

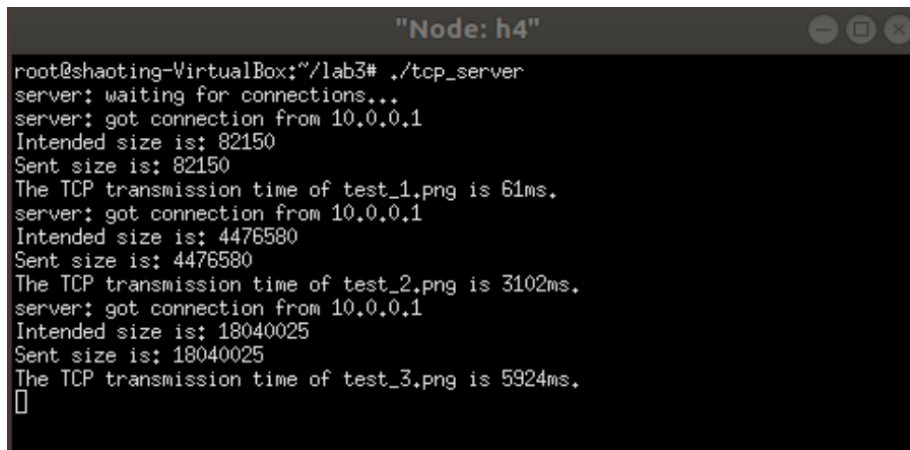
## Lab 3: Socket Programming

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### 1. File Transmission System implementation using TCP and UDP protocols.

#### i. Test the transmission condition with respect to different file size when transmitting files using TCP and UDP protocols.



```
"Node: h4"
root@shaoting-VirtualBox:~/lab3# ./tcp_server
server: waiting for connections...
server: got connection from 10.0.0.1
Intended size is: 82150
Sent size is: 82150
The TCP transmission time of test_1.png is 61ms.
server: got connection from 10.0.0.1
Intended size is: 4476580
Sent size is: 4476580
The TCP transmission time of test_2.png is 3102ms.
server: got connection from 10.0.0.1
Intended size is: 18040025
Sent size is: 18040025
The TCP transmission time of test_3.png is 5924ms.
□
```

Figure 1 TCP transmission (server terminal)

```

"Node: h1"
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_1.png
client: connecting to 10.0.0.4
Received size is: 82150
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_2.png
client: connecting to 10.0.0.4
Received size is: 4476580
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_3.png
client: connecting to 10.0.0.4
Received size is: 18040025
root@shaoting-VirtualBox:~/lab3#

```

Figure 2 TCP transmission (client terminal)

```

"Node: h4"
Firefox 网络浏览器
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_1.png"
Intended size is: 82150
Sent size is: 82150
The UDP transmission time of test_1.png is 272ms.
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_2.png"
Intended size is: 4476580
Sent size is: 4476580
The UDP transmission time of test_2.png is 7530ms.
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_3.png"
Intended size is: 18040025
Sent size is: 18040025
The UDP transmission time of test_3.png is 35338ms.
root@shaoting-VirtualBox:~/lab3#

```

Figure 3 UDP transmission (server terminal)

```

root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_1.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
82150 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3#
root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_2.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
100000 has been received.
150000 has been received.
200000 has been received.
4476580 has been received.
4476580 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3#
root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_3.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
100000 has been received.
150000 has been received.
200000 has been received.
17950000 has been received.
18000000 has been received.
18040025 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3#

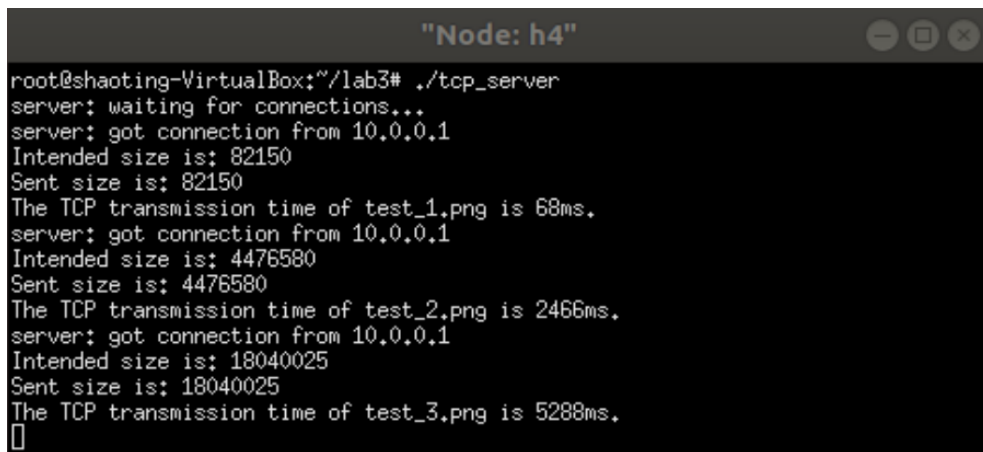
```

Figure 4 UDP transmission (client terminal)

Figure 4 is edited, since the output is a bit long. All the output screenshots of UDP client sockets are edited.

ii. Set the packet loss rate of the link (s1,s2) as 5% and 30% respectively. Then retransmit the above three files using TCP and UDP protocols.

5%

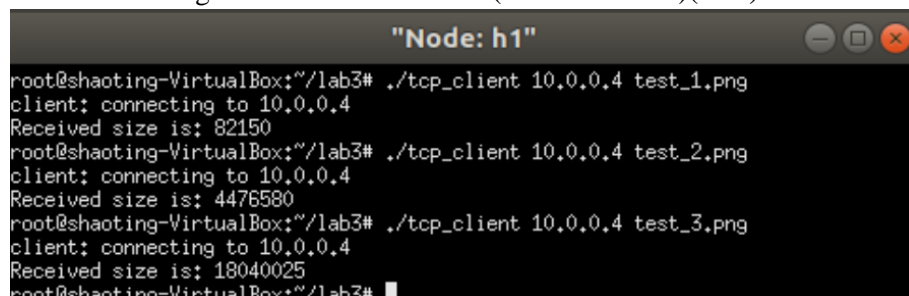


```

"Node: h4"
root@shaoting-VirtualBox:~/lab3# ./tcp_server
server: waiting for connections...
server: got connection from 10.0.0.1
Intended size is: 82150
Sent size is: 82150
The TCP transmission time of test_1.png is 68ms.
server: got connection from 10.0.0.1
Intended size is: 4476580
Sent size is: 4476580
The TCP transmission time of test_2.png is 2466ms.
server: got connection from 10.0.0.1
Intended size is: 18040025
Sent size is: 18040025
The TCP transmission time of test_3.png is 5288ms.

```

Figure 5 TCP transmission (server terminal)( 5%)

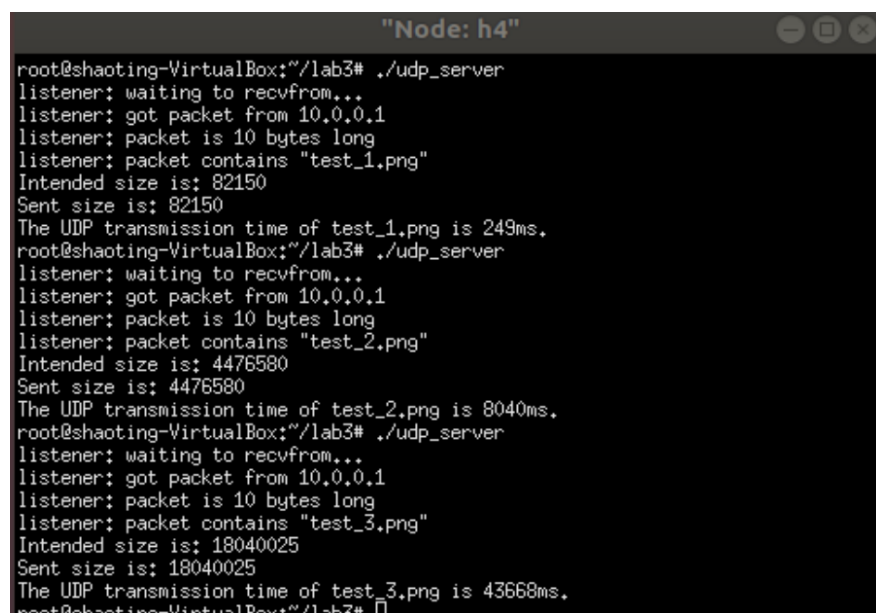


```

"Node: h1"
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_1.png
client: connecting to 10.0.0.4
Received size is: 82150
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_2.png
client: connecting to 10.0.0.4
Received size is: 4476580
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_3.png
client: connecting to 10.0.0.4
Received size is: 18040025
root@shaoting-VirtualBox:~/lab3#

```

Figure 6 TCP transmission (client terminal)( 5%)



```

"Node: h4"
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_1.png"
Intended size is: 82150
Sent size is: 82150
The UDP transmission time of test_1.png is 249ms.
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_2.png"
Intended size is: 4476580
Sent size is: 4476580
The UDP transmission time of test_2.png is 8040ms.
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_3.png"
Intended size is: 18040025
Sent size is: 18040025
The UDP transmission time of test_3.png is 43668ms.
root@shaoting-VirtualBox:~/lab3#

```

Figure 7 UDP transmission (server terminal)(5%)

```

root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_1.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
82150 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_2.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
100000 has been received.
150000 has been received.
400000 has been received.
4050000 has been received.
4076580 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_3.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
100000 has been received.
1500000 has been received.
18000000 has been received.
18040025 has been received.
recvfrom: Resource temporarily unavailable

```

Figure 8 UDP transmission (client terminal)(5%)

30%

```

root@shaoting-VirtualBox:~/lab3# ./tcp_server
server: waiting for connections...
server: got connection from 10.0.0.1
Intended size is: 82150
Sent size is: 82150
The TCP transmission time of test_1.png is 62ms.
server: got connection from 10.0.0.1
Intended size is: 4476580
Sent size is: 4476580
The TCP transmission time of test_2.png is 2237ms.
server: got connection from 10.0.0.1
Intended size is: 18040025
Sent size is: 18040025
The TCP transmission time of test_3.png is 5234ms.

```

Figure 9 TCP transmission (server terminal)(30%)

```

root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_1.png
client: connecting to 10.0.0.4
Received size is: 82150
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_2.png
client: connecting to 10.0.0.4
Received size is: 4476580
root@shaoting-VirtualBox:~/lab3# ./tcp_client 10.0.0.4 test_3.png
client: connecting to 10.0.0.4
Received size is: 18040025
root@shaoting-VirtualBox:~/lab3#

```

Figure 10 UDP transmission (client terminal)(30%)

```

"Node: h4"
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_1.png"
Intended size is: 82150
Sent size is: 82150
The UDP transmission time of test_1.png is 310ms.
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_2.png"
Intended size is: 4476580
Sent size is: 4476580
The UDP transmission time of test_2.png is 10017ms.
root@shaoting-VirtualBox:~/lab3# ./udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_3.png"
Intended size is: 18040025
Sent size is: 18040025
The UDP transmission time of test_3.png is 37144ms.
root@shaoting-VirtualBox:~/lab3# █

```

Figure 11 UDP transmission (server terminal)(30%)

```

root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_1.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
82150 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_2.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
100000 has been received.
150000 has been received.
2000000 has been received.
2850000 has been received.
2876580 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3# ./udp_client 10.0.0.4 test_3.png
talker: sent 10 bytes to 10.0.0.4
50000 has been received.
100000 has been received.
150000 has been received.
9600000 has been received.
9650000 has been received.
9700000 has been received.
recvfrom: Resource temporarily unavailable
root@shaoting-VirtualBox:~/lab3# █

```

Figure 12 UDP transmission (client terminal)(30%)

### iii. Findings

| message    | loss rate | acceptance rate |        | transmission time(ms) |       |
|------------|-----------|-----------------|--------|-----------------------|-------|
|            |           | TCP             | UDP    | TCP                   | UDP   |
| test_1.png | 0%        | 100%            | 100%   | 61                    | 272   |
|            | 5%        | 100%            | 100%   | 68                    | 249   |
|            | 30%       | 100%            | 100%   | 62                    | 310   |
| test_2.png | 0%        | 100%            | 100%   | 3102                  | 7530  |
|            | 5%        | 100%            | 91.06% | 2466                  | 8040  |
|            | 30%       | 100%            | 64.26% | 2237                  | 10017 |
| test_3.png | 0%        | 100%            | 100%   | 5924                  | 35338 |
|            | 5%        | 100%            | 100%   | 5288                  | 43668 |
|            | 30%       | 100%            | 53.77% | 5234                  | 37144 |

(1) TCP can provide **reliable data transfer**, while UDP cannot when the loss rate for the link is high.

(2) I have repeated the experiment several times. But the transmission time for the same protocol for different loss rate seems to be random (TCP time does not increase with loss rate and UDP time is not a constant.). Therefore, I came to a conclusion that **the random variables in the mininet affect the result more than loss rate**.

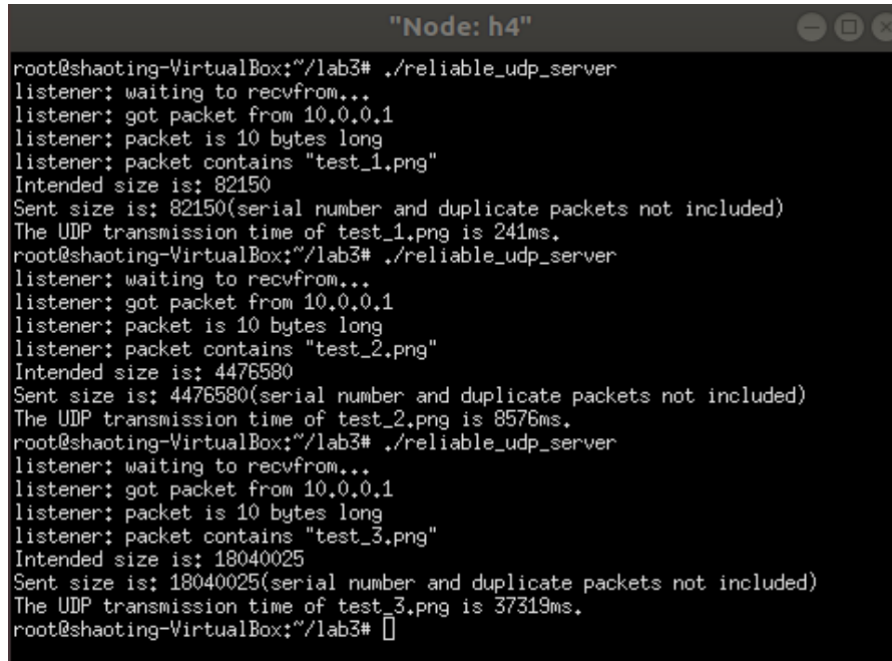
(3) UDP is supposed to be faster than TCP. However, my implementation does not prove that. I think that's because I have to **break down the big packet** into small packets less than 65536 bits and send them asynchronously. And that's not an efficient method. I also find that when transferring test\_1.png, I only needed to divide it into two packets, but UDP also takes obviously longer time than TCP. I suppose the **encapsulated function** in the cpp libraries for UDP is less efficient than that of TCP.



## 2. Modify the UDP protocol to make it support reliable file transmissions.

I set the loss rate to 70%.

### i. screenshots

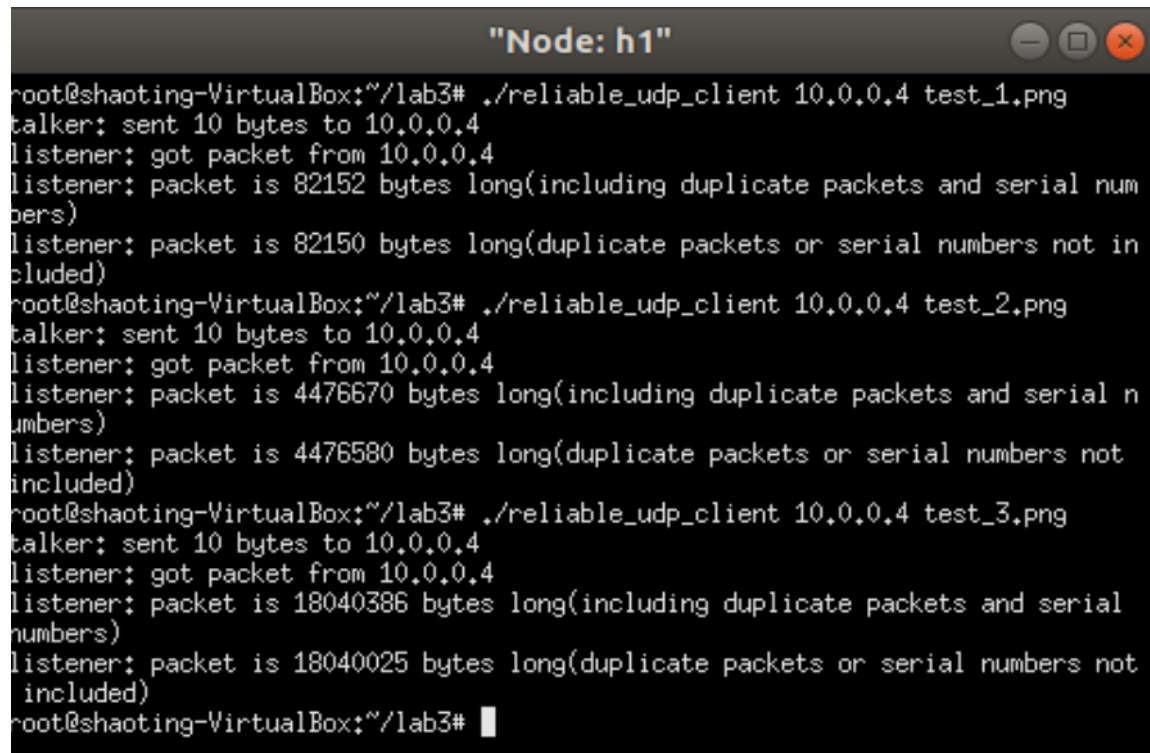


```

"Node: h4"
root@shaoting-VirtualBox:~/lab3# ./reliable_udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_1.png"
Intended size is: 82150
Sent size is: 82150(serial number and duplicate packets not included)
The UDP transmission time of test_1.png is 241ms.
root@shaoting-VirtualBox:~/lab3# ./reliable_udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_2.png"
Intended size is: 4476580
Sent size is: 4476580(serial number and duplicate packets not included)
The UDP transmission time of test_2.png is 8576ms.
root@shaoting-VirtualBox:~/lab3# ./reliable_udp_server
listener: waiting to recvfrom...
listener: got packet from 10.0.0.1
listener: packet is 10 bytes long
listener: packet contains "test_3.png"
Intended size is: 18040025
Sent size is: 18040025(serial number and duplicate packets not included)
The UDP transmission time of test_3.png is 37319ms.
root@shaoting-VirtualBox:~/lab3#

```

Figure 13 reliable UDP transmission (server terminal)(70%)



```

"Node: h1"
root@shaoting-VirtualBox:~/lab3# ./reliable_udp_client 10.0.0.4 test_1.png
talker: sent 10 bytes to 10.0.0.4
listener: got packet from 10.0.0.4
listener: packet is 82152 bytes long(including duplicate packets and serial numbers)
listener: packet is 82150 bytes long(duplicate packets or serial numbers not included)
root@shaoting-VirtualBox:~/lab3# ./reliable_udp_client 10.0.0.4 test_2.png
talker: sent 10 bytes to 10.0.0.4
listener: got packet from 10.0.0.4
listener: packet is 4476670 bytes long(including duplicate packets and serial numbers)
listener: packet is 4476580 bytes long(duplicate packets or serial numbers not included)
root@shaoting-VirtualBox:~/lab3# ./reliable_udp_client 10.0.0.4 test_3.png
talker: sent 10 bytes to 10.0.0.4
listener: got packet from 10.0.0.4
listener: packet is 18040386 bytes long(including duplicate packets and serial numbers)
listener: packet is 18040025 bytes long(duplicate packets or serial numbers not included)
root@shaoting-VirtualBox:~/lab3#

```

Figure 14 reliable UDP transmission (client terminal)(70%)

**ii. Findings**

| message    | acceptance rate |              | transmission time(ms) |              |
|------------|-----------------|--------------|-----------------------|--------------|
|            | UDP             | reliable UDP | UDP                   | reliable UDP |
| test_1.png | 100%            | 100%         | 221                   | 241          |
| test_2.png | 73.19%          | 100%         | 10951                 | 8576         |
| test_3.png | 15.24%          | 100%         | 45053                 | 37319        |

It can be proved that reliable UDP has implemented reliable data transfer. The transmission time does not increase and I suppose that's because the encapsulated socket programming for UDP in cpp library include some functions for improvement but require some time.