<2018 Computer Network Homework>

Motivation

We divide the homework into two parts. First, you should understand the mechanism of TCP in detail including data transmission, flow control, delayed ACKs, and congestion contro etc. Second, you have to implement TCP in application layer and call UDP to transmit TCP packets.

Rules

1. Run your program on Ubuntu 16.04 platform.
2. Do not copy homework from your classmates or senior, etc. If TAs find the situation, any participants will get a grade of ZERO.
3. You have to deeply understand what your program do because TAs will ask you the concept of your code.
4. If you have any question, you can send email or come to F-5008(High Speed Network Lab) to ask TAs but debugging.
5. You have to create Makefile to compile your program, and ensure your program can be compiled correctly.
6. You also need to submit a PDF that contains the picture of your program run's result in every step.
7. In each step, you can write a new program, respectively (but the program has to including the function of previous step).
8. The format of filename you upload should be "StudentID_Name.zip".
9.輸出格式僅供參考，實際輸出結果請依題目需求呈現。

Ex: B063040000_王小明.zip

Deadline

You should upload your homework to the Cyber University before 2018/06/22 23:59. If you do not submit your assignment on time, you will get a grade of ZERO.

Demo

The following figure shows the time you can come for demo.
Demo deadline: 2017/06/23 17:00

	Mon.	Tue.	Wed.	Thu.	Fri.
10:00 – 12:00	✓	✓	✓		✓
14:00 – 17:00		✓	✓		✓

Description

You have to obey the following schema:
- The TCP segment structure
- The initial sequence number should be set randomly (1~10000).

Step 1:

1. Set the parameters including RTT (200 ms), MSS (1024 bytes), threshold (65535) and the receiver's buffer size (32KB), etc.

2. You also have to implement the data transmission (You need to ensure the data that can transmit from server to client, and ACK packet transmit from client to server).

Server:

```
CNTA@ubuntu:~/Desktop$ ./Server 12345
=====Parameter=====
The RTT delay = 200 ms
The threshold = 65535 bytes
The MSS = 1024 bytes
The buffer size = 32468 bytes
Server's IP is 192.168.0.1
Server is listening on port 12345
```

```
Start to send file 1 to 192.168.0.2 : 23456, the file size is 123431 bytes
cwnd = 1, rwnd = 32768, threshold = 65535
        Send a packet at : 1 bytes
        Receive a packet (seq_num = 4567, ack_num = 2)
cwnd = 2, rwnd = 32767, threshold = 65535
        Send a packet at : 2 bytes
```

Client:

```
CNTA@ubuntu:~/Desktop$ ./Client 23456
=====Parameter=====
The RTT delay = 200 ms
The threshold = 65535 bytes
The MSS = 1024 bytes
The buffer size = 32468 bytes
Client's IP is 192.168.0.2
Client is listening on port 23456
================
Please Input Sever [IP] [Port] you want to connect:
192.0.0.1 12345
```

```
Receive a file from 192.168.0.1 : 12345
        Receive a packet (seq_num = 1, ack_num = 4567)
        Receive a packet (seq_num = 2, ack_num = 4568)
```

Step 2:

1. Including the previous step's function.
2.First, you have to transmit the video files in this step. A client should request multiple files in one packet. The server should send the data to multiple clients in the same time. (You can use fork or thread.)
3. If you cannot send the video file, you can send a data created by yourself (ex. an 10240 bytes char array). (But you won't get all score in the part if you do it in this way.)
4. Second, you also have to implement the data transmission (You need to ensure the data that can transmit from server to client, and ACK packet transmit from client to server).
5. You have to print out which client the server is sending to and which file is sent in this step.

Server:

```
Start to send file 1 to 192.168.0.2 : 23456, the file size is 123431 byte
cwnd = 1, rwnd = 32768, threshold = 65535
                (Send to 192.168.0.2 : 23456, file 1)
        Send a packet at : 1 bytes
                (Send to 192.168.0.2 : 23456, file 1)
        Receive a packet (seq_num = 4567, ack_num = 2)
                (Receive from 192.168.0.2 : 23456, file 1)
Start to send file 3 to 192.168.0.3 : 34555, the file size is 44608 bytes
cwnd = 1, rwnd = 32768, threshold = 65535
                (Send to 192.168.0.3 : 34555, file 3)
        Send a packet at : 1 bytes
                (Send to 192.168.0.3 : 34555, file 3)
        Receive a packet (seq_num = 2222, ack_num = 2)
                (Receive from 192.168.0.3 : 34567, file 3)
cwnd = 2, rwnd = 32767, threshold = 65535
                (Send to 192.168.0.2 : 23456, file 1)
        Send a packet at : 2 bytes
                (Send to 192.168.0.2 : 23456, file 1)
        Receive a packet (seq_num = 4568, ack_num = 4)
                (Receive from 192.168.0.2 : 23456, file 1)
cwnd = 2, rwnd = 32767, threshold = 65535
                (Send to 192.168.0.3 : 34555, file 3)
        Send a packet at : 2 bytes
                (Send to 192.168.0.3 : 34555, file 3)
```

Client A:

```
Receive a file 1 from 192.168.0.1 : 12345
        Receive a packet (seq_num = 1, ack_num = 4567)
        Receive a packet (seq_num = 2, ack_num = 4568)
        Receive a packet (seq_num = 4, ack_num = 4569)
```

Client B:

```
Receive a file 3 from 192.168.0.1 : 12345
        Receive a packet (seq_num = 1, ack_num = 2222)
        Receive a packet (seq_num = 2, ack_num = 2223)
        Receive a packet (seq_num = 4, ack_num = 2224)
```

Step 3:

1. Including the previous step's function.

2. Implement the delayed ACKs, you can wait up to 500ms for next packet, or delay for two packets, then send an ACK packet to server

3. You don't have to print out which client the server is sending. (Or you can let only one client to connect to server.)

Server:

```
cwnd = 1, rwnd = 10240, threshold = 4096
        Send a packet at : 1 byte
cwnd = 2, rwnd = 10239, threshold = 4096
        Send a packet at : 2 byte
        Receive a packet (seq_num = 3924, ack_num = 4)
cwnd = 4, rwnd = 10238, threshold = 4096
        Send a packet at : 4 byte
cwnd = 8, rwnd = 10236, threshold = 4096
        Send a packet at : 8 byte
        Receive a packet (seq_num = 3926, ack_num = 16)
cwnd = 16, rwnd = 10232, threshold = 4096
        Send a packet at : 16 byte
cwnd = 32, rwnd = 10224, threshold = 4096
        Send a packet at : 32 byte
        Receive a packet (seq_num = 3928, ack_num = 64)
```

Step 4:

1. Including the previous step's function.
2. Implement the congestion control including slow start and congestion avoidance.
3. You need to reset the threshold as 8192 in order to enter the status of congestion avoidance.

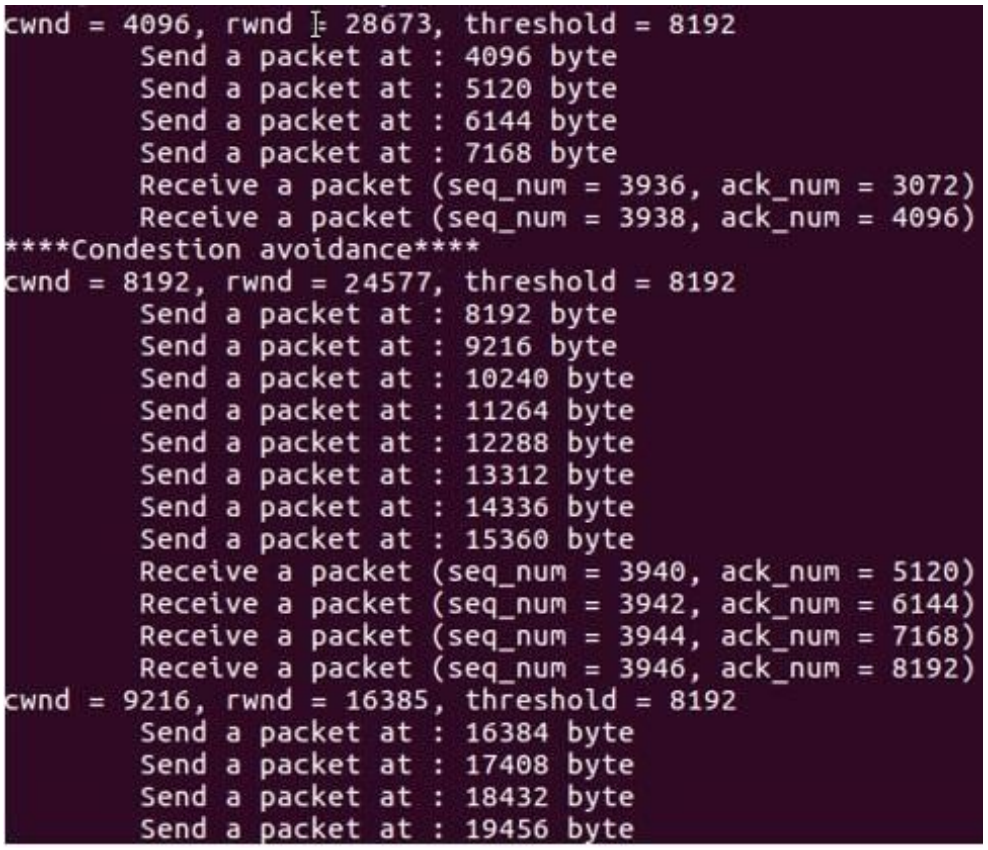
Server (slow start):

```
*****Slow atart*****
cwnd = 1, rwnd = 32768, threshold = 8192
        Send a packet at : 1 bytes
cwnd = 2, rwnd = 32767, threshold = 8192
        Send a packet at : 2 byte
        Receive a packet (seq_num = 4568, ack_num = 4)
cwnd = 4, rwnd = 32765, threshold = 8192
        Send a packet at : 4 byte
cwnd = 8, rwnd = 32761, threshold = 8192
        Send a packet at : 8 byte
        Receive a packet (seq_num = 4570, ack_num = 16)
cwnd = 16, rwnd = 32753, threshold = 8192
        Send a packet at : 16 byte
cwnd = 32, rwnd = 32737, threshold = 8192
        Send a packet at : 32 byte
        Receive a packet (seq_num = 4572, ack_num = 64)
```

Client (slow start):

```
Receive a packet (seq_num = 1, ack_num = 2416)
Receive a packet (seq_num = 2, ack_num = 2417)
Receive a packet (seq_num = 4, ack_num = 2418)
Receive a packet (seq_num = 8, ack_num = 2419)
Receive a packet (seq_num = 16, ack_num = 2420)
Receive a packet (seq_num = 32, ack_num = 2421)
```

Server (congestion avoidance):



Step 5:

1. Including the previous step's function.
2. Implement the mechanism of fast retransmit. (Tahoe)
3. You need to design a packet loss at byte 4096 to get duplicated ACKs, then the fast retransmit will execute.
4. You can ignore the mechanism of delayed ACK to implement this step in order to check the receive packets.

Server :

```
cwnd = 4096, rwnd = 28673, threshold = 8192
        Send a packet at : 4096 byte
        Send a packet at : 5120 byte
        Send a packet at : 6144 byte
        Send a packet at : 7168 byte
        Receive a packet (seq_num = 3936, ack_num = 4096)
        Receive a packet (seq_num = 3936, ack_num = 4096)
        Receive a packet (seq_num = 3936, ack_num = 4096)
Receive three duplicated ACKs.
*****Fast retransmit*****
*****Slow start****
cwnd = 1, rwnd = 32768 threshold = 2048
        Send a packet at : 4096 byte
        Receive a packet (seq_num = 3937, ack_num = 4097)
cwnd = 2, rwnd = 32767 threshold = 2048
        Send a packet at : 4097 byte
        Receive a packet (seq_num = 3938, ack_num = 4099)
cwnd = 4, rwnd = 32765 threshold = 2048
        Send a packet at : 4099 byte
        Receive a packet (seq_num = 3939, ack_num = 4103)
```

Client:

```
        Receive a packet (seq_num = 4096, ack_num = 3937)
        Receive a packet (seq_num = 4097, ack_num = 3938)
        Receive a packet (seq_num = 4099, ack_num = 3939)
        Receive a packet (seq_num = 4103, ack_num = 3940)
```

Step 6:

1. Including the previous step's function.
2. Implement the mechanism of fast recovery. (TCP Reno)
3. You need to design a packet loss at byte 2048 to get duplicated ACKs, then the fast retransmit will execute, and enter the state of fast recovery.
4. You can ignore the mechanism of delayed ACK to implement this step in order to check the receive packets

Server:

```
cwnd = 4096, rwnd = 28673, threshold = 8192
        Send a packet at : 4096 byte **loss
        Send a packet at : 5120 byte
        Send a packet at : 6144 byte
        Send a packet at : 7168 byte
        Receive a packet (seq_num = 3936, ack_num = 4096)
        Receive a packet (seq_num = 3936, ack_num = 4096)
        Receive a packet (seq_num = 3936, ack_num = 4096)
Receive three duplicated ACKs.
*****Fast recovery*****
*****Congetion avoidance****
cwnd = 2048, rwnd = 32768 threshold = 2048
        Send a packet at : 4096 byte
        Receive a packet (seq_num = 3937, ack_num = 6144)
cwnd = 3072, rwnd = 30720 threshold = 2048
        Send a packet at : 4097 byte
        Receive a packet (seq_num = 3938, ack_num = 9216)
cwnd = 4096, rwnd = 27648 threshold = 2048
        Send a packet at : 4099 byte
        Receive a packet (seq_num = 3939, ack_num = 13312)
```

Client :

```
        Receive a packet (seq_num = 4096, ack_num = 3937)
        Receive a packet (seq_num = 6144, ack_num = 3938)
        Receive a packet (seq_num = 9216, ack_num = 3939)
        Receive a packet (seq_num = 13312, ack_num = 3940)
```

Step 7:

1. Including the previous step's function.

2. Implement the mechanism of TCP SACK, and using three blocks in this step.

3. You need to design a packet loss at byte 10240, 12288 and 14336 to create three SACK blocks.

4. You can ignore the mechanism of delayed ACK to implement this step in order to check the receive packets.

Server :

```
cwnd = 4096, rwnd = 28673, threshold = 8192
        Send a packet at : 4096 byte
        Send a packet at : 5120 byte
        Send a packet at : 6144 byte
        Send a packet at : 7168 byte
        Receive a packet (seq_num = 5202, ack_num = 5120)
        Receive a packet (seq_num = 5203, ack_num = 6144)
        Receive a packet (seq_num = 5204, ack_num = 7168)
        Receive a packet (seq_num = 5205, ack_num = 8192)
*****Congestion avoidance*****
cwnd = 8192, rwnd = 24577, threshold = 8192
        Send a packet at : 8192 byte
        Send a packet at : 9216 byte
        Send a packet at : 10240 byte
***Data loss at byte : 10240
        Send a packet at : 11264 byte
        Send a packet at : 12288 byte
***Data loss at byte : 12288
        Send a packet at : 13312 byte
        Send a packet at : 14336 byte
***Data loss at byte : 14336
        Send a packet at : 15360 byte
        Receive a packet (seq_num = 5206, ack_num = 9216)
        Receive a packet (seq_num = 5207, ack_num = 10240)
        Receive a packet (seq_num = 5207, ack_num = 10240)
        Receive a packet (seq_num = 5207, ack_num = 10240)
        Receive a packet (seq_num = 5207, ack_num = 10240)
Receive three duplicate ACKs.
*****Fast recovery*****
*****Congestion avoidance*****
cwnd = 4096, rwnd = 5632, threshold = 4096
        Send a packet at : 10240 byte
        Send a packet at : 11264 byte
        Send a packet at : 12288 byte
        Send a packet at : 13312 byte
        Receive a packet (seq_num = 5208, ack_num = 11264)
        Receive a packet (seq_num = 5209, ack_num = 12288)
        Receive a packet (seq_num = 5210, ack_num = 13312)
        Receive a packet (seq_num = 5211, ack_num = 14336)
```

Client (the output format of client is different, print each ACK packet) :

```
Receive a file from 196.0.0.1 : 12345
ACK     1 Left  1 Right 2 Left 2 Right 3 Left 3 Right
2
4
6
8
16
32
128
```

```
8192
9216
10240
10240   11264   12288
10240   11264   12288   13312   14336
10240   11264   12288   13312   14336   15360   16384
12288   13312   14336   15360   16384
14336   15360   16384
15360
16384
```

Step 8:

1. Including the previous step's function.
2. Implement the TCP Reno, if the channel speed is lower than 95% of original speed, you need to discard the packet and retransmit the packet.
3. Implement multi-connections in each direction, and transmission rate limit
4. There is no strict output format, you just show your result in demo.