	D	300	120

last 20 segments for sender + statistics:

snd	2018-10-20 21:17:37.449104	0	D	1604950	120
snd	2018-10-20 21:17:37.449730	0	D	1605000	120
rord	2018-10-20 21:17:37.450335	0	D	1605100	120
snd	2018-10-20 21:17:37.451019	0	D	1605150	120
snd	2018-10-20 21:17:37.451605	0	D	1605200	120
snd	2018-10-20 21:17:37.452176	0	D	1605250	120
snd	2018-10-20 21:17:37.452770	0	D	1605300	120
snd	2018-10-20 21:17:37.453945	0	D	1605350	120
snd	2018-10-20 21:17:37.454497	0	D	1605400	120
corr	2018-10-20 21:17:37.455322	0	D	1604950	120
corr	2018-10-20 21:17:37.465144	0	D	1605450	120
snd	2018-10-20 21:17:37.466196	0	D	1605500	120
snd	2018-10-20 21:17:37.467164	0	D	1605050	120
snd	2018-10-20 21:17:37.475752	0	D	1605050	120
snd	2018-10-20 21:17:37.482801	0	D	1605550	120
snd	2018-10-20 21:17:37.483701	0	F	0	120
rcv	2018-10-20 21:17:37.483811	1605550	A	0	136
rcv	2018-10-20 21:17:37.483898	1605550	A	0	136
rcv	2018-10-20 21:17:37.483984	1605585	A	1605550	136
rcv	2018-10-20 21:17:37.484064	0	FA	0	136
snd	2018-10-20 21:17:37.484163	0	A	0	120

***** !END OF TRANSMISSION! *****

SENDER STATS: -----

1. Size of the file (in Bytes): 1605585
2. Segments transmitted (including drop & RXT): 45594
3. Number of Segments handled by PLD: 45594
4. Number of Segments Dropped: 4679
5. Number of Segments Corrupted: 3720
6. Number of Segments Re-ordered: 2453
7. Number of Segments Duplicated: 4039
8. Number of Segments Delayed: 0
9. Number of Retransmissions due to timeout: 1700
10. Number of Fast Retransmissions: 10196
11. Number of Duplicate Acknowledgements received: 10196

first 20 segments for Receiver:

Receiver Log File for Transmission at 2018-10-20 21:11:01.252779

<event>	<time>	<ack-number>	<type-of-packet>	<seq-number>	<number-of-bytes-data>
rcv	2018-10-20 21:11:42.972962	0	S	0	136
snd	2018-10-20 21:11:42.973052	1	SA	0	136
rcv	2018-10-20 21:11:43.150115	0	D	0	136
snd	2018-10-20 21:11:43.150551	50	A	0	136
rcv	2018-10-20 21:11:43.150966	0	D	50	136
snd	2018-10-20 21:11:43.151273	100	A	50	136
rcv	2018-10-20 21:11:43.151882	0	D	100	136
snd	2018-10-20 21:11:43.152157	150	A	100	136
rcv	2018-10-20 21:11:43.152804	0	D	100	136
snd	2018-10-20 21:11:43.152967	150	A	0	120
rcv	2018-10-20 21:11:43.153759	0	D	150	136
snd	2018-10-20 21:11:43.153889	200	A	150	136
rcv	2018-10-20 21:11:43.154504	0	D	200	136
snd	2018-10-20 21:11:43.154616	250	A	200	136
rcv	2018-10-20 21:11:43.155337	0	D	250	136
snd	2018-10-20 21:11:43.155437	300	A	250	136
rcv	2018-10-20 21:11:43.156024	0	D	250	136
snd	2018-10-20 21:11:43.156092	300	A	0	120
rcv	2018-10-20 21:11:43.157452	0	D	350	136
snd	2018-10-20 21:11:43.157521	300	A	0	120
rcv	2018-10-20 21:11:43.158824	0	D	450	136

last 20 segments for Receiver + statistics:

snd	2018-10-20 21:17:37.453126	1605350	A	0	120
rcv	2018-10-20 21:17:37.453459	0	D	1605350	136
snd	2018-10-20 21:17:37.453536	1605400	A	1605350	136
rcv	2018-10-20 21:17:37.453979	0	D	1605350	136
snd	2018-10-20 21:17:37.454033	1605400	A	0	120
rcv	2018-10-20 21:17:37.454558	0	D	1605400	136
snd	2018-10-20 21:17:37.454692	1605450	A	1605400	136
rcv	2018-10-20 21:17:37.455489	0	D	1604950	136
snd	2018-10-20 21:17:37.455581	1605450	A	0	120
rcv	2018-10-20 21:17:37.465438	0	D	1605450	136
snd	2018-10-20 21:17:37.465629	1605500	A	1605450	136
rcv	2018-10-20 21:17:37.466270	0	D	1605500	136
snd	2018-10-20 21:17:37.466424	1605550	A	1605500	136
rcv	2018-10-20 21:17:37.467236	0	D	1605050	136
snd	2018-10-20 21:17:37.467333	1605550	A	0	120
rcv	2018-10-20 21:17:37.475906	0	D	1605050	136
snd	2018-10-20 21:17:37.476030	1605550	A	0	120
rcv	2018-10-20 21:17:37.482958	0	D	1605550	136
snd	2018-10-20 21:17:37.483161	1605585	A	1605550	136
rcv	2018-10-20 21:17:37.483831	0	F	0	136
snd	2018-10-20 21:17:37.484033	0	FA	0	136

***** !END OF TRANSMISSION! *****

RECEIVER STATS: -----

1. Amount of Data Received (bytes): 1605585
2. Total segments received: 43371
3. Data segments received: 30808
4. Data Segments with bit errors: 3721
5. Duplicate data segments received: 9504
6. Duplicate Acks sent: 30808