

Лабораторная работа №2

Измерение и тестирование пропускной способности сети. Интерактивный эксперимент

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Цели и задачи

Основной целью работы является знакомство с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получение навыков проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.

1. Установить на виртуальную машину mininet iPerf3 и дополнительное программное обеспечения для визуализации и обработки данных.
2. Провести ряд интерактивных экспериментов по измерению пропускной способности с помощью iPerf3 с построением графиков.

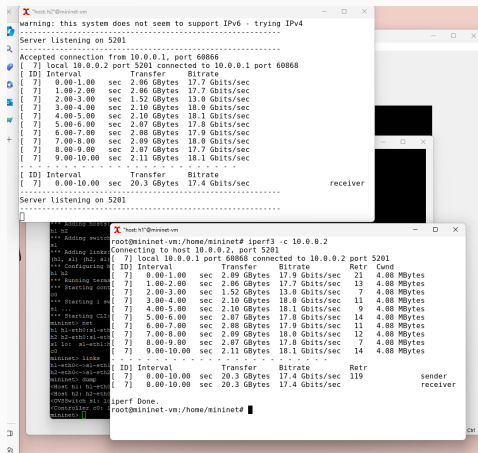
Процесс выполнения лабораторной работы

Установить mininet iPerf3 и дополнительное программное обеспечения

```
mininet@mininet-vm:~$ sudo apt-get install iperf3
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libiperf0 libstpl
Suggested packages:
  libstpl-tools
The following NEW packages will be installed:
  iperf3 libiperf0 libstpl
0 upgraded, 3 newly installed, 0 to remove and 378 not upgraded.
Need to get 94.1 kB of archives.
After this operation, 331 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libstpl amd64 1.0.18+dfsg-1 [7,876 B]
Get:2 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 libiperf0 amd64 3.7-3 [72.0 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 iperf3 amd64 3.7-3 [14.2 kB]
Fetched 94.1 kB in 1s (97.7 kB/s)
Selecting previously unselected package libstpl:amd64.
(Reading database ... 102146 files and directories currently installed.)
Preparing to unpack .../libstpl_1.0.18+dfsg-1_amd64.deb ...
Unpacking libstpl:amd64 (1.0.18+dfsg-1) ...
Selecting previously unselected package libiperf0:amd64.
Preparing to unpack .../libiperf0_3.7-3_amd64.deb ...
Unpacking libiperf0:amd64 (3.7-3) ...
Selecting previously unselected package iperf3.
Preparing to unpack .../iperf3_3.7-3_amd64.deb ...
```

Рис. 1: Установка iperf3 и дополнительное программное обеспечение

Интерактивные эксперименты



```
host: h2@mininet-vn
warning: this system does not seem to support IPv6 - trying IPv4
Server listening on 5201
Accepted connection from 10.0.0.1, port 60866
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60866
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-1.00 sec  2.06 GBytes  17.7 Gbits/sec
[ 7] 1.00-2.00 sec  2.06 GBytes  17.7 Gbits/sec
[ 7] 2.00-3.00 sec  1.52 GBytes  13.0 Gbits/sec
[ 7] 3.00-4.00 sec  2.10 GBytes  18.0 Gbits/sec
[ 7] 4.00-5.00 sec  2.10 GBytes  18.1 Gbits/sec
[ 7] 5.00-6.00 sec  2.07 GBytes  17.8 Gbits/sec
[ 7] 6.00-7.00 sec  2.08 GBytes  17.9 Gbits/sec
[ 7] 7.00-8.00 sec  2.09 GBytes  18.0 Gbits/sec
[ 7] 8.00-9.00 sec  2.07 GBytes  17.7 Gbits/sec
[ 7] 9.00-10.00 sec 2.11 GBytes  18.1 Gbits/sec
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-10.00 sec 20.3 GBytes  17.4 Gbits/sec
Server listening on 5201

root@mininet-vn: /home/mininet# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 60866 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Retr  Cwnd
[ 7] 0.00-1.00 sec  2.09 GBytes  17.9 Gbits/sec  21    4.00 MBytes
[ 7] 1.00-2.00 sec  2.06 GBytes  17.7 Gbits/sec  13    4.00 MBytes
[ 7] 2.00-3.00 sec  1.52 GBytes  13.0 Gbits/sec  7     4.00 MBytes
[ 7] 3.00-4.00 sec  2.10 GBytes  18.0 Gbits/sec  11    4.00 MBytes
[ 7] 4.00-5.00 sec  2.10 GBytes  18.1 Gbits/sec  9     4.00 MBytes
[ 7] 5.00-6.00 sec  2.07 GBytes  17.8 Gbits/sec  14    4.00 MBytes
[ 7] 6.00-7.00 sec  2.08 GBytes  17.9 Gbits/sec  11    4.00 MBytes
[ 7] 7.00-8.00 sec  2.09 GBytes  18.0 Gbits/sec  12    4.00 MBytes
[ 7] 8.00-9.00 sec  2.07 GBytes  17.8 Gbits/sec  7     4.00 MBytes
[ 7] 9.00-10.00 sec 2.11 GBytes  18.1 Gbits/sec  14    4.00 MBytes
[ ID] Interval      Transfer      Bitrate      Retr
[ 7] 0.00-10.00 sec 20.3 GBytes  17.4 Gbits/sec  119
[ 7] 0.00-10.00 sec 20.3 GBytes  17.4 Gbits/sec
iperf Done.
root@mininet-vn: /home/mininet#
```

Рис. 2: Проведите простейший интерактивный эксперимент

Интерактивные эксперименты

```
root@kali:~# mininet-vn
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 68870
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 68872
[ ID Interval Transfer Bitrate
[ 7] 0.00-1.00 sec 2.82 GBytes 17.3 Gbits/sec
[ 7] 1.00-2.00 sec 2.19 GBytes 18.1 Gbits/sec
[ 7] 2.00-3.00 sec 1.91 GBytes 16.4 Gbits/sec
[ 7] 3.00-4.00 sec 1.16 GBytes 9.97 Gbits/sec
[ 7] 4.00-5.00 sec 1.37 GBytes 11.8 Gbits/sec
[ 7] 5.00-6.00 sec 1.36 GBytes 11.7 Gbits/sec
[ 7] 6.00-7.00 sec 1.24 GBytes 10.7 Gbits/sec
[ 7] 7.00-8.00 sec 2.86 GBytes 17.7 Gbits/sec
[ 7] 8.00-9.00 sec 2.89 GBytes 18.8 Gbits/sec
[ 7] 9.00-10.00 sec 1.63 GBytes 14.0 Gbits/sec
[ 7] 10.00-10.00 sec 128 KBytes 366 Mbits/sec
[ ID Interval Transfer Bitrate
[ 7] 0.00-10.00 sec 17.0 GBytes 14.6 Gbits/sec
-----
Server listening on 5201
-----
iperf3: interrupt - the server has terminated
root@mininet-vn:~# mininet
mininet> host 10
eth1: 10.0.0.1
eth2: 10.0.0.2
eth3: 10.0.0.3
eth4: 10.0.0.4
eth5: 10.0.0.5
eth6: 10.0.0.6
eth7: 10.0.0.7
eth8: 10.0.0.8
eth9: 10.0.0.9
eth10: 10.0.0.10
eth11: 10.0.0.11
eth12: 10.0.0.12
eth13: 10.0.0.13
eth14: 10.0.0.14
eth15: 10.0.0.15
eth16: 10.0.0.16
eth17: 10.0.0.17
eth18: 10.0.0.18
eth19: 10.0.0.19
eth20: 10.0.0.20
eth21: 10.0.0.21
eth22: 10.0.0.22
eth23: 10.0.0.23
eth24: 10.0.0.24
eth25: 10.0.0.25
eth26: 10.0.0.26
eth27: 10.0.0.27
eth28: 10.0.0.28
eth29: 10.0.0.29
eth30: 10.0.0.30
eth31: 10.0.0.31
eth32: 10.0.0.32
eth33: 10.0.0.33
eth34: 10.0.0.34
eth35: 10.0.0.35
eth36: 10.0.0.36
eth37: 10.0.0.37
eth38: 10.0.0.38
eth39: 10.0.0.39
eth40: 10.0.0.40
eth41: 10.0.0.41
eth42: 10.0.0.42
eth43: 10.0.0.43
eth44: 10.0.0.44
eth45: 10.0.0.45
eth46: 10.0.0.46
eth47: 10.0.0.47
eth48: 10.0.0.48
eth49: 10.0.0.49
eth50: 10.0.0.50
eth51: 10.0.0.51
eth52: 10.0.0.52
eth53: 10.0.0.53
eth54: 10.0.0.54
eth55: 10.0.0.55
eth56: 10.0.0.56
eth57: 10.0.0.57
eth58: 10.0.0.58
eth59: 10.0.0.59
eth60: 10.0.0.60
eth61: 10.0.0.61
eth62: 10.0.0.62
eth63: 10.0.0.63
eth64: 10.0.0.64
eth65: 10.0.0.65
eth66: 10.0.0.66
eth67: 10.0.0.67
eth68: 10.0.0.68
eth69: 10.0.0.69
eth70: 10.0.0.70
eth71: 10.0.0.71
eth72: 10.0.0.72
eth73: 10.0.0.73
eth74: 10.0.0.74
eth75: 10.0.0.75
eth76: 10.0.0.76
eth77: 10.0.0.77
eth78: 10.0.0.78
eth79: 10.0.0.79
eth80: 10.0.0.80
eth81: 10.0.0.81
eth82: 10.0.0.82
eth83: 10.0.0.83
eth84: 10.0.0.84
eth85: 10.0.0.85
eth86: 10.0.0.86
eth87: 10.0.0.87
eth88: 10.0.0.88
eth89: 10.0.0.89
eth90: 10.0.0.90
eth91: 10.0.0.91
eth92: 10.0.0.92
eth93: 10.0.0.93
eth94: 10.0.0.94
eth95: 10.0.0.95
eth96: 10.0.0.96
eth97: 10.0.0.97
eth98: 10.0.0.98
eth99: 10.0.0.99
eth100: 10.0.0.100
eth101: 10.0.0.101
eth102: 10.0.0.102
eth103: 10.0.0.103
eth104: 10.0.0.104
eth105: 10.0.0.105
eth106: 10.0.0.106
eth107: 10.0.0.107
eth108: 10.0.0.108
eth109: 10.0.0.109
eth110: 10.0.0.110
eth111: 10.0.0.111
eth112: 10.0.0.112
eth113: 10.0.0.113
eth114: 10.0.0.114
eth115: 10.0.0.115
eth116: 10.0.0.116
eth117: 10.0.0.117
eth118: 10.0.0.118
eth119: 10.0.0.119
eth120: 10.0.0.120
eth121: 10.0.0.121
eth122: 10.0.0.122
eth123: 10.0.0.123
eth124: 10.0.0.124
eth125: 10.0.0.125
eth126: 10.0.0.126
eth127: 10.0.0.127
eth128: 10.0.0.128
eth129: 10.0.0.129
eth130: 10.0.0.130
eth131: 10.0.0.131
eth132: 10.0.0.132
eth133: 10.0.0.133
eth134: 10.0.0.134
eth135: 10.0.0.135
eth136: 10.0.0.136
eth137: 10.0.0.137
eth138: 10.0.0.138
eth139: 10.0.0.139
eth140: 10.0.0.140
eth141: 10.0.0.141
eth142: 10.0.0.142
eth143: 10.0.0.143
eth144: 10.0.0.144
eth145: 10.0.0.145
eth146: 10.0.0.146
eth147: 10.0.0.147
eth148: 10.0.0.148
eth149: 10.0.0.149
eth150: 10.0.0.150
eth151: 10.0.0.151
eth152: 10.0.0.152
eth153: 10.0.0.153
eth154: 10.0.0.154
eth155: 10.0.0.155
eth156: 10.0.0.156
eth157: 10.0.0.157
eth158: 10.0.0.158
eth159: 10.0.0.159
eth160: 10.0.0.160
eth161: 10.0.0.161
eth162: 10.0.0.162
eth163: 10.0.0.163
eth164: 10.0.0.164
eth165: 10.0.0.165
eth166: 10.0.0.166
eth167: 10.0.0.167
eth168: 10.0.0.168
eth169: 10.0.0.169
eth170: 10.0.0.170
eth171: 10.0.0.171
eth172: 10.0.0.172
eth173: 10.0.0.173
eth174: 10.0.0.174
eth175: 10.0.0.175
eth176: 10.0.0.176
eth177: 10.0.0.177
eth178: 10.0.0.178
eth179: 10.0.0.179
eth180: 10.0.0.180
eth181: 10.0.0.181
eth182: 10.0.0.182
eth183: 10.0.0.183
eth184: 10.0.0.184
eth185: 10.0.0.185
eth186: 10.0.0.186
eth187: 10.0.0.187
eth188: 10.0.0.188
eth189: 10.0.0.189
eth190: 10.0.0.190
eth191: 10.0.0.191
eth192: 10.0.0.192
eth193: 10.0.0.193
eth194: 10.0.0.194
eth195: 10.0.0.195
eth196: 10.0.0.196
eth197: 10.0.0.197
eth198: 10.0.0.198
eth199: 10.0.0.199
eth200: 10.0.0.200
eth201: 10.0.0.201
eth202: 10.0.0.202
eth203: 10.0.0.203
eth204: 10.0.0.204
eth205: 10.0.0.205
eth206: 10.0.0.206
eth207: 10.0.0.207
eth208: 10.0.0.208
eth209: 10.0.0.209
eth210: 10.0.0.210
eth211: 10.0.0.211
eth212: 10.0.0.212
eth213: 10.0.0.213
eth214: 10.0.0.214
eth215: 10.0.0.215
eth216: 10.0.0.216
eth217: 10.0.0.217
eth218: 10.0.0.218
eth219: 10.0.0.219
eth220: 10.0.0.220
eth221: 10.0.0.221
eth222: 10.0
```

Рис. 3: Проведите аналогичный эксперимент в интерфейсе mininet

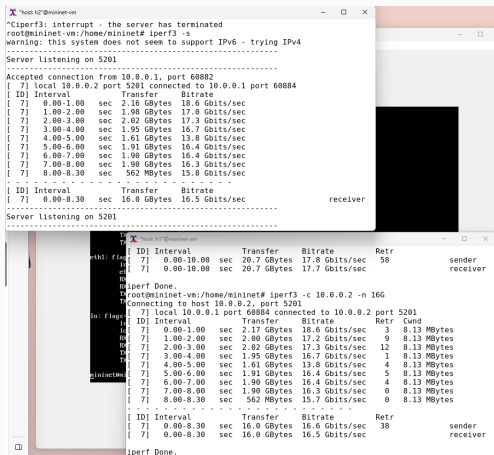
Интерактивные эксперименты

```
root@mininet-vn: /home/mininet# iperf3 -s -i 2
warning: this system does not seem to support IPv6 - trying IPv4
Server Listening on 5201
-----
Accepted connection from 10.0.0.1, port 60878
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60880
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-2.00 sec  4.15 GBytes  17.8 Gbits/sec
[ 7] 2.00-4.00 sec  4.08 GBytes  17.5 Gbits/sec
[ 7] 4.00-6.00 sec  4.12 GBytes  17.7 Gbits/sec
[ 7] 6.00-8.00 sec  4.17 GBytes  17.9 Gbits/sec
[ 7] 8.00-10.00 sec 4.14 GBytes  17.8 Gbits/sec
-----
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-10.00 sec 20.7 GBytes  17.7 Gbits/sec
Server Listening on 5201
-----
^Ciperf3: interrupt - the server has terminated
root@mininet-vn: /home/mininet#

root@mininet-vn: /home/mininet# iperf3 -c 10.0.0.2 -i 2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 60880 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Retr      Cwnd
[ 7] 0.00-2.00 sec  4.17 GBytes  17.9 Gbits/sec  17      4.88 MBytes
[ 7] 2.00-4.00 sec  4.08 GBytes  17.5 Gbits/sec  10      4.88 MBytes
[ 7] 4.00-6.00 sec  4.12 GBytes  17.7 Gbits/sec  11      4.88 MBytes
[ 7] 6.00-8.00 sec  4.17 GBytes  17.9 Gbits/sec  15      4.88 MBytes
[ 7] 8.00-10.00 sec 4.14 GBytes  17.8 Gbits/sec   5      4.88 MBytes
-----
[ ID] Interval      Transfer      Bitrate      Retr      sender receiver
[ 7] 0.00-10.00 sec 20.7 GBytes  17.8 Gbits/sec  58          sender receiver
[ 7] 0.00-10.00 sec 20.7 GBytes  17.7 Gbits/sec
-----
iperf Done.
root@mininet-vn: /home/mininet#
```

Рис. 4: Передача использовать ключ -i

Интерактивные эксперименты

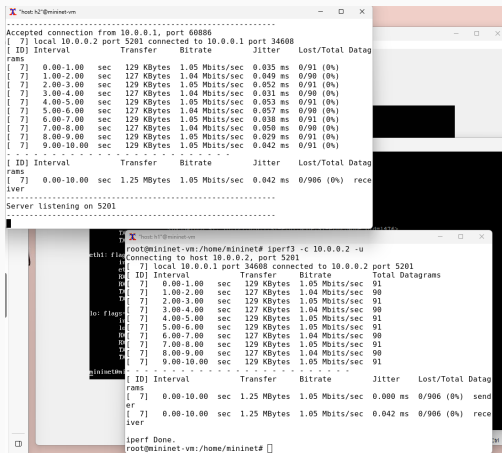


```
root@mininet-vn:~# iperf3 -s
Warning: this system does not seem to support IPv6 - trying IPv4
Server listening on 5201
Accepted connection from 10.0.0.1, port 60802
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60804
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-1.00 sec  2.16 GBytes  18.6 Gbits/sec
[ 7] 1.00-2.00 sec  1.98 GBytes  17.0 Gbits/sec
[ 7] 2.00-3.00 sec  2.02 GBytes  17.3 Gbits/sec
[ 7] 3.00-4.00 sec  1.95 GBytes  16.7 Gbits/sec
[ 7] 4.00-5.00 sec  1.61 GBytes  13.8 Gbits/sec
[ 7] 5.00-6.00 sec  1.91 GBytes  16.4 Gbits/sec
[ 7] 6.00-7.00 sec  1.98 GBytes  16.4 Gbits/sec
[ 7] 7.00-8.00 sec  1.98 GBytes  16.3 Gbits/sec
[ 7] 8.00-8.30 sec  562 MBytes  15.8 Gbits/sec
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-8.30 sec  16.0 GBytes  16.5 Gbits/sec
Server listening on 5201

root@mininet-vn:~# iperf3 -c 10.0.0.2 -n 166
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 60804 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Retr      Cwnd
[ 7] 0.00-1.00 sec  2.17 GBytes  18.6 Gbits/sec  3      8.13 MBytes
[ 7] 1.00-2.00 sec  2.00 GBytes  17.2 Gbits/sec  9      8.13 MBytes
[ 7] 2.00-3.00 sec  2.02 GBytes  17.3 Gbits/sec  12     8.13 MBytes
[ 7] 3.00-4.00 sec  1.95 GBytes  16.7 Gbits/sec  1      8.13 MBytes
[ 7] 4.00-5.00 sec  1.61 GBytes  13.8 Gbits/sec  4      8.13 MBytes
[ 7] 5.00-6.00 sec  1.91 GBytes  16.4 Gbits/sec  5      8.13 MBytes
[ 7] 6.00-7.00 sec  1.98 GBytes  16.4 Gbits/sec  4      8.13 MBytes
[ 7] 7.00-8.00 sec  1.98 GBytes  16.3 Gbits/sec  0      8.13 MBytes
[ 7] 8.00-8.30 sec  562 MBytes  15.7 Gbits/sec  0      8.13 MBytes
[ ID] Interval      Transfer      Bitrate      Retr      sender receiver
[ 7] 0.00-8.30 sec  16.0 GBytes  16.6 Gbits/sec  38
[ 7] 0.00-8.30 sec  16.0 GBytes  16.5 Gbits/sec
iperf3 Done.
```

Рис. 5: Передача использовать опцию -n

Интерактивные эксперименты



The screenshot shows a terminal window with the following content:

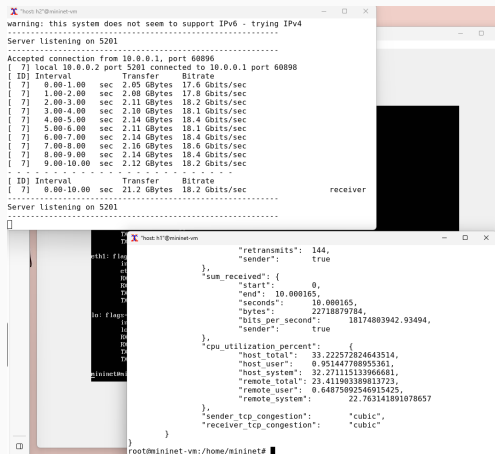
```
root@mininet-vn: /home/mininet# iperf3 -c 10.0.0.2 -u
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 34608
[ ID] Interval      Transfer      Bitrate      Jitter      Lost/Totl  Datar
rams
[ 7] 0.00-1.00 sec   129 KBytes    1.05 Mbits/sec  0.035 ms    0/91 (0%)
[ 7] 1.00-2.00 sec   127 KBytes    1.04 Mbits/sec  0.049 ms    0/90 (0%)
[ 7] 2.00-3.00 sec   129 KBytes    1.05 Mbits/sec  0.052 ms    0/91 (0%)
[ 7] 3.00-4.00 sec   127 KBytes    1.04 Mbits/sec  0.031 ms    0/90 (0%)
[ 7] 4.00-5.00 sec   129 KBytes    1.05 Mbits/sec  0.053 ms    0/91 (0%)
[ 7] 5.00-6.00 sec   127 KBytes    1.04 Mbits/sec  0.057 ms    0/90 (0%)
[ 7] 6.00-7.00 sec   129 KBytes    1.05 Mbits/sec  0.038 ms    0/91 (0%)
[ 7] 7.00-8.00 sec   127 KBytes    1.04 Mbits/sec  0.050 ms    0/90 (0%)
[ 7] 8.00-9.00 sec   129 KBytes    1.05 Mbits/sec  0.029 ms    0/91 (0%)
[ 7] 9.00-10.00 sec  129 KBytes    1.05 Mbits/sec  0.042 ms    0/91 (0%)
[ ID] Interval      Transfer      Bitrate      Jitter      Lost/Totl  Datar
rams
[ 7] 0.00-10.00 sec  1.25 MBytes   1.05 Mbits/sec  0.042 ms    0/906 (0%) rece
iver
Server listening on 5201
```

The terminal window also shows the output of the iperf3 command on the server side:

```
root@mininet-vn: /home/mininet# iperf3 -s -c 10.0.0.2 -u
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 34608 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Jitter      Lost/Totl  Datar
grams
[ 7] 0.00-1.00 sec   129 KBytes    1.05 Mbits/sec  0.035 ms    0/91 (0%)
[ 7] 1.00-2.00 sec   127 KBytes    1.04 Mbits/sec  0.049 ms    0/90 (0%)
[ 7] 2.00-3.00 sec   129 KBytes    1.05 Mbits/sec  0.052 ms    0/91 (0%)
[ 7] 3.00-4.00 sec   127 KBytes    1.04 Mbits/sec  0.031 ms    0/90 (0%)
[ 7] 4.00-5.00 sec   129 KBytes    1.05 Mbits/sec  0.053 ms    0/91 (0%)
[ 7] 5.00-6.00 sec   127 KBytes    1.04 Mbits/sec  0.057 ms    0/90 (0%)
[ 7] 6.00-7.00 sec   129 KBytes    1.05 Mbits/sec  0.038 ms    0/91 (0%)
[ 7] 7.00-8.00 sec   127 KBytes    1.04 Mbits/sec  0.050 ms    0/90 (0%)
[ 7] 8.00-9.00 sec   129 KBytes    1.05 Mbits/sec  0.029 ms    0/91 (0%)
[ 7] 9.00-10.00 sec  129 KBytes    1.05 Mbits/sec  0.042 ms    0/91 (0%)
[ ID] Interval      Transfer      Bitrate      Jitter      Lost/Totl  Datar
grams
[ 7] 0.00-10.00 sec  1.25 MBytes   1.05 Mbits/sec  0.042 ms    0/906 (0%) send
er
[ 7] 0.00-10.00 sec  1.25 MBytes   1.05 Mbits/sec  0.042 ms    0/906 (0%) rece
iver
iperf Done.
```

Рис. 6: Передача по протоколу UDP

Интерактивные эксперименты



The image shows a terminal window with two overlapping windows. The top window displays network performance metrics for a connection between 10.0.0.1 and 10.0.0.2. The bottom window displays system statistics, including CPU utilization, memory usage, and network congestion parameters.

```
root@ht@mininet-vn
warning: this system does not seem to support IPv6 - trying IPv4
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 60896
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60896
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-1.00 sec  2.05 GBytes  17.6 Gbits/sec
[ 7] 1.00-2.00 sec  2.08 GBytes  17.8 Gbits/sec
[ 7] 2.00-3.00 sec  2.11 GBytes  18.2 Gbits/sec
[ 7] 3.00-4.00 sec  2.10 GBytes  18.1 Gbits/sec
[ 7] 4.00-5.00 sec  2.14 GBytes  18.4 Gbits/sec
[ 7] 5.00-6.00 sec  2.11 GBytes  18.1 Gbits/sec
[ 7] 6.00-7.00 sec  2.14 GBytes  18.4 Gbits/sec
[ 7] 7.00-8.00 sec  2.16 GBytes  18.6 Gbits/sec
[ 7] 8.00-9.00 sec  2.14 GBytes  18.4 Gbits/sec
[ 7] 9.00-10.00 sec 2.12 GBytes  18.2 Gbits/sec
-----
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-10.00 sec 21.2 GBytes  18.2 Gbits/sec
-----
Server listening on 5201
-----

eth1: flag
...
root@mininet-vn: /home/mininet#
```

```

    "retransmits": 144,
    "sender": true
  },
  "sum_received": {
    "start": 0,
    "end": 10.000165,
    "seconds": 10.000165,
    "bytes": 22718879784,
    "bits_per_second": 18174803942.93494,
    "sender": true
  },
  "cpu_utilization_percent": {
    "host_total": 33.222572024643514,
    "host_user": 0.951447788955361,
    "host_system": 32.27115133966681,
    "remote_total": 23.411903389813723,
    "remote_user": 0.64875092546915425,
    "remote_system": 22.763141891078657
  },
  "sender_tcp_congestion": "cubic",
  "receiver_tcp_congestion": "cubic"
}
root@mininet-vn: /home/mininet#
```

Рис. 7: Параметр -J

Визуализация результатов эксперимента

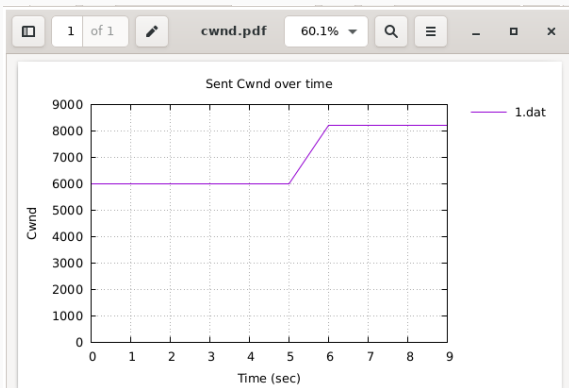


Рис. 8: Окно перегрузки

Визуализация результатов эксперимента

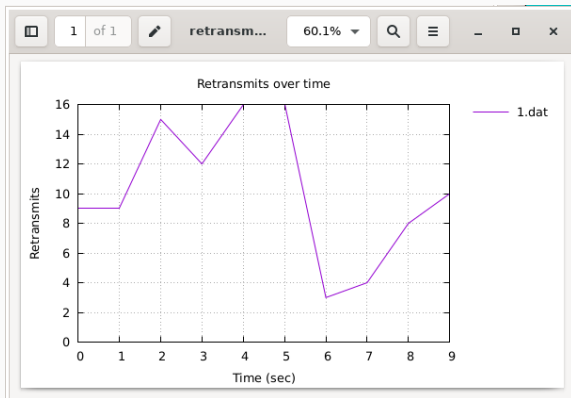


Рис. 9: Повторная передача

Визуализация результатов эксперимента

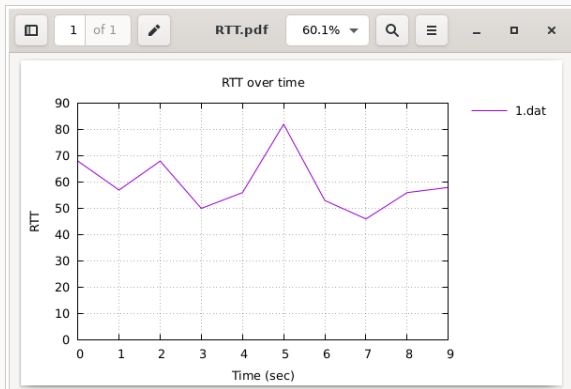


Рис. 10: Время приема-передачи

Визуализация результатов эксперимента

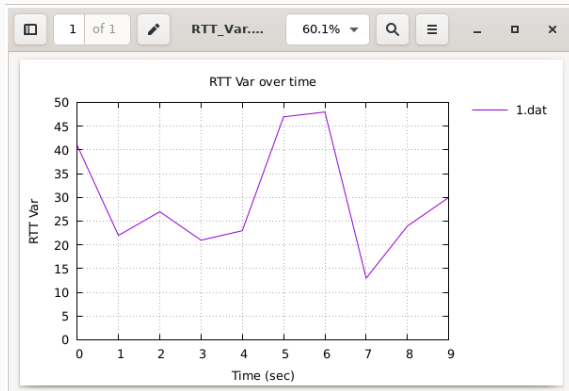


Рис. 11: Отклонение времени приема-передачи

Визуализация результатов эксперимента

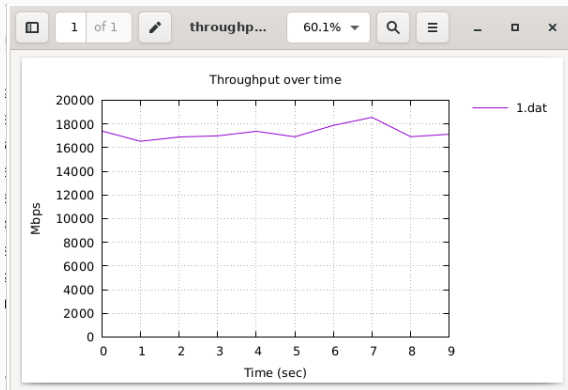


Рис. 12: Пропускная способность

Визуализация результатов эксперимента

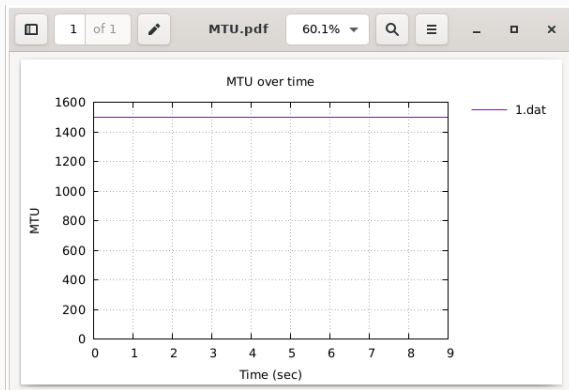


Рис. 13: Максимальная единица передачи

Визуализация результатов эксперимента

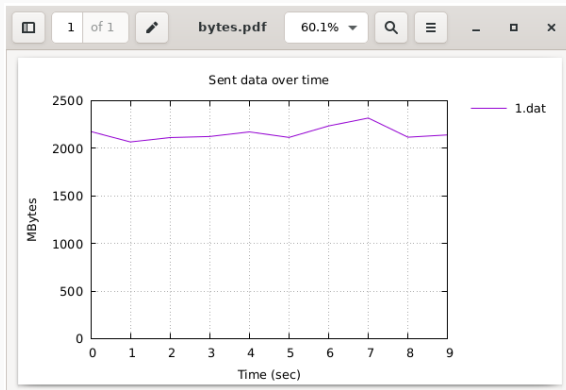


Рис. 14: Количество переданных байтов

Выводы по проделанной работе

Я познакомилась с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получение навыков проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.