

HW

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- Test under localhost
- Client is assigned random port

```
testserver.py: server
test.py: client
```

Step 1

File transmission

- Testfile = 8192.txt

Server:

```
python3 ./testserver.py
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.1:12345
>1 | ****RECEIVED CONNECTION FROM 127.0.0.2:35355****
>1 |      receive: ACK 0 SEQ 8495 <<< 127.0.0.2:35355
>1 | (Connection from 127.0.0.2:35355)
(0) (LISTEN)
(1) sent: SYN, ACK : (1) ACK 8496 SEQ 5897: 0 bytes
(1) (SYN_RCVD)
(1) receive: ACK : (1) ACK 5898 SEQ 8496: 0 bytes
(1) (ESTABLISHED)
(1) (Connection established with 127.0.0.2:35355)
(1) sent: ACK : (1) ACK 8497 SEQ 5898: 0 bytes
(1) receive: ACK : (1) ACK 5899 SEQ 8497: 38 bytes
(1) sent: ACK : (1) ACK 8535 SEQ 5899: 0 bytes
File Request for ./files/8192.txt
(task) File Transfer for ./files/8192.txt
(1) receive: ACK : (1) ACK 5900 SEQ 8535: 0 bytes
(1) sent: ACK : (1) ACK 8536 SEQ 5900: 39 bytes
(1) receive: ACK : (1) ACK 5939 SEQ 8536: 0 bytes
(1) sent: ACK : (1) ACK 8537 SEQ 5939: 10 bytes
(1) receive: ACK : (1) ACK 5949 SEQ 8537: 0 bytes
(1) sent: ACK : (1) ACK 8538 SEQ 5949: 1004 bytes
(1) receive: ACK : (1) ACK 6953 SEQ 8538: 0 bytes
(1) sent: ACK : (1) ACK 8539 SEQ 6953: 1004 bytes
(1) receive: ACK : (1) ACK 7957 SEQ 8539: 0 bytes
(1) sent: ACK : (1) ACK 8540 SEQ 7957: 1004 bytes
(1) receive: ACK : (1) ACK 8961 SEQ 8540: 0 bytes
(1) sent: ACK : (1) ACK 8541 SEQ 8961: 1004 bytes
(1) receive: ACK : (1) ACK 9965 SEQ 8541: 0 bytes
(1) sent: ACK : (1) ACK 8542 SEQ 9965: 1004 bytes
(1) receive: ACK : (1) ACK 10969 SEQ 8542: 0 bytes
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(1) sent: ACK : (1) ACK 8543 SEQ 10969: 1004 bytes
(1) receive: ACK : (1) ACK 11973 SEQ 8543: 0 bytes
(1) sent: ACK : (1) ACK 8544 SEQ 11973: 1004 bytes
(1) receive: ACK : (1) ACK 12977 SEQ 8544: 0 bytes
(1) sent: ACK : (1) ACK 8545 SEQ 12977: 1004 bytes
(1) receive: ACK : (1) ACK 13981 SEQ 8545: 0 bytes
(1) sent: ACK : (1) ACK 8546 SEQ 13981: 160 bytes
(1) receive: ACK : (1) ACK 14141 SEQ 8546: 0 bytes
(1) sent: ACK : (1) ACK 8547 SEQ 14141: 8 bytes
(1) receive: FIN : (1) ACK 14149 SEQ 8547: 0 bytes
(1) sent: ACK : (1) ACK 8548 SEQ 14149: 0 bytes
(1) (CLOSE_WAIT)
(1) (LAST_ACK)
(1) sent: FIN : (1) ACK 8548 SEQ 14150: 0 bytes
(1) receive: ACK : (1) ACK 14151 SEQ 8548: 0 bytes
(1) (CLOSED)
(1) Terminating connection with 127.0.0.2:35355
(1) Connection with 127.0.0.2:35355 terminated
1 Thread Closed

```

Client:

```

python3 ./test.py --file ./files/8192.txt --output 1
****NEW CLIENT CREATED****
Number of Threads: 1
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.2:7667
(0) sent: SYN : (0) ACK 0 SEQ 5168: 0 bytes
(0) (SYN_SENT)
(0) receive: SYN, ACK : (0) ACK 5169 SEQ 4356: 0 bytes
(0) sent: ACK : (0) ACK 4357 SEQ 5169: 0 bytes
(0) (ESTABLISHED)
(task3: ./files/8192.txt)
(0) receive: ACK : (0) ACK 5170 SEQ 4357: 0 bytes
(0) sent: ACK : (0) ACK 4358 SEQ 5170: 0 bytes
(0) receive: ACK : (0) ACK 5171 SEQ 4358: 0 bytes
(0) sent: ACK : (0) ACK 4359 SEQ 5171: 38 bytes
(0) receive: ACK : (0) ACK 5209 SEQ 4359: 0 bytes
(0) sent: ACK : (0) ACK 4360 SEQ 5209: 0 bytes
(0) receive: ACK : (0) ACK 5210 SEQ 4360: 39 bytes
(0) sent: ACK : (0) ACK 4399 SEQ 5210: 0 bytes
(0) receive: ACK : (0) ACK 5211 SEQ 4399: 10 bytes
(0) sent: ACK : (0) ACK 4409 SEQ 5211: 0 bytes
(0) receive: ACK : (0) ACK 5212 SEQ 4409: 1004 bytes
(0) sent: ACK : (0) ACK 5413 SEQ 5212: 0 bytes
(0) receive: ACK : (0) ACK 5213 SEQ 5413: 1004 bytes
(0) sent: ACK : (0) ACK 6417 SEQ 5213: 0 bytes
(0) receive: ACK : (0) ACK 5214 SEQ 6417: 1004 bytes
(0) sent: ACK : (0) ACK 7421 SEQ 5214: 0 bytes
(0) receive: ACK : (0) ACK 5215 SEQ 7421: 1004 bytes
(0) sent: ACK : (0) ACK 8425 SEQ 5215: 0 bytes
(0) receive: ACK : (0) ACK 5216 SEQ 8425: 1004 bytes
(0) sent: ACK : (0) ACK 9429 SEQ 5216: 0 bytes
(0) receive: ACK : (0) ACK 5217 SEQ 9429: 1004 bytes
(0) sent: ACK : (0) ACK 10433 SEQ 5217: 0 bytes
(0) receive: ACK : (0) ACK 5218 SEQ 10433: 1004 bytes

```



```
(1) (CLOSED)
(1) Terminating connection with 127.0.0.2:32643
(1) Connection with 127.0.0.2:32643 terminated
1 Thread Closed
```

Client

```
python3 ./test.py --cal 1+1
****NEW CLIENT CREATED****
Number of Threads: 1
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.2:32643
(0) sent: SYN : (0) ACK 0 SEQ 132: 0 bytes
(0) (SYN_SENT)
(0) receive: SYN, ACK : (0) ACK 133 SEQ 521: 0 bytes
(0) sent: ACK : (0) ACK 522 SEQ 133: 0 bytes
(0) (ESTABLISHED)
(0) receive: ACK : (0) ACK 134 SEQ 522: 0 bytes
(0) sent: ACK : (0) ACK 523 SEQ 134: 24 bytes
(0) receive: ACK : (0) ACK 158 SEQ 523: 0 bytes
(0) sent: ACK : (0) ACK 524 SEQ 158: 0 bytes
(0) receive: ACK : (0) ACK 159 SEQ 524: 22 bytes
(0) sent: ACK : (0) ACK 546 SEQ 159: 0 bytes
(task2: 2)
BUFFER: 0
(0) sent: FIN : (0) ACK 546 SEQ 160: 0 bytes
(0) (FIN_WAIT_1)
(0) receive: ACK : (0) ACK 161 SEQ 546: 0 bytes
(0) (FIN_WAIT_2)
(0) receive: FIN : (0) ACK 161 SEQ 547: 0 bytes
(0) sent: ACK : (0) ACK 548 SEQ 161: 0 bytes
(0) (TIME_WAIT)
(0) (CLOSED)
(0) Terminating connection with 127.0.0.1:12345
(0) Connection with 127.0.0.1:12345 terminated
Socket closed
Thread 1 Closed
```

DNS Query

Server

```
python3 ./testserver.py
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.1:12345
>1 | ****RECEIVED CONNECTION FROM 127.0.0.2:31262****
>1 | receive: ACK 0 SEQ 445 <<< 127.0.0.2:31262
>1 | (Connection from 127.0.0.2:31262)
(0) (LISTEN)
(1) sent: SYN, ACK : (1) ACK 446 SEQ 608: 0 bytes
(1) (SYN_RCVD)
(1) receive: ACK : (1) ACK 609 SEQ 446: 0 bytes
(1) (ESTABLISHED)
(1) (Connection established with 127.0.0.2:31262)
```

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(1) sent: ACK : (1) ACK 447 SEQ 609: 0 bytes
(1) receive: ACK : (1) ACK 610 SEQ 447: 39 bytes
(1) sent: ACK : (1) ACK 486 SEQ 610: 0 bytes
(task) DNS Query for hsnl.cse.nsysu.edu.tw
(1) receive: ACK : (1) ACK 611 SEQ 486: 0 bytes
(1) sent: ACK : (1) ACK 487 SEQ 611: 0 bytes
(1) receive: ACK : (1) ACK 612 SEQ 487: 0 bytes
(1) sent: ACK : (1) ACK 488 SEQ 612: 33 bytes
(1) receive: ACK : (1) ACK 645 SEQ 488: 0 bytes
(1) receive: FIN : (1) ACK 645 SEQ 489: 0 bytes
(1) sent: ACK : (1) ACK 490 SEQ 645: 0 bytes
(1) (CLOSE_WAIT)
(1) (LAST_ACK)
(1) sent: FIN : (1) ACK 490 SEQ 646: 0 bytes
(1) receive: ACK : (1) ACK 647 SEQ 490: 0 bytes
(1) (CLOSED)
(1) Terminating connection with 127.0.0.2:31262
(1) Connection with 127.0.0.2:31262 terminated
1 Thread Closed

```

Client

```

python3 ./test.py --dns hsnl.cse.nsysu.edu.tw
***NEW CLIENT CREATED***
Number of Threads: 1
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.2:31262
(0) sent: SYN : (0) ACK 0 SEQ 445: 0 bytes
(0) (SYN_SENT)
(0) receive: SYN, ACK : (0) ACK 446 SEQ 608: 0 bytes
(0) sent: ACK : (0) ACK 609 SEQ 446: 0 bytes
(0) (ESTABLISHED)
(0) receive: ACK : (0) ACK 447 SEQ 609: 0 bytes
(0) sent: ACK : (0) ACK 610 SEQ 447: 39 bytes
(0) receive: ACK : (0) ACK 486 SEQ 610: 0 bytes
(0) sent: ACK : (0) ACK 611 SEQ 486: 0 bytes
(0) receive: ACK : (0) ACK 487 SEQ 611: 0 bytes
(0) sent: ACK : (0) ACK 612 SEQ 487: 0 bytes
(0) receive: ACK : (0) ACK 488 SEQ 612: 33 bytes
(0) sent: ACK : (0) ACK 645 SEQ 488: 0 bytes
(task1: 140.117.172.136)
BUFFER: 0
(0) sent: FIN : (0) ACK 645 SEQ 489: 0 bytes
(0) (FIN_WAIT_1)
(0) receive: ACK : (0) ACK 490 SEQ 645: 0 bytes
(0) receive: FIN : (0) ACK 490 SEQ 646: 0 bytes
(0) (FIN_WAIT_2)
(0) sent: ACK : (0) ACK 647 SEQ 490: 0 bytes
(0) (TIME_WAIT)
(0) (CLOSED)
(0) Terminating connection with 127.0.0.1:12345
(0) Connection with 127.0.0.1:12345 terminated
Socket closed
Thread 1 Closed

```

Step 2

- Two client, one server
- Client is executed simultaneously using bash script.

Server

```
python3 ./testserver.py
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.1:12345
>1 | ****RECEIVED CONNECTION FROM 127.0.0.2:14146****
>1 | ****RECEIVED CONNECTION FROM 127.0.0.2:32567****
>1 |      receive: ACK 0 SEQ 9505 <<< 127.0.0.2:14146
>1 | (Connection from 127.0.0.2:14146)
(0) (LISTEN)
(1) sent: SYN, ACK : (1) ACK 9506 SEQ 3824: 0 bytes
(1) (SYN_RCVD)
(1) receive: ACK : (1) ACK 3825 SEQ 9506: 0 bytes
>2 |      receive: ACK 0 SEQ 6573 <<< 127.0.0.2:32567
>2 | (Connection from 127.0.0.2:32567)
(1) (ESTABLISHED)
(1) (Connection established with 127.0.0.2:14146)
(1) sent: ACK : (1) ACK 9507 SEQ 3825: 0 bytes
(0) (LISTEN)
(2) sent: SYN, ACK : (2) ACK 6574 SEQ 4272: 0 bytes
(2) (SYN_RCVD)
(1) receive: ACK : (1) ACK 3826 SEQ 9507: 38 bytes
(1) sent: ACK : (1) ACK 9545 SEQ 3826: 0 bytes
(2) receive: ACK : (2) ACK 4273 SEQ 6574: 0 bytes
File Request for ./files/8192.txt
(task) File Transfer for ./files/8192.txt
(2) (ESTABLISHED)
(2) (Connection established with 127.0.0.2:32567)
(2) sent: ACK : (2) ACK 6575 SEQ 4273: 0 bytes
(1) receive: ACK : (1) ACK 3827 SEQ 9545: 0 bytes
(1) sent: ACK : (1) ACK 9546 SEQ 3827: 39 bytes
(2) receive: ACK : (2) ACK 4274 SEQ 6575: 38 bytes
(2) sent: ACK : (2) ACK 6613 SEQ 4274: 0 bytes
File Request for ./files/8192.txt
(task) File Transfer for ./files/8192.txt
(1) receive: ACK : (1) ACK 3866 SEQ 9546: 0 bytes
(1) sent: ACK : (1) ACK 9547 SEQ 3866: 10 bytes
(2) receive: ACK : (2) ACK 4275 SEQ 6613: 0 bytes
(1) receive: ACK : (1) ACK 3876 SEQ 9547: 0 bytes
(2) sent: ACK : (2) ACK 6614 SEQ 4275: 39 bytes
(1) sent: ACK : (1) ACK 9548 SEQ 3876: 1004 bytes
(2) receive: ACK : (2) ACK 4314 SEQ 6614: 0 bytes
(2) sent: ACK : (2) ACK 6615 SEQ 4314: 10 bytes
(1) receive: ACK : (1) ACK 4880 SEQ 9548: 0 bytes
(1) sent: ACK : (1) ACK 9549 SEQ 4880: 1004 bytes
(2) receive: ACK : (2) ACK 4324 SEQ 6615: 0 bytes
(2) sent: ACK : (2) ACK 6616 SEQ 4324: 1004 bytes
(1) receive: ACK : (1) ACK 5884 SEQ 9549: 0 bytes
(1) sent: ACK : (1) ACK 9550 SEQ 5884: 1004 bytes
(2) receive: ACK : (2) ACK 5328 SEQ 6616: 0 bytes
(1) receive: ACK : (1) ACK 6888 SEQ 9550: 0 bytes
```

```
(1) sent: ACK : (1) ACK 9551 SEQ 6888: 1004 bytes
(2) sent: ACK : (2) ACK 6617 SEQ 5328: 1004 bytes
(1) receive: ACK : (1) ACK 7892 SEQ 9551: 0 bytes
(2) receive: ACK : (2) ACK 6332 SEQ 6617: 0 bytes
(2) sent: ACK : (2) ACK 6618 SEQ 6332: 1004 bytes
(1) sent: ACK : (1) ACK 9552 SEQ 7892: 1004 bytes
(2) receive: ACK : (2) ACK 7336 SEQ 6618: 0 bytes
(2) sent: ACK : (2) ACK 6619 SEQ 7336: 1004 bytes
(1) receive: ACK : (1) ACK 8896 SEQ 9552: 0 bytes
(1) sent: ACK : (1) ACK 9553 SEQ 8896: 1004 bytes
(2) receive: ACK : (2) ACK 8340 SEQ 6619: 0 bytes
(2) sent: ACK : (2) ACK 6620 SEQ 8340: 1004 bytes
(1) receive: ACK : (1) ACK 9900 SEQ 9553: 0 bytes
(1) sent: ACK : (1) ACK 9554 SEQ 9900: 1004 bytes
(2) receive: ACK : (2) ACK 9344 SEQ 6620: 0 bytes
(2) sent: ACK : (2) ACK 6621 SEQ 9344: 1004 bytes
(1) receive: ACK : (1) ACK 10904 SEQ 9554: 0 bytes
(2) receive: ACK : (2) ACK 10348 SEQ 6621: 0 bytes
(1) sent: ACK : (1) ACK 9555 SEQ 10904: 1004 bytes
(2) sent: ACK : (2) ACK 6622 SEQ 10348: 1004 bytes
(2) receive: ACK : (2) ACK 11352 SEQ 6622: 0 bytes
(1) receive: ACK : (1) ACK 11908 SEQ 9555: 0 bytes
(2) sent: ACK : (2) ACK 6623 SEQ 11352: 1004 bytes
(1) sent: ACK : (1) ACK 9556 SEQ 11908: 160 bytes
(2) receive: ACK : (2) ACK 12356 SEQ 6623: 0 bytes
(2) sent: ACK : (2) ACK 6624 SEQ 12356: 160 bytes
(1) receive: ACK : (1) ACK 12068 SEQ 9556: 0 bytes
(2) receive: ACK : (2) ACK 12516 SEQ 6624: 0 bytes
(2) sent: ACK : (2) ACK 6625 SEQ 12516: 8 bytes
(1) sent: ACK : (1) ACK 9557 SEQ 12068: 8 bytes
(2) receive: ACK : (2) ACK 12524 SEQ 6625: 0 bytes
(2) receive: FIN : (2) ACK 12524 SEQ 6626: 0 bytes
(2) sent: ACK : (2) ACK 6627 SEQ 12524: 0 bytes
(2) (CLOSE_WAIT)
(2) (LAST_ACK)
(2) sent: FIN : (2) ACK 6627 SEQ 12525: 0 bytes
(1) receive: ACK : (1) ACK 12076 SEQ 9557: 0 bytes
(1) receive: FIN : (1) ACK 12076 SEQ 9558: 0 bytes
(1) sent: ACK : (1) ACK 9559 SEQ 12076: 0 bytes
(1) (CLOSE_WAIT)
(1) (LAST_ACK)
(1) sent: FIN : (1) ACK 9559 SEQ 12077: 0 bytes
(2) receive: ACK : (2) ACK 12526 SEQ 6627: 0 bytes
(2) (CLOSED)
(2) Terminating connection with 127.0.0.2:32567
(2) Terminating connection with 127.0.0.2:32567
(2) Connection with 127.0.0.2:32567 terminated
(1) receive: ACK : (1) ACK 12078 SEQ 9559: 0 bytes
(1) (CLOSED)
(2) Connection with 127.0.0.2:32567 terminated
1 Thread Closed
1 Thread Closed
```

Client1

[illegible]

[illegible]

```
Socket closed
Thread 1 Closed
```

Step 3

- Timeout retransmission

Server

```
python3 ./testserver.py
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.1:12345
>1 | ****RECEIVED CONNECTION FROM 127.0.0.2:20418****
>1 |     receive: ACK 0 SEQ 9547 <<< 127.0.0.2:20418
>1 | (Connection from 127.0.0.2:20418)
(0) (LISTEN)
(1) sent: SYN, ACK : (1) ACK 9548 SEQ 403: 0 bytes
(1) (SYN_RCVD)
(1) receive: ACK : (1) ACK 404 SEQ 9548: 0 bytes
(1)     |Received SEQ 9548
(1) (ESTABLISHED)
(1) (Connection established with 127.0.0.2:20418)
(1) sent: ACK : (1) ACK 9549 SEQ 404: 0 bytes
(1) receive: ACK : (1) ACK 405 SEQ 9549: 38 bytes
(1)     |Received SEQ 9549
(1) sent: ACK : (1) ACK 9587 SEQ 405: 0 bytes
(1)     >>>>>Packet loss: ACK 9587 SEQ 405<<<<<<
(1)     Curr RTO: 1
File Request for ./files/2048.txt
(task) File Transfer for ./files/2048.txt
LATE LIST:
(1.0761678218841553, 405)
(1)     Current RTO: 1
(1)     Timeout: ACK 9587 SEQ 405
(1)     Resending: ACK 9587 SEQ 405: 0 bytes
(1) receive: ACK : (1) ACK 405 SEQ 9549: 38 bytes
(1)     |Received duplicate SEQ 9549
(1)     |1 Duplicate ACK 1 SEQ 9549
(1)     |Inflight full: 3
(1) receive: ACK : (1) ACK 406 SEQ 9587: 0 bytes
(1)     |Received SEQ 9587
(1) sent: ACK : (1) ACK 9588 SEQ 406: 39 bytes
(1)     |Inflight full: 1
LATE LIST:
(1.003661870956421, 406)
(1)     Current RTO: 1
(1)     Timeout: ACK 9588 SEQ 406
(1)     Resending: ACK 9588 SEQ 406: 39 bytes
(1) receive: ACK : (1) ACK 445 SEQ 9588: 0 bytes
(1)     |Received SEQ 9588
(1) receive: ACK : (1) ACK 445 SEQ 9589: 0 bytes
(1)     |Received SEQ 9589
(1)     |1 Duplicate ACK 1 SEQ 9589
(1) sent: ACK : (1) ACK 9590 SEQ 445: 10 bytes
(1)     |Inflight full: 1
```

```

(1) receive: ACK : (1) ACK 455 SEQ 9590: 0 bytes
(1)      |Received SEQ 9590
(1) sent: ACK : (1) ACK 9591 SEQ 455: 1004 bytes
(1)      |Inflight full: 1
(1) receive: ACK : (1) ACK 1459 SEQ 9591: 0 bytes
(1)      |Received SEQ 9591
(1) sent: ACK : (1) ACK 9592 SEQ 1459: 1004 bytes
(1)      |Inflight full: 1
(1) receive: ACK : (1) ACK 2463 SEQ 9592: 0 bytes
(1)      |Received SEQ 9592
(1) sent: ACK : (1) ACK 9593 SEQ 2463: 40 bytes
(1)      |Inflight full: 1
(1) receive: ACK : (1) ACK 2503 SEQ 9593: 0 bytes
(1)      |Received SEQ 9593
(1) sent: ACK : (1) ACK 9594 SEQ 2503: 8 bytes
(1)      |Inflight full: 1
(1) receive: ACK : (1) ACK 2511 SEQ 9594: 0 bytes
(1)      |Received SEQ 9594
(1) sent: ACK : (1) ACK 9595 SEQ 2511: 0 bytes
(1) receive: ACK : (1) ACK 2512 SEQ 9595: 0 bytes
(1)      |Received SEQ 9595
(1) sent: ACK : (1) ACK 9596 SEQ 2512: 0 bytes
(1) receive: FIN : (1) ACK 2512 SEQ 9596: 0 bytes
(1)      |Received SEQ 9596
(1)      |1 Duplicate ACK 1 SEQ 9596
(1) sent: ACK : (1) ACK 9597 SEQ 2513: 0 bytes
(1)      >>>>>Packet loss: ACK 9597 SEQ 2513<<<<<<
(1)      Curr RTO: 1
(1) (CLOSE_WAIT)
(1) (LAST_ACK)
(1) sent: FIN : (1) ACK 9597 SEQ 2514: 0 bytes
LATE LIST:
(1.02250337600708, 2512)
(1)      Current RTO: 1
(1)      Timeout: ACK 9596 SEQ 2512
(1)      Resending: ACK 9596 SEQ 2512: 0 bytes
LATE LIST:
(1.0097646713256836, 2513)
(1)      Current RTO: 1
(1)      Timeout: ACK 9597 SEQ 2513
(1)      Resending: ACK 9597 SEQ 2513: 0 bytes
LATE LIST:
(1.2121121883392334, 2514)
(1)      Current RTO: 1
(1)      Timeout: ACK 9597 SEQ 2514
(1)      Resending: ACK 9597 SEQ 2514: 0 bytes
(1) receive: ACK : (1) ACK 2515 SEQ 9597: 0 bytes
(1)      |Received SEQ 9597
(1) (CLOSED)
(1) Dropped: 2 packets
(1) Terminating connection with 127.0.0.2:20418
(1) Connection with 127.0.0.2:20418 terminated
1 Thread Closed

```

Client

[illegible]

```

./files/2048.txt: size 2048 bytes
BUFFER: 1
Dropped: 1
(0) sent: FIN : (0) ACK 2512 SEQ 9596: 0 bytes
(0) (FIN_WAIT_1)
(0) receive: ACK : (0) ACK 9596 SEQ 2512: 0 bytes
(0) |Received SEQ 2512
(0) (FIN_WAIT_2)
(0) receive: FIN : (0) ACK 9597 SEQ 2514: 0 bytes
(0) |Received out of order SEQ 2514
(0) receive: ACK : (0) ACK 9597 SEQ 2512: 0 bytes
(0) |Received duplicate SEQ 2512
(0) receive: ACK : (0) ACK 9597 SEQ 2513: 0 bytes
(0) |Received SEQ 2513
(0) receive: FIN : (0) ACK 9597 SEQ 2514: 0 bytes
(0) |Received SEQ 2514
(0) sent: ACK : (0) ACK 2515 SEQ 9597: 0 bytes
(0) (TIME_WAIT)
(0) (CLOSED)
(0) Dropped: 1 packets
(0) Terminating connection with 127.0.0.1:12345
(0) Connection with 127.0.0.1:12345 terminated
Socket closed
Thread 1 Closed

```

Step 4

- Delayed ack
- Function is closed during handshake and termination
- Slow start is implemented

Server

```

python3 ./testserver.py
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.1:12345
>1 | ****RECEIVED CONNECTION FROM 127.0.0.2:32364****
>1 | receive: ACK 0 SEQ 7937 <<< 127.0.0.2:32364
>1 | (Connection from 127.0.0.2:32364)
(0) (LISTEN)
(1) sent: SYN, ACK : (1) ACK 7938 SEQ 4535: 0 bytes
(1) (SYN_RCVD)
(1) receive: ACK : (1) ACK 4536 SEQ 7938: 0 bytes
(1) |Received SEQ 7938
(1) (ESTABLISHED)
(1) (Connection established with 127.0.0.2:32364)
(1) sent: ACK : (1) ACK 7939 SEQ 4536: 0 bytes
(1) receive: ACK : (1) ACK 4537 SEQ 7939: 38 bytes
(1) |Received SEQ 7939
(1) >>>slow start mode<<<
File Request for ./files/8192.txt
(task) File Transfer for ./files/8192.txt
(1) | (cwnd: 2048 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7977 SEQ 4537: 0 bytes

```

```
(1)      |Inflight full: 1
(1) receive: ACK : (1) ACK 4538 SEQ 7977: 0 bytes
(1)      |Received SEQ 7977
(1)      >>>slow start mode<<<
(1)      |(cwnd: 3072 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7978 SEQ 4538: 39 bytes
(1) sent: ACK : (1) ACK 7978 SEQ 4577: 10 bytes
(1) sent: ACK : (1) ACK 7978 SEQ 4587: 1004 bytes
(1)      |Inflight full: 3
(1) receive: ACK : (1) ACK 4587 SEQ 7978: 0 bytes
(1)      |Received SEQ 7978
(1)      >>>slow start mode<<<
(1)      |(cwnd: 4096 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7979 SEQ 5591: 1004 bytes
(1) sent: ACK : (1) ACK 7979 SEQ 6595: 1004 bytes
(1)      |Inflight full: 4
(1) receive: ACK : (1) ACK 6595 SEQ 7979: 0 bytes
(1)      |Received SEQ 7979
(1)      >>>slow start mode<<<
(1)      |(cwnd: 5120 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7980 SEQ 7599: 1004 bytes
(1) sent: ACK : (1) ACK 7980 SEQ 8603: 1004 bytes
(1) sent: ACK : (1) ACK 7980 SEQ 9607: 1004 bytes
(1)      |Inflight full: 5
(1) receive: ACK : (1) ACK 8603 SEQ 7980: 0 bytes
(1)      |Received SEQ 7980
(1)      >>>slow start mode<<<
(1)      |(cwnd: 6144 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 10611 SEQ 7981: 0 bytes
(1)      |Received SEQ 7981
(1)      >>>slow start mode<<<
(1)      |(cwnd: 7168 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7982 SEQ 10611: 1004 bytes
(1) sent: ACK : (1) ACK 7982 SEQ 11615: 1004 bytes
(1) sent: ACK : (1) ACK 7982 SEQ 12619: 160 bytes
(1) sent: ACK : (1) ACK 7982 SEQ 12779: 8 bytes
(1)      |Inflight full: 4
(1) receive: ACK : (1) ACK 12619 SEQ 7982: 0 bytes
(1)      |Received SEQ 7982
(1)      >>>slow start mode<<<
(1)      |(cwnd: 8192 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 12787 SEQ 7983: 0 bytes
(1)      |Received SEQ 7983
(1)      >>>slow start mode<<<
(1)      |(cwnd: 9216 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7984 SEQ 12787: 0 bytes
(1)      |Inflight full: 1
(1) receive: FIN : (1) ACK 12787 SEQ 7984: 0 bytes
(1)      |Received SEQ 7984
(1)      |1 Duplicate ACK 1 SEQ 7984
(1)      >>>slow start mode<<<
(1)      |(cwnd: 10240 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 7985 SEQ 12788: 0 bytes
(1) (CLOSE_WAIT)
(1) (LAST_ACK)
(1) sent: FIN : (1) ACK 7985 SEQ 12789: 0 bytes
(1) receive: ACK : (1) ACK 12790 SEQ 7985: 0 bytes
(1)      |Received SEQ 7985
```

```
(1) (CLOSED)
(1) Dropped: 0 packets
(1) Terminating connection with 127.0.0.2:32364
(1) Connection with 127.0.0.2:32364 terminated
1 Thread Closed
```

Client

```
python3 ./test.py --file ./files/8192.txt
***NEW CLIENT CREATED***
Number of Threads: 1
>1 | Server State: LISTEN
>1 | Server is listening on 127.0.0.2:32364
(0) sent: SYN : (0) ACK 0 SEQ 7937: 0 bytes
(0) (SYN_SENT)
(0) receive: SYN, ACK : (0) ACK 7938 SEQ 4535: 0 bytes
(0) |Received SEQ 4535
(0) sent: ACK : (0) ACK 4536 SEQ 7938: 0 bytes
(0) (ESTABLISHED)
(task3: ./files/8192.txt)
(0) receive: ACK : (0) ACK 7939 SEQ 4536: 0 bytes
(0) |Received SEQ 4536
(0) | (Delayed ACK)
(0) | (Delayed ACK) SEND
(0) sent: ACK : (0) ACK 4537 SEQ 7939: 38 bytes
(0) receive: ACK : (0) ACK 7977 SEQ 4537: 0 bytes
(0) |Received SEQ 4537
(0) | (Delayed ACK)
(0) | (Delayed ACK) SEND
(0) sent: ACK : (0) ACK 4538 SEQ 7977: 0 bytes
(0) receive: ACK : (0) ACK 7978 SEQ 4538: 39 bytes
(0) |Received SEQ 4538
(0) | (Delayed ACK)
(0) receive: ACK : (0) ACK 7978 SEQ 4577: 10 bytes
(0) |Received SEQ 4577
(0) sent: ACK : (0) ACK 4587 SEQ 7978: 0 bytes
(0) receive: ACK : (0) ACK 7978 SEQ 4587: 1004 bytes
(0) |Received SEQ 4587
(0) | (Delayed ACK)
(0) receive: ACK : (0) ACK 7979 SEQ 5591: 1004 bytes
(0) |Received SEQ 5591
(0) sent: ACK : (0) ACK 6595 SEQ 7979: 0 bytes
(0) receive: ACK : (0) ACK 7979 SEQ 6595: 1004 bytes
(0) |Received SEQ 6595
(0) | (Delayed ACK)
(0) receive: ACK : (0) ACK 7980 SEQ 7599: 1004 bytes
(0) |Received SEQ 7599
(0) sent: ACK : (0) ACK 8603 SEQ 7980: 0 bytes
(0) receive: ACK : (0) ACK 7980 SEQ 8603: 1004 bytes
(0) |Received SEQ 8603
(0) | (Delayed ACK)
(0) receive: ACK : (0) ACK 7980 SEQ 9607: 1004 bytes
(0) |Received SEQ 9607
(0) sent: ACK : (0) ACK 10611 SEQ 7981: 0 bytes
(0) receive: ACK : (0) ACK 7982 SEQ 10611: 1004 bytes
```

```
(0)      |Received SEQ 10611  
(0)      |(Delayed ACK)  
(0) receive: ACK : (0) ACK 7982 SEQ 11615: 1004 bytes  
(0)      |Received SEQ 11615  
(0) sent: ACK : (0) ACK 12619 SEQ 7982: 0 bytes  
(0) receive: ACK : (0) ACK 7982 SEQ 12619: 160 bytes  
(0)      |Received SEQ 12619  
(0)      |(Delayed ACK)  
(0) receive: ACK : (0) ACK 7982 SEQ 12779: 8 bytes  
(0)      |Received SEQ 12779  
(0) sent: ACK : (0) ACK 12787 SEQ 7983: 0 bytes  
~~~~~>>>Writing to file<<<  
Received file:  
. /files/8192.txt: size 8192 bytes  
BUFFER: 0  
Dropped: 0  
(0) sent: FIN : (0) ACK 12787 SEQ 7984: 0 bytes  
(0) (FIN_WAIT_1)  
(0) receive: ACK : (0) ACK 7984 SEQ 12787: 0 bytes  
(0)      |Received SEQ 12787  
(0) (FIN_WAIT_2)  
(0) receive: ACK : (0) ACK 7985 SEQ 12788: 0 bytes  
(0)      |Received SEQ 12788  
(0) receive: FIN : (0) ACK 7985 SEQ 12789: 0 bytes  
(0)      |Received SEQ 12789  
(0) sent: ACK : (0) ACK 12790 SEQ 7985: 0 bytes  
(0) (TIME_WAIT)  
(0) (CLOSED)  
(0) Dropped: 0 packets  
(0) Terminating connection with 127.0.0.1:12345  
(0) Connection with 127.0.0.1:12345 terminated  
Socket closed  
Thread 1 Closed
```

Step 5

- Slow start and congestion avoidance
- The log is truncated
- The ack is delayed since the receiver is slow (python, list, threading, buffer), it will eventually timeout and resume.
- The cwnd sometimes undercalculated, because of the gap and delay between the ack bursting thread and the inflight_buf, the inflight_buf length calculation is not locked to avoid race condition.

Server

```
(1) sent: ACK : (1) ACK 3985 SEQ 143149: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 144153: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 145157: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 146161: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 147165: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 148169: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 149173: 1004 bytes
```



```

(1) sent: ACK : (1) ACK 3985 SEQ 150177: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 151181: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 152185: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 153189: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 154193: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 155197: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 156201: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 157205: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 158209: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 159213: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 160217: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 161221: 1004 bytes
(1) sent: ACK : (1) ACK 3985 SEQ 162225: 1004 bytes
(1)      |Inflight full: 59
(1) receive: ACK : (1) ACK 118777 SEQ 3985: 0 bytes
(1)      |Received SEQ 3985
(1)      >>>slow start mode<<<
(1)      |(cwnd: 61440 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 120785 SEQ 3986: 0 bytes
(1)      |Received SEQ 3986
(1)      >>>slow start mode<<<
(1)      |(cwnd: 62464 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 122793 SEQ 3987: 0 bytes
(1)      |Received SEQ 3987
(1)      >>>slow start mode<<<
(1)      |(cwnd: 63488 MSS: 1024 threshold: 64)
(1)      |Inflight full: 82
(1) receive: ACK : (1) ACK 124801 SEQ 3988: 0 bytes
(1)      |Received SEQ 3988
(1)      >>>slow start mode<<<
(1)      |(cwnd: 64512 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 126809 SEQ 3989: 0 bytes
(1)      |Received SEQ 3989
(1)      >>>slow start mode<<<
(1)      |(cwnd: 65536 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 128817 SEQ 3990: 0 bytes
(1)      |Received SEQ 3990
(1)      >>>congestion avoidance mode<<<
(1)      |(cwnd: 65552.0 MSS: 1024 threshold: 64)
(1)      |Inflight full: 70
(1) receive: ACK : (1) ACK 130825 SEQ 3991: 0 bytes
(1)      |Received SEQ 3991
(1)      >>>congestion avoidance mode<<<
(1)      |(cwnd: 65567.99609470344 MSS: 1024 threshold: 64)

```

Client

```

(0) sent: ACK : (0) ACK 118777 SEQ 3985: 0 bytes
(0) receive: ACK : (0) ACK 3980 SEQ 118777: 1004 bytes
(0)      |Received SEQ 118777
(0)      |(Delayed ACK)
(0) receive: ACK : (0) ACK 3980 SEQ 119781: 1004 bytes
(0)      |Received SEQ 119781
(0) sent: ACK : (0) ACK 120785 SEQ 3986: 0 bytes
(0) receive: ACK : (0) ACK 3981 SEQ 120785: 1004 bytes
(0)      |Received SEQ 120785

```

```

(0)      | (Delayed ACK)
(0) receive: ACK : (0) ACK 3981 SEQ 121789: 1004 bytes
(0)      | Received SEQ 121789
(0) sent: ACK : (0) ACK 122793 SEQ 3987: 0 bytes
(0) receive: ACK : (0) ACK 3981 SEQ 122793: 1004 bytes
(0)      | Received SEQ 122793
(0)      | (Delayed ACK)
(0) receive: ACK : (0) ACK 3981 SEQ 123797: 1004 bytes
(0)      | Received SEQ 123797
(0) sent: ACK : (0) ACK 124801 SEQ 3988: 0 bytes
(0) receive: ACK : (0) ACK 3981 SEQ 124801: 1004 bytes
(0)      | Received SEQ 124801
(0)      | (Delayed ACK)
(0) receive: ACK : (0) ACK 3981 SEQ 125805: 1004 bytes
(0)      | Received SEQ 125805
(0) sent: ACK : (0) ACK 126809 SEQ 3989: 0 bytes
(0) receive: ACK : (0) ACK 3981 SEQ 126809: 1004 bytes
(0)      | Received SEQ 126809
(0)      | (Delayed ACK)
(0) receive: ACK : (0) ACK 3981 SEQ 127813: 1004 bytes
(0)      | Received SEQ 127813
(0) sent: ACK : (0) ACK 128817 SEQ 3990: 0 bytes
(0) receive: ACK : (0) ACK 3981 SEQ 128817: 1004 bytes
(0)      | Received SEQ 128817
(0)      | (Delayed ACK)
(0) receive: ACK : (0) ACK 3981 SEQ 129821: 1004 bytes
(0)      | Received SEQ 129821
(0) sent: ACK : (0) ACK 130825 SEQ 3991: 0 bytes

```

Step 6, 7

- Fast recovery

Server

```

(1) sent: ACK : (1) ACK 8786 SEQ 6351: 39 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 6390: 10 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 6400: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 7404: 1004 bytes
(1)      >>>>>Packet loss: ACK 8786 SEQ 7404<<<<<<
(1)      Curr RTO: 1
(1) sent: ACK : (1) ACK 8786 SEQ 8408: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 9412: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 10416: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 11420: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 12424: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 13428: 1004 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 14432: 160 bytes
(1) sent: ACK : (1) ACK 8786 SEQ 14592: 8 bytes
(1)      | Inflight full: 12
(1) receive: ACK : (1) ACK 6390 SEQ 8786: 0 bytes
(1)      | Received SEQ 8786
(1)      >>>congestion avoidance mode<<<
(1)      | (cwnd: 65552.0 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 8787 SEQ 14600: 0 bytes

```

```

(1)      |Inflight full: 22
(1) receive: ACK : (1) ACK 6400 SEQ 8787: 0 bytes
(1)      |Received SEQ 8787
(1)      >>>congestion avoidance mode<<<
(1)      |(cwnd: 65552.0 MSS: 1024 threshold: 64)
(1) sent: ACK : (1) ACK 8788 SEQ 14601: 0 bytes
(1)      |Inflight full: 22
(1) receive: ACK : (1) ACK 7404 SEQ 8788: 0 bytes
(1)      |Received SEQ 8788
(1)      >>>congestion avoidance mode<<<
(1)      |(cwnd: 65552.0 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 7404 SEQ 8789: 0 bytes
(1)      |Received SEQ 8789
(1)      |1 Duplicate ACK 1 SEQ 8789
(1)      >>>congestion avoidance mode<<<
(1)      |(cwnd: 65567.99609470344 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 7404 SEQ 8790: 0 bytes
(1)      |Received SEQ 8790
(1)      |2 Duplicate ACK 2 SEQ 8790
(1)      >>>congestion avoidance mode<<<
(1)      |(cwnd: 65583.98828696879 MSS: 1024 threshold: 64)
(1) receive: ACK : (1) ACK 7404 SEQ 8791: 0 bytes
(1)      |Received SEQ 8791
(1)      |3 Duplicate ACK 3 SEQ 8791
(1)      |Expected SEQ 8792 but got SEQ 8791
(1)      Resending: ACK 8792 SEQ 7404: 1004 bytes
(1) receive: ACK : (1) ACK 7404 SEQ 8792: 0 bytes
(1)      |Received SEQ 8792
(1)      |1 Duplicate ACK 1 SEQ 8792
(1)      >>>fast recovery mode<<<
(1)      |(cwnd: 33815.99414348439 MSS: 1024 threshold: 32.02343178074648)
(1) receive: ACK : (1) ACK 7404 SEQ 8793: 0 bytes
(1)      |Received SEQ 8793
(1)      |2 Duplicate ACK 2 SEQ 8793
(1)      >>>fast recovery mode<<<
(1)      |(cwnd: 34839.99414348439 MSS: 1024 threshold: 32.02343178074648)

```

Client

```

(0) receive: ACK : (0) ACK 8786 SEQ 6351: 39 bytes
(0)      |Received SEQ 6351
(0) sent: ACK : (0) ACK 6390 SEQ 8786: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 6390: 10 bytes
(0)      |Received SEQ 6390
(0) sent: ACK : (0) ACK 6400 SEQ 8787: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 6400: 1004 bytes
(0)      |Received SEQ 6400
(0) sent: ACK : (0) ACK 7404 SEQ 8788: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 8408: 1004 bytes
(0)      |Received out of order SEQ 8408
(0) sent: ACK : (0) ACK 7404 SEQ 8789: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 9412: 1004 bytes
(0)      |Received out of order SEQ 9412
(0) sent: ACK : (0) ACK 7404 SEQ 8790: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 10416: 1004 bytes

```

```
(0)      |Received out of order SEQ 10416
(0) sent: ACK : (0) ACK 7404 SEQ 8791: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 11420: 1004 bytes
(0)      |Received out of order SEQ 11420
(0) sent: ACK : (0) ACK 7404 SEQ 8792: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 12424: 1004 bytes
(0)      |Received out of order SEQ 12424
(0) sent: ACK : (0) ACK 7404 SEQ 8793: 0 bytes
(0) receive: ACK : (0) ACK 8786 SEQ 13428: 1004 bytes
(0)      |Received out of order SEQ 13428
```