

Лабораторная Работа №2

Измерение и тестирование пропускной способности сети.
Интерактивный эксперимент.

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Выполнение лабораторной работы

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.

Подключился к машине по ssh

```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS C:\Users\vsvld> ssh -Y mininet@192.168.56.101
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

New release '22.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Sat Sep 20 09:06:00 2025 from 192.168.56.1
mininet@mininet-vm:~$ mkdir -p ~/work/lab_iperf3
mininet@mininet-vm:~$ |
```

Figure 1: Подключился к машине по ssh

Посмотрите IP-адреса машины

```
mininet@mininet-vm:~$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.3.15 netmask 255.255.255.0 broadcast 10.0.3.255
    ether 08:00:27:dc:d0:44 txqueuelen 1000 (Ethernet)
    RX packets 392 bytes 46902 (46.9 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 414 bytes 37790 (37.7 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.56.101 netmask 255.255.255.0 broadcast 192.168.56.255
    ether 08:00:27:6f:1e:d6 txqueuelen 1000 (Ethernet)
    RX packets 176 bytes 25940 (25.9 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 139 bytes 23742 (23.7 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 59 bytes 5310 (5.3 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 59 bytes 5310 (5.3 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Figure 2: IP-адреса машины

Устанлвил iperf3

```
mininet@mininet-vm:~$ sudo apt-get update
Hit:1 http://security.ubuntu.com/ubuntu focal-security InRelease
Hit:2 http://us.archive.ubuntu.com/ubuntu focal InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease
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:
  lksctp-tools
The following NEW packages will be installed:
  iperf3 libiperf0 libsctp1
0 upgraded, 3 newly installed, 0 to remove and 381 not upgraded.
```

Figure 3: Установка iperf3

Установил необходимое дополнительное программное обеспечение

```
mininet@mininet-vm:~$ sudo apt-get install git jq gnuplot-nox evince
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  aglfn evince-common fonts-liberation gnuplot-data groff imagemagick imagemagick-6.q16 libdjvulibre-t
  libevdocument3-4 libevview3-3 libgxps2 libilmbase24 libjq1 libkpathsea6 liblua5.3-0 libmagickcore-6.
  libnautilus-extension1a libnetpbm10 libonig5 libopenexr24 libpoppler-glib8 libpoppler97 libspectrel
  netpbm psutils
Suggested packages:
  gvfs nautilus-sendto unrar git-daemon-run | git-daemon-sysvinit git-doc git-el git-email git-gui git
  git-svn gnuplot-doc imagemagick-doc autotrace cups-bsd | lpr | lprng curl enscript ffmpeg gimp grads
  libwmf-bin mplayer povray radiance texlive-base-bin transfig ufw xdg-utils inkscape libjxr-t
The following NEW packages will be installed:
  aglfn evince evince-common fonts-liberation gnuplot-data gnuplot-nox groff imagemagick imagemagick-6
  libdjvulibre21 libevdocument3-4 libevview3-3 libgxps2 libilmbase24 libjq1 libkpathsea6 liblua5.3-0
  libmagickcore-6.q16-6-extra libnautilus-extension1a libnetpbm10 libonig5 libopenexr24 libpoppler-gli
```

Figure 4: Необходимое дополнительное программное обеспечение

Установил iperf3_plotter

```
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 | 520.00 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$
```

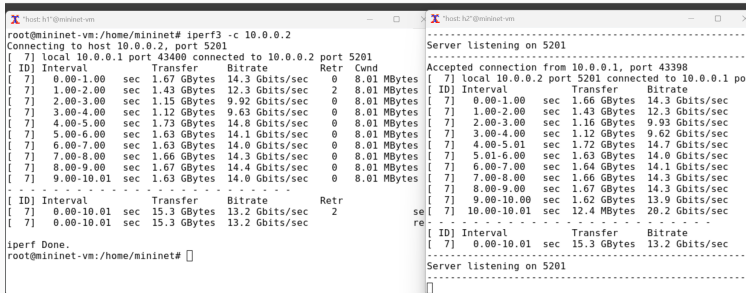
Figure 5: Установка iperf3_plotter

Простейшая топология, состоящая из двух хостов и коммутатора

с назначенной по умолчанию mininet сетью 10.0.0.0/8

```
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
Error starting terms: Cannot connect to display
*** 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=5110>
<Host h2: h2-eth0:10.0.0.2 pid=5111>
<Switch s1: s1-eth1:10.0.0.3 s1-eth2:10.0.0.4 pid=5112>
```

Проведем простейший интерактивный эксперимент по измерению пропускной способности с помощью iPerf3



The image shows two terminal windows side-by-side, illustrating an iPerf3 test. The left window is the client (host: h1) and the right window is the server (host: h2).

Left Window (Client):

```
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 43400 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr  Cwnd
[ 7] 0.00-1.00 sec  1.67 GBytes 14.3 Gbits/sec  0    8.01 MBytes
[ 7] 1.00-2.00 sec  1.43 GBytes 12.3 Gbits/sec  2    8.01 MBytes
[ 7] 2.00-3.00 sec  1.15 GBytes 9.92 Gbits/sec  0    8.01 MBytes
[ 7] 3.00-4.00 sec  1.12 GBytes 9.63 Gbits/sec  0    8.01 MBytes
[ 7] 4.00-5.00 sec  1.73 GBytes 14.8 Gbits/sec  0    8.01 MBytes
[ 7] 5.00-6.00 sec  1.63 GBytes 14.1 Gbits/sec  0    8.01 MBytes
[ 7] 6.00-7.00 sec  1.63 GBytes 14.0 Gbits/sec  0    8.01 MBytes
[ 7] 7.00-8.00 sec  1.66 GBytes 14.3 Gbits/sec  0    8.01 MBytes
[ 7] 8.00-9.00 sec  1.67 GBytes 14.4 Gbits/sec  0    8.01 MBytes
[ 7] 9.00-10.01 sec 1.63 GBytes 14.0 Gbits/sec  0    8.01 MBytes
-----
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-10.01 sec 15.3 GBytes 13.2 Gbits/sec  2
[ 7] 0.00-10.01 sec 15.3 GBytes 13.2 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

Right Window (Server):

```
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 43398
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 po
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  1.66 GBytes 14.3 Gbits/sec
[ 7] 1.00-2.00 sec  1.43 GBytes 12.3 Gbits/sec
[ 7] 2.00-3.00 sec  1.16 GBytes 9.93 Gbits/sec
[ 7] 3.00-4.00 sec  1.12 GBytes 9.62 Gbits/sec
[ 7] 4.00-5.01 sec  1.72 GBytes 14.7 Gbits/sec
[ 7] 5.01-6.00 sec  1.63 GBytes 14.0 Gbits/sec
[ 7] 6.00-7.00 sec  1.64 GBytes 14.1 Gbits/sec
[ 7] 7.00-8.00 sec  1.66 GBytes 14.3 Gbits/sec
[ 7] 8.00-9.00 sec  1.67 GBytes 14.3 Gbits/sec
[ 7] 9.00-10.00 sec 1.62 GBytes 13.9 Gbits/sec
[ 7] 10.00-10.01 sec 12.4 MBytes 20.2 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.01 sec 15.3 GBytes 13.2 Gbits/sec
Server listening on 5201
```

Figure 7: Простейший интерактивный эксперимент

Проанализируем полученный в результате выполнения теста сводный отчёт, отобразившийся как на клиенте, так и на сервере iPerf3. Он содержит следующие данные:

- ID: идентификационный номер соединения – 7.
- интервал (Interval): временной интервал для периодических отчетов о пропускной способности (по умолчанию временной интервал равен 1 секунде);
- передача (Transfer): сколько данных было передано за каждый интервал времени – было передано от 1.98 до 2.39 GB в секунду;
- пропускная способность (Bitrate): измеренная пропускная способность в каждом временном интервале – от 17 до 20.5 Gbit/sec;
- Retr: количество повторно переданных TCP-сегментов за каждый временной интервал (это поле увеличивается, когда TCP-сегменты теряются в сети из-за перегрузки или повреждения); чем больше

Проведем аналогичный эксперимент в интерфейсе mininet

```
mininet> h2 iperf3 -s &
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 43424 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 5]  0.00-1.00    sec  1.52 GBytes  13.0 Gbits/sec    0   8.33 MBytes
[ 5]  1.00-2.00    sec  1.40 GBytes  12.0 Gbits/sec    0   8.33 MBytes
[ 5]  2.00-3.00    sec  1.47 GBytes  12.6 Gbits/sec    0   8.33 MBytes
[ 5]  3.00-4.00    sec  1.47 GBytes  12.6 Gbits/sec    0   8.33 MBytes
[ 5]  4.00-5.00    sec  1.45 GBytes  12.4 Gbits/sec    0   8.33 MBytes
[ 5]  5.00-6.00    sec  1.42 GBytes  12.2 Gbits/sec    0   8.33 MBytes
[ 5]  6.00-7.00    sec  1.42 GBytes  12.3 Gbits/sec    0   8.33 MBytes
[ 5]  7.00-8.00    sec  1.42 GBytes  12.2 Gbits/sec    0   8.33 MBytes
[ 5]  8.00-9.00    sec  1.45 GBytes  12.5 Gbits/sec    0   8.33 MBytes
[ 5]  9.00-10.00   sec  1.22 GBytes  10.5 Gbits/sec    0   8.33 MBytes
- - - - -
[ ID] Interval      Transfer    Bitrate      Retr
[ 5]  0.00-10.00   sec  14.2 GBytes  12.2 Gbits/sec    0
[ 5]  0.00-10.00   sec  14.2 GBytes  12.2 Gbits/sec    0
                                     sender
                                     receiver

iperf Done.
mininet> h2 killall iperf3
```

Figure 8: Аналогичный эксперимент в интерфейсе mininet

Сравним результаты. Увидим, что во втором случае было передано на 4,8 GB больше; пропускная способность увеличилась на 4,1; потери пакетов все также нет.

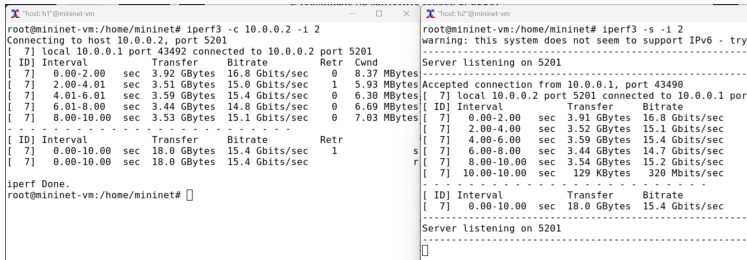
Эксперимент с указанием времени для передачи (по умол 5)

```
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 -
Server listening on 5201
Accepted connection from 10.0.0.1, port 43466
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00    sec 1.59 GBytes 13.5 Gbits/sec
[ 7] 1.00-2.00    sec 1.50 GBytes 13.0 Gbits/sec
[ 7] 2.00-3.00    sec 1.44 GBytes 12.4 Gbits/sec
[ 7] 3.00-4.00    sec 1.50 GBytes 12.9 Gbits/sec
[ 7] 4.00-5.01    sec 1.46 GBytes 12.4 Gbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-5.01    sec 7.50 GBytes 12.9 Gbits/sec
Server listening on 5201
```

```
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 43468 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr    Cwnd
[ 7] 0.00-1.00    sec 1.60 GBytes 13.7 Gbits/sec    0    8.18 MByte
[ 7] 1.00-2.00    sec 1.50 GBytes 12.9 Gbits/sec    0    8.18 MByte
[ 7] 2.00-3.00    sec 1.45 GBytes 12.4 Gbits/sec    0    8.18 MByte
[ 7] 3.00-4.01    sec 1.51 GBytes 12.9 Gbits/sec    0    8.18 MByte
[ 7] 4.01-5.00    sec 1.45 GBytes 12.5 Gbits/sec    0    8.18 MByte
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-5.00    sec 7.50 GBytes 12.9 Gbits/sec    0
[ 7] 0.00-5.01    sec 7.50 GBytes 12.9 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

Figure 9: Указание времени для передачи

Выполнение теста пропускной способности с 2-секундным интервалом времени отсчёта



```
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 43492 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr    Cwnd
[ 7]  0.00-2.00    sec  3.92 GBytes  16.8 Gbits/sec  0      8.37 MBytes
[ 7]  2.00-4.01    sec  3.51 GBytes  15.0 Gbits/sec  1      5.93 MBytes
[ 7]  4.01-6.01    sec  3.59 GBytes  15.4 Gbits/sec  0      6.30 MBytes
[ 7]  6.01-8.00    sec  3.44 GBytes  14.8 Gbits/sec  0      6.69 MBytes
[ 7]  8.00-10.00   sec  3.53 GBytes  15.1 Gbits/sec  0      7.03 MBytes
-----
[ ID] Interval      Transfer    Bitrate      Retr
[ 7]  0.00-10.00   sec  18.0 GBytes  15.4 Gbits/sec  1
[ 7]  0.00-10.00   sec  18.0 GBytes  15.4 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

```
root@mininet-vm:/home/mininet# iperf3 -s -i 2
warning: this system does not seem to support IPv6 - try
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 43490
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 43490
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-2.00    sec  3.91 GBytes  16.8 Gbits/sec
[ 7]  2.00-4.00    sec  3.52 GBytes  15.1 Gbits/sec
[ 7]  4.00-6.00    sec  3.59 GBytes  15.4 Gbits/sec
[ 7]  6.00-8.00    sec  3.44 GBytes  14.7 Gbits/sec
[ 7]  8.00-10.00   sec  3.54 GBytes  15.2 Gbits/sec
[ 7] 10.00-10.00   sec  129 KBytes  320 Mbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-10.00   sec  18.0 GBytes  15.4 Gbits/sec
Server listening on 5201

```

Figure 10: 2-секундный интервал времени отсчёта

Можно увидеть, что действительно интервал увеличился в два раза, в результате чего в два раза увеличился также вес переданный за один интервал времени, но пропускная способность и суммарные величины очевидно практически не изменились.

Задал на клиенте iPerf3 отправку определённого объёма данных

```
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 43518 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr  Cwnd
[ 7] 0.00-1.00 sec  1.74 GBytes 14.9 Gbits/sec  0    8.28 MBytes
[ 7] 1.00-2.00 sec  1.46 GBytes 12.5 Gbits/sec  0    8.28 MBytes
[ 7] 2.00-3.01 sec  1.35 GBytes 11.5 Gbits/sec  1    8.28 MBytes
[ 7] 3.01-4.00 sec  1.59 GBytes 13.8 Gbits/sec  0    8.28 MBytes
[ 7] 4.00-5.00 sec  1.66 GBytes 14.2 Gbits/sec  0    8.28 MBytes
[ 7] 5.00-6.00 sec  1.67 GBytes 14.4 Gbits/sec  0    8.28 MBytes
[ 7] 6.00-7.00 sec  1.63 GBytes 14.0 Gbits/sec  0    8.28 MBytes
[ 7] 7.00-8.00 sec  1.63 GBytes 14.0 Gbits/sec  0    8.28 MBytes
[ 7] 8.00-9.00 sec  1.69 GBytes 14.5 Gbits/sec  0    8.28 MBytes
[ 7] 9.00-9.97 sec  1.57 GBytes 13.9 Gbits/sec  0    8.28 MBytes
-----
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-9.97 sec  16.0 GBytes 13.8 Gbits/sec  1
[ 7] 0.00-9.98 sec  16.0 GBytes 13.8 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

```
host: h2@mininet-vm
warning: this system does not seem to support IPv6 - try
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 43516
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 43516
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  1.74 GBytes 14.9 Gbits/sec
[ 7] 1.00-2.01 sec  1.45 GBytes 12.3 Gbits/sec
[ 7] 2.01-3.00 sec  1.35 GBytes 11.7 Gbits/sec
[ 7] 3.00-4.00 sec  1.59 GBytes 13.6 Gbits/sec
[ 7] 4.00-5.00 sec  1.67 GBytes 14.4 Gbits/sec
[ 7] 5.00-6.00 sec  1.66 GBytes 14.3 Gbits/sec
[ 7] 6.00-7.00 sec  1.64 GBytes 14.1 Gbits/sec
[ 7] 7.00-8.00 sec  1.63 GBytes 14.0 Gbits/sec
[ 7] 8.00-9.00 sec  1.69 GBytes 14.6 Gbits/sec
[ 7] 9.00-9.98 sec  1.56 GBytes 13.7 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-9.98 sec  16.0 GBytes 13.8 Gbits/sec
Server listening on 5201
-----
```

Figure 11: Отправка определённого объёма данных

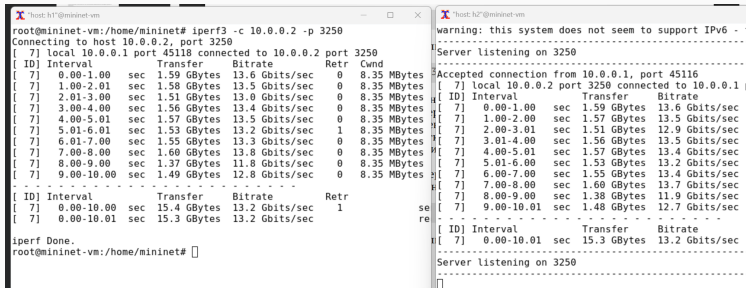
Изменим в тесте протокол передачи данных с TCP на UDP

```
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 44248 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Total
[ 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  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  124 KBytes  1.02 Mbits/sec  88
[ 7] 9.00-10.00 sec 132 KBytes  1.08 Mbits/sec  93
[ ID] Interval      Transfer    Bitrate    Jitter
[ 7] 0.00-10.00 sec 1.25 MBytes  1.05 Mbits/sec  0.000
[ 7] 0.00-10.01 sec 1.25 MBytes  1.05 Mbits/sec  0.115
iperf Done.
root@mininet-vm:/home/mininet#
```

```
Accepted connection from 10.0.0.1, port 43558
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 44248
[ ID] Interval      Transfer    Bitrate    Jitter    Loss
[ 7] 0.00-1.00 sec  127 KBytes  1.04 Mbits/sec  0.022 ms  0%
[ 7] 1.00-2.00 sec  129 KBytes  1.05 Mbits/sec  0.078 ms  0%
[ 7] 2.00-3.00 sec  127 KBytes  1.04 Mbits/sec  0.041 ms  0%
[ 7] 3.00-4.00 sec  129 KBytes  1.05 Mbits/sec  0.023 ms  0%
[ 7] 4.00-5.00 sec  127 KBytes  1.04 Mbits/sec  0.081 ms  0%
[ 7] 5.00-6.00 sec  129 KBytes  1.05 Mbits/sec  0.113 ms  0%
[ 7] 6.00-7.00 sec  127 KBytes  1.04 Mbits/sec  0.066 ms  0%
[ 7] 7.00-8.00 sec  129 KBytes  1.05 Mbits/sec  0.040 ms  0%
[ 7] 8.00-9.01 sec  126 KBytes  1.02 Mbits/sec  0.204 ms  0%
[ 7] 9.01-10.00 sec  130 KBytes  1.08 Mbits/sec  0.119 ms  0%
[ 7] 10.00-10.01 sec 1.41 KBytes  1.16 Mbits/sec  0.115 ms  0%
[ ID] Interval      Transfer    Bitrate    Jitter    Loss
[ 7] 0.00-10.01 sec 1.25 MBytes  1.05 Mbits/sec  0.115 ms  0%
Server listening on 5201
```

Figure 12: Протокол передачи данных

Изменим номер порта для отправки/получения пакетов или датаграмм



```
*host: h1@mininet-vm
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 45118 connected to 10.0.0.2 port 3250
[ ID] Interval      Transfer    Bitrate      Retr    Cwnd
[ 7] 0.00-1.00 sec  1.59 GBytes 13.6 Gbits/sec  0      8.35 MBytes
[ 7] 1.00-2.01 sec  1.58 GBytes 13.5 Gbits/sec  0      8.35 MBytes
[ 7] 2.01-3.00 sec  1.51 GBytes 13.0 Gbits/sec  0      8.35 MBytes
[ 7] 3.00-4.00 sec  1.56 GBytes 13.4 Gbits/sec  0      8.35 MBytes
[ 7] 4.00-5.01 sec  1.57 GBytes 13.5 Gbits/sec  0      8.35 MBytes
[ 7] 5.01-6.01 sec  1.53 GBytes 13.2 Gbits/sec  1      8.35 MBytes
[ 7] 6.01-7.00 sec  1.55 GBytes 13.3 Gbits/sec  0      8.35 MBytes
[ 7] 7.00-8.00 sec  1.60 GBytes 13.8 Gbits/sec  0      8.35 MBytes
[ 7] 8.00-9.00 sec  1.37 GBytes 11.8 Gbits/sec  0      8.35 MBytes
[ 7] 9.00-10.00 sec 1.49 GBytes 12.8 Gbits/sec  0      8.35 MBytes
[ ID] Interval      Transfer    Bitrate      Retr
[ 7] 0.00-10.00 sec 15.4 GBytes 13.2 Gbits/sec  1
[ 7] 0.00-10.01 sec 15.3 GBytes 13.2 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

```
*host: h2@mininet-vm
warning: this system does not seem to support IPv6 - f
Server listening on 3250
Accepted connection from 10.0.0.1, port 45116
[ 7] local 10.0.0.2 port 3250 connected to 10.0.0.1
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  1.59 GBytes 13.6 Gbits/sec
[ 7] 1.00-2.00 sec  1.57 GBytes 13.5 Gbits/sec
[ 7] 2.00-3.01 sec  1.51 GBytes 12.9 Gbits/sec
[ 7] 3.01-4.00 sec  1.56 GBytes 13.5 Gbits/sec
[ 7] 4.00-5.01 sec  1.57 GBytes 13.4 Gbits/sec
[ 7] 5.01-6.00 sec  1.53 GBytes 13.2 Gbits/sec
[ 7] 6.00-7.00 sec  1.55 GBytes 13.4 Gbits/sec
[ 7] 7.00-8.00 sec  1.60 GBytes 13.7 Gbits/sec
[ 7] 8.00-9.00 sec  1.38 GBytes 11.9 Gbits/sec
[ 7] 9.00-10.01 sec 1.48 GBytes 12.7 Gbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.01 sec 15.3 GBytes 13.2 Gbits/sec
Server listening on 3250
```

Figure 13: Номер порта

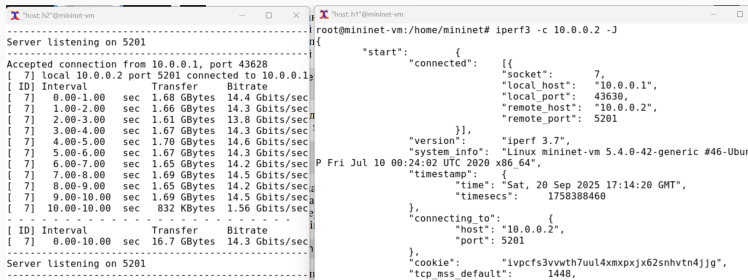
Параметр обработки данных только от одного клиента

```
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 43606 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr    Cwnd
[ 7] 0.00-1.01 sec  1.63 GBytes 13.8 Gbits/sec  0      8.07 MBytes
[ 7] 1.01-2.00 sec  1.46 GBytes 12.7 Gbits/sec  0      8.07 MBytes
[ 7] 2.00-3.00 sec  1.52 GBytes 13.0 Gbits/sec  0      8.07 MBytes
[ 7] 3.00-4.00 sec  1.40 GBytes 12.0 Gbits/sec  0      8.07 MBytes
[ 7] 4.00-5.00 sec  1.62 GBytes 14.0 Gbits/sec  0      8.07 MBytes
[ 7] 5.00-6.00 sec  1.48 GBytes 12.6 Gbits/sec  0      8.07 MBytes
[ 7] 6.00-7.00 sec  1.53 GBytes 13.1 Gbits/sec  0      8.07 MBytes
[ 7] 7.00-8.00 sec  1.53 GBytes 13.2 Gbits/sec  0      8.07 MBytes
[ 7] 8.00-9.00 sec  1.52 GBytes 13.0 Gbits/sec  0      8.07 MBytes
[ 7] 9.00-10.00 sec 1.52 GBytes 13.1 Gbits/sec  0      8.07 MBytes
- - - - -
[ ID] Interval      Transfer    Bitrate      Retr
[ 7] 0.00-10.00 sec 15.2 GBytes 13.1 Gbits/sec  0
[ 7] 0.00-10.01 sec 15.2 GBytes 13.0 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

```
root@mininet-vm:/home/mininet# iperf3 -s -1
warning: this system does not seem to support IPv6 - t
Server listening on 5201
Accepted connection from 10.0.0.1, port 43604
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 p
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.01 sec  1.61 GBytes 13.8 Gbits/sec
[ 7] 1.01-2.00 sec  1.48 GBytes 12.8 Gbits/sec
[ 7] 2.00-3.00 sec  1.52 GBytes 13.0 Gbits/sec
[ 7] 3.00-4.00 sec  1.40 GBytes 12.0 Gbits/sec
[ 7] 4.00-5.01 sec  1.61 GBytes 13.8 Gbits/sec
[ 7] 5.01-6.00 sec  1.49 GBytes 12.9 Gbits/sec
[ 7] 6.00-7.00 sec  1.53 GBytes 13.1 Gbits/sec
[ 7] 7.00-8.00 sec  1.52 GBytes 13.1 Gbits/sec
[ 7] 8.00-9.00 sec  1.52 GBytes 13.1 Gbits/sec
[ 7] 9.00-10.01 sec 1.52 GBytes 12.9 Gbits/sec
- - - - -
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.01 sec 15.2 GBytes 13.0 Gbits/sec
root@mininet-vm:/home/mininet#
```

Figure 14: Параметр обработки данных только от одного клиента

Результат в формате json



```
host: h2@mininet-vm
Server listening on 5201
Accepted connection from 10.0.0.1, port 43628
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-1.00 sec  1.68 GBytes 14.4 Gbits/sec
[ 7]  1.00-2.00 sec  1.66 GBytes 14.3 Gbits/sec
[ 7]  2.00-3.00 sec  1.61 GBytes 13.8 Gbits/sec
[ 7]  3.00-4.00 sec  1.67 GBytes 14.3 Gbits/sec
[ 7]  4.00-5.00 sec  1.70 GBytes 14.6 Gbits/sec
[ 7]  5.00-6.00 sec  1.67 GBytes 14.3 Gbits/sec
[ 7]  6.00-7.00 sec  1.65 GBytes 14.2 Gbits/sec
[ 7]  7.00-8.00 sec  1.69 GBytes 14.5 Gbits/sec
[ 7]  8.00-9.00 sec  1.65 GBytes 14.2 Gbits/sec
[ 7]  9.00-10.00 sec 1.69 GBytes 14.5 Gbits/sec
[ 7] 10.00-10.00 sec 832 KBytes  1.56 Gbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-10.00 sec 16.7 GBytes 14.3 Gbits/sec
Server listening on 5201

host: h1@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -J
{
  "start": {
    "connected": [
      {
        "socket": 7,
        "local_host": "10.0.0.1",
        "local_port": 43630,
        "remote_host": "10.0.0.2",
        "remote_port": 5201
      }
    ],
    "version": "iperf 3.7",
    "system info": "Linux mininet-vm 5.4.0-42-generic #46-Ubu
P Fri Jul 10 00:24:02 UTC 2020 x86_64",
    "timestamp": {
      "time": "Sat, 20 Sep 2025 17:14:20 GMT",
      "timesecs": 1758388460
    },
    "connecting to": {
      "host": "10.0.0.2",
      "port": 5201
    },
    "cookie": "ivpcfs3vvwth7uul4xmmpxjx62snhvt4jjg",
    "tcp_mss_default": 1448,
  }
}
```

Figure 15: Результат в формате json

Сохраним результат в виде json

```
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# cd /home/mininet/work/lab_iperf3  
root@mininet-vm:/home/mininet/work/lab_iperf3# ls -l  
total 8  
-rw-r--r-- 1 root root 7796 Sep 20 10:17 iperf_results.json  
root@mininet-vm:/home/mininet/work/lab_iperf3#
```

Figure 16: Сохранение результата в виде json

Сгенерировал выходные данные для файла JSON iPerf3

```
mininet@mininet-vm:~/work/lab_iperf3$ plot_iperf.sh iperf_results.json  
mininet@mininet-vm:~/work/lab_iperf3$  
mininet@mininet-vm:~/work/lab_iperf3$
```

Figure 17: Генерация выходных данных

Просмотр сгенерированных файлов

```
mininet@mininet-vm:~/work/lab_iperf3$ cd results
mininet@mininet-vm:~/work/lab_iperf3/results$ ls
l.dat      cwnd.pdf  retransmits.pdf  RTT_Var.pdf
bytes.pdf  MTU.pdf   RTT.pdf          throughput.pdf
```

Figure 18: Просмотр сгенерированных файлов

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