

## **Лабораторная работа №2**

Моделирование сетей передачи данных

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# Докладчик

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## Цель работы

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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

```
Mininet-VM [Работает] - Oracle VM VirtualBox
Файл Машина Вид Ввод Устройства Справка
Ubuntu 20.04.1 LTS mininet-vm tty1

mininet-vm login:
Password:
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-42-generic x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage

Last login: Tue Sep  9 08:15:43 PDT 2025 from 192.168.56.1 on pts/1
mininet@mininet-vm:~$ ifconfig
eth0: flags=4169<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 192.168.56.102 netmask 255.255.255.0 broadcast 192.168.56.255
              ether 08:00:27:06:0f:9f txqueuelen 1000 (Ethernet)
            RX packets 3 bytes 1240 (1.2 KB)
            RX errors 0 dropped 0 overruns 0 frame 0
            TX packets 2 bytes 684 (684.0 B)
            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 08:00:27:76:68:42 txqueuelen 1000 (Ethernet)
            RX packets 159 bytes 26094 (26.0 KB)
            RX errors 0 dropped 0 overruns 0 frame 0
            TX packets 164 bytes 15521 (15.5 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 28 bytes 2912 (2.9 KB)
      RX errors 0 dropped 0 overruns 0 frame 0
      TX packets 28 bytes 2912 (2.9 KB)
      TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet@mininet-vm:~$ _
```

```
mininet@mininet-vm:~$ cd /tmp
mininet@mininet-vm:/tmp$ git clone https://github.com/ekfouri/iperf3_plotter.git
Cloning into 'iperf3_plotter'...
^C
mininet@mininet-vm:/tmp$ git clone https://github.com/ekfouri/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 | 146.00 KiB/s, done.
mininet@mininet-vm:/tmp$ cd 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$ cd ~
mininet@mininet-vm:~$ sudo mn
```

**Рисунок 2:** Развёртывание iperf3\_plotter

```
mininet@mininet-vm:~$ sudo mn --topo=single,2 -x
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Running terms on localhost:10.0
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
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=732>
<Host h2: h2-eth0:10.0.0.2 pid=736>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=741>
<Controller c0: 127.0.0.1:6653 pid=725>
mininet>
```

**Рисунок 3:** Задание простейшей топологии. Параметры

```

X "host: h2"@mininet-vm
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 56970
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 56972
[ ID] Interval Transfer Bitrate
[ 7] 0.00-1.00 sec 2.15 GBytes 18.5 Gbytes/sec
[ 7] 1.00-2.00 sec 2.19 GBytes 18.8 Gbytes/sec
[ 7] 2.00-3.00 sec 2.16 GBytes 18.6 Gbytes/sec
[ 7] 3.00-4.00 sec 2.20 GBytes 18.9 Gbytes/sec
[ 7] 4.00-5.00 sec 2.15 GBytes 18.5 Gbytes/sec
[ 7] 5.00-6.00 sec 2.15 GBytes 18.4 Gbytes/sec
[ 7] 6.00-7.00 sec 2.13 GBytes 18.3 Gbytes/sec
[ 7] 7.00-8.00 sec 2.11 GBytes 18.1 Gbytes/sec
[ 7] 8.00-9.00 sec 2.13 GBytes 18.3 Gbytes/sec
[ 7] 9.00-10.00 sec 1.90 GBytes 16.3 Gbytes/sec
[ 7] 10.00-10.00 sec 4.25 MBytes 9.96 Gbytes/sec
-----
[ ID] Interval Transfer Bitrate
[ 7] 0.00-10.00 sec 21.3 GBytes 18.3 Gbytes/sec
----- receiver
-----
Server listening on 5201
X "host: h1"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 56972 connected to 10.0.0.2 port 5201
[ ID] Interval Transfer Bitrate Retr Cwnd
[ 7] 0.00-1.00 sec 2.15 GBytes 18.5 Gbytes/sec 0 461 KBytes
[ 7] 1.00-2.00 sec 2.19 GBytes 18.9 Gbytes/sec 0 533 KBytes
[ 7] 2.00-3.00 sec 2.16 GBytes 18.6 Gbytes/sec 0 588 KBytes
[ 7] 3.00-4.00 sec 2.20 GBytes 18.9 Gbytes/sec 0 1.19 MBytes
[ 7] 4.00-5.00 sec 2.14 GBytes 18.4 Gbytes/sec 0 2.14 MBytes
[ 7] 5.00-6.00 sec 2.14 GBytes 18.4 Gbytes/sec 0 2.87 MBytes
[ 7] 6.00-7.00 sec 2.13 GBytes 18.3 Gbytes/sec 0 3.33 MBytes
[ 7] 7.00-8.00 sec 2.11 GBytes 18.1 Gbytes/sec 0 3.85 MBytes
[ 7] 8.00-9.00 sec 2.13 GBytes 18.3 Gbytes/sec 0 5.69 MBytes
[ 7] 9.00-10.00 sec 1.89 GBytes 16.3 Gbytes/sec 0 6.27 MBytes
-----
[ ID] Interval Transfer Bitrate Retr
[ 7] 0.00-10.00 sec 21.3 GBytes 18.3 Gbytes/sec 0
----- sender
[ 7] 0.00-10.00 sec 21.3 GBytes 18.3 Gbytes/sec
----- receiver
-----
iperf Done.
root@mininet-vm:/home/mininet# 

```

**Рисунок 4:** Тестовое соединение между хостами

```

<controller> h2 iperf3 -s &
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 56976 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 5]  0.00-1.00   sec  2.09 GBytes  18.0 Gbytes/sec  0   489 KBytes
[ 5]  1.00-2.00   sec  2.15 GBytes  18.5 Gbytes/sec  0   540 KBytes
[ 5]  2.00-3.00   sec  2.08 GBytes  17.9 Gbytes/sec  0   625 KBytes
[ 5]  3.00-4.00   sec  2.14 GBytes  18.4 Gbytes/sec  0   723 KBytes
[ 5]  4.00-5.00   sec  2.14 GBytes  18.4 Gbytes/sec  0   1.33 MBytes
[ 5]  5.00-6.00   sec  2.10 GBytes  18.0 Gbytes/sec  0   1.62 MBytes
[ 5]  6.00-7.00   sec  2.15 GBytes  18.4 Gbytes/sec  0   1.62 MBytes
[ 5]  7.00-8.00   sec  2.15 GBytes  18.4 Gbytes/sec  0   1.87 MBytes
[ 5]  8.00-9.00   sec  1.96 GBytes  16.9 Gbytes/sec  0   2.51 MBytes
[ 5]  9.00-10.00  sec  1.27 GBytes  10.9 Gbytes/sec  0   4.09 MBytes
-----
[ ID] Interval          Transfer     Bitrate      Retr
[ 5]  0.00-10.00  sec  20.2 GBytes  17.4 Gbits/sec  0
[ 5]  0.00-10.00  sec  20.2 GBytes  17.4 Gbits/sec
                                         sender
                                         receiver

iperf Done.
mininet> h2 killall iperf3
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 56974
[ 5] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 56974
[ ID] Interval           Transfer     Bitrate      Retr
[ 5]  0.00-1.00   sec  2.09 GBytes  17.9 Gbytes/sec
[ 5]  1.00-2.00   sec  2.15 GBytes  18.5 Gbytes/sec
[ 5]  2.00-3.00   sec  2.08 GBytes  17.9 Gbytes/sec
[ 5]  3.00-4.00   sec  2.14 GBytes  18.4 Gbytes/sec
[ 5]  4.00-5.00   sec  2.14 GBytes  18.4 Gbytes/sec
[ 5]  5.00-6.00   sec  2.09 GBytes  18.0 Gbytes/sec
[ 5]  6.00-7.00   sec  2.15 GBytes  18.4 Gbytes/sec
[ 5]  7.00-8.00   sec  2.15 GBytes  18.5 Gbytes/sec
[ 5]  8.00-9.00   sec  1.97 GBytes  16.9 Gbytes/sec
[ 5]  9.00-10.00  sec  1.27 GBytes  10.9 Gbytes/sec
[ 5] 10.00-10.00  sec  3.13 MBytes  5.39 Gbytes/sec
-----
[ ID] Interval          Transfer     Bitrate      Retr
[ 5]  0.00-10.00  sec  20.2 GBytes  17.4 Gbits/sec
                                         receiver

Server listening on 5201
-----
iperf3: interrupt - the server has terminated
mininet>

```

Рисунок 5: Эксперимент в интерфейсе mininet

```

root@mininet-vm:/home/mininet# 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 56978
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 56980
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-1.00   sec  2.16 GBytes  18.5 Gbits/sec
[ 7]  1.00-2.00   sec  2.17 GBytes  18.6 Gbits/sec
[ 7]  2.00-3.00   sec  2.17 GBytes  18.7 Gbits/sec
[ 7]  3.00-4.00   sec  2.09 GBytes  17.9 Gbits/sec
[ 7]  4.00-5.00   sec  2.16 GBytes  18.6 Gbits/sec
[ 7]  5.00-5.00   sec  1.31 MBytes  2.73 Gbits/sec
-----
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-5.00   sec 10.8 GBytes  18.5 Gbits/sec
                                         receiver
-----
Server listening on 5201
X "host: h1"@mininet-vm
[ 7]  9.00-10.00  sec  1.89 GBytes  16.3 Gbits/sec    0  6.27 MBytes
-----
[ ID] Interval      Transfer     Bitrate      Retr
[ 7]  0.00-10.00  sec 21.3 GBytes  18.3 Gbits/sec    0
                                         sender
[ 7]  0.00-10.00  sec 21.3 GBytes  18.3 Gbits/sec
                                         receiver

iperf Done.
root@mininet-vm:/home/mininet# ^C
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -t 5
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 56980 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00   sec  2.16 GBytes  18.5 Gbits/sec    0   354 KBytes
[ 7]  1.00-2.00   sec  2.17 GBytes  18.6 Gbits/sec    0   451 KBytes
[ 7]  2.00-3.00   sec  2.17 GBytes  18.7 Gbits/sec    0   451 KBytes
[ 7]  3.00-4.00   sec  2.09 GBytes  17.9 Gbits/sec    0   523 KBytes
[ 7]  4.00-5.00   sec  2.16 GBytes  18.6 Gbits/sec    0   735 KBytes
-----
[ ID] Interval      Transfer     Bitrate      Retr
[ 7]  0.00-5.00   sec 10.8 GBytes  18.5 Gbits/sec    0
                                         sender
[ 7]  0.00-5.00   sec 10.8 GBytes  18.5 Gbits/sec
                                         receiver

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

```

**Рисунок 6:** Указание периода времени передачи

```

root@mininet-vm:/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 56982
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 56984
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-2.00   sec  4.34 GBytes  18.6 Gbits/sec
[ 7]  2.00-4.00   sec  4.06 GBytes  17.4 Gbits/sec
[ 7]  4.00-6.00   sec  3.83 GBytes  16.4 Gbits/sec
[ 7]  6.00-8.00   sec  3.87 GBytes  16.6 Gbits/sec
[ 7]  8.00-10.00  sec  4.27 GBytes  18.3 Gbits/sec
[ 7] 10.00-10.01  sec   768 KBytes  1.05 Gbits/sec
-----
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-10.01  sec  20.4 GBytes  17.5 Gbits/sec
                                         receiver
-----
Server listening on 5201
X "host:h1"@mininet-vm
[ 7]  4.00-5.00   sec  2.16 GBytes  18.6 Gbits/sec  0   735 KBytes
-----
[ ID] Interval      Transfer     Bitrate      Retr
[ 7]  0.00-5.00   sec  10.8 GBytes  18.5 Gbits/sec  0
                                         sender
[ 7]  0.00-5.00   sec  10.8 GBytes  18.5 Gbits/sec
                                         receiver
iperf Done.
root@mininet-vm:/home/mininet# ^C
root@mininet-vm:/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 56984 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-2.00   sec  4.34 GBytes  18.6 Gbits/sec  0   433 KBytes
[ 7]  2.00-4.00   sec  4.06 GBytes  17.4 Gbits/sec  0   433 KBytes
[ 7]  4.00-6.00   sec  3.83 GBytes  16.5 Gbits/sec  0   1.30 MBytes
[ 7]  6.00-8.00   sec  3.87 GBytes  16.6 Gbits/sec  0   2.70 MBytes
[ 7]  8.00-10.00  sec  4.27 GBytes  18.3 Gbits/sec  0   5.09 MBytes
-----
[ ID] Interval      Transfer     Bitrate      Retr
[ 7]  0.00-10.00  sec  20.4 GBytes  17.5 Gbits/sec  0
                                         sender
[ 7]  0.00-10.01  sec  20.4 GBytes  17.5 Gbits/sec
                                         receiver
iperf Done.
root@mininet-vm:/home/mininet# █

```

**Рисунок 7:** Выполнения теста пропускной способности с 2-секундным интервалом

```

root@mininet-vm:/home/mininet# 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 56986
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 56988
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-1.00  sec  2.12 GBytes  18.2 Gbits/sec
[ 7]  1.00-2.00  sec  2.15 GBytes  18.5 Gbits/sec
[ 7]  2.00-3.00  sec  2.14 GBytes  18.4 Gbits/sec
[ 7]  3.00-4.00  sec  2.15 GBytes  18.5 Gbits/sec
[ 7]  4.00-5.00  sec  2.16 GBytes  18.5 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]  7.00-7.51  sec  1.04 GBytes  17.5 Gbits/sec
-----
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-7.51  sec  16.0 GBytes  18.3 Gbits/sec
                                         receiver
-----
Server listening on 5201
X "host: h1" @mininet-vm
- □ ×
[ 7]  0.00-10.00  sec  20.4 GBytes  17.5 Gbits/sec  0
                                         sender
[ 7]  0.00-10.01  sec  20.4 GBytes  17.5 Gbits/sec
                                         receiver
ipperf Done.
root@mininet-vm:/home/mininet# ^C
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -n 16G
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 56988 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer     Bitrate     Retr Cwnd
[ 7]  0.00-1.00  sec  2.12 GBytes  18.2 Gbits/sec  0  723 KBytes
[ 7]  1.00-2.00  sec  2.15 GBytes  18.5 Gbits/sec  0  723 KBytes
[ 7]  2.00-3.00  sec  2.14 GBytes  18.4 Gbits/sec  0  798 KBytes
[ 7]  3.00-4.00  sec  2.15 GBytes  18.4 Gbits/sec  0  798 KBytes
[ 7]  4.00-5.00  sec  2.16 GBytes  18.5 Gbits/sec  0  969 KBytes
[ 7]  5.00-6.00  sec  2.11 GBytes  18.1 Gbits/sec  0  1.40 MBytes
[ 7]  6.00-7.00  sec  2.14 GBytes  18.4 Gbits/sec  0  1.40 MBytes
[ 7]  7.00-7.50  sec  1.03 GBytes  17.6 Gbits/sec  0  1.62 MBytes
-----
[ ID] Interval      Transfer     Bitrate     Retr
[ 7]  0.00-7.50  sec  16.0 GBytes  18.3 Gbits/sec  0
                                         sender
[ 7]  0.00-7.51  sec  16.0 GBytes  18.3 Gbits/sec
                                         receiver
ipperf Done.
root@mininet-vm:/home/mininet# ■

```

**Рисунок 8:** Задание в teste определённого объёма данных

```

X "host: h2"@mininet-vm
-----
Accepted connection from 10.0.0.1, port 56990
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 43393
[ ID] Interval          Transfer     Bitrate      Jitter Lost/Total Datag
rams
[ 7]  0.00-1.00  sec   129 KBytes  1.05 Mbits/sec  0.039 ms  0/91 (0%)
[ 7]  1.00-2.00  sec   127 KBytes  1.04 Mbits/sec  0.025 ms  0/90 (0%)
[ 7]  2.00-3.00  sec   129 KBytes  1.05 Mbits/sec  0.041 ms  0/91 (0%)
[ 7]  3.00-4.00  sec   127 KBytes  1.04 Mbits/sec  0.034 ms  0/90 (0%)
[ 7]  4.00-5.00  sec   129 KBytes  1.05 Mbits/sec  0.039 ms  0/91 (0%)
[ 7]  5.00-6.00  sec   127 KBytes  1.04 Mbits/sec  0.091 ms  0/90 (0%)
[ 7]  6.00-7.00  sec   129 KBytes  1.05 Mbits/sec  0.065 ms  0/91 (0%)
[ 7]  7.00-8.00  sec   127 KBytes  1.04 Mbits/sec  0.063 ms  0/90 (0%)
[ 7]  8.00-9.00  sec   129 KBytes  1.05 Mbits/sec  0.024 ms  0/91 (0%)
[ 7]  9.00-10.00 sec   129 KBytes  1.05 Mbits/sec  0.078 ms  0/91 (0%)
-----
[ ID] Interval          Transfer     Bitrate      Jitter Lost/Total Datag
rams
[ 7]  0.00-10.00 sec   1.25 MBytes  1.05 Mbits/sec  0.078 ms  0/906 (0%) receiver
-----
Server listening on 5201
X "host: h1"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -u
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 43393 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   129 KBytes  1.05 Mbits/sec  91
[ 7]  2.00-3.00  sec   127 KBytes  1.04 Mbits/sec  90
[ 7]  3.00-4.00  sec   129 KBytes  1.05 Mbits/sec  91
[ 7]  4.00-5.00  sec   127 KBytes  1.04 Mbits/sec  90
[ 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 Datag
rams
[ 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  0.078 ms  0/906 (0%) receiver
-----
iperf Done.
root@mininet-vm:/home/mininet# ■

```

**Рисунок 9:** Изменение протокола передачи данных

```

x host: h2@mininet-vm
-----
Server listening on 3250
-----
Accepted connection from 10.0.0.1, port 48726
[ 7] local 10.0.0.2 port 3250 connected to 10.0.0.1 port 48728
[ ID] Interval Transfer Bitrate
[ 7] 0.00-1.00 sec 2.10 GBytes 18.0 Gbits/sec
[ 7] 1.00-2.00 sec 2.11 GBytes 18.1 Gbits/sec
[ 7] 2.00-3.00 sec 2.15 GBytes 18.5 Gbits/sec
[ 7] 3.00-4.00 sec 2.10 GBytes 18.0 Gbits/sec
[ 7] 4.00-5.00 sec 2.12 GBytes 18.2 Gbits/sec
[ 7] 5.00-6.00 sec 2.01 GBytes 17.3 Gbits/sec
[ 7] 6.00-7.00 sec 2.03 GBytes 17.4 Gbits/sec
[ 7] 7.00-8.00 sec 1.37 GBytes 11.7 Gbits/sec
[ 7] 8.00-9.00 sec 1.69 GBytes 14.5 Gbits/sec
[ 7] 9.00-10.00 sec 2.02 GBytes 17.3 Gbits/sec
[ 7] 10.00-10.01 sec 21.9 MBytes 13.8 Gbits/sec
-----
[ ID] Interval Transfer Bitrate
[ 7] 0.00-10.01 sec 19.7 GBytes 16.9 Gbits/sec
----- receiver
-----
Server listening on 3250
x host: h1@mininet-vm
-----
iperf Done.
root@mininet-vm:/home/mininet# ^C
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -p 3250
Connecting to host 10.0.0.2, port 3250
[ 7] local 10.0.0.1 port 48728 connected to 10.0.0.2 port 3250
[ ID] Interval Transfer Bitrate Retr Cwnd
[ 7] 0.00-1.00 sec 2.12 GBytes 18.2 Gbits/sec 0 262 KBytes
[ 7] 1.00-2.00 sec 2.11 GBytes 18.1 Gbits/sec 0 660 KBytes
[ 7] 2.00-3.00 sec 2.15 GBytes 18.5 Gbits/sec 0 660 KBytes
[ 7] 3.00-4.00 sec 2.10 GBytes 18.0 Gbits/sec 0 976 KBytes
[ 7] 4.00-5.00 sec 2.13 GBytes 18.3 Gbits/sec 0 976 KBytes
[ 7] 5.00-6.00 sec 2.01 GBytes 17.3 Gbytes/sec 0 976 KBytes
[ 7] 6.00-7.00 sec 2.03 GBytes 17.4 Gbits/sec 0 976 KBytes
[ 7] 7.00-8.00 sec 1.35 GBytes 11.6 Gbits/sec 0 1.10 MBytes
[ 7] 8.00-9.00 sec 1.70 GBytes 14.6 Gbits/sec 0 1.10 MBytes
[ 7] 9.00-10.00 sec 2.02 GBytes 17.3 Gbits/sec 0 1.48 MBytes
-----
[ ID] Interval Transfer Bitrate Retr
[ 7] 0.00-10.00 sec 19.7 GBytes 16.9 Gbits/sec 0
----- sender
[ 7] 0.00-10.01 sec 19.7 GBytes 16.9 Gbits/sec
----- receiver
-----
iperf Done.
root@mininet-vm:/home/mininet# █

```

**Рисунок 10:** Изменение номера порта для отправки/получения пакетов

```
X "host h2" @mininet-vm
root@mininet-vm:/home/mininet# ^C
root@mininet-vm:/home/mininet# iperf3 -s -l
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 56996
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 56998
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-1.00   sec  2.11 GBytes  18.1 Gbits/sec
[ 7]  1.00-2.00   sec  2.15 GBytes  18.5 Gbits/sec
[ 7]  2.00-3.00   sec  2.12 GBytes  18.2 Gbits/sec
[ 7]  3.00-4.00   sec  2.13 GBytes  18.3 Gbits/sec
[ 7]  4.00-5.00   sec  2.16 GBytes  18.5 Gbits/sec
[ 7]  5.00-6.00   sec  2.19 GBytes  18.8 Gbits/sec
[ 7]  6.00-7.00   sec  2.16 GBytes  18.6 Gbits/sec
[ 7]  7.00-8.00   sec  2.17 GBytes  18.7 Gbits/sec
[ 7]  8.00-9.00   sec  2.15 GBytes  18.5 Gbits/sec
[ 7]  9.00-10.00  sec  2.16 GBytes  18.6 Gbits/sec
[ 7] 10.00-10.00  sec   897 KBytes  1.89 Gbits/sec
-----
[ ID] Interval      Transfer     Bitrate
[ 7]  0.00-10.00  sec  21.5 GBytes  18.5 Gbits/sec
root@mininet-vm:/home/mininet# receiver

iperf Done.
root@mininet-vm:/home/mininet# ^C
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 56998 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer     Bitrate      Retr Cwnd
[ 7]  0.00-1.00   sec  2.11 GBytes  18.1 Gbytes/sec  0  403 KBytes
[ 7]  1.00-2.00   sec  2.15 GBytes  18.5 Gbytes/sec  0  403 KBytes
[ 7]  2.00-3.00   sec  2.12 GBytes  18.2 Gbytes/sec  0  798 KBytes
[ 7]  3.00-4.00   sec  2.13 GBytes  18.3 Gbytes/sec  0  1.21 MBytes
[ 7]  4.00-5.00   sec  2.16 GBytes  18.5 Gbytes/sec  0  1.40 MBytes
[ 7]  5.00-6.00   sec  2.19 GBytes  18.8 Gbytes/sec  0  1.40 MBytes
[ 7]  6.00-7.00   sec  2.16 GBytes  18.6 Gbytes/sec  0  1.87 MBytes
[ 7]  7.00-8.00   sec  2.17 GBytes  18.7 Gbytes/sec  0  2.17 MBytes
[ 7]  8.00-9.00   sec  2.15 GBytes  18.5 Gbytes/sec  0  3.90 MBytes
[ 7]  9.00-10.00  sec  2.16 GBytes  18.6 Gbytes/sec  0  5.22 MBytes
-----
[ ID] Interval      Transfer     Bitrate      Retr
[ 7]  0.00-10.00  sec  21.5 GBytes  18.5 Gbits/sec  0
[ 7]  0.00-10.00  sec  21.5 GBytes  18.5 Gbits/sec
root@mininet-vm:/home/mininet# sender
root@mininet-vm:/home/mininet# receiver

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

**Рисунок 11:** Параметр обработки данных только от одного клиента с остановкой сервера по завершении теста

```

x host: h2@mininet-vm
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 57000
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 57002
[ ID] Interval           Transfer     Bitrate
[ 7]  0.00-1.00   sec  2.14 GBytes  18.4 Gbits/sec
[ 7]  1.00-2.00   sec  2.14 GBytes  18.4 Gbits/sec
[ 7]  2.00-3.00   sec  2.16 GBytes  18.5 Gbits/sec
[ 7]  3.00-4.00   sec  2.12 GBytes  18.2 Gbits/sec
[ 7]  4.00-5.00   sec  2.14 GBytes  18.4 Gbits/sec
[ 7]  5.00-6.00   sec  2.09 GBytes  18.0 Gbits/sec
[ 7]  6.00-7.00   sec  2.20 GBytes  18.9 Gbits/sec
[ 7]  7.00-8.00   sec  2.19 GBytes  18.8 Gbits/sec
[ 7]  8.00-9.00   sec  2.16 GBytes  18.5 Gbits/sec
[ 7]  9.00-10.00  sec  2.13 GBytes  18.3 Gbits/sec
[ 7] 10.00-10.01  sec 10.5 MBytes  10.5 Gbits/sec
-----
[ ID] Interval           Transfer     Bitrate
[ 7]  0.00-10.01  sec 21.5 GBytes  18.4 Gbits/sec
                                         receiver
-----
Server listening on 5201
-----
x host: h1@mininet-vm
-----
{
    "retransmits": 0,
    "sender": true
},
    "sum_received": {
        "start": 0,
        "end": 10.008376,
        "seconds": 10.008376,
        "bytes": 23063203336,
        "bits_per_second": 18435121411.106056,
        "sender": true
},
    "cpu_utilization_percent": {
        "host_total": 60.414236515443129,
        "host_user": 0.94874967035121338,
        "host_system": 59.465486845091917,
        "remote_total": 14.351635565620397,
        "remote_user": 1.7892679702193173,
        "remote_system": 12.562360202755144
},
    "sender_tcp_congestion": "cubic",
    "receiver_tcp_congestion": "cubic"
}
root@mininet-vm:/home/mininet# 

```

**Рисунок 12:** iPerf3 в JSON

```

X "host: h2"@mininet-vm
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 57004
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 57006
[ ID] Interval Transfer Bitrate
[ 7] 0.00-1.00 sec 2.12 GBytes 18.2 Gbits/sec
[ 7] 1.00-2.00 sec 2.11 GBytes 18.1 Gbits/sec
[ 7] 2.00-3.00 sec 2.12 GBytes 18.2 Gbits/sec
[ 7] 3.00-4.00 sec 2.17 GBytes 18.6 Gbits/sec
[ 7] 4.00-5.00 sec 2.18 GBytes 18.8 Gbits/sec
[ 7] 5.00-6.00 sec 2.14 GBytes 18.4 Gbits/sec
[ 7] 6.00-7.00 sec 2.15 GBytes 18.5 Gbits/sec
[ 7] 7.00-8.00 sec 2.16 GBytes 18.6 Gbits/sec
[ 7] 8.00-9.00 sec 2.15 GBytes 18.5 Gbits/sec
[ 7] 9.00-10.00 sec 2.10 GBytes 18.0 Gbits/sec
[ 7] 10.00-10.00 sec 1.19 MBytes 2.11 Gbits/sec
-----
[ ID] Interval Transfer Bitrate
[ 7] 0.00-10.00 sec 21.4 GBytes 18.4 Gbits/sec
----- receiver
-----
Server listening on 5201
-----

X "host: h1"@mininet-vm
-----
},
"sum_received": {
    "start": 0,
    "end": 10.008376,
    "seconds": 10.008376,
    "bytes": 23063203336,
    "bits_per_second": 18435121411.106056,
    "sender": true
},
"cpu_utilization_percent": {
    "host_total": 60.414236515443129,
    "host_user": 0.94874967035121338,
    "host_system": 59.465486845091917,
    "remote_total": 14.351635565620397,
    "remote_user": 1.7892679702193173,
    "remote_system": 12.562360202755144
},
"sender_tcp_congestion": "cubic",
"receiver_tcp_congestion": "cubic"
}
}
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -J > /home/mininet/work/lab_i
perf3/iperf_results.json
|root@mininet-vm:/home/mininet# |

```

**Рисунок 13:** Экспорт результатов теста измерения пропускной способности iPerf3 в файл JSON

```
mkdir -p ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 root root 7796 Sep 24 08:08 iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$ cat iperf_results.json
```

**Рисунок 14:** Проверка создания файла iperf\_results.json

```
iperf3: interrupt - the server has terminated
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 8 terms
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 945.346 seconds
mininet@mininet-vm:~$ cd ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 root root 7796 Sep 24 08:08 iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$ █
```

**Рисунок 15:** Конец эмуляции

```
'  
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 7796 Sep 24 08:08 iperf_results.json  
mininet@mininet-vm:~/work/lab_iperf3$ plot_iperf.sh iperf_results.json  
mininet@mininet-vm:~/work/lab_iperf3$ ls -l  
total 16  
-rw-rw-r-- 1 mininet mininet 958 Sep 24 08:13 iperf.csv  
-rw-r--r-- 1 mininet mininet 7796 Sep 24 08:08 iperf_results.json  
drwxrwxr-x 2 mininet mininet 4096 Sep 24 08:13 results  
mininet@mininet-vm:~/work/lab_iperf3$ cd results  
mininet@mininet-vm:~/work/lab_iperf3/results$ ls -l  
total 88  
-rw-rw-r-- 1 mininet mininet 496 Sep 24 08:13 1.dat  
-rw-rw-r-- 1 mininet mininet 9723 Sep 24 08:13 bytes.pdf  
-rw-rw-r-- 1 mininet mininet 9574 Sep 24 08:13 cwnd.pdf  
-rw-rw-r-- 1 mininet mininet 9036 Sep 24 08:13 MTU.pdf  
-rw-rw-r-- 1 mininet mininet 8978 Sep 24 08:13 retransmits.pdf  
-rw-rw-r-- 1 mininet mininet 8999 Sep 24 08:13 RTT.pdf  
-rw-rw-r-- 1 mininet mininet 9155 Sep 24 08:13 RTT_Var.pdf  
-rw-rw-r-- 1 mininet mininet 9620 Sep 24 08:13 throughput.pdf  
mininet@mininet-vm:~/work/lab_iperf3/results$ █
```

**Рисунок 16:** Визуализация результатов эксперимента

## Выводы

В результате выполнения лабораторной работы я познакомилась с инструментом для измерения пропускной способности сети в режиме реального времени – iPerf3, а также получила навыки проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.