

➤ Step 1

DNS Function

Client:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
====Start the three-way handshake====
Send a packet(SYN) to 127.0.0.1 : 2345
    Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
    Receive a packet (seq_num = 5307, ack_num = 2356)
Send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 1025 byte
====Complete the three-way handshake====
Enter command (type 'exit' to close connection): dns google.com
Send a command
    Send a packet at : 2049 byte
Finding IP address of google.com by 127.0.0.1 : 2345
    Receive a packet (seq_num = 5309, ack_num = 2358)
Result: 142.251.43.14
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 3073 byte
Finish finding
google.com
Enter command (type 'exit' to close connection): dns amazon.com
Send a command
    Send a packet at : 4097 byte
Finding IP address of amazon.com by 127.0.0.1 : 2345
    Receive a packet (seq_num = 5311, ack_num = 2360)
Result: 52.94.236.248
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 5121 byte
Finish finding
amazon.com
Enter command (type 'exit' to close connection):
```

Server:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./server 2345
====Start the three-way handshake====
Receive a packet(SYN) from 127.0.0.1 : 50131
    Receive a packet (seq_num = 2355, ack_num = 0)
cwnd = 1, rwnd = 524288, threshold = 65536
Send a packet(SYN/ACK) to 127.0.0.1 : 50131
    Send a packet at : 1 byte
Receive a packet(ACK) from 127.0.0.1 : 50131
    Receive a packet (seq_num = 2356, ack_num = 5308)
====Complete the three-way handshake====
    Receive a packet (seq_num = 2357, ack_num = 5309)
dns google.com
==Start finding: google.com to 127.0.0.1 : 50131
cwnd = 2, rwnd = 524288, threshold = 65536
    Send a packet at : 1025 byte
    Receive a packet (seq_num = 2358, ack_num = 5310)
==Finish finding==
    Receive a packet (seq_num = 2359, ack_num = 5311)
dns amazon.com
==Start finding: amazon.com to 127.0.0.1 : 50131
cwnd = 2, rwnd = 524288, threshold = 65536
    Send a packet at : 2049 byte
    Receive a packet (seq_num = 2360, ack_num = 5312)
==Finish finding==
```

MATH Function

Client:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
====Start the three-way handshake====
Send a packet(SYN) to 127.0.0.1 : 2345
    Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
    Receive a packet (seq_num = 599, ack_num = 9542)
Send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 1025 byte
====Complete the three-way handshake====
Enter command (type 'exit' to close connection): cal 5 add 13
Send a command
    Send a packet at : 2049 byte
Calculating 5 add 13 by 127.0.0.1 : 2345
    Receive a packet (seq_num = 601, ack_num = 9544)
Result: 18
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 3073 byte
Finish calculation
Enter command (type 'exit' to close connection): cal 8 sub 2
Send a command
    Send a packet at : 4097 byte
Calculating 8 sub 2 by 127.0.0.1 : 2345
    Receive a packet (seq_num = 603, ack_num = 9546)
Result: 6
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 5121 byte
Finish calculation
Enter command (type 'exit' to close connection): cal 9 mul 5
Send a command
    Send a packet at : 6145 byte
Calculating 9 mul 5 by 127.0.0.1 : 2345
    Receive a packet (seq_num = 605, ack_num = 9548)
Result: 45
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 7169 byte
Finish calculation
```

Server:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./server 2345
====Start the three-way handshake====
Receive a packet(SYN) from 127.0.0.1 : 33785
    Receive a packet (seq_num = 9541, ack_num = 0)
cwnd = 1, rwnd = 524288, threshold = 65536
Send a packet(SYN/ACK) to 127.0.0.1 : 33785
    Send a packet at : 1 byte
Receive a packet(ACK) from 127.0.0.1 : 33785
    Receive a packet (seq_num = 9542, ack_num = 600)
====Complete the three-way handshake====
    Receive a packet (seq_num = 9543, ack_num = 601)
cal 5 add 13
==Start calculation to 127.0.0.1 : 33785
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 1025 byte
    Receive a packet (seq_num = 9544, ack_num = 602)
==Finish calculation==
    Receive a packet (seq_num = 9545, ack_num = 603)
cal 8 sub 2
==Start calculation to 127.0.0.1 : 33785
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 2049 byte
    Receive a packet (seq_num = 9546, ack_num = 604)
==Finish calculation==
    Receive a packet (seq_num = 9547, ack_num = 605)
cal 9 mul 5
==Start calculation to 127.0.0.1 : 33785
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 3073 byte
    Receive a packet (seq_num = 9548, ack_num = 606)
==Finish calculation==
```

Client:

```
Enter command (type 'exit' to close connection): cal 34 div 2
Send a command
    Send a packet at : 8193 byte
Calculating 34 div 2 by 127.0.0.1 : 2345
    Receive a packet (seq_num = 607, ack_num = 9550)
Result: 17
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 9217 byte
Finish calculation
Enter command (type 'exit' to close connection): cal 2 pow 5
Send a command
    Send a packet at : 10241 byte
Calculating 2 pow 5 by 127.0.0.1 : 2345
    Receive a packet (seq_num = 609, ack_num = 9552)
Result: 32.000000
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 11265 byte
Finish calculation
Enter command (type 'exit' to close connection): cal 8 sqrt
Send a command
    Send a packet at : 12289 byte
Calculating 8 sqrt by 127.0.0.1 : 2345
    Receive a packet (seq_num = 611, ack_num = 9554)
Result: 2.828427
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 13313 byte
Finish calculation
Enter command (type 'exit' to close connection): █
```

Server:

```
    Receive a packet (seq_num = 9549, ack_num = 607)
cal 34 div 2
==Start calculation to 127.0.0.1 : 33785
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 4097 byte
    Receive a packet (seq_num = 9550, ack_num = 608)
==Finish calculation==
    Receive a packet (seq_num = 9551, ack_num = 609)
cal 2 pow 5
==Start calculation to 127.0.0.1 : 33785
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 5121 byte
    Receive a packet (seq_num = 9552, ack_num = 610)
==Finish calculation==
    Receive a packet (seq_num = 9553, ack_num = 611)
cal 8 sqrt
==Start calculation to 127.0.0.1 : 33785
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 6145 byte
    Receive a packet (seq_num = 9554, ack_num = 612)
==Finish calculation==
█
```

Video transmission

Client:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
=====Start the three-way handshake=====
Send a packet(SYN) to 127.0.0.1 : 2345
    Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
    Receive a packet (seq_num = 8063, ack_num = 6594)
Send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 1025 byte
=====Complete the three-way handshake=====
Enter command (type 'exit' to close connection): get 1.mp4
Send a command
    Send a packet at : 2049 byte
Receive video: 1.mp4 from 127.0.0.1 : 2345
    Receive a packet (seq_num = 8065, ack_num = 6596)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 3073 byte
    Receive a packet (seq_num = 8066, ack_num = 6597)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 4097 byte
    Receive a packet (seq_num = 8067, ack_num = 6598)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 5121 byte
    Receive a packet (seq_num = 8068, ack_num = 6599)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 6145 byte
    Receive a packet (seq_num = 8069, ack_num = 6600)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 7169 byte
    Receive a packet (seq_num = 8070, ack_num = 6601)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 8193 byte
    Receive a packet (seq_num = 8071, ack_num = 6602)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 9217 byte
    Receive a packet (seq_num = 8072, ack_num = 6603)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 10241 byte
    Receive a packet (seq_num = 8073, ack_num = 6604)
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send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 403457 byte
    Receive a packet (seq_num = 8457, ack_num = 6988)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 404481 byte
    Receive a packet (seq_num = 8458, ack_num = 6989)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 405505 byte
    Receive a packet (seq_num = 8459, ack_num = 6990)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 406529 byte
    Receive a packet (seq_num = 8460, ack_num = 6991)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 407553 byte
    Receive a packet (seq_num = 8461, ack_num = 6992)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 408577 byte
Finish transmission
Enter command (type 'exit' to close connection):
```

Server:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./server 2345
=====Start the three-way handshake=====
Receive a packet(SYN) from 127.0.0.1 : 60480
    Receive a packet (seq_num = 6593, ack_num = 0)
cwnd = 1, rwnd = 524288, threshold = 65536
Send a packet(SYN/ACK) to 127.0.0.1 : 60480
    Send a packet at : 1 byte
Receive a packet(ACK) from 127.0.0.1 : 60480
    Receive a packet (seq_num = 6594, ack_num = 8064)
=====Complete the three-way handshake=====
    Receive a packet (seq_num = 6595, ack_num = 8065)
get 1.mp4
==Sending video: 1.mp4 to 127.0.0.1 : 60480
    Send a packet at : 1025 byte
    Receive a packet (seq_num = 6596, ack_num = 8066)
    Send a packet at : 3073 byte
    Receive a packet (seq_num = 6597, ack_num = 8067)
    Send a packet at : 4097 byte
    Receive a packet (seq_num = 6598, ack_num = 8068)
    Send a packet at : 5121 byte
    Receive a packet (seq_num = 6599, ack_num = 8069)
    Send a packet at : 6145 byte
    Receive a packet (seq_num = 6600, ack_num = 8070)
    Send a packet at : 7169 byte
    Receive a packet (seq_num = 6601, ack_num = 8071)
    Send a packet at : 8193 byte
    Receive a packet (seq_num = 6602, ack_num = 8072)
    Send a packet at : 9217 byte
    Receive a packet (seq_num = 6603, ack_num = 8073)
    Send a packet at : 10241 byte
    Receive a packet (seq_num = 6604, ack_num = 8074)
    Send a packet at : 11265 byte
    Receive a packet (seq_num = 6605, ack_num = 8075)
    Send a packet at : 12289 byte
    Receive a packet (seq_num = 6606, ack_num = 8076)
    Send a packet at : 13313 byte
    Receive a packet (seq_num = 6607, ack_num = 8077)
    Send a packet at : 14337 byte
    Receive a packet (seq_num = 6608, ack_num = 8078)
    Send a packet at : 15361 byte
    Receive a packet (seq_num = 6609, ack_num = 8079)
    Send a packet at : 16385 byte
    Receive a packet (seq_num = 6610, ack_num = 8080)
    Send a packet at : 17409 byte
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    Send a packet at : 402433 byte
    Receive a packet (seq_num = 6987, ack_num = 8457)
    Send a packet at : 403457 byte
    Receive a packet (seq_num = 6988, ack_num = 8458)
    Send a packet at : 404481 byte
    Receive a packet (seq_num = 6989, ack_num = 8459)
    Send a packet at : 405505 byte
    Receive a packet (seq_num = 6990, ack_num = 8460)
    Send a packet at : 406529 byte
    Receive a packet (seq_num = 6991, ack_num = 8461)
    Send a packet at : 407553 byte
    Receive a packet (seq_num = 6992, ack_num = 8462)
==Video transmission complete==
```

➤ Step 2

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step1_2
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
====Start the three-way handshake====
Send a packet(SYN) to 127.0.0.1 : 2345
    Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
    Receive a packet (seq_num = 7073, ack_num = 8153)
Send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 1025 byte
====Complete the three-way handshake====
Enter command (type 'exit' to close connection): dns google.com
Send a command
    Send a packet at : 2049 byte
Finding IP address of google.com by 127.0.0.1 : 2345
    Receive a packet (seq_num = 7075, ack_num = 8155)
Result: 142.251.43.14
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 3073 byte
Finish finding
google.com

terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
====Start the three-way handshake====
Send a packet(SYN) to 127.0.0.1 : 2345
    Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
    Receive a packet (seq_num = 3554, ack_num = 386)
Send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 1025 byte
====Complete the three-way handshake====
Enter command (type 'exit' to close connection): cal 5 add 13
Send a command
    Send a packet at : 2049 byte
Calculating 5 add 13 by 127.0.0.1 : 2345
    Receive a packet (seq_num = 3556, ack_num = 388)
Result: 18
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 3073 byte
Finish calculation

terry08@ubuntu:~/Desktop/B092040016_陳昱達/step1_2$ ./server 2345
====Start the three-way handshake====
Receive a packet(SYN) from 127.0.0.1 : 19320
    Receive a packet (seq_num = 8152, ack_num = 0)
cwnd = 1, rwnd = 524288, threshold = 65536
Send a packet(SYN/ACK) to 127.0.0.1 : 19320
    Send a packet at : 1 byte
Receive a packet(ACK) from 127.0.0.1 : 19320
    Receive a packet (seq_num = 8153, ack_num = 7074)
====Complete the three-way handshake====
====Start the three-way handshake====
Receive a packet(SYN) from 127.0.0.1 : 59176
    Receive a packet (seq_num = 385, ack_num = 0)
cwnd = 1, rwnd = 524288, threshold = 65536
Send a packet(SYN/ACK) to 127.0.0.1 : 59176
    Send a packet at : 1 byte
Receive a packet(ACK) from 127.0.0.1 : 59176
    Receive a packet (seq_num = 386, ack_num = 3555)
====Complete the three-way handshake====
    Receive a packet (seq_num = 8154, ack_num = 7075)
dns google.com
==Start finding: google.com to 127.0.0.1 : 19320
cwnd = 2, rwnd = 524288, threshold = 65536
    Send a packet at : 1025 byte
    Receive a packet (seq_num = 8155, ack_num = 7076)
==Finish finding==
    Receive a packet (seq_num = 387, ack_num = 3556)
cal 5 add 13
==Start calculation to 127.0.0.1 : 59176
cwnd = 2, rwnd = 524288, threshold = 65536
    send a packet at : 1025 byte
    Receive a packet (seq_num = 388, ack_num = 3557)
==Finish calculation==

```

➤ Step 3

Client:

```
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 403457 byte
    Receive a packet (seq_num = 5232, ack_num = 5908)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 404481 byte
    Receive a packet (seq_num = 5233, ack_num = 5909)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 405505 byte
    Receive a packet (seq_num = 5234, ack_num = 5910)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 406529 byte
Packet loss: ack => 5911
    Receive a packet (seq_num = 5236, ack_num = 5912)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 407553 byte
    Receive a packet (seq_num = 5237, ack_num = 5913)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 408577 byte
lost ack num: 5621 5752 5757 5772 5824 5911
Finish transmission
Enter command (type 'exit' to close connection):
```

Server:

```
Receive a packet (seq_num = 5906, ack_num = 5231)
Send a packet at : 402433 byte
Receive a packet (seq_num = 5907, ack_num = 5232)
Send a packet at : 403457 byte
Receive a packet (seq_num = 5908, ack_num = 5233)
Send a packet at : 404481 byte
Receive a packet (seq_num = 5909, ack_num = 5234)
Send a packet at : 405505 byte
Receive a packet (seq_num = 5910, ack_num = 5235)
Send a packet at : 406529 byte
Receive a packet (seq_num = 5912, ack_num = 5237)
Send a packet at : 407553 byte
Receive a packet (seq_num = 5913, ack_num = 5238)
==Video transmission complete==

```

➤ Step 4

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step4
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step4$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
=====Start the three-way handshake=====
Send a packet(SYN) to 127.0.0.1 : 2345
    Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
    Receive a packet (seq_num = 2335, ack_num = 3873)
Send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 1025 byte
=====Complete the three-way handshake=====
Enter command (type 'exit' to close connection): get 1.mp4
Send a command
    Send a packet at : 2049 byte
get 1.mp4 from 127.0.0.1 : 2345
    Receive a packet (seq_num = 2337, ack_num = 3875)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 3073 byte
    Receive a packet (seq_num = 2338, ack_num = 3876)
    Receive a packet (seq_num = 2339, ack_num = 3876)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 4097 byte
    Receive a packet (seq_num = 2339, ack_num = 3877)
    Receive a packet (seq_num = 2340, ack_num = 3877)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 5121 byte
    Receive a packet (seq_num = 2340, ack_num = 3878)
    Receive a packet (seq_num = 2341, ack_num = 3878)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 6145 byte
    Receive a packet (seq_num = 2341, ack_num = 3879)
    Receive a packet (seq_num = 2342, ack_num = 3879)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 7169 byte
    Receive a packet (seq_num = 2342, ack_num = 3880)
    Receive a packet (seq_num = 2343, ack_num = 3880)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 8193 byte
    Receive a packet (seq_num = 2343, ack_num = 3881)
    Receive a packet (seq_num = 2344, ack_num = 3881)
```

Server:

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step4$ ./server 2345
=====Start the three-way handshake=====
Receive a packet(SYN) from 127.0.0.1 : 47658
    Receive a packet (seq_num = 3872, ack_num = 0)
Send a packet(SYN/ACK) to 127.0.0.1 : 47658
    Send a packet at : 1 byte
Receive a packet(ACK) from 127.0.0.1 : 47658
    Receive a packet (seq_num = 3873, ack_num = 2336)
=====Complete the three-way handshake=====
    Receive a packet (seq_num = 3874, ack_num = 2337)
get 1.mp4
==Sending video: 1.mp4 to 127.0.0.1 : 47658
    Send a packet at : 1025 byte
    Receive a packet (seq_num = 3875, ack_num = 2338)
    Send a packet at : 3073 byte
    Send a packet at : 4097 byte
    Receive a packet (seq_num = 3876, ack_num = 2339)
    Send a packet at : 5121 byte
    Send a packet at : 6145 byte
    Receive a packet (seq_num = 3877, ack_num = 2340)
    Send a packet at : 7169 byte
    Send a packet at : 8193 byte
    Receive a packet (seq_num = 3878, ack_num = 2341)
    Send a packet at : 9217 byte
    Send a packet at : 10241 byte
    Receive a packet (seq_num = 3879, ack_num = 2342)
    Send a packet at : 11265 byte
    Send a packet at : 12289 byte
    Receive a packet (seq_num = 3880, ack_num = 2343)
    Send a packet at : 13313 byte
    Send a packet at : 14337 byte
    Receive a packet (seq_num = 3881, ack_num = 2344)
    Send a packet at : 15361 byte
    Send a packet at : 16385 byte
    Receive a packet (seq_num = 3882, ack_num = 2345)
    Send a packet at : 17409 byte
    Send a packet at : 18433 byte
    Receive a packet (seq_num = 3883, ack_num = 2346)
```


➤ Step 5

Client:

```
Enter command (type 'exit' to close connection): get 1.mp4
Send a command
  Send a packet at : 2049 byte
Receive video: 1.mp4 from 127.0.0.1 : 2345
  Receive a packet (seq_num = 8072, ack_num = 349)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 3073 byte
  Receive a packet (seq_num = 8073, ack_num = 350)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 4097 byte
  Receive a packet (seq_num = 8074, ack_num = 351)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 5121 byte
  Receive a packet (seq_num = 8075, ack_num = 352)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 6145 byte
  Receive a packet (seq_num = 8076, ack_num = 353)
```

Server: Slow start

```
*****slow start*****
cwnd = 2048, rwnd = 524288, threshold = 65536
  Send a packet at : 1025 byte
  Receive a packet (seq_num = 349, ack_num = 8073)
cwnd = 2048, rwnd = 523264, threshold = 65536
  Send a packet at : 3073 byte
  Receive a packet (seq_num = 350, ack_num = 8074)
cwnd = 4096, rwnd = 522240, threshold = 65536
  Send a packet at : 4097 byte
  Receive a packet (seq_num = 351, ack_num = 8075)
cwnd = 4096, rwnd = 521216, threshold = 65536
  Send a packet at : 5121 byte
  Receive a packet (seq_num = 352, ack_num = 8076)
cwnd = 4096, rwnd = 520192, threshold = 65536
  Send a packet at : 6145 byte
  Receive a packet (seq_num = 353, ack_num = 8077)
cwnd = 4096, rwnd = 519168, threshold = 65536
  Send a packet at : 7169 byte
  Receive a packet (seq_num = 354, ack_num = 8078)
cwnd = 8192, rwnd = 518144, threshold = 65536
  Send a packet at : 8193 byte
  Receive a packet (seq_num = 355, ack_num = 8079)
cwnd = 8192, rwnd = 517120, threshold = 65536
  Send a packet at : 9217 byte
  Receive a packet (seq_num = 356, ack_num = 8080)
cwnd = 8192, rwnd = 516096, threshold = 65536
  Send a packet at : 10241 byte
  Receive a packet (seq_num = 357, ack_num = 8081)
```

Server: CA

```
cwnd = 32768, rwnd = 463872, threshold = 65536
  Send a packet at : 62465 byte
  Receive a packet (seq_num = 408, ack_num = 8132)
cwnd = 32768, rwnd = 462848, threshold = 65536
  Send a packet at : 63489 byte
  Receive a packet (seq_num = 409, ack_num = 8133)
cwnd = 32768, rwnd = 461824, threshold = 65536
  Send a packet at : 64513 byte
  Receive a packet (seq_num = 410, ack_num = 8134)
*****Congestion avoidance*****
cwnd = 65536, rwnd = 460800, threshold = 65536
  Send a packet at : 65537 byte
  Receive a packet (seq_num = 411, ack_num = 8135)
cwnd = 65536, rwnd = 459776, threshold = 65536
  Send a packet at : 66561 byte
  Receive a packet (seq_num = 412, ack_num = 8136)
cwnd = 65536, rwnd = 458752, threshold = 65536
  Send a packet at : 67585 byte
  Receive a packet (seq_num = 413, ack_num = 8137)
cwnd = 65536, rwnd = 457728, threshold = 65536
  Send a packet at : 68609 byte
  Receive a packet (seq_num = 414, ack_num = 8138)
cwnd = 65536, rwnd = 456704, threshold = 65536
  Send a packet at : 69633 byte
  Receive a packet (seq_num = 415, ack_num = 8139)
```

➤ Step 6

Client:

```
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 8193 byte
    Receive a packet (seq_num = 6685, ack_num = 2714)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 9217 byte
Packet loss: ack => 2715
    Receive a packet (seq_num = 6687, ack_num = 2716)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 10241 byte
    Receive a packet (seq_num = 6688, ack_num = 2717)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 11265 byte
    Receive a packet (seq_num = 6689, ack_num = 2718)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 12289 byte
    Receive a packet (seq_num = 6687, ack_num = 2716)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 13313 byte
    Receive a packet (seq_num = 6688, ack_num = 2717)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 14337 byte
    Receive a packet (seq_num = 6689, ack_num = 2718)
send a packet(ACK) to 127.0.0.1 : 2345
    Send a packet at : 15361 byte
    Receive a packet (seq_num = 6690, ack_num = 2719)
```

Server:

```
cwnd = 8192, rwnd = 518144, threshold = 65536
    Send a packet at : 7169 byte
    Receive a packet (seq_num = 2714, ack_num = 6686)
cwnd = 8192, rwnd = 517120, threshold = 65536
    Send a packet at : 8193 byte
cwnd = 8192, rwnd = 516096, threshold = 65536
    Send a packet at : 9217 byte
    Receive a packet (seq_num = 2715, ack_num = 6687)
cwnd = 8192, rwnd = 515072, threshold = 65536
    Send a packet at : 10241 byte
    Receive a packet (seq_num = 2715, ack_num = 6687)
cwnd = 8192, rwnd = 514048, threshold = 65536
    Send a packet at : 11265 byte
    Receive a packet (seq_num = 2715, ack_num = 6687)
Receive duplicate ACKs.
*****Fast retransmit*****
*****slow start*****
cwnd = 1024, rwnd = 524288, threshold = 4096
    Send a packet at : 9217 byte
    Receive a packet (seq_num = 2716, ack_num = 6688)
cwnd = 2048, rwnd = 523264, threshold = 4096
    Send a packet at : 10241 byte
    Receive a packet (seq_num = 2717, ack_num = 6689)
cwnd = 2048, rwnd = 522240, threshold = 4096
    Send a packet at : 11265 byte
    Receive a packet (seq_num = 2718, ack_num = 6690)
*****Congestion avoidance*****
cwnd = 4096, rwnd = 521216, threshold = 4096
    Send a packet at : 12289 byte
    Receive a packet (seq_num = 2719, ack_num = 6691)
cwnd = 4096, rwnd = 520192, threshold = 4096
    Send a packet at : 13313 byte
    Receive a packet (seq_num = 2720, ack_num = 6692)
```


➤ Step 7

Client:

```
Enter command (type 'exit' to close connection): get 1.mp4
Send a command
  Send a packet at : 2049 byte
Receive video: 1.mp4 from 127.0.0.1 : 2345
  Receive a packet (seq_num = 4667, ack_num = 7392)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 3073 byte
  Receive a packet (seq_num = 4668, ack_num = 7393)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 4097 byte
  Receive a packet (seq_num = 4669, ack_num = 7394)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 5121 byte
Packet loss: ack => 7395
  Receive a packet (seq_num = 4671, ack_num = 7396)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 6145 byte
  Receive a packet (seq_num = 4672, ack_num = 7397)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 7169 byte
  Receive a packet (seq_num = 4673, ack_num = 7398)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 8193 byte
  Receive a packet (seq_num = 4671, ack_num = 7396)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 9217 byte
  Receive a packet (seq_num = 4672, ack_num = 7397)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 10241 byte
  Receive a packet (seq_num = 4673, ack_num = 7398)
send a packet(ACK) to 127.0.0.1 : 2345
  Send a packet at : 11265 byte
  Receive a packet (seq_num = 4674, ack_num = 7399)
```

Server:

```
cwnd = 4096, rwnd = 522240, threshold = 65536
  Send a packet at : 3073 byte
  Receive a packet (seq_num = 7394, ack_num = 4670)
cwnd = 4096, rwnd = 521216, threshold = 65536
  Send a packet at : 4097 byte
cwnd = 4096, rwnd = 520192, threshold = 65536
  Send a packet at : 5121 byte
  Receive a packet (seq_num = 7395, ack_num = 4671)
cwnd = 4096, rwnd = 519168, threshold = 65536
  Send a packet at : 6145 byte
  Receive a packet (seq_num = 7395, ack_num = 4671)
cwnd = 8192, rwnd = 518144, threshold = 65536
  Send a packet at : 7169 byte
  Receive a packet (seq_num = 7395, ack_num = 4671)
Receive duplicate ACKs.
****Fast recovery****
****Congestion avoidance****
cwnd = 7168, rwnd = 524288, threshold = 4096
  Send a packet at : 5121 byte
  Receive a packet (seq_num = 7396, ack_num = 4672)
cwnd = 7168, rwnd = 523264, threshold = 4096
  Send a packet at : 6145 byte
  Receive a packet (seq_num = 7397, ack_num = 4673)
cwnd = 7168, rwnd = 522240, threshold = 4096
  Send a packet at : 7169 byte
  Receive a packet (seq_num = 7398, ack_num = 4674)
```

- Step 8
右上角為 server 其他為 client

```
terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step7_8
Receive a packet (seq_num = 4487, ack_num = 1128)
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 404481 byte
Receive a packet (seq_num = 4488, ack_num = 1129)
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 405505 byte
Receive a packet (seq_num = 4489, ack_num = 1130)
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 406529 byte
Receive a packet (seq_num = 4490, ack_num = 1131)
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 407553 byte
Receive a packet (seq_num = 4491, ack_num = 1132)
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 408577 byte
lost ack num: 741
Finish transmission
Enter command (type 'exit' to close connection):

d. terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step7_8
terry08@ubuntu:~/Desktop/B092040016_陳昱達/step7_8$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
====Start the three-way handshake====
Send a packet(SYN) to 127.0.0.1 : 2345
Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
Receive a packet (seq_num = 2463, ack_num = 2104)
Send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 1025 byte
====Complete the three-way handshake====
Enter command (type 'exit' to close connection): dns google.com
Send a command
Send a packet at : 2049 byte
Finding IP address of google.com by 127.0.0.1 : 2345
Receive a packet (seq_num = 2465, ack_num = 2106)
Result: 142.251.42.230
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 3073 byte
Finish finding
google.com
Enter command (type 'exit' to close connection):

terry08@ubuntu: ~/Desktop/B092040016_陳昱達/step7_8
Send a packet at : 403457 byte
Receive a packet (seq_num = 1131, ack_num = 4491)
cwnd = 11983, rwnd = 124928, threshold = 4096
Send a packet at : 404481 byte
Receive a packet (seq_num = 1132, ack_num = 4492)
==Video transmission complete==
Receive a packet (seq_num = 2105, ack_num = 2465)
dns google.com
==Start finding: google.com to 127.0.0.1 : 6953
Send a packet at : 1025 byte
Receive a packet (seq_num = 2106, ack_num = 2466)
==Finish finding==
Receive a packet (seq_num = 6792, ack_num = 5195)
cal 5 add 3
==Start calculation to 127.0.0.1 : 19504
send a packet at : 1025 byte
Receive a packet (seq_num = 6793, ack_num = 5196)
==Finish calculation==

terry08@ubuntu:~/Desktop/B092040016_陳昱達/step7_8$ ./client 127.0.0.1 2345
Server's IP address: 127.0.0.1
Server's port: 2345
====Start the three-way handshake====
Send a packet(SYN) to 127.0.0.1 : 2345
Send a packet at : 1 byte
Receive a packet(SYN/ACK) from 127.0.0.1 : 2345
Receive a packet (seq_num = 5193, ack_num = 6791)
Send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 1025 byte
====Complete the three-way handshake====
Enter command (type 'exit' to close connection): cal 5 add 3
Send a command
Send a packet at : 2049 byte
cal 5 add 3 by 127.0.0.1 : 2345
Receive a packet (seq_num = 5195, ack_num = 6793)
Result: 8
send a packet(ACK) to 127.0.0.1 : 2345
Send a packet at : 3073 byte
Finish calculation
Enter command (type 'exit' to close connection):
```