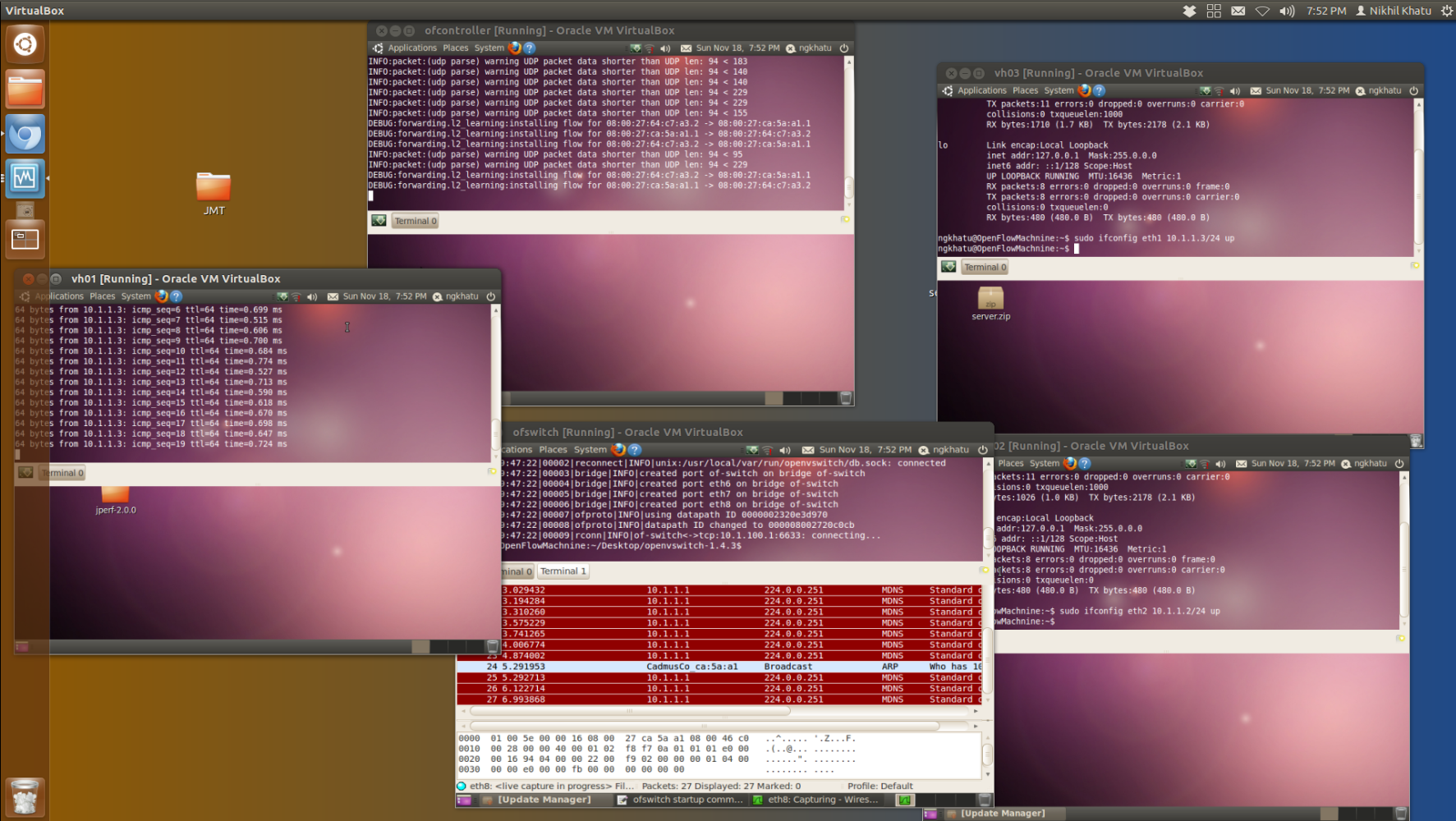
**Nikhil G. Khatu**

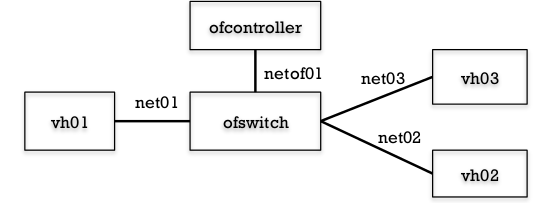
**CSC/ECE570 OpenFlow Lab**

**Professor: Thuente**

The OpenFlow Lab is setup by creating Virtual Machines running Ubuntu 10.04 on the Oracle VirtualBox hypervisor.



The combination of these VMs represent the following topology[[1]](#footnote-0):



**OpenFlow Setup:**

1) Install the Python ‘pox’ controller on the ofcontroller

2) Install the OpenvSwitch on the ofswitch

3) Configure the 10.1.100.0/24 ip addresses on the ofswitch and ofcontroller and confirm connectivity.

4) Configure the 10.1.1.0/24 ip addresses on hosts vh01, vh02, and vh03.

5) Once the ofswitch database is configured start the ofswitch and add the ports to the ‘of-switch’ bridge. Define the fail mode and the bridge’s controller.

6) Start the ‘pox’ controller with the desired code. (Either hub or switch)

7) Once connectivity between virtual hosts is confirmed we can generate the desired traffic.

(Wireshark and OpenFlow dissector can be used to confirm setup)

**Performance Measurement:**

Now that we have established connectivity with ofswitch (hub and switch) we can measure udp transmission bandwidth between the virtualhosts. In our example the Jperf[[2]](#footnote-1) tool is used to generate udp traffic from vh01 to vh03. The two base scenarios are the hub model and switch model.

**Analysis of Data**

We generate 1MByte, 10MBytes, 100MBytes, 250MBytes, and 500MBytes (in a 10 second period) within each of the Hub and Switch scenarios. The results are derived from the the appended data generated by Jperf.

122 Kbytes per second interval in Kbits/second

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **net01** | **net02** | **net03** | **netof01** |
| **hub** | 1000 | 1000 | 1000 | 0 |
| **switch** | 1000 | 0 | 1000 | 0 |

1220 Kbytes per second interval in Kbits/second

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **net01** | **net02** | **net03** | **netof01** |
| **hub** | 10004 | 10004 | 10004 | 0 |
| **switch** | 10017 | 0 | 10017 |  |

12200 Kbytes per second interval in Kbits/second

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **net01** | **net02** | **net03** | **netof01** |
| **hub** | 99325 | 99325 | 99325 | 0 |
| **switch** | 100020 | 0 | 100020 | 0 |

29090 Kbytes per second interval in Kbits/second

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **net01** | **net02** | **net03** | **netof01** |
| **hub** | 238119 | 238119 | 238119 | 0 |
| **switch** | 238392 | 0 | 238392 | 0 |

29746 Kbytes per second interval in Kbits/second

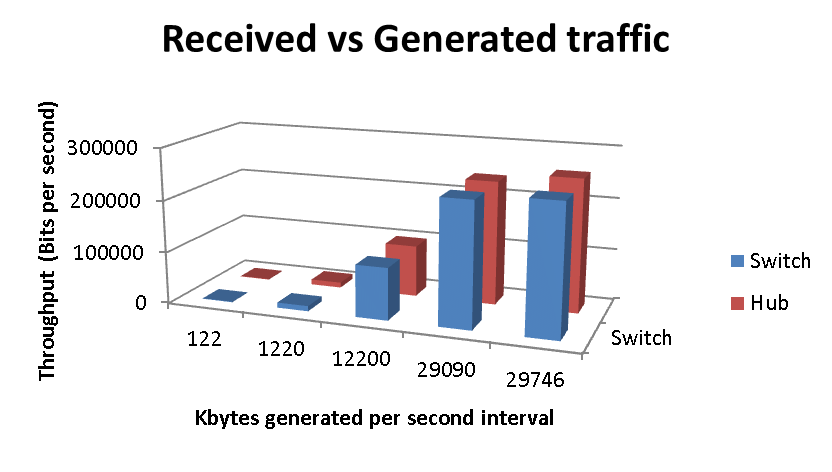
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **net01** | **net02** | **net03** | **netof01** |
| **hub** | 255699 | 255699 | 255699 | 0 |
| **switch** | 248854 | 0 | 248854 | 0 |

As one can see:

- In the hub model traffic will be flooded to net02.

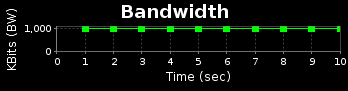
- In the switch model traffic flows only on net01 and net03.

The following figure can be generated for the overall throughput between vh01 and vh03.

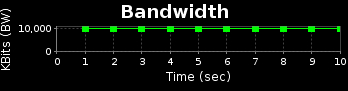


**APPENDIX**

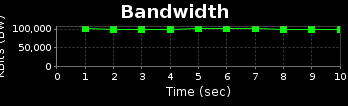
**Switch Code**



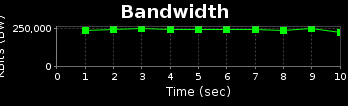
|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 1M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 43352 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 123 KBytes 1011 Kbits/sec  [ 3] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 3.0- 4.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 4.0- 5.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 5.0- 6.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 6.0- 7.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 7.0- 8.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 8.0- 9.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 9.0-10.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 0.0-10.0 sec 1223 KBytes 1000 Kbits/sec  [ 3] Sent 852 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 1223 KBytes 1004 Kbits/sec 0.103 ms 0/ 852 (0%)  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 43352  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 126 KBytes 1035 Kbits/sec 0.128 ms 0/ 88 (0%)  [ 3] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec 0.069 ms 0/ 85 (0%)  [ 3] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec 0.098 ms 0/ 85 (0%)  [ 3] 3.0- 4.0 sec 122 KBytes 1000 Kbits/sec 0.112 ms 0/ 85 (0%)  [ 3] 4.0- 5.0 sec 122 KBytes 1000 Kbits/sec 0.118 ms 0/ 85 (0%)  [ 3] 5.0- 6.0 sec 122 KBytes 1000 Kbits/sec 0.066 ms 0/ 85 (0%)  [ 3] 6.0- 7.0 sec 122 KBytes 1000 Kbits/sec 0.094 ms 0/ 85 (0%)  [ 3] 7.0- 8.0 sec 123 KBytes 1011 Kbits/sec 0.156 ms 0/ 86 (0%)  [ 3] 8.0- 9.0 sec 122 KBytes 1000 Kbits/sec 0.103 ms 0/ 85 (0%)  [ 3] 0.0-10.0 sec 1223 KBytes 1004 Kbits/sec 0.104 ms 0/ 852 (0%) |



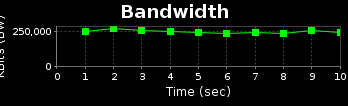
|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 10M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 42138 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 1.0- 2.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 2.0- 3.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 3.0- 4.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 4.0- 5.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 5.0- 6.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 6.0- 7.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 7.0- 8.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 8.0- 9.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 9.0-10.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 0.0-10.0 sec 12209 KBytes 9999 Kbits/sec  [ 3] Sent 8505 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 12209 KBytes 10017 Kbits/sec 0.081 ms 10/ 8504 (0.12%)  [ 3] 0.0-10.0 sec 11 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 42138  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 1232 KBytes 10090 Kbits/sec 0.030 ms 10/ 858 (1.2%)  [ 3] 0.0- 1.0 sec 10 datagrams received out-of-order  [ 3] 1.0- 2.0 sec 1226 KBytes 10043 Kbits/sec 0.051 ms 0/ 854 (0%)  [ 3] 2.0- 3.0 sec 1220 KBytes 9996 Kbits/sec 0.060 ms 0/ 850 (0%)  [ 3] 3.0- 4.0 sec 1223 KBytes 10020 Kbits/sec 0.048 ms 0/ 852 (0%)  [ 3] 4.0- 5.0 sec 1219 KBytes 9984 Kbits/sec 0.061 ms 0/ 849 (0%)  [ 3] 5.0- 6.0 sec 1214 KBytes 9949 Kbits/sec 0.042 ms 0/ 846 (0%)  [ 3] 6.0- 7.0 sec 1223 KBytes 10020 Kbits/sec 0.030 ms 0/ 852 (0%)  [ 3] 7.0- 8.0 sec 1227 KBytes 10055 Kbits/sec 0.056 ms 0/ 855 (0%)  [ 3] 8.0- 9.0 sec 1223 KBytes 10020 Kbits/sec 0.075 ms 0/ 852 (0%)  [ 3] 0.0-10.0 sec 12209 KBytes 10017 Kbits/sec 0.081 ms 10/ 8504 (0.12%)  [ 3] 0.0-10.0 sec 11 datagrams received out-of-order |



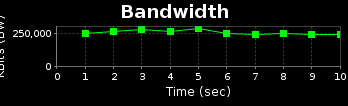
|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 100M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 37080 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 12255 KBytes 100395 Kbits/sec  [ 3] 1.0- 2.0 sec 12182 KBytes 99795 Kbits/sec  [ 3] 2.0- 3.0 sec 12196 KBytes 99913 Kbits/sec  [ 3] 3.0- 4.0 sec 12178 KBytes 99760 Kbits/sec  [ 3] 4.0- 5.0 sec 12267 KBytes 100489 Kbits/sec  [ 3] 5.0- 6.0 sec 12231 KBytes 100195 Kbits/sec  [ 3] 6.0- 7.0 sec 12270 KBytes 100513 Kbits/sec  [ 3] 7.0- 8.0 sec 12142 KBytes 99466 Kbits/sec  [ 3] 8.0- 9.0 sec 12192 KBytes 99878 Kbits/sec  [ 3] 9.0-10.0 sec 12188 KBytes 99842 Kbits/sec  [ 3] 0.0-10.0 sec 122102 KBytes 100024 Kbits/sec  [ 3] Sent 85056 datagrams  [ 3] Server Report:  [ 3] 0.0- 9.9 sec 121463 KBytes 100020 Kbits/sec 0.013 ms 444/85055 (0.52%)  [ 3] 0.0- 9.9 sec 256 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 37080  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 12600 KBytes 103218 Kbits/sec 0.025 ms 143/ 8920 (1.6%)  [ 3] 0.0- 1.0 sec 255 datagrams received out-of-order  [ 3] 1.0- 2.0 sec 12119 KBytes 99278 Kbits/sec 0.007 ms 24/ 8466 (0.28%)  [ 3] 2.0- 3.0 sec 12156 KBytes 99584 Kbits/sec 0.021 ms 20/ 8488 (0.24%)  [ 3] 3.0- 4.0 sec 12205 KBytes 99984 Kbits/sec 0.007 ms 42/ 8544 (0.49%)  [ 3] 4.0- 5.0 sec 12227 KBytes 100160 Kbits/sec 0.044 ms 10/ 8527 (0.12%)  [ 3] 5.0- 6.0 sec 12189 KBytes 99854 Kbits/sec 0.010 ms 55/ 8546 (0.64%)  [ 3] 6.0- 7.0 sec 12185 KBytes 99819 Kbits/sec 0.007 ms 19/ 8507 (0.22%)  [ 3] 7.0- 8.0 sec 12010 KBytes 98384 Kbits/sec 0.019 ms 92/ 8458 (1.1%)  [ 3] 8.0- 9.0 sec 12181 KBytes 99784 Kbits/sec 0.011 ms 21/ 8506 (0.25%)  [ 3] 0.0- 9.9 sec 121463 KBytes 100020 Kbits/sec 0.014 ms 444/85055 (0.52%)  [ 3] 0.0- 9.9 sec 256 datagrams received out-of-order |



|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 250M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 37296 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 28665 KBytes 234824 Kbits/sec  [ 3] 1.0- 2.0 sec 29032 KBytes 237834 Kbits/sec  [ 3] 2.0- 3.0 sec 29933 KBytes 245208 Kbits/sec  [ 3] 3.0- 4.0 sec 29172 KBytes 238975 Kbits/sec  [ 3] 4.0- 5.0 sec 29090 KBytes 238305 Kbits/sec  [ 3] 5.0- 6.0 sec 29736 KBytes 243597 Kbits/sec  [ 3] 6.0- 7.0 sec 29678 KBytes 243126 Kbits/sec  [ 3] 7.0- 8.0 sec 28698 KBytes 235094 Kbits/sec  [ 3] 8.0- 9.0 sec 29829 KBytes 244361 Kbits/sec  [ 3] 9.0-10.0 sec 27198 KBytes 222805 Kbits/sec  [ 3] 0.0-10.0 sec 291033 KBytes 238413 Kbits/sec  [ 3] Sent 202733 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 289877 KBytes 238392 Kbits/sec 0.046 ms 804/202732 (0.4%)  [ 3] 0.0-10.0 sec 888 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 37296  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 28985 KBytes 237446 Kbits/sec 0.045 ms 88/20279 (0.43%)  [ 3] 0.0- 1.0 sec 887 datagrams received out-of-order  [ 3] 1.0- 2.0 sec 29228 KBytes 239434 Kbits/sec 0.043 ms 58/20418 (0.28%)  [ 3] 2.0- 3.0 sec 29768 KBytes 243855 Kbits/sec 0.054 ms 107/20843 (0.51%)  [ 3] 3.0- 4.0 sec 29183 KBytes 239069 Kbits/sec 0.044 ms 60/20389 (0.29%)  [ 3] 4.0- 5.0 sec 28932 KBytes 237011 Kbits/sec 0.057 ms 57/20211 (0.28%)  [ 3] 5.0- 6.0 sec 29617 KBytes 242621 Kbits/sec 0.047 ms 110/20741 (0.53%)  [ 3] 6.0- 7.0 sec 29343 KBytes 240374 Kbits/sec 0.053 ms 69/20509 (0.34%)  [ 3] 7.0- 8.0 sec 28826 KBytes 236141 Kbits/sec 0.048 ms 74/20154 (0.37%)  [ 3] 8.0- 9.0 sec 29216 KBytes 239340 Kbits/sec 0.048 ms 182/20534 (0.89%)  [ 3] 0.0-10.0 sec 289877 KBytes 238392 Kbits/sec 0.047 ms 804/202732 (0.4%)  [ 3] 0.0-10.0 sec 888 datagrams received out-of-order |

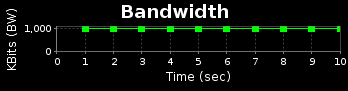


|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 500M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 43337 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 30523 KBytes 250041 Kbits/sec  [ 3] 1.0- 2.0 sec 33267 KBytes 272526 Kbits/sec  [ 3] 2.0- 3.0 sec 31760 KBytes 260178 Kbits/sec  [ 3] 3.0- 4.0 sec 30531 KBytes 250112 Kbits/sec  [ 3] 4.0- 5.0 sec 29778 KBytes 243938 Kbits/sec  [ 3] 5.0- 6.0 sec 29564 KBytes 242185 Kbits/sec  [ 3] 6.0- 7.0 sec 29746 KBytes 243679 Kbits/sec  [ 3] 7.0- 8.0 sec 29440 KBytes 241174 Kbits/sec  [ 3] 8.0- 9.0 sec 31437 KBytes 257532 Kbits/sec  [ 3] 9.0-10.0 sec 29716 KBytes 243432 Kbits/sec  [ 3] 0.0-10.0 sec 305763 KBytes 250479 Kbits/sec  [ 3] Sent 212994 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 302415 KBytes 248854 Kbits/sec 0.058 ms 2331/212993 (1.1%)  [ 3] 0.0-10.0 sec 316 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 43337  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 29894 KBytes 244890 Kbits/sec 0.050 ms 872/21696 (4%)  [ 3] 0.0- 1.0 sec 315 datagrams received out-of-order  [ 3] 1.0- 2.0 sec 33151 KBytes 271574 Kbits/sec 0.058 ms 259/23352 (1.1%)  [ 3] 2.0- 3.0 sec 31349 KBytes 256815 Kbits/sec 0.048 ms 290/22128 (1.3%)  [ 3] 3.0- 4.0 sec 30434 KBytes 249312 Kbits/sec 0.050 ms 109/21309 (0.51%)  [ 3] 4.0- 5.0 sec 29271 KBytes 239786 Kbits/sec 0.053 ms 69/20459 (0.34%)  [ 3] 5.0- 6.0 sec 29558 KBytes 242138 Kbits/sec 0.056 ms 183/20773 (0.88%)  [ 3] 6.0- 7.0 sec 29588 KBytes 242385 Kbits/sec 0.045 ms 91/20702 (0.44%)  [ 3] 7.0- 8.0 sec 29447 KBytes 241233 Kbits/sec 0.057 ms 97/20610 (0.47%)  [ 3] 8.0- 9.0 sec 31263 KBytes 256109 Kbits/sec 0.044 ms 177/21955 (0.81%)  [ 3] 0.0-10.0 sec 302415 KBytes 248854 Kbits/sec 0.058 ms 2331/212993 (1.1%)  [ 3] 0.0-10.0 sec 316 datagrams received out-of-order |

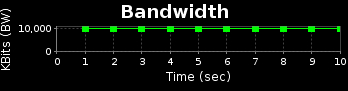


|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 1000M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 32824 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 30695 KBytes 251452 Kbits/sec  [ 3] 1.0- 2.0 sec 32733 KBytes 268152 Kbits/sec  [ 3] 2.0- 3.0 sec 34663 KBytes 283957 Kbits/sec  [ 3] 3.0- 4.0 sec 33249 KBytes 272373 Kbits/sec  [ 3] 4.0- 5.0 sec 35339 KBytes 289496 Kbits/sec  [ 3] 5.0- 6.0 sec 31080 KBytes 254604 Kbits/sec  [ 3] 6.0- 7.0 sec 30290 KBytes 248136 Kbits/sec  [ 3] 7.0- 8.0 sec 30514 KBytes 249971 Kbits/sec  [ 3] 8.0- 9.0 sec 30020 KBytes 245925 Kbits/sec  [ 3] 9.0-10.0 sec 29813 KBytes 244232 Kbits/sec  [ 3] 0.0-10.0 sec 318397 KBytes 260829 Kbits/sec  [ 3] Sent 221795 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 315052 KBytes 258674 Kbits/sec 0.046 ms 2329/221794 (1.1%)  [ 3] 0.0-10.0 sec 410 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 32824  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 30547 KBytes 250241 Kbits/sec 0.053 ms 304/21583 (1.4%)  [ 3] 0.0- 1.0 sec 409 datagrams received out-of-order  [ 3] 1.0- 2.0 sec 32617 KBytes 267199 Kbits/sec 0.048 ms 84/22805 (0.37%)  [ 3] 2.0- 3.0 sec 34123 KBytes 279535 Kbits/sec 0.060 ms 313/24083 (1.3%)  [ 3] 3.0- 4.0 sec 33376 KBytes 273420 Kbits/sec 0.054 ms 0/23250 (0%)  [ 3] 4.0- 5.0 sec 34572 KBytes 283216 Kbits/sec 0.073 ms 606/24689 (2.5%)  [ 3] 5.0- 6.0 sec 30824 KBytes 252511 Kbits/sec 0.048 ms 85/21557 (0.39%)  [ 3] 6.0- 7.0 sec 29966 KBytes 245478 Kbits/sec 0.050 ms 270/21144 (1.3%)  [ 3] 7.0- 8.0 sec 30224 KBytes 247595 Kbits/sec 0.053 ms 263/21317 (1.2%)  [ 3] 8.0- 9.0 sec 29376 KBytes 240645 Kbits/sec 0.053 ms 300/20763 (1.4%)  [ 3] 0.0-10.0 sec 315052 KBytes 258674 Kbits/sec 0.047 ms 2329/221794 (1.1%)  [ 3] 0.0-10.0 sec 410 datagrams received out-of-order |

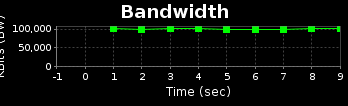
**Hub Code**



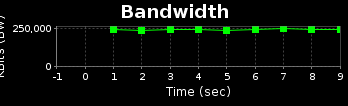
|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 1M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 44183 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 123 KBytes 1011 Kbits/sec  [ 3] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 3.0- 4.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 4.0- 5.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 5.0- 6.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 6.0- 7.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 7.0- 8.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 8.0- 9.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 9.0-10.0 sec 122 KBytes 1000 Kbits/sec  [ 3] 0.0-10.0 sec 1223 KBytes 1000 Kbits/sec  [ 3] Sent 852 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 1223 KBytes 1000 Kbits/sec 0.158 ms 0/ 852 (0%)  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 44183  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec 0.089 ms 0/ 85 (0%)  [ 3] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec 0.110 ms 0/ 85 (0%)  [ 3] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec 0.090 ms 0/ 85 (0%)  [ 3] 3.0- 4.0 sec 122 KBytes 1000 Kbits/sec 0.086 ms 0/ 85 (0%)  [ 3] 4.0- 5.0 sec 122 KBytes 1000 Kbits/sec 0.085 ms 0/ 85 (0%)  [ 3] 5.0- 6.0 sec 122 KBytes 1000 Kbits/sec 0.092 ms 0/ 85 (0%)  [ 3] 6.0- 7.0 sec 122 KBytes 1000 Kbits/sec 0.070 ms 0/ 85 (0%)  [ 3] 7.0- 8.0 sec 122 KBytes 1000 Kbits/sec 0.108 ms 0/ 85 (0%)  [ 3] 8.0- 9.0 sec 122 KBytes 1000 Kbits/sec 0.140 ms 0/ 85 (0%)  [ 3] 9.0-10.0 sec 122 KBytes 1000 Kbits/sec 0.166 ms 0/ 85 (0%)  [ 3] 0.0-10.0 sec 1223 KBytes 1000 Kbits/sec 0.158 ms 0/ 852 (0%) |



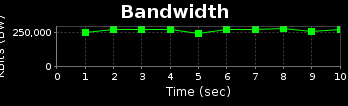
|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 10M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 40244 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 1.0- 2.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 2.0- 3.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 3.0- 4.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 4.0- 5.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 5.0- 6.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 6.0- 7.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 7.0- 8.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 8.0- 9.0 sec 1220 KBytes 9996 Kbits/sec  [ 3] 9.0-10.0 sec 1222 KBytes 10008 Kbits/sec  [ 3] 0.0-10.0 sec 12209 KBytes 10000 Kbits/sec  [ 3] Sent 8505 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 12209 KBytes 10004 Kbits/sec 0.034 ms 0/ 8504 (0%)  [ 3] 0.0-10.0 sec 1 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 40244  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 1220 KBytes 9996 Kbits/sec 0.074 ms 0/ 850 (0%)  [ 3] 1.0- 2.0 sec 1222 KBytes 10008 Kbits/sec 0.088 ms 0/ 851 (0%)  [ 3] 2.0- 3.0 sec 1222 KBytes 10008 Kbits/sec 0.062 ms 0/ 851 (0%)  [ 3] 3.0- 4.0 sec 1220 KBytes 9996 Kbits/sec 0.074 ms 0/ 850 (0%)  [ 3] 4.0- 5.0 sec 1222 KBytes 10008 Kbits/sec 0.064 ms 0/ 851 (0%)  [ 3] 5.0- 6.0 sec 1220 KBytes 9996 Kbits/sec 0.037 ms 0/ 850 (0%)  [ 3] 6.0- 7.0 sec 1223 KBytes 10020 Kbits/sec 0.045 ms 0/ 852 (0%)  [ 3] 7.0- 8.0 sec 1219 KBytes 9984 Kbits/sec 0.035 ms 0/ 849 (0%)  [ 3] 8.0- 9.0 sec 1223 KBytes 10020 Kbits/sec 0.054 ms 0/ 852 (0%)  [ 3] 0.0-10.0 sec 12209 KBytes 10004 Kbits/sec 0.035 ms 0/ 8504 (0%)  [ 3] 0.0-10.0 sec 1 datagrams received out-of-order |



|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 100M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 55645 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 12261 KBytes 100442 Kbits/sec  [ 3] 1.0- 2.0 sec 12199 KBytes 99936 Kbits/sec  [ 3] 2.0- 3.0 sec 12268 KBytes 100501 Kbits/sec  [ 3] 3.0- 4.0 sec 12227 KBytes 100160 Kbits/sec  [ 3] 4.0- 5.0 sec 12172 KBytes 99713 Kbits/sec  [ 3] 5.0- 6.0 sec 12192 KBytes 99878 Kbits/sec  [ 3] 6.0- 7.0 sec 12208 KBytes 100007 Kbits/sec  [ 3] 7.0- 8.0 sec 12268 KBytes 100501 Kbits/sec  [ 3] 8.0- 9.0 sec 12270 KBytes 100513 Kbits/sec  [ 3] 0.0-10.0 sec 121592 KBytes 99608 Kbits/sec  [ 3] Sent 84701 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 121180 KBytes 99325 Kbits/sec 0.056 ms 286/84700 (0.34%)  [ 3] 0.0-10.0 sec 1 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 55645  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 12268 KBytes 100501 Kbits/sec 0.047 ms 0/ 8546 (0%)  [ 3] 1.0- 2.0 sec 12165 KBytes 99654 Kbits/sec 0.041 ms 27/ 8501 (0.32%)  [ 3] 2.0- 3.0 sec 12212 KBytes 100042 Kbits/sec 0.010 ms 41/ 8548 (0.48%)  [ 3] 3.0- 4.0 sec 12215 KBytes 100066 Kbits/sec 0.008 ms 15/ 8524 (0.18%)  [ 3] 4.0- 5.0 sec 12133 KBytes 99396 Kbits/sec 0.050 ms 26/ 8478 (0.31%)  [ 3] 5.0- 6.0 sec 12204 KBytes 99972 Kbits/sec 0.012 ms 0/ 8501 (0%)  [ 3] 6.0- 7.0 sec 12214 KBytes 100054 Kbits/sec 0.021 ms 0/ 8508 (0%)  [ 3] 7.0- 8.0 sec 12195 KBytes 99901 Kbits/sec 0.054 ms 54/ 8549 (0.63%)  [ 3] 8.0- 9.0 sec 12208 KBytes 100007 Kbits/sec 0.095 ms 49/ 8553 (0.57%)  [ 3] 0.0-10.0 sec 121180 KBytes 99325 Kbits/sec 0.057 ms 286/84700 (0.34%)  [ 3] 0.0-10.0 sec 1 datagrams received out-of-order |



|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 250M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 36919 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 29330 KBytes 240269 Kbits/sec  [ 3] 1.0- 2.0 sec 28236 KBytes 231307 Kbits/sec  [ 3] 2.0- 3.0 sec 29450 KBytes 241256 Kbits/sec  [ 3] 3.0- 4.0 sec 29169 KBytes 238951 Kbits/sec  [ 3] 4.0- 5.0 sec 28477 KBytes 233283 Kbits/sec  [ 3] 5.0- 6.0 sec 29647 KBytes 242868 Kbits/sec  [ 3] 6.0- 7.0 sec 29935 KBytes 245231 Kbits/sec  [ 3] 7.0- 8.0 sec 29367 KBytes 240574 Kbits/sec  [ 3] 8.0- 9.0 sec 29045 KBytes 237940 Kbits/sec  [ 3] 0.0-10.0 sec 292098 KBytes 239286 Kbits/sec  [ 3] Sent 203475 datagrams  [ 3] Server Report:  [ 3] 0.0-10.0 sec 290535 KBytes 238119 Kbits/sec 0.061 ms 1088/203474 (0.53%)  [ 3] 0.0-10.0 sec 1 datagrams received out-of-order  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 36919  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 28958 KBytes 237223 Kbits/sec 0.047 ms 26/20198 (0.13%)  [ 3] 1.0- 2.0 sec 27967 KBytes 229108 Kbits/sec 0.066 ms 197/19679 (1%)  [ 3] 2.0- 3.0 sec 29393 KBytes 240786 Kbits/sec 0.059 ms 286/20761 (1.4%)  [ 3] 3.0- 4.0 sec 29155 KBytes 238834 Kbits/sec 0.056 ms 24/20333 (0.12%)  [ 3] 4.0- 5.0 sec 28491 KBytes 233401 Kbits/sec 0.059 ms 0/19847 (0%)  [ 3] 5.0- 6.0 sec 29589 KBytes 242397 Kbits/sec 0.061 ms 50/20662 (0.24%)  [ 3] 6.0- 7.0 sec 29459 KBytes 241327 Kbits/sec 0.046 ms 110/20631 (0.53%)  [ 3] 7.0- 8.0 sec 29364 KBytes 240551 Kbits/sec 0.062 ms 204/20659 (0.99%)  [ 3] 8.0- 9.0 sec 28672 KBytes 234882 Kbits/sec 0.057 ms 97/20070 (0.48%)  [ 3] 0.0-10.0 sec 290535 KBytes 238119 Kbits/sec 0.061 ms 1088/203474 (0.53%)  [ 3] 0.0-10.0 sec 1 datagrams received out-of-order |



|  |  |
| --- | --- |
| iperf -c 10.1.1.3 -u -P 1 -i 1 -p 5001 -f k -b 500M -t 10 -T 1  ------------------------------------------------------------  Client connecting to 10.1.1.3, UDP port 5001  Sending 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.1 port 45331 connected with 10.1.1.3 port 5001  [ ID] Interval Transfer Bandwidth  [ 3] 0.0- 1.0 sec 30167 KBytes 247125 Kbits/sec  [ 3] 1.0- 2.0 sec 33049 KBytes 270739 Kbits/sec  [ 3] 2.0- 3.0 sec 33355 KBytes 273244 Kbits/sec  [ 3] 3.0- 4.0 sec 33056 KBytes 270798 Kbits/sec  [ 3] 4.0- 5.0 sec 29350 KBytes 240433 Kbits/sec  [ 3] 5.0- 6.0 sec 33069 KBytes 270903 Kbits/sec  [ 3] 6.0- 7.0 sec 33480 KBytes 274267 Kbits/sec  [ 3] 7.0- 8.0 sec 33649 KBytes 275654 Kbits/sec  [ 3] 8.0- 9.0 sec 31473 KBytes 257826 Kbits/sec  [ 3] 9.0-10.0 sec 32709 KBytes 267952 Kbits/sec  [ 3] 0.0-10.0 sec 323358 KBytes 264894 Kbits/sec  [ 3] Sent 225251 datagrams  [ 3] Server Report:  [ 3] 0.0-10.2 sec 319771 KBytes 255699 Kbits/sec 15.081 ms 2469/225221 (1.1%)  Done. | iperf -s -u -P 0 -i 1 -p 5001 -f k  ------------------------------------------------------------  Server listening on UDP port 5001  Receiving 1470 byte datagrams  UDP buffer size: 122 KByte (default)  ------------------------------------------------------------  [ 3] local 10.1.1.3 port 5001 connected with 10.1.1.1 port 45331  [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams  [ 3] 0.0- 1.0 sec 29482 KBytes 241515 Kbits/sec 0.049 ms 255/20792 (1.2%)  [ 3] 1.0- 2.0 sec 32385 KBytes 265294 Kbits/sec 0.055 ms 474/23033 (2.1%)  [ 3] 2.0- 3.0 sec 32845 KBytes 269069 Kbits/sec 0.044 ms 362/23242 (1.6%)  [ 3] 3.0- 4.0 sec 32857 KBytes 269163 Kbits/sec 0.055 ms 150/23038 (0.65%)  [ 3] 4.0- 5.0 sec 29492 KBytes 241597 Kbits/sec 0.053 ms 156/20700 (0.75%)  [ 3] 5.0- 6.0 sec 32456 KBytes 265882 Kbits/sec 0.055 ms 189/22798 (0.83%)  [ 3] 6.0- 7.0 sec 33295 KBytes 272750 Kbits/sec 0.059 ms 155/23348 (0.66%)  [ 3] 7.0- 8.0 sec 33219 KBytes 272126 Kbits/sec 0.042 ms 349/23489 (1.5%)  [ 3] 8.0- 9.0 sec 31189 KBytes 255498 Kbits/sec 0.052 ms 165/21891 (0.75%)  [ 3] 9.0-10.0 sec 32551 KBytes 266658 Kbits/sec 0.043 ms 111/22786 (0.49%)  [ 3] 0.0-10.2 sec 319771 KBytes 255699 Kbits/sec 15.081 ms 2469/225221 (1.1%) |

1. From CSC570 Lab description [↑](#footnote-ref-0)
2. The Jperf tool is a java based derivative of the Iperf performance measurement tool. [↑](#footnote-ref-1)