

Лабораторная работа №2

Моделирование сетей передачи данных

Хрусталеv В.Н.

Российский университет дружбы народов, Москва, Россия

Информация

- Хрусталев Влад Николаевич
- студент
- Российский университет дружбы народов
- 1132222011@pfur.ru

Цель 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.

Выполнение лабораторной работы

Активация и подключение по ssh к mininet

```
mininet@mininet-vm:~$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.56.105 netmask 255.255.255.0 broadcast 192.168.56.255
    ether 08:00:27:e8:34:b9 txqueuelen 1000 (Ethernet)
    RX packets 8313 bytes 1376282 (1.3 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 8176 bytes 2152032 (2.1 MB)
    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:d0:e5:b3 txqueuelen 1000 (Ethernet)
    RX packets 1061 bytes 200137 (200.1 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 1042 bytes 90447 (90.4 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 16721 bytes 2776380 (2.7 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 16721 bytes 2776380 (2.7 MB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Рис. 1: Активация и подключение по ssh к mininet

```
mininet@mininet-vm:~$ sudo apt-get update
Hit:1 http://us.archive.ubuntu.com/ubuntu focal InRelease
Hit:2 http://security.ubuntu.com/ubuntu focal-security InRelease
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [128 kB]
Hit:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease
Fetched 128 kB in 2s (80.6 kB/s)
Reading package lists... Done
```

Рис. 2: Проверка обновлений ПО


```
mininet@mininet-vm:~$ sudo apt-get install iperf3
Reading package lists... Done
Reading package lists... Done
Building dependency tree
Reading state information... Done
iperf3 is already the newest version (3.7-3).
0 upgraded, 0 newly installed, 0 to remove and 394 not upgraded.
```

Рис. 3: Установка iperf3

```
mininet@mininet-vm:~$ sudo apt-get install git jq gnuplot-nox evince
Reading package lists... Done
Building dependency tree
Reading state information... Done
gnuplot-nox is already the newest version (5.2.8+dfsg1-2).
evince is already the newest version (3.36.10-0ubuntu1).
git is already the newest version (1:2.25.1-lubuntu3.14).
jq is already the newest version (1.6-lubuntu0.20.04.1).
0 upgraded, 0 newly installed, 0 to remove and 394 not upgraded.
```

Рис. 4: Установка необходимого ПО

Развертывание iperf3_plotter

```
mininet@mininet-vm:~$ cd /tmp
mininet@mininet-vm:/tmp$ git clone https://github.com/ekfoury/iperf3_plotter.git
fatal: destination path 'iperf3_plotter' already exists and is not an empty directory.
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. 5: Развертывание iperf3_plotter

Задание простейшей топологии. Параметры

```
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=2188>
<Host h2: h2-eth0:10.0.0.2 pid=2192>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=2197>
<Controller c0: 127.0.0.1:6653 pid=2181>
```

Рис. 6: Задание простейшей топологии. Параметры

Тестовое соединение между хостами

```
host: h2*@mininet-vm
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 60172
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60174
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00    sec  3.03 GBytes  26.0 Gbits/sec
[ 7] 1.00-2.00    sec  2.90 GBytes  24.8 Gbits/sec
[ 7] 2.00-3.00    sec  2.75 GBytes  23.7 Gbits/sec
[ 7] 3.00-4.00    sec  2.97 GBytes  25.5 Gbits/sec
[ 7] 4.00-5.00    sec  2.40 GBytes  20.7 Gbits/sec
[ 7] 5.00-6.00    sec  2.77 GBytes  23.8 Gbits/sec
[ 7] 6.00-7.00    sec  2.83 GBytes  24.3 Gbits/sec
[ 7] 7.00-8.00    sec  2.46 GBytes  21.2 Gbits/sec
[ 7] 8.00-9.00    sec  2.37 GBytes  20.4 Gbits/sec
[ 7] 9.00-10.00   sec  2.75 GBytes  23.7 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.01   sec  27.2 GBytes  23.4 Gbits/sec
-----
Server listening on 5201
-----
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 60174 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate  Retr  Cwnd
[ 7] 0.00-1.00    sec  3.03 GBytes  26.0 Gbits/sec    0   8.37 MBytes
[ 7] 1.00-2.00    sec  2.91 GBytes  25.0 Gbits/sec    0   8.37 MBytes
[ 7] 2.00-3.00    sec  2.76 GBytes  23.6 Gbits/sec    0   8.37 MBytes
[ 7] 3.00-4.00    sec  2.96 GBytes  25.5 Gbits/sec    0   8.37 MBytes
[ 7] 4.00-5.00    sec  2.40 GBytes  20.7 Gbits/sec    0   8.37 MBytes
[ 7] 5.00-6.00    sec  2.76 GBytes  23.7 Gbits/sec    0   8.37 MBytes
[ 7] 6.00-7.00    sec  2.83 GBytes  24.3 Gbits/sec    0   8.37 MBytes
[ 7] 7.00-8.00    sec  2.46 GBytes  21.1 Gbits/sec    0   8.37 MBytes
[ 7] 8.00-9.00    sec  2.37 GBytes  20.4 Gbits/sec    0   8.37 MBytes
[ 7] 9.00-10.00   sec  2.76 GBytes  23.7 Gbits/sec    0   8.37 MBytes
-----
[ ID] Interval      Transfer    Bitrate  Retr
[ 7] 0.00-10.00   sec  27.3 GBytes  23.4 Gbits/sec    0
[ 7] 0.00-10.01   sec  27.2 GBytes  23.4 Gbits/sec    0
-----
sender
receiver

iperf Done.
```

Эксперимент в интерфейсе mininet

```
mininet> h2 iperf3 -s &
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 60178 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 5] 0.00-1.00 sec  3.24 GBytes 27.8 Gbits/sec  0    8.10 MBytes
[ 5] 1.00-2.00 sec  3.30 GBytes 28.3 Gbits/sec  0    8.10 MBytes
[ 5] 2.00-3.00 sec  2.79 GBytes 24.0 Gbits/sec  0    8.10 MBytes
[ 5] 3.00-4.00 sec  2.68 GBytes 23.0 Gbits/sec  0    8.10 MBytes
[ 5] 4.00-5.00 sec  2.90 GBytes 24.9 Gbits/sec  0    8.10 MBytes
[ 5] 5.00-6.00 sec  2.70 GBytes 23.2 Gbits/sec  0    8.10 MBytes
[ 5] 6.00-7.00 sec  2.35 GBytes 20.2 Gbits/sec  0    8.10 MBytes
[ 5] 7.00-8.00 sec  1.48 GBytes 12.7 Gbits/sec  0    8.10 MBytes
[ 5] 8.00-9.00 sec  1.46 GBytes 12.6 Gbits/sec  0    8.10 MBytes
[ 5] 9.00-10.00 sec 1.19 GBytes 10.2 Gbits/sec  0    8.10 MBytes
-----
[ ID] Interval      Transfer    Bitrate      Retr
[ 5] 0.00-10.00 sec 24.1 GBytes 20.7 Gbits/sec  0          sender
[ 5] 0.00-10.00 sec 24.1 GBytes 20.7 Gbits/sec                receiver

iperf Done.
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 60176
[ 5] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60178
[ ID] Interval      Transfer    Bitrate
[ 5] 0.00-1.00 sec  3.23 GBytes 27.7 Gbits/sec
[ 5] 1.00-2.00 sec  3.29 GBytes 28.3 Gbits/sec
[ 5] 2.00-3.00 sec  2.80 GBytes 24.0 Gbits/sec
[ 5] 3.00-4.00 sec  2.68 GBytes 23.0 Gbits/sec
[ 5] 4.00-5.00 sec  2.90 GBytes 24.9 Gbits/sec
[ 5] 5.00-6.00 sec  2.70 GBytes 23.2 Gbits/sec
[ 5] 6.00-7.00 sec  2.35 GBytes 20.2 Gbits/sec
[ 5] 7.00-8.00 sec  1.48 GBytes 12.7 Gbits/sec
[ 5] 8.00-9.00 sec  1.46 GBytes 12.5 Gbits/sec
[ 5] 9.00-10.00 sec 1.19 GBytes 10.3 Gbits/sec
[ 5] 10.00-10.00 sec 3.69 MBytes 6.92 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 5] 0.00-10.00 sec 24.1 GBytes 20.7 Gbits/sec
-----
Server listening on 5201
-----
iperf3: interrupt the server has terminated
```

Тест с указанием периода времени передачи

```
"host: h2"@mininet-vm
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 60180
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60182
[ ID] Interval           Transfer     Bitrate
[ 7]   0.00-1.00    sec   3.14 GBytes  26.9 Gbits/sec
[ 7]   1.00-2.00    sec   2.89 GBytes  24.9 Gbits/sec
[ 7]   2.00-3.00    sec   3.29 GBytes  28.2 Gbits/sec
^C[ 7]   3.00-3.37    sec   1.13 GBytes  26.2 Gbits/sec
-----
[ ID] Interval           Transfer     Bitrate
[ 7]   0.00-3.37    sec  10.5 GBytes  26.6 Gbits/sec
iperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet#

"host: h1"@mininet-vm
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 60182 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]   0.00-1.00    sec   3.16 GBytes  27.0 Gbits/sec    0   8.10 MBytes
[ 7]   1.00-2.00    sec   2.89 GBytes  24.9 Gbits/sec    0   8.10 MBytes
[ 7]   2.00-3.00    sec   3.30 GBytes  28.3 Gbits/sec    0   8.10 MBytes
iperf3: error - unable to write to stream socket: Connection reset by peer
root@mininet-vm:/home/mininet#
```

Тест с указанием пропускной способности с 2-секундным интервалом

```
*host: h2*@mininet-vm
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 60184
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60186
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-2.00    sec  5.88 GBytes  25.3 Gbits/sec
[ 7]  2.00-4.00    sec  5.90 GBytes  25.3 Gbits/sec
[ 7]  4.00-6.00    sec  5.49 GBytes  23.6 Gbits/sec
^C[ 7]  6.00-7.38    sec  4.11 GBytes  25.6 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-7.38    sec  21.4 GBytes  24.9 Gbits/sec
iperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet#
```

```
*host: h1*@mininet-vm
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 60186 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-2.00    sec  5.89 GBytes  25.3 Gbits/sec    0   8.33 MBytes
[ 7]  2.00-4.00    sec  5.90 GBytes  25.3 Gbits/sec    0   8.33 MBytes
[ 7]  4.00-6.00    sec  5.49 GBytes  23.6 Gbits/sec    0   8.33 MBytes
iperf3: error - unable to write to stream socket: Connection reset by peer
root@mininet-vm:/home/mininet#
```


Задание в тесте определённого объёма данных

```
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 60188
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60190
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  3.03 GBytes 26.1 Gbits/sec
[ 7] 1.00-2.00 sec  2.78 GBytes 23.8 Gbits/sec
[ 7] 2.00-3.00 sec  3.02 GBytes 26.0 Gbits/sec
[ 7] 3.00-4.00 sec  2.90 GBytes 24.9 Gbits/sec
[ 7] 4.00-5.00 sec  3.32 GBytes 28.5 Gbits/sec
[ 7] 5.00-5.33 sec   972 MBytes 24.6 Gbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-5.33 sec  16.0 GBytes 25.8 Gbits/sec
Server listening on 5201
```

receiver

```
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 60190 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr    Cwnd
[ 7] 0.00-1.00 sec  3.04 GBytes 26.1 Gbits/sec    0    8.04 MBytes
[ 7] 1.00-2.00 sec  2.78 GBytes 23.9 Gbits/sec    0    8.04 MBytes
[ 7] 2.00-3.00 sec  3.02 GBytes 26.0 Gbits/sec    0    8.04 MBytes
[ 7] 3.00-4.00 sec  2.89 GBytes 24.8 Gbits/sec    0    8.04 MBytes
[ 7] 4.00-5.00 sec  3.32 GBytes 28.5 Gbits/sec    0    8.04 MBytes
[ 7] 5.00-5.33 sec   976 MBytes 25.1 Gbits/sec    0    8.04 MBytes
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-5.33 sec  16.0 GBytes 25.8 Gbits/sec    0
[ 7] 0.00-5.33 sec  16.0 GBytes 25.8 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

sender
receiver

Тест с изменённым протоколом передачи данных

```
host: h2" @mininet-vm
-----
Accepted connection from 10.0.0.1, port 60192
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 41108
[ ID] Interval      Transfer    Bitrate      Jitter    Lost/Total Datagrams
[ 7] 0.00-1.00 sec    129 KBytes  1.05 Mbits/sec  0.056 ms  0/91 (0%)
[ 7] 1.00-2.00 sec    127 KBytes  1.04 Mbits/sec  0.054 ms  0/90 (0%)
[ 7] 2.00-3.00 sec    129 KBytes  1.05 Mbits/sec  0.028 ms  0/91 (0%)
[ 7] 3.00-4.00 sec    127 KBytes  1.04 Mbits/sec  0.022 ms  0/90 (0%)
[ 7] 4.00-5.00 sec    129 KBytes  1.05 Mbits/sec  0.045 ms  0/91 (0%)
[ 7] 5.00-6.00 sec    127 KBytes  1.04 Mbits/sec  0.023 ms  0/90 (0%)
[ 7] 6.00-7.00 sec    129 KBytes  1.06 Mbits/sec  0.023 ms  0/91 (0%)
[ 7] 7.00-8.00 sec    129 KBytes  1.05 Mbits/sec  0.061 ms  0/91 (0%)
[ 7] 8.00-9.00 sec    127 KBytes  1.04 Mbits/sec  0.027 ms  0/90 (0%)
[ 7] 9.00-10.00 sec   129 KBytes  1.05 Mbits/sec  0.029 ms  0/91 (0%)
-----
[ ID] Interval      Transfer    Bitrate      Jitter    Lost/Total Datagrams
[ 7] 0.00-10.00 sec   1.25 MBytes  1.05 Mbits/sec  0.029 ms  0/906 (0%) receiver
-----
Server listening on 5201
-----
```

```
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 41108 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    127 KBytes  1.04 Mbits/sec  90
[ 7] 6.00-7.00 sec    129 KBytes  1.06 Mbits/sec  91
[ 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
-----
```

Тест с изменённым номером порта для отправки/получения пакетов

```
root@mininet-vm:~# iperf3 -s -p 3250
Server listening on 5201

^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet# iperf3 -s -p 3250
warning: this system does not seem to support IPv6 - trying IPv4

Server listening on 3250

Accepted connection from 10.0.0.1, port 48516
[ 7] local 10.0.0.2 port 3250 connected to 10.0.0.1 port 48518
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-1.00    sec  2.95 GBytes  25.3 Gbits/sec
[ 7] 1.00-2.00    sec  2.91 GBytes  25.0 Gbits/sec
^C[ 7] 2.00-2.62    sec  1.71 GBytes  23.8 Gbits/sec

[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-2.62    sec  7.57 GBytes  24.8 Gbits/sec
iperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet#
```

receiver

```
7.00-8.00    sec  1.48 GBytes  12.7 Gbits/sec  0  8.10 MBytes
8.00-9.00    sec  1.46 GBytes  12.6 Gbits/sec  0  8.10 MBytes
```

```
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 48518 connected to 10.0.0.2 port 3250
[ ID] Interval      Transfer      Bitrate      Retr  Cwnd
[ 7] 0.00-1.01    sec  2.95 GBytes  25.2 Gbits/sec    0   8.05 MBytes
[ 7] 1.01-2.00    sec  2.91 GBytes  25.1 Gbits/sec    0   8.05 MBytes
[ 7] 1.01-2.00    sec  2.91 GBytes  25.1 Gbits/sec    0   8.05 MBytes

[ ID] Interval      Transfer      Bitrate      Retr
[ 7] 0.00-2.00    sec  7.57 GBytes  32.5 Gbits/sec    0
[ 7] 0.00-2.00    sec  0.00 Bytes  0.00 bits/sec    0
iperf3: error - the server has terminated
root@mininet-vm:/home/mininet#
```

sender
receiver

Тест с параметром обработки данных только от одного клиента с остановкой сервера по завершении теста

```
*host: h2*@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s -1
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 60198
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60200
[ ID] Interval           Transfer             Bitrate
[ 7] 0.00-1.00 sec      3.09 GBytes        26.5 Gbits/sec
[ 7] 1.00-2.00 sec      2.75 GBytes        23.6 Gbits/sec
[ 7] 2.00-3.00 sec      2.97 GBytes        25.5 Gbits/sec
[ 7] 3.00-4.00 sec      2.88 GBytes        24.7 Gbits/sec
[ 7] 4.00-5.00 sec      2.44 GBytes        21.0 Gbits/sec
[ 7] 5.00-6.00 sec      2.77 GBytes        23.7 Gbits/sec
[ 7] 6.00-7.00 sec      2.95 GBytes        25.4 Gbits/sec
[ 7] 7.00-8.00 sec      3.08 GBytes        26.5 Gbits/sec
[ 7] 8.00-9.00 sec      2.80 GBytes        24.1 Gbits/sec
[ 7] 9.00-10.00 sec     2.78 GBytes        23.9 Gbits/sec
[ 7] 10.00-10.00 sec    12.3 MBytes        34.4 Gbits/sec
-----
[ ID] Interval           Transfer             Bitrate
[ 7] 0.00-10.00 sec    28.5 GBytes        24.5 Gbits/sec
root@mininet-vm:/home/mininet# receiver
1.00-2.00 sec  1.48 GBytes  12.7 Gbits/sec  0  8.10 MBytes
0.00-9.00 sec  1.46 GBytes  12.6 Gbits/sec  0  8.10 MBytes
*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 60200 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer             Bitrate      Retr      Cwnd
[ 7] 0.00-1.00 sec      3.10 GBytes        26.4 Gbits/sec    0     4.99 MBytes
[ 7] 1.01-2.00 sec      2.74 GBytes        23.7 Gbits/sec    0     6.69 MBytes
[ 7] 2.00-3.00 sec      2.97 GBytes        25.5 Gbits/sec    0     8.13 MBytes
[ 7] 3.00-4.00 sec      2.88 GBytes        24.7 Gbits/sec    0     8.13 MBytes
[ 7] 4.00-5.00 sec      2.44 GBytes        21.0 Gbits/sec    0     8.13 MBytes
[ 7] 5.00-6.00 sec      2.78 GBytes        23.9 Gbits/sec    0     8.13 MBytes
[ 7] 6.00-7.00 sec      2.94 GBytes        25.2 Gbits/sec    0     8.13 MBytes
[ 7] 7.00-8.00 sec      3.08 GBytes        26.5 Gbits/sec    0     8.13 MBytes
[ 7] 8.00-9.00 sec      2.80 GBytes        24.0 Gbits/sec    0     8.13 MBytes
[ 7] 9.00-10.00 sec     2.79 GBytes        24.0 Gbits/sec    0     8.13 MBytes
-----
[ ID] Interval           Transfer             Bitrate      Retr      sender
[ 7] 0.00-10.00 sec    28.5 GBytes        24.5 Gbits/sec    0          receiver
[ 7] 0.00-10.00 sec    28.5 GBytes        24.5 Gbits/sec    0          receiver
```

Создание директории для результатов iperf3

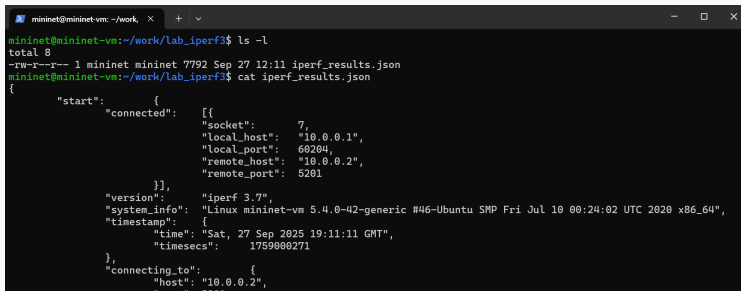
```
mininet@mininet-vm:~$ mkdir -p ~/work/lab_iperf3  
mininet@mininet-vm:~$
```

Рис. 15: Создание директории для результатов iperf3

Тест с сохранением в файл в формате json

```
"host: h2"@mininet-vm
-----
Accepted connection from 10.0.0.1, port 60202
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60204
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-1.00    sec  3.22 GBytes  27.7 Gbits/sec
[ 7]  1.00-2.00    sec  3.23 GBytes  27.7 Gbits/sec
[ 7]  2.00-3.00    sec  2.90 GBytes  24.9 Gbits/sec
[ 7]  3.00-4.00    sec  3.04 GBytes  26.1 Gbits/sec
[ 7]  4.00-5.00    sec  2.75 GBytes  23.6 Gbits/sec
[ 7]  5.00-6.00    sec  2.87 GBytes  24.7 Gbits/sec
[ 7]  6.00-7.00    sec  2.56 GBytes  22.0 Gbits/sec
[ 7]  7.00-8.00    sec  2.72 GBytes  23.4 Gbits/sec
[ 7]  8.00-9.00    sec  2.86 GBytes  24.6 Gbits/sec
[ 7]  9.00-10.00   sec  2.85 GBytes  24.5 Gbits/sec
[ 7] 10.00-10.00   sec   192 KBytes    887 Mbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-10.00   sec  29.0 GBytes  24.9 Gbits/sec
-----
Server listening on 5201
-----
^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet#
7.00-8.00 sec 1.4 * Support: https://ubuntu.com/advantage
8.00-9.00 sec 1.4
"host: h1"@mininet-vm
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#
```

Проверка создания файла iperf_results.json



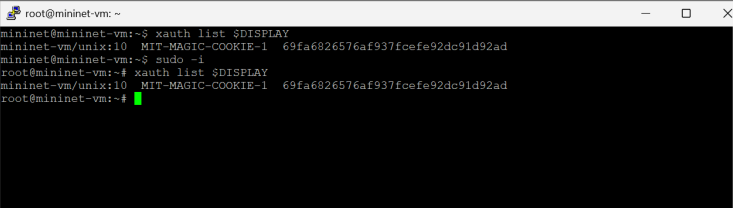
```
mininet@mininet-vm: ~/work
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 mininet mininet 7792 Sep 27 12:11 iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$ cat iperf_results.json
{
  "start": {
    "connected": [
      {
        "socket": 7,
        "local_host": "10.0.0.1",
        "local_port": 60204,
        "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": "Sat, 27 Sep 2025 19:11:11 GMT",
      "timesecs": 1759080271
    },
    "connecting_to": {
      "host": "10.0.0.2",
      "port": 5201
    }
  }
}
```

Рис. 17: Проверка создания файла iperf_results.json

```
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 8 terms
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 929.929 seconds
```

Рис. 18: Конец эмуляции

Исправление прав запуска X-соединения

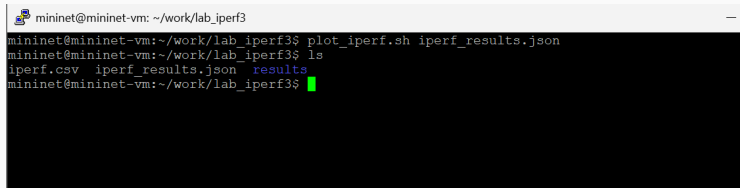


```
root@mininet-vm: ~  
mininet@mininet-vm:~$ xauth list $DISPLAY  
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 69fa6826576af937fcef92dc91d92ad  
mininet@mininet-vm:~$ sudo -i  
root@mininet-vm:~# xauth list $DISPLAY  
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 69fa6826576af937fcef92dc91d92ad  
root@mininet-vm:~#
```

Рис. 19: Исправление прав запуска X-соединения

```
mininet@mininet-vm:~$ cd work/lab_iperf3/
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 mininet mininet 7792 Sep 27 12:11 iperf_results.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 7792 Sep 27 12:11 iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$
```

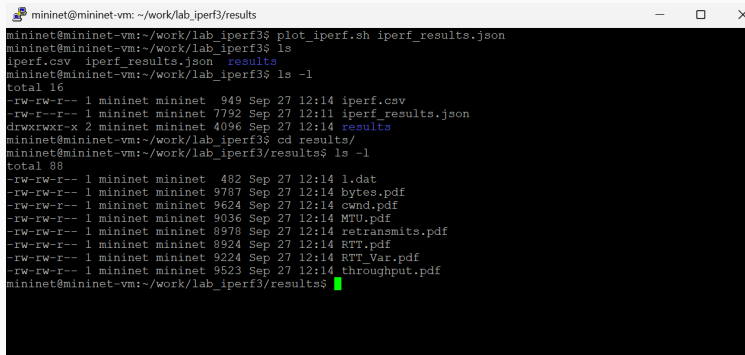
Рис. 20: Визуализация результатов эксперимента

A terminal window with a light gray title bar. The title bar contains a small icon of a computer monitor and the text "mininet@mininet-vm: ~/work/lab_iperf3". The terminal area has a black background with white text. The text shows a sequence of commands and their outputs: "mininet@mininet-vm:~/work/lab_iperf3\$ plot_iperf.sh iperf_results.json", "mininet@mininet-vm:~/work/lab_iperf3\$ ls", and the output "iperf.csv iperf_results.json results". The prompt "mininet@mininet-vm:~/work/lab_iperf3\$" is followed by a green cursor block.

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

Рис. 21: Визуализация результатов эксперимента

Визуализация результатов эксперимента (3/3)



```
mininet@mininet-vm: ~/work/lab_iperf3/results
mininet@mininet-vm:~/work/lab_iperf3$ plot_iperf.sh iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$ ls
iperf.csv  iperf_results.json  results
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 16
-rw-rw-r-- 1 mininet mininet  949 Sep 27 12:14 iperf.csv
-rw-rw-r-- 1 mininet mininet 7792 Sep 27 12:11 iperf_results.json
drwxrwxr-x 2 mininet mininet 4096 Sep 27 12:14 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  482 Sep 27 12:14 1.dat
-rw-rw-r-- 1 mininet mininet 9787 Sep 27 12:14 bytes.pdf
-rw-rw-r-- 1 mininet mininet 9624 Sep 27 12:14 cwnd.pdf
-rw-rw-r-- 1 mininet mininet 9036 Sep 27 12:14 MTU.pdf
-rw-rw-r-- 1 mininet mininet 8978 Sep 27 12:14 retransmits.pdf
-rw-rw-r-- 1 mininet mininet 8924 Sep 27 12:14 RTT.pdf
-rw-rw-r-- 1 mininet mininet 9224 Sep 27 12:14 RTT_Var.pdf
-rw-rw-r-- 1 mininet mininet 9523 Sep 27 12:14 throughput.pdf
mininet@mininet-vm:~/work/lab_iperf3/results$
```

Рис. 22: Визуализация результатов эксперимента

Выводы

В результате выполнения лабораторной работы я познакомился с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, и приобрёл навыки проведения эксперимента в моделируемой сети среды Mininet по измерению пропускной способности сети.

Список литературы

1. Mininet [Электронный ресурс]. Mininet Project Contributors. URL: <http://mininet.org/> (дата обращения: 27.09.2025).
2. iPerf3 [Электронный ресурс]. URL: <http://iperf.fr/> (дата обращения: 27.09.2025).
