

❖ A short summary of my findings

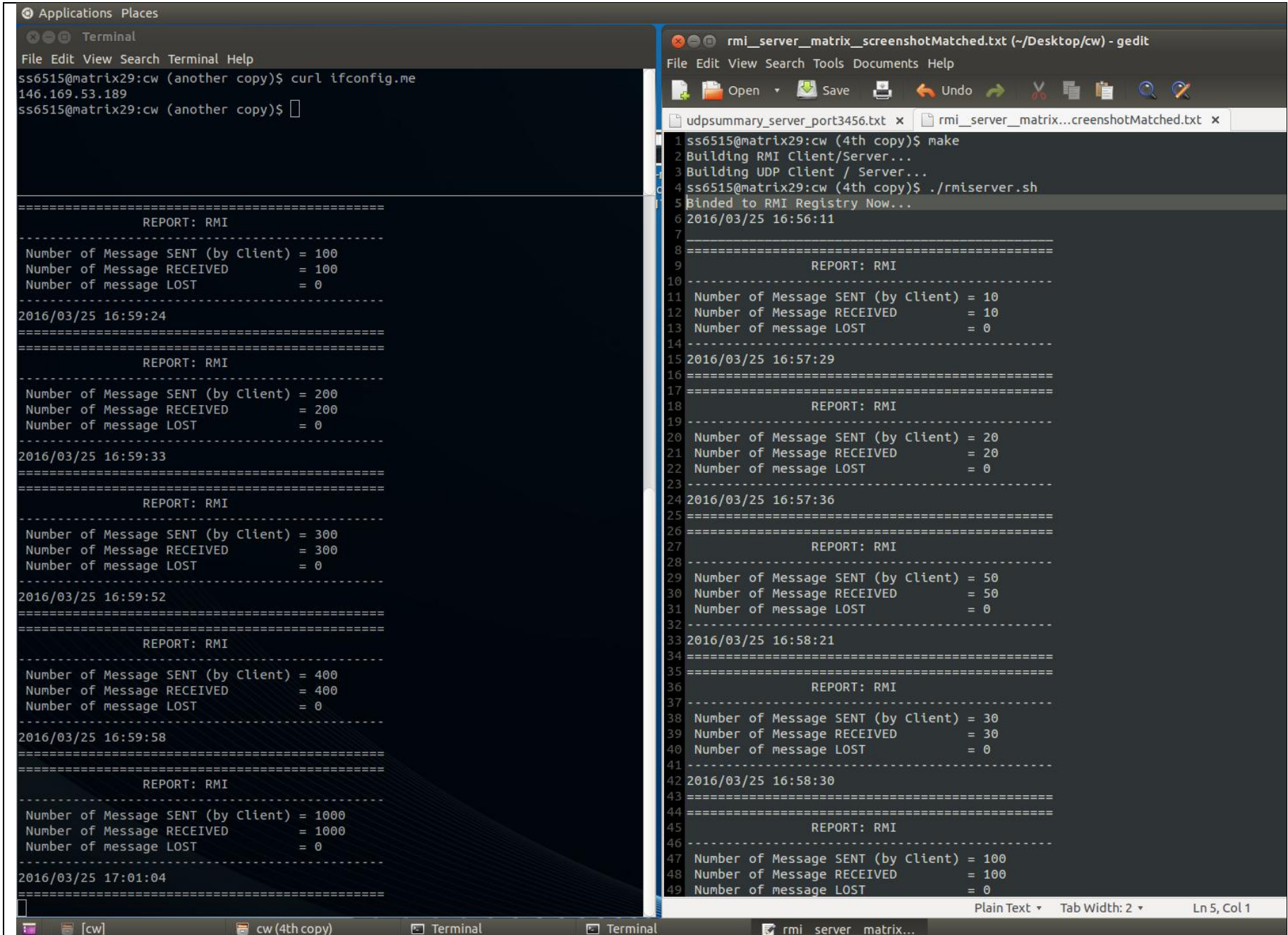
Item (Questions)			RMI	UDP		
Tests			All Tests	Test 1	Test 2	Test 3
Experiments Summaries	Number of LOST msg	20	0	0	0	0
		30	0	0	29	1
		40	0	0	39	23
		50	0	0	23	29
		100	0	90	0	14
		200	0	113	0	199
		300	0	0	0	154
		400	0	0	0	0
a. What are the possible causes, if any, of messages being lost?		Implementing RMI, no packet will be lost, since RMI is based on TCP. (Practically, the RMI registry runs on TCP port 1099). The packets will be sent and received in order and if a packet is missed, the sender will resend the packet until getting acknowledgment.	Packet loss is generally caused by network congestion. It can happen when a packet in a given router or network segment is greater than the possible capacity to send and consequently, there is no other option than dropping packet.			
b. Are there any patterns in the way messages are lost?		There is no packet loss in RMI.	As it can be seen in the results, there is no specific pattern in the packet loss. But generally when the number of packets increases, the packet loss will be more. It can be a result of instantaneous congestion. However, most of the time, there is no specific pattern for that. For example, in some case, no packet lost in 2000 packets, but 9 packets were lost in only 10 sent packets.			
c. What is the relative reliability of the different communication mechanisms?		RMI and in general TCP, is connection-oriented in which it requires acknowledgment of received data. If the data is not received, a retransmission will be requested. Thus, there is a absolute guarantee that the data transferred remains intact and arrives in the same order in which it sent.	UDP is unreliable. It is a connectionless protocol and it means there is no connection setup and handshake mechanism in UDP. It does not retransmit the lost packets. Consequently less delay will happen. Therefore, UDP applications must generally accept some packet loss and, as an exemplary case, it can be more functional for live conferences and transferring multi media.			
Which one is easier to program?		RMI seems easier to program, especially for large scale distributed systems. It is easy to implement the function based program and there is no need to take care of datagram details. But it seems there are some limitations in implementing RMI. For complicated programs, it requires users to implement complicated steps due to the predefined static interfaces.				

❖ Screen shots:

RMI client was my laptop (Shahrokhs-MacBook-Pro) and the messages were sent to the server on a lab's machine with IP 146.169.53.189:

```
1 file changed, 75 insertions(+), 2 deletions(-)
Shahrokhs-MacBook-Pro:~$ make
Building RMI Client/Server...
Building UDP Client / Server...
Shahrokhs-MacBook-Pro:~$ ./rmiclient.sh 146.169.53.189 10
RMI -> Message No.0 has just been sent
RMI -> Message No.1 has just been sent
RMI -> Message No.2 has just been sent
RMI -> Message No.3 has just been sent
RMI -> Message No.4 has just been sent
RMI -> Message No.5 has just been sent
RMI -> Message No.6 has just been sent
RMI -> Message No.7 has just been sent
RMI -> Message No.8 has just been sent
RMI -> Message No.9 has just been sent
Shahrokhs-MacBook-Pro:~$ ./rmiclient.sh 146.169.53.189 20
RMI -> Message No.0 has just been sent
RMI -> Message No.1 has just been sent
RMI -> Message No.2 has just been sent
RMI -> Message No.3 has just been sent
RMI -> Message No.4 has just been sent
RMI -> Message No.5 has just been sent
RMI -> Message No.6 has just been sent
RMI -> Message No.7 has just been sent
RMI -> Message No.8 has just been sent
RMI -> Message No.9 has just been sent
RMI -> Message No.10 has just been sent
RMI -> Message No.11 has just been sent
RMI -> Message No.12 has just been sent
RMI -> Message No.13 has just been sent
RMI -> Message No.14 has just been sent
RMI -> Message No.15 has just been sent
RMI -> Message No.16 has just been sent
RMI -> Message No.17 has just been sent
RMI -> Message No.18 has just been sent
RMI -> Message No.19 has just been sent
Shahrokhs-MacBook-Pro:~$
```

The RMI Server was a lab's machine (a Matrix series):



The image shows two terminal windows side-by-side. The left window is a standard Linux terminal with a dark background, showing the execution of a curl command and several periodic reports from an RMI client. The right window is a Gedit editor showing a file named 'rmi_server_matrix_screenshotMatched.txt' which contains a log of RMI server operations, including build commands and periodic reports. Both reports show message counts for sent, received, and lost messages over time.

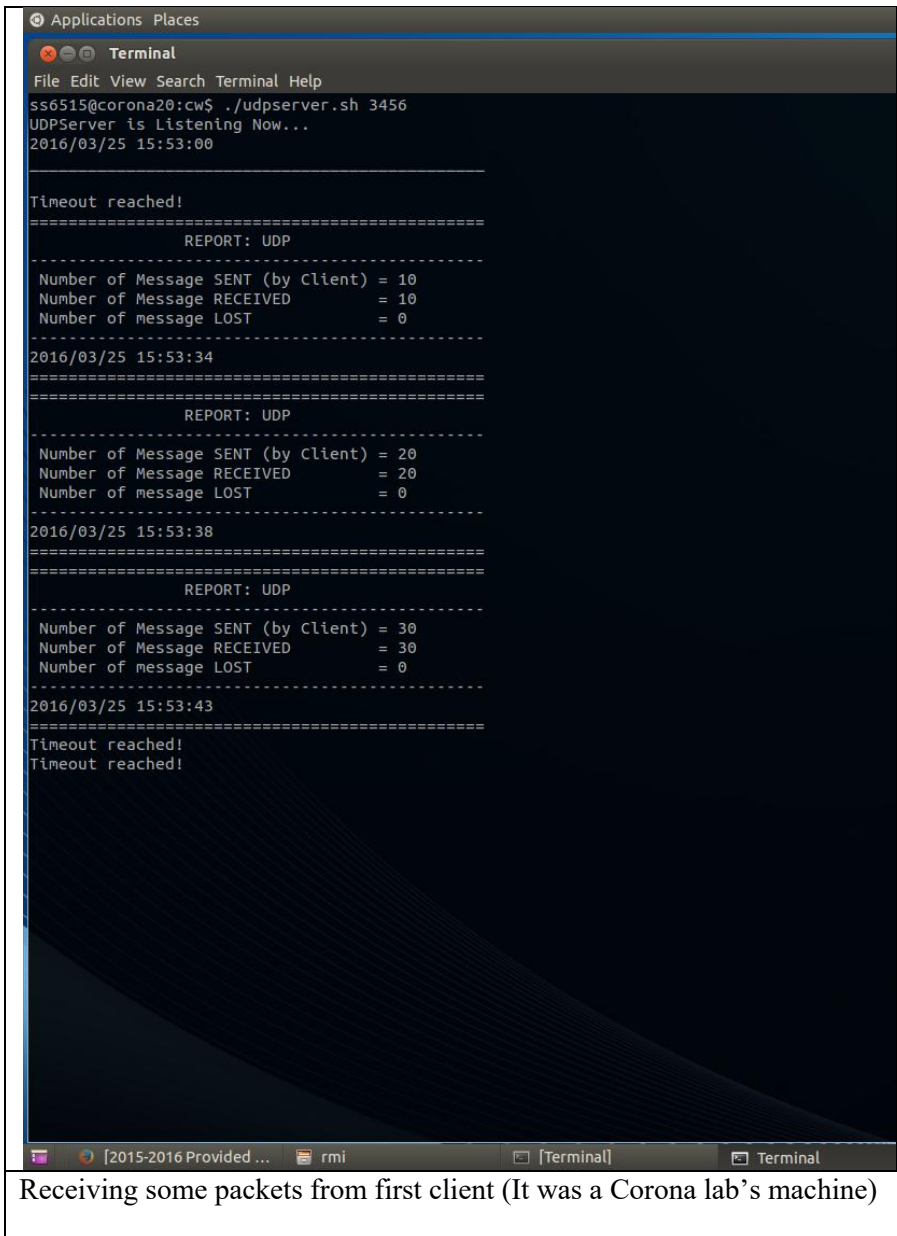
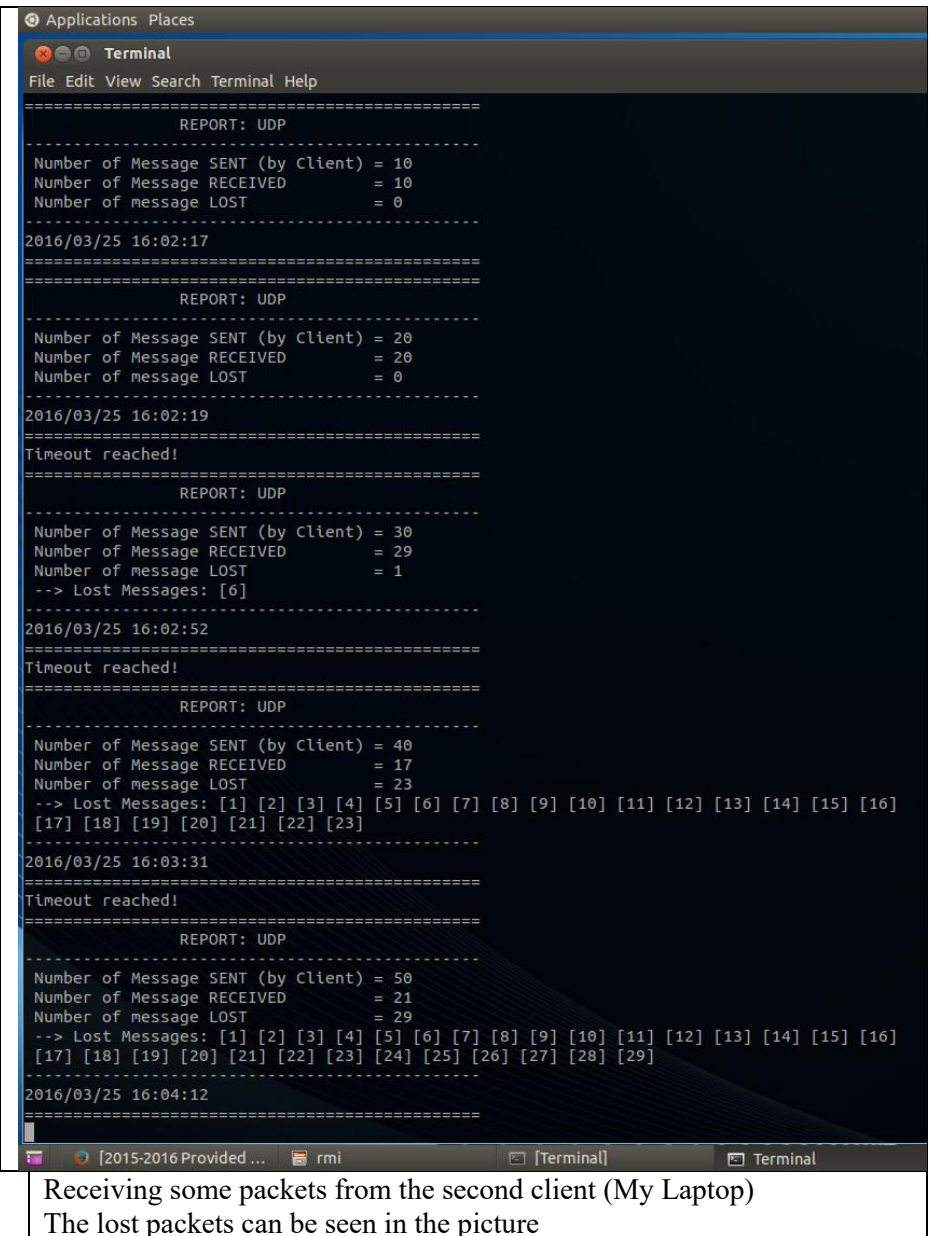
```
Applications Places
Terminal
File Edit View Search Terminal Help
ss6515@matrix29:cw (another copy)$ curl ifconfig.me
146.169.53.189
ss6515@matrix29:cw (another copy)$

=====
REPORT: RMI
=====
Number of Message SENT (by Client) = 100
Number of Message RECEIVED          = 100
Number of message LOST               = 0
=====
2016/03/25 16:59:24
=====
REPORT: RMI
=====
Number of Message SENT (by Client) = 200
Number of Message RECEIVED          = 200
Number of message LOST               = 0
=====
2016/03/25 16:59:33
=====
REPORT: RMI
=====
Number of Message SENT (by Client) = 300
Number of Message RECEIVED          = 300
Number of message LOST               = 0
=====
2016/03/25 16:59:52
=====
REPORT: RMI
=====
Number of Message SENT (by Client) = 400
Number of Message RECEIVED          = 400
Number of message LOST               = 0
=====
2016/03/25 16:59:58
=====
REPORT: RMI
=====
Number of Message SENT (by Client) = 1000
Number of Message RECEIVED          = 1000
Number of message LOST               = 0
=====
2016/03/25 17:01:04
=====

rmi_server_matrix_screenshotMatched.txt (~/Desktop/cw) - gedit
File Edit View Search Tools Documents Help
Open Save Undo Redo
udpsummary_server_port3456.txt x rmi_server_matrix...screenshotMatched.txt x
1 ss6515@matrix29:cw (4th copy)$ make
2 Building RMI Client/Server...
3 Building UDP Client / Server...
4 ss6515@matrix29:cw (4th copy)$ ./rmiserver.sh
5 Binded to RMI Registry Now...
6 2016/03/25 16:56:11
7
8 =====
9 REPORT: RMI
10 =====
11 Number of Message SENT (by Client) = 10
12 Number of Message RECEIVED          = 10
13 Number of message LOST               = 0
14 =====
15 2016/03/25 16:57:29
16 =====
17 REPORT: RMI
18 =====
19 Number of Message SENT (by Client) = 20
20 Number of Message RECEIVED          = 20
21 Number of message LOST               = 0
22 =====
23 2016/03/25 16:57:36
24 =====
25 REPORT: RMI
26 =====
27 Number of Message SENT (by Client) = 50
28 Number of Message RECEIVED          = 50
29 Number of message LOST               = 0
30 =====
31 2016/03/25 16:58:21
32 =====
33 REPORT: RMI
34 =====
35 Number of Message SENT (by Client) = 30
36 Number of Message RECEIVED          = 30
37 Number of message LOST               = 0
38 =====
39 2016/03/25 16:58:30
40 =====
41 REPORT: RMI
42 =====
43 Number of Message SENT (by Client) = 100
44 Number of Message RECEIVED          = 100
45 Number of message LOST               = 0
46 =====
47
48
49
```

For the UDP test, different machines with different ports around the lab and also my laptop have been tried:

- UDP Server: Corona-20 IP: 146.169.53.100 PORT: 3456

 <pre>Applications Places Terminal File Edit View Search Terminal Help ss6515@corona20:cw\$./udpserver.sh 3456 UDPServer is Listening Now... 2016/03/25 15:53:00 Timeout reached! ===== REPORT: UDP ----- Number of Message SENT (by Client) = 10 Number of Message RECEIVED = 10 Number of message LOST = 0 ----- 2016/03/25 15:53:34 ===== REPORT: UDP ----- Number of Message SENT (by Client) = 20 Number of Message RECEIVED = 20 Number of message LOST = 0 ----- 2016/03/25 15:53:38 ===== REPORT: UDP ----- Number of Message SENT (by Client) = 30 Number of Message RECEIVED = 30 Number of message LOST = 0 ----- 2016/03/25 15:53:43 ===== Timeout reached! Timeout reached!</pre>	 <pre>Applications Places Terminal File Edit View Search Terminal Help ===== REPORT: UDP ----- Number of Message SENT (by Client) = 10 Number of Message RECEIVED = 10 Number of message LOST = 0 ----- 2016/03/25 16:02:17 ===== REPORT: UDP ----- Number of Message SENT (by Client) = 20 Number of Message RECEIVED = 20 Number of message LOST = 0 ----- 2016/03/25 16:02:19 Timeout reached! ===== REPORT: UDP ----- Number of Message SENT (by Client) = 30 Number of Message RECEIVED = 29 Number of message LOST = 1 --> Lost Messages: [6] ----- 2016/03/25 16:02:52 Timeout reached! ===== REPORT: UDP ----- Number of Message SENT (by Client) = 40 Number of Message RECEIVED = 17 Number of message LOST = 23 --> Lost Messages: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] ----- 2016/03/25 16:03:31 Timeout reached! ===== REPORT: UDP ----- Number of Message SENT (by Client) = 50 Number of Message RECEIVED = 21 Number of message LOST = 29 --> Lost Messages: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] ----- 2016/03/25 16:04:12 =====</pre>
Receiving some packets from first client (It was a Corona lab's machine)	Receiving some packets from the second client (My Laptop) The lost packets can be seen in the picture


```
Applications Places
Terminal
File Edit View Search Terminal Help
Timeout reached!
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 100
Number of Message RECEIVED          = 86
Number of Message LOST               = 14
--> Lost Messages: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14]
-----
2016/03/25 16:05:28
=====
Timeout reached!
Timeout reached!
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 200
Number of Message RECEIVED          = 1
Number of Message LOST              = 199
--> Lost Messages: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17]
] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36]
[37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55]
[56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74]
[75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93]
[94] [95] [96] [97] [98] [99] [100] [101] [102] [103] [104] [105] [106] [107] [108] [109] [110]
[111] [112] [113] [114] [115] [116] [117] [118] [119] [120] [121] [122] [123] [124] [125] [126]
[127] [128] [129] [130] [131] [132] [133] [134] [135] [136] [137] [138] [139] [140] [141] [142]
[143] [144] [145] [146] [147] [148] [149] [150] [151] [152] [153] [154] [155] [156] [157] [158]
[159] [160] [161] [162] [163] [164] [165] [166] [167] [168] [169] [170] [171] [172] [173] [174]
[175] [176] [177] [178] [179] [180] [181] [182] [183] [184] [185] [186] [187] [188] [189] [190]
[191] [192] [193] [194] [195] [196] [197] [198] [199]
-----
2016/03/25 16:06:53
=====
Timeout reached!
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 300
Number of Message RECEIVED          = 146
Number of Message LOST              = 154
--> Lost Messages: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17]
] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36]
[37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55]
[56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74]
[75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93]
[94] [95] [96] [97] [98] [99] [100] [101] [102] [103] [104] [105] [106] [107] [108] [109] [110]
[111] [112] [113] [114] [115] [116] [117] [118] [119] [120] [121] [122] [123] [124] [125] [126]
[127] [128] [129] [130] [131] [132] [133] [134] [135] [136] [137] [138] [139] [140] [141] [142]
[143] [144] [145] [146] [147] [148] [149] [150] [151] [152] [153] [154]
-----
2016/03/25 16:07:36
=====
```

A lot of packets are lost in 200 and 300 sent messages but there is no pattern for that (199 out of 200, 154 out of 300)

```
Applications Places
Terminal
File Edit View Search Terminal Help
72] [173] [174] [175] [176] [177] [178] [179] [180] [181] [182] [183] [184] [185] [186] [187]
[188] [189] [190] [191] [192] [193] [194] [195] [196] [197] [198] [199]
-----
2016/03/25 16:06:53
=====
Timeout reached!
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 300
Number of Message RECEIVED          = 146
Number of Message LOST              = 154
--> Lost Messages: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17]
] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36]
[37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55]
[56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74]
[75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93]
[94] [95] [96] [97] [98] [99] [100] [101] [102] [103] [104] [105] [106] [107] [108] [109] [110]
[111] [112] [113] [114] [115] [116] [117] [118] [119] [120] [121] [122] [123] [124] [125] [126]
[127] [128] [129] [130] [131] [132] [133] [134] [135] [136] [137] [138] [139] [140] [141] [142]
[143] [144] [145] [146] [147] [148] [149] [150] [151] [152] [153] [154]
-----
2016/03/25 16:07:36
=====
Timeout reached!
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 400
Number of Message RECEIVED          = 400
Number of Message LOST              = 0
-----
2016/03/25 16:08:32
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 400
Number of Message RECEIVED          = 400
Number of Message LOST              = 0
-----
2016/03/25 16:08:36
=====
Timeout reached!
=====
REPORT: UDP
-----
Number of Message SENT (by Client) = 500
Number of Message RECEIVED          = 500
Number of Message LOST              = 0
-----
2016/03/25 16:09:11
=====
```

Again, all packets are received!

- UDP Client: Corona-39 and Matrix-29

<pre>Terminal File Edit View Search Terminal Help UDP --> Message No. 22 has just been sent UDP --> Message No. 23 has just been sent UDP --> Message No. 24 has just been sent UDP --> Message No. 25 has just been sent UDP --> Message No. 26 has just been sent UDP --> Message No. 27 has just been sent UDP --> Message No. 28 has just been sent UDP --> Message No. 29 has just been sent UDP --> DONE ss6515@corona39:~\$./udpclient.sh 146.169.53.100 3456 10 Creating UDP Client Instance Starting to Sending Messages UDP --> Message No. 0 has just been sent UDP --> Message No. 1 has just been sent UDP --> Message No. 2 has just been sent UDP --> Message No. 3 has just been sent UDP --> Message No. 4 has just been sent UDP --> Message No. 5 has just been sent UDP --> Message No. 6 has just been sent UDP --> Message No. 7 has just been sent UDP --> Message No. 8 has just been sent UDP --> Message No. 9 has just been sent UDP --> DONE ss6515@corona39:~\$./udpclient.sh 146.169.53.100 3456 20 Creating UDP Client Instance Starting to Sending Messages UDP --> Message No. 0 has just been sent UDP --> Message No. 1 has just been sent UDP --> Message No. 2 has just been sent UDP --> Message No. 3 has just been sent UDP --> Message No. 4 has just been sent UDP --> Message No. 5 has just been sent UDP --> Message No. 6 has just been sent UDP --> Message No. 7 has just been sent UDP --> Message No. 8 has just been sent UDP --> Message No. 9 has just been sent UDP --> Message No. 10 has just been sent UDP --> Message No. 11 has just been sent UDP --> Message No. 12 has just been sent UDP --> Message No. 13 has just been sent UDP --> Message No. 14 has just been sent UDP --> Message No. 15 has just been sent UDP --> Message No. 16 has just been sent UDP --> Message No. 17 has just been sent UDP --> Message No. 18 has just been sent UDP --> Message No. 19 has just been sent UDP --> DONE ss6515@corona39:~\$./udpclient.sh 146.169.53.100 3456 30 Creating UDP Client Instance Starting to Sending Messages UDP --> Message No. 0 has just been sent UDP --> Message No. 1 has just been sent</pre>	<pre>Applications Places Terminal File Edit View Search Terminal Help ss6515@matrix29:~\$ make Building RMI Client/Server... Building UDP Client / Server... ss6515@matrix29:~\$./udpclient.sh 146.169.53.100 3456 10 Creating UDP Client Instance Starting to Sending Messages UDP --> Message No. 0 has just been sent UDP --> Message No. 1 has just been sent UDP --> Message No. 2 has just been sent UDP --> Message No. 3 has just been sent UDP --> Message No. 4 has just been sent UDP --> Message No. 5 has just been sent UDP --> Message No. 6 has just been sent UDP --> Message No. 7 has just been sent UDP --> Message No. 8 has just been sent UDP --> Message No. 9 has just been sent UDP --> DONE ss6515@matrix29:~\$./udpclient.sh 146.169.53.100 3456 20 Creating UDP Client Instance Starting to Sending Messages UDP --> Message No. 0 has just been sent UDP --> Message No. 1 has just been sent UDP --> Message No. 2 has just been sent UDP --> Message No. 3 has just been sent UDP --> Message No. 4 has just been sent UDP --> Message No. 5 has just been sent UDP --> Message No. 6 has just been sent UDP --> Message No. 7 has just been sent UDP --> Message No. 8 has just been sent UDP --> Message No. 9 has just been sent UDP --> Message No. 10 has just been sent UDP --> Message No. 11 has just been sent UDP --> Message No. 12 has just been sent UDP --> Message No. 13 has just been sent UDP --> Message No. 14 has just been sent UDP --> Message No. 15 has just been sent UDP --> Message No. 16 has just been sent UDP --> Message No. 17 has just been sent UDP --> Message No. 18 has just been sent UDP --> Message No. 19 has just been sent UDP --> DONE ss6515@matrix29:~\$./udpclient.sh 146.169.53.100 3456 30 Creating UDP Client Instance Starting to Sending Messages UDP --> Message No. 0 has just been sent UDP --> Message No. 1 has just been sent UDP --> Message No. 2 has just been sent UDP --> Message No. 3 has just been sent UDP --> Message No. 4 has just been sent UDP --> Message No. 5 has just been sent UDP --> Message No. 6 has just been sent UDP --> Message No. 7 has just been sent UDP --> Message No. 8 has just been sent</pre>
Corona-39 as UDP Client	Matrix-29 as UDP client

❖ All the results are saved in text files attached to submitted zip file.