

# Измерение и тестирование пропускной способности сети.

## Интерактивный эксперимент

### Лабораторная работа № 2

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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.

## Выполнение лабораторной работы

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## Установка необходимого программного обеспечения

```
mininet@mininet-vm:~$ sudo dhclient eth1
RTNETLINK answers: File exists
mininet@mininet-vm:~$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.56.113 netmask 255.255.255.0 broadcast 192.168.56.255
    ether 08:00:27:1e:4c:7d txqueuelen 1000 (Ethernet)
    RX packets 141 bytes 14736 (14.7 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 122 bytes 17041 (17.0 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
    ether 08:00:27:e1:f7:c5 txqueuelen 1000 (Ethernet)
    RX packets 254 bytes 38089 (38.0 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 259 bytes 24443 (24.4 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    loop txqueuelen 1000 (Local Loopback)
    RX packets 271 bytes 29046 (29.0 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 271 bytes 29046 (29.0 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet@mininet-vm:~$
```

Рис. 1: активирование адреса NAT

## Установка необходимого программного обеспечения

```
mininet@mininet-vm:~$ sudo apt-get update
Hit:1 http://us.archive.ubuntu.com/ubuntu focal InRelease
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [128 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease [128 kB]
Get:4 http://security.ubuntu.com/ubuntu focal-security InRelease [128 kB]
Fetched 383 kB in 10s (36.7 kB/s)
Reading package lists... Done
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 libsctp1
Suggested packages:
  libsctp-tools
The following NEW packages will be installed:
  iperf3 libiperf0 libsctp1
0 upgraded, 3 newly installed, 0 to remove and 395 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]
```

Рис. 2: установка необходимого программного обеспечения

```
mininet@mininet-vm:~$ cd /tmp
mininet@mininet-vm:/tmp$ git clone https://github.com/ekfoury/iperf3\_plotter.git
Cloning into 'iperf3_plotter'...
remote: Enumerating objects: 74, done.
remote: Total 74 (delta 0), reused 0 (delta 0), pack-reused 74 (from 1)
Unpacking objects: 100% (74/74), 100.09 KiB | 575.00 KiB/s, done.
mininet@mininet-vm:/tmp$ cd /tmp/iperf3_plotter
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo cp plot_* /usr/bin
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo cp *.sh /usr/bin
mininet@mininet-vm:/tmp/iperf3_plotter$ █
```

Рис. 3: развертывание iperf3\_plotter

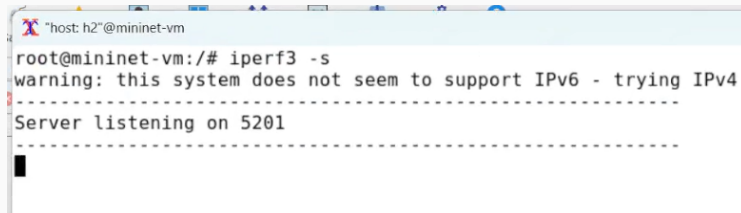


Рис. 4: топология сети

```
mininet> net
h1 h1-eth0:s1-eth1
h2 h2-eth0:s1-eth2
s1 lo: s1-eth1:h1-eth0 s1-eth2:h2-eth0
c0
mininet> links
h1-eth0<->s1-eth1 (OK OK)
h2-eth0<->s1-eth2 (OK OK)
mininet> dump
<Host h1: h1-eth0:10.0.0.1 pid=4672>
<Host h2: h2-eth0:10.0.0.2 pid=4674>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=4679>
<Controller c0: 127.0.0.1:6653 pid=4665>
mininet> █
```

Рис. 5: параметры топологии



A terminal window titled '"host: h2"@mininet-vm' showing the execution of the 'iperf3 -s' command. The output indicates that the system does not support IPv6 and is attempting IPv4, followed by a dashed line and the message 'Server listening on 5201'.

```
"host: h2"@mininet-vm
root@mininet-vm:/# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
█
```

Рис. 6: запуск сервера на на 2 хосте

# Интерактивные эксперименты

```
root@mininet-vm:~# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 37748 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr    Cwnd
[ 7]  0.00-1.00      sec   3.47 GBytes  29.8 Gbits/sec    0    8.34 MBytes
[ 7]  1.00-2.00      sec   3.42 GBytes  29.4 Gbits/sec    0    8.34 MBytes
[ 7]  2.00-3.00      sec   3.33 GBytes  28.6 Gbits/sec    0    8.34 MBytes
[ 7]  3.00-4.00      sec   1.59 GBytes  13.6 Gbits/sec    0    8.34 MBytes
[ 7]  4.00-5.00      sec   1.68 GBytes  14.4 Gbits/sec    0    8.34 MBytes
[ 7]  5.00-6.00      sec   1.62 GBytes  13.9 Gbits/sec    0    8.34 MBytes
[ 7]  6.00-7.00      sec   1.65 GBytes  14.2 Gbits/sec    0    8.34 MBytes
[ 7]  7.00-8.00      sec   1.66 GBytes  14.2 Gbits/sec    0    8.34 MBytes
[ 7]  8.00-9.00      sec   3.41 GBytes  29.3 Gbits/sec    0    8.34 MBytes
[ 7]  9.00-10.00     sec   3.37 GBytes  28.9 Gbits/sec    0    8.34 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-10.00      sec  25.2 GBytes  21.6 Gbits/sec    0
[ 7]  0.00-10.00      sec  25.2 GBytes  21.6 Gbits/sec    0
sender
receiver

iperf Done.
root@mininet-vm:~#
```

Рис. 7: запуск клиента на 1 хосте

```
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 37752 connected to 10.0.0.2 port 5201
[ ID] Interval          Transfer    Bitrate      Retr   Cwnd
[ 5]  0.00-1.00      sec   3.86 GBytes  33.2 Gbits/sec    0   8.36 MBytes
[ 5]  1.00-2.00      sec   3.44 GBytes  29.6 Gbits/sec    0   8.36 MBytes
[ 5]  2.00-3.00      sec   3.29 GBytes  28.3 Gbits/sec    0   8.36 MBytes
[ 5]  3.00-4.00      sec   3.28 GBytes  28.2 Gbits/sec    0   8.36 MBytes
[ 5]  4.00-5.00      sec   3.27 GBytes  28.1 Gbits/sec    0   8.36 MBytes
[ 5]  5.00-6.00      sec   3.30 GBytes  28.3 Gbits/sec    0   8.36 MBytes
[ 5]  6.00-7.00      sec   3.42 GBytes  29.4 Gbits/sec    0   8.36 MBytes
[ 5]  7.00-8.00      sec   3.35 GBytes  28.8 Gbits/sec    0   8.36 MBytes
[ 5]  8.00-9.00      sec   3.43 GBytes  29.5 Gbits/sec    0   8.36 MBytes
[ 5]  9.00-10.00     sec   3.43 GBytes  29.4 Gbits/sec    0   8.36 MBytes
- - - - -
[ ID] Interval          Transfer    Bitrate      Retr
[ 5]  0.00-10.00     sec   34.1 GBytes  29.3 Gbits/sec    0
[ 5]  0.00-10.01     sec   34.1 GBytes  29.2 Gbits/sec
                                     sender
                                     receiver

iperf Done.
```

Рис. 8: запуск сервера и клиента на в интерфейсе mininet

```
mininet> h2 killall iperf3
warning: this system does not seem to support IPv6 - trying IPv4
iperf3: error - unable to start listener for connections: Address already in use
iperf3: exiting
Accepted connection from 10.0.0.1, port 37754
[ 5] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 37756
[ ID] Interval      Transfer    Bitrate
[ 5] 0.00-1.00    sec  4.06 GBytes  34.8 Gbits/sec
[ 5] 1.00-2.00    sec  3.66 GBytes  31.4 Gbits/sec
[ 5] 2.00-3.00    sec  3.41 GBytes  29.4 Gbits/sec
[ 5] 3.00-4.00    sec  3.38 GBytes  29.0 Gbits/sec
[ 5] 4.00-5.00    sec  3.43 GBytes  29.5 Gbits/sec
[ 5] 5.00-6.00    sec  3.43 GBytes  29.5 Gbits/sec
[ 5] 6.00-7.00    sec  3.27 GBytes  28.1 Gbits/sec
[ 5] 7.00-8.00    sec  3.50 GBytes  30.1 Gbits/sec
[ 5] 8.00-9.00    sec  3.31 GBytes  28.4 Gbits/sec
[ 5] 9.00-10.00   sec  3.29 GBytes  28.2 Gbits/sec
[ 5] 10.00-10.00  sec  5.88 MBytes  20.8 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 5] 0.00-10.00   sec  34.7 GBytes  29.8 Gbits/sec
-----
Server listening on 5201
-----
iperf3: interrupt - the server has terminated
mininet> █
```

Рис. 9: остановка серверного процесса

```
root@mininet-vm:/# iperf3 -c 10.0.0.2 -t 5
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 37760 connected to 10.0.0.2 port 5201
[ ID] Interval            Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-1.00      sec   2.47 GBytes  21.2 Gbits/sec    0   8.29 MBytes
[ 7]  1.00-2.00      sec   3.69 GBytes  31.7 Gbits/sec    0   8.29 MBytes
[ 7]  2.00-3.00      sec   3.77 GBytes  32.4 Gbits/sec    0   8.29 MBytes
[ 7]  3.00-4.00      sec   3.40 GBytes  29.2 Gbits/sec    0   8.29 MBytes
[ 7]  4.00-5.00      sec   3.35 GBytes  28.8 Gbits/sec    0   8.29 MBytes
- - - - -
[ ID] Interval            Transfer    Bitrate      Retr
[ 7]  0.00-5.00      sec  16.7 GBytes  28.7 Gbits/sec    0
[ 7]  0.00-5.01      sec  16.7 GBytes  28.6 Gbits/sec    0
                                     sender
                                     receiver

iperf Done.
```

Рис. 10: параметр для указания общего времени передачи

```
root@mininet-vm:/# iperf3 -c 10.0.0.2 -i 2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 37764 connected to 10.0.0.2 port 5201
[ ID] Interval          Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-2.00 sec      7.12 GBytes 30.6 Gbits/sec    9  4.18 MBytes
[ 7]  2.00-4.00 sec      6.95 GBytes 29.8 Gbits/sec    0  4.18 MBytes
[ 7]  4.00-6.00 sec      7.23 GBytes 31.1 Gbits/sec    0  4.19 MBytes
[ 7]  6.00-8.00 sec      7.34 GBytes 31.5 Gbits/sec    0  4.20 MBytes
[ 7]  8.00-10.00 sec     7.33 GBytes 31.5 Gbits/sec    0  4.21 MBytes
- - - - -
[ ID] Interval          Transfer    Bitrate      Retr
[ 7]  0.00-10.00 sec    36.0 GBytes 30.9 Gbits/sec    9
[ 7]  0.00-10.01 sec    36.0 GBytes 30.9 Gbits/sec
iperf Done.
root@mininet-vm:/#
```

Рис. 11: настройка интервала пропускной способности

```
root@mininet-vm:/# iperf3 -c 10.0.0.2 -n 16G
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 37768 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00    sec   3.21 GBytes  27.6 Gbits/sec    0   8.11 MBytes
[ 7]  1.00-2.00    sec   3.17 GBytes  27.3 Gbits/sec    0   8.11 MBytes
[ 7]  2.00-3.00    sec   3.28 GBytes  28.1 Gbits/sec    0   8.11 MBytes
[ 7]  3.00-4.00    sec   3.29 GBytes  28.3 Gbits/sec    0   8.11 MBytes
[ 7]  4.00-4.92    sec   3.05 GBytes  28.4 Gbits/sec    0   8.11 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-4.92    sec  16.0 GBytes  27.9 Gbits/sec    0
[ 7]  0.00-4.92    sec  16.0 GBytes  27.9 Gbits/sec
                                     sender
                                     receiver

iperf Done.
root@mininet-vm:/#
```

Рис. 12: параметр, определяющий объем передаваемых данных

```
host: h1"@mininet-vm
root@mininet-vm:/# iperf3 -c 10.0.0.2 -u
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 43329 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer    Bitrate        Total Datagrams
[ 7] 0.00-1.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 1.00-2.00 sec      127 KBytes  1.04 Mbits/sec  90
[ 7] 2.00-3.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 3.00-4.00 sec      127 KBytes  1.04 Mbits/sec  90
[ 7] 4.00-5.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 5.00-6.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 6.00-7.00 sec      127 KBytes  1.04 Mbits/sec  90
[ 7] 7.00-8.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 8.00-9.00 sec      127 KBytes  1.04 Mbits/sec  90
[ 7] 9.00-10.00 sec     129 KBytes  1.05 Mbits/sec  91
- - - - -
[ ID] Interval           Transfer    Bitrate        Jitter    Lost/Total Datagrams
[ 7] 0.00-10.00 sec     1.25 MBytes  1.05 Mbits/sec  0.000 ms  0/906 (0%) sender
[ 7] 0.00-10.00 sec     1.25 MBytes  1.05 Mbits/sec  0.029 ms  0/906 (0%) receiver
iperf Done.
root@mininet-vm:/#
```

Рис. 13: задание протокола для запуска клиента



```
root@mininet-vm:/# iperf3 -c 10.0.0.2 -p 3250
Connecting to host 10.0.0.2, port 3250
[ 7] local 10.0.0.1 port 32828 connected to 10.0.0.2 port 3250
[ ID] Interval            Transfer        Bitrate         Retr  Cwnd
[ 7]  0.00-1.00      sec   3.35 GBytes    28.6 Gbits/sec     0   8.23 MBytes
[ 7]  1.00-2.00      sec   3.17 GBytes    27.3 Gbits/sec     0   8.23 MBytes
[ 7]  2.00-3.00      sec   3.35 GBytes    28.8 Gbits/sec     0   8.23 MBytes
[ 7]  3.00-4.00      sec   3.17 GBytes    27.1 Gbits/sec     0   8.23 MBytes
[ 7]  4.00-5.00      sec   3.22 GBytes    27.7 Gbits/sec     0   8.23 MBytes
[ 7]  5.00-6.00      sec   3.28 GBytes    28.2 Gbits/sec     0   8.23 MBytes
[ 7]  6.00-7.00      sec   3.32 GBytes    28.5 Gbits/sec     0   8.23 MBytes
[ 7]  7.00-8.00      sec   3.36 GBytes    28.9 Gbits/sec     0   8.23 MBytes
[ 7]  8.00-9.00      sec   3.40 GBytes    29.2 Gbits/sec     0   8.23 MBytes
[ 7]  9.00-10.00     sec   3.59 GBytes    30.8 Gbits/sec     0   8.23 MBytes
- - - - -
[ ID] Interval            Transfer        Bitrate         Retr
[ 7]  0.00-10.00     sec   33.2 GBytes    28.5 Gbits/sec     0
[ 7]  0.00-10.00     sec   33.2 GBytes    28.5 Gbits/sec
                                     sender
                                     receiver

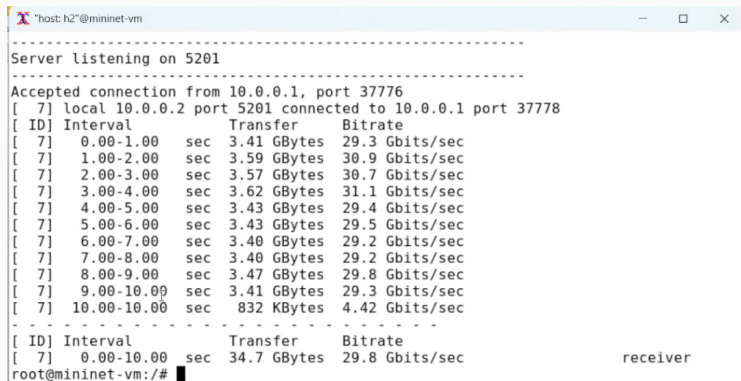
iperf Done.
root@mininet-vm:/#
```

Рис. 14: запуск клиента и сервера с изменением прослушиваемого порта

# Интерактивные эксперименты

```
host: h1" @mininet-vm
[ 7] 0.00-10.00 sec 33.2 GBytes 28.5 Gbits/sec receiver
iperf Done.
root@mininet-vm: /# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 37778 connected to 10.0.0.2 port 5201
[ ID] Interval Transfer Bitrate Retr Cwnd
[ 7] 0.00-1.00 sec 3.42 GBytes 29.3 Gbits/sec 10 4.17 MBytes
[ 7] 1.00-2.00 sec 3.58 GBytes 30.8 Gbits/sec 0 4.18 MBytes
[ 7] 2.00-3.00 sec 3.57 GBytes 30.7 Gbits/sec 0 4.18 MBytes
[ 7] 3.00-4.00 sec 3.62 GBytes 31.1 Gbits/sec 0 4.19 MBytes
[ 7] 4.00-5.00 sec 3.43 GBytes 29.4 Gbits/sec 0 4.19 MBytes
[ 7] 5.00-6.00 sec 3.44 GBytes 29.5 Gbits/sec 0 4.19 MBytes
[ 7] 6.00-7.00 sec 3.40 GBytes 29.2 Gbits/sec 0 4.20 MBytes
[ 7] 7.00-8.00 sec 3.40 GBytes 29.2 Gbits/sec 0 4.20 MBytes
[ 7] 8.00-9.00 sec 3.48 GBytes 29.9 Gbits/sec 0 4.21 MBytes
[ 7] 9.00-10.00 sec 3.40 GBytes 29.2 Gbits/sec 0 4.21 MBytes
- - - - -
[ ID] Interval Transfer Bitrate Retr
[ 7] 0.00-10.00 sec 34.7 GBytes 29.8 Gbits/sec 10 sender
[ 7] 0.00-10.00 sec 34.7 GBytes 29.8 Gbits/sec receiver
iperf Done.
root@mininet-vm: /#
```

Рис. 15: параметр обработки данных только от одного клиента с остановкой сервера по завершении теста



The screenshot shows a terminal window titled "host: h2"@mininet-vm. The output of a command is as follows:

```
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 37776
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 37778
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-1.00    sec  3.41 GBytes 29.3 Gbits/sec
[ 7]  1.00-2.00    sec  3.59 GBytes 30.9 Gbits/sec
[ 7]  2.00-3.00    sec  3.57 GBytes 30.7 Gbits/sec
[ 7]  3.00-4.00    sec  3.62 GBytes 31.1 Gbits/sec
[ 7]  4.00-5.00    sec  3.43 GBytes 29.4 Gbits/sec
[ 7]  5.00-6.00    sec  3.43 GBytes 29.5 Gbits/sec
[ 7]  6.00-7.00    sec  3.40 GBytes 29.2 Gbits/sec
[ 7]  7.00-8.00    sec  3.40 GBytes 29.2 Gbits/sec
[ 7]  8.00-9.00    sec  3.47 GBytes 29.8 Gbits/sec
[ 7]  9.00-10.00   sec  3.41 GBytes 29.3 Gbits/sec
[ 7] 10.00-10.00   sec    832 KBytes 4.42 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-10.00   sec  34.7 GBytes 29.8 Gbits/sec
root@mininet-vm:/#
```

The word "receiver" is printed on the right side of the terminal window.

Рис. 16: завершение теста на сервере

```
root@mininet-vm:/# iperf3 -c 10.0.0.2 -J
{
  "start": {
    "connected": [{
      "socket": 7,
      "local_host": "10.0.0.1",
      "local_port": 37782,
      "remote_host": "10.0.0.2",
      "remote_port": 5201
    }],
    "version": "iperf 3.7",
    "system_info": "Linux mininet-vm 5.4.0-42-generic #46-Ubuntu SMP Fri Jul 10 00:24:02 UTC 2020 x86_64",
    "timestamp": {
      "time": "Mon, 15 Sep 2025 17:49:55 GMT",
      "timesecs": 1757958595
    }
  }
}
```

Рис. 17: параметр для отображения вывода результатов в формате JSON

```
root@mininet-vm:/# iperf3 -c 10.0.0.2 -J > /home/mininet/work/lab_iperf3/iperf_
result.json
root@mininet-vm:/# █
```

Рис. 18: экспортирование вывода результатов теста в файл

```
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 root root 7791 Sep 15 10:52 iperf_result.json
mininet@mininet-vm:~/work/lab_iperf3$
```

Рис. 19: просмотр файла на наличие

```
mininet@mininet-vm:~$ cd ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 root root 7791 Sep 15 10:52 iperf_result.json
mininet@mininet-vm:~/work/lab_iperf3$ sudo chown -R mininet:mininet ~/work
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 mininet mininet 7791 Sep 15 10:52 iperf_result.json
mininet@mininet-vm:~/work/lab_iperf3$ plot_iperf.sh iperf3_results.json
Error: iperf3_results.json is not a file. Quitting...
mininet@mininet-vm:~/work/lab_iperf3$ plot_iperf.sh iperf_result.json
mininet@mininet-vm:~/work/lab_iperf3$
```

Рис. 20: генерация выходных файлов

Этот компьютер > Windows (C:) > Пользователи > airan > sim-net > lab\_iperf3 > results

Имя				Дата изменения		Тип		Размер	
1.dat				15.09.2025	21:22	Файл "DAT"		1	КБ
bytes				15.09.2025	21:22	Microsoft Edge PD...		10	КБ
cwnd				15.09.2025	21:22	Microsoft Edge PD...		10	КБ
MTU				15.09.2025	21:22	Microsoft Edge PD...		9	КБ
retransmits				15.09.2025	21:22	Microsoft Edge PD...		9	КБ
RTT				15.09.2025	21:22	Microsoft Edge PD...		9	КБ
RTT_Var				15.09.2025	21:22	Microsoft Edge PD...		9	КБ
throughput				15.09.2025	21:22	Microsoft Edge PD...		10	КБ

Рис. 21: выходные файлы



## Выводы

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В результате выполнения лабораторной работы было проведено 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