

# Лабораторная Работа №2.

Моделирование сетей передачи данных

---

Боровиков Д.А.

Российский университет дружбы народов им. Патриса Лумумбы, Москва, Россия

- Боровиков Даниил Александрович
- НПИБд-01-22
- Российский университет дружбы народов
- [1132222006@pfur.ru]

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.

# Обновление репозитория программного обеспечения

```
mininet@mininet-vm:~$ sudo apt-get update
Hit:1 http://us.archive.ubuntu.com/ubuntu focal InRelease
Get:2 http://security.ubuntu.com/ubuntu focal-security InRelease [128 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [128 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease [128 kB]
Fetched 383 kB in 1s (268 kB/s)
Reading package lists... Done
```

**Figure 1:** Обновление репозитория программного обеспечения

# Установка iperf3

```
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 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] y
Get:1 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libsctp1 amd64 1.0.18+dfsg-1 [7,876 B]
Get:2 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 libiperf0 amd64 3.7-3 [72.0 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 iperf3 amd64 3.7-3 [14.2 kB]
Fetched 94.1 kB in 1s (96.3 kB/s)
Selecting previously unselected package libsctp1:amd64.
(Reading database ... 102271 files and directories currently installed.)
Preparing to unpack .../libsctp1_1.0.18+dfsg-1_amd64.deb ...
Unpacking libsctp1:amd64 (1.0.18+dfsg-1) ...
Selecting previously unselected package libiperf0:amd64.
Preparing to unpack .../libiperf0_3.7-3_amd64.deb ...
Unpacking libiperf0:amd64 (3.7-3) ...
Selecting previously unselected package iperf3.
Preparing to unpack .../iperf3_3.7-3_amd64.deb ...
Unpacking iperf3 (3.7-3) ...
Setting up libsctp1:amd64 (1.0.18+dfsg-1) ...
Setting up libiperf0:amd64 (3.7-3) ...
Setting up iperf3 (3.7-3) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9) ...
mininet@mininet-vm:~$
```

Figure 2: Установка iperf3

# Установка программного обеспечения

```
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 aspell aspell-en bubblewrap enchant-2 evince-common fonts-liberation gnome-desktop3-data gnuplot-data
  groff hunspell-en-us imagemagick imagemagick-6.q16 libarchive13 libaspell15 libdjvulibre-text libdjvulibre21
  libenchant-2-2 libevdocument3-4 libevview3-3 libgnome-desktop-3-19 libgspell-1-2 libgspell-1-common libgxps2
  libhunspell-1.7-0 libilmbase24 libjq1 libkpathsea6 liblua5.3-0 libmagickcore-6.q16-6-extra
  libnautilus-extension1a libnetpbm10 libnspr4 libnss3 libonig5 libopenexr24 libpoppler-glib8 libpoppler97
  libsecret-1-0 libsecret-common libspectre1 libsyntax2 libwmf0.2-7 netpbm psutils
Suggested packages:
  aspell-doc spellutils gvfs nautilus-sendto unrar git-daemon-run | git-daemon-sysvinit git-doc git-el
  git-email git-gui gitweb git-cvs git-mediawiki git-svn gnuplot-doc hunspell openoffice.org-hunspell
  | openoffice.org-core imagemagick-doc autotrace cups-bsd | lpr | lprng curl enscript ffmpeg gimp grads
  graphviz hp2xx html2ps libwmf-bin mplayer povray radiance sane-utils texlive-base-bin transfig ufwraw-batch
  xdg-utils lrzip libenchant-2-voikko inkscape libjxr-tools libwmf0.2-7-gtk
The following NEW packages will be installed:
  aglfn aspell aspell-en bubblewrap enchant-2 evince evince-common fonts-liberation gnome-desktop3-data
  gnuplot-data gnuplot-nox groff hunspell-en-us imagemagick imagemagick-6.q16 jq libarchive13 libaspell15
  libdjvulibre-text libdjvulibre21 libenchant-2-2 libevdocument3-4 libevview3-3 libgnome-desktop-3-19
  libgspell-1-2 libgspell-1-common libgxps2 libhunspell-1.7-0 libilmbase24 libjq1 libkpathsea6 liblua5.3-0
  libmagickcore-6.q16-6-extra libnautilus-extension1a libnetpbm10 libnspr4 libnss3 libonig5 libopenexr24
  libpoppler-glib8 libpoppler97 libsecret-1-0 libsecret-common libspectre1 libsyntax2 libwmf0.2-7 netpbm
  psutils
```

**Figure 3:** Установка необходимого дополнительного программного обеспечения на виртуальную машину

# Развертывание 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 | 665.00 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 4: Развертывание iperf3\_plotter

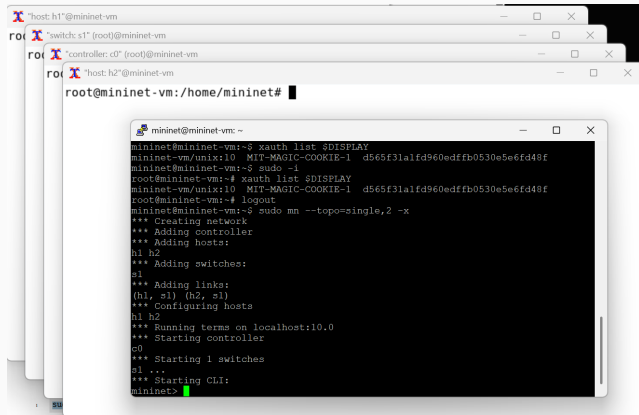
# Исправление прав запуска X-соединения

```
mininet@mininet-vm:/tmp/iperf3_plotter$ xauth list $DISPLAY
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 61e576330e7e3ad466ee1c28aee5c935
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo
usage: sudo -h | -K | -k | -V
usage: sudo -v [-AknS] [-g group] [-h host] [-p prompt] [-u user]
usage: sudo -l [-AknS] [-g group] [-h host] [-p prompt] [-U user] [-u user] [command]
usage: sudo [-AbEHknPS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt]
        [-T timeout] [-u user] [VAR=value] [-i|-s] [<command>]
usage: sudo -e [-AknS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt]
        [-T timeout] [-u user] file ...
mininet@mininet-vm:/tmp/iperf3_plotter$ xauth add mininet-vm/unix:10 MIT-MAGIC-COOKIE-
1 61e576330e7e3ad466ee1c28aee5c935
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo -i
root@mininet-vm:~# xauth list $DISPLAY
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 61e576330e7e3ad466ee1c28aee5c935
root@mininet-vm:~# logout
mininet@mininet-vm:/tmp/iperf3_plotter$ cd
mininet@mininet-vm:~$ |
```

Figure 5: Исправление прав запуска X-соединения



# Создание простейшей топологии

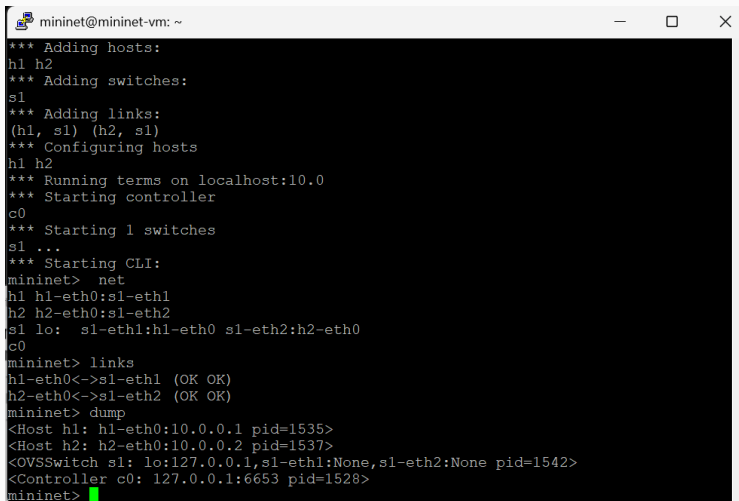


The image shows a stack of terminal windows from the Mininet environment. The top window is titled "host: h1" and shows the prompt "root@mininet-vm: /home/mininet#". Below it, another window titled "switch: s1" shows the prompt "root@mininet-vm: /home/mininet#". The bottom window, titled "mininet@mininet-vm: ~", shows the execution of the command "sudo mn --topo=single,2 -x". The output of this command is as follows:

```
mininet@mininet-vm:~$ xauth list $DISPLAY
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 d565f31afd960edffb0530e5e6fd48f
mininet@mininet-vm:~$ sudo -i
root@mininet-vm:~# xauth list $DISPLAY
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 d565f31afd960edffb0530e5e6fd48f
root@mininet-vm:~# logout
mininet@mininet-vm:~$ 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>
```

**Figure 6:** Создание простейшей топологии, состоящей из двух хостов и коммутатора

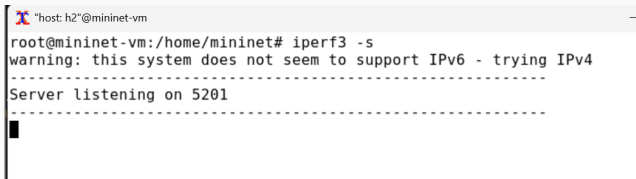
# Просмотр параметров топологии

A terminal window titled 'mininet@mininet-vm: ~' with standard window controls. The terminal displays the output of Mininet commands. It starts with '\*\*\* Adding hosts:', followed by 'h1 h2'. Then '\*\*\* Adding switches:' followed by 's1'. Next is '\*\*\* Adding links:' followed by '(h1, s1) (h2, s1)'. This is followed by '\*\*\* Configuring hosts', 'h1 h2', '\*\*\* Running terms on localhost:10.0', '\*\*\* Starting controller', 'c0', '\*\*\* Starting 1 switches', 's1 ...', and '\*\*\* Starting CLI:'. The user enters 'mininet> net', which shows the configuration for hosts h1 and h2, and switch s1. Then the user enters 'mininet> links', which shows the connections between h1-eth0 and s1-eth1, and h2-eth0 and s1-eth2. Finally, the user enters 'mininet> dump', which shows the details of the hosts, switch, and controller, including their IP addresses and PIDs. The prompt 'mininet>' is followed by a green cursor.

```
mininet@mininet-vm: ~
*** 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=1535>
<Host h2: h2-eth0:10.0.0.2 pid=1537>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=1542>
<Controller c0: 127.0.0.1:6653 pid=1528>
mininet>
```

Figure 7: Просмотр параметров топологии

## Запуск сервера iperf3 в терминале h2



```
"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
-----
█
```

**Figure 8:** Запуск сервера iperf3 в терминале h2

# Запуск клиента iperf3 в терминале хоста h1

```
"host: h1"@mininet-vm
root@mininet-vm:/home/mininet#
root@mininet-vm:/home/mininet#
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 60116 connected to 10.0.0.2 port 5201
[ ID] Interval          Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-1.01      sec  1.22 GBytes  10.4 Gbits/sec    0   8.33 MBytes
[ 7]  1.01-2.00      sec  1.24 GBytes  10.7 Gbits/sec    0   8.33 MBytes
[ 7]  2.00-3.00      sec  1.12 GBytes  9.66 Gbits/sec   0   8.33 MBytes
[ 7]  3.00-4.00      sec  1.86 GBytes  15.9 Gbits/sec   0   8.33 MBytes
[ 7]  4.00-5.01      sec  1.30 GBytes  11.2 Gbits/sec   0   8.33 MBytes
[ 7]  5.01-6.00      sec  1.33 GBytes  11.4 Gbits/sec   0   8.33 MBytes
[ 7]  6.00-7.01      sec  1.24 GBytes  10.6 Gbits/sec   1   8.33 MBytes
[ 7]  7.01-8.00      sec  1.29 GBytes  11.1 Gbits/sec   0   8.33 MBytes
[ 7]  8.00-9.00      sec  1.14 GBytes  9.79 Gbits/sec   0   8.33 MBytes
[ 7]  9.00-10.00     sec  1.21 GBytes  10.4 Gbits/sec   0   8.33 MBytes
- - - - -
[ ID] Interval          Transfer    Bitrate      Retr
[ 7]  0.00-10.00     sec  12.9 GBytes  11.1 Gbits/sec    1
[ 7]  0.00-10.00     sec  12.9 GBytes  11.1 Gbits/sec

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

**Figure 9:** Запуск клиента iperf3 в терминале хоста h1

# Остановка сервера iPerf3 в терминале хоста h2

```
*host: h2"@mininet-vm
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 60114
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60116
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-1.00    sec  1.22 GBytes  10.5 Gbits/sec
[ 7]  1.00-2.00    sec  1.24 GBytes  10.7 Gbits/sec
[ 7]  2.00-3.00    sec  1.12 GBytes  9.65 Gbits/sec
[ 7]  3.00-4.00    sec  1.86 GBytes  15.9 Gbits/sec
[ 7]  4.00-5.00    sec  1.30 GBytes  11.2 Gbits/sec
[ 7]  5.00-6.00    sec  1.33 GBytes  11.4 Gbits/sec
[ 7]  6.00-7.00    sec  1.23 GBytes  10.5 Gbits/sec
[ 7]  7.00-8.01    sec  1.29 GBytes  11.0 Gbits/sec
[ 7]  8.01-9.01    sec  1.15 GBytes  9.81 Gbits/sec
[ 7]  9.01-10.00   sec  1.21 GBytes  10.5 Gbits/sec
[ 7] 10.00-10.00   sec   64.4 KBytes  153 Mbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-10.00   sec  12.9 GBytes  11.1 Gbits/sec
-----
Server listening on 5201
-----
^Ciperf3: interrupt - the server has terminated
-----
```

**Figure 10:** Остановка сервера iPerf3 в терминале хоста h2

# Запуск сервера iperf3

```
mininet> h2 iperf3 -s 4
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 60120 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 5] 0.00-1.00    sec  1.23 GBytes 10.6 Gbits/sec  0    8.28 MBytes
[ 5] 1.00-2.00    sec  1.27 GBytes 10.9 Gbits/sec  0    8.28 MBytes
[ 5] 2.00-3.00    sec  1.29 GBytes 11.1 Gbits/sec  0    8.28 MBytes
[ 5] 3.00-4.00    sec  1.14 GBytes 9.75 Gbits/sec  0    8.28 MBytes
[ 5] 4.00-5.00    sec  1.34 GBytes 11.5 Gbits/sec  0    8.28 MBytes
[ 5] 5.00-6.00    sec  1.11 GBytes 9.51 Gbits/sec  0    8.28 MBytes
[ 5] 6.00-7.00    sec  1.09 GBytes 9.42 Gbits/sec  0    8.28 MBytes
[ 5] 7.00-8.01    sec  1.16 GBytes 9.84 Gbits/sec  0    8.28 MBytes
[ 5] 8.01-9.00    sec  1.20 GBytes 10.4 Gbits/sec  0    8.28 MBytes
[ 5] 9.00-10.00   sec  1.17 GBytes 10.0 Gbits/sec  0    8.28 MBytes
-----
[ ID] Interval      Transfer    Bitrate      Retr
[ 5] 0.00-10.00   sec  12.0 GBytes 10.3 Gbits/sec  0
[ 5] 0.00-10.02   sec  12.0 GBytes 10.3 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 60118
[ 5] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60120
[ ID] Interval      Transfer    Bitrate
[ 5] 0.00-1.00    sec  1.22 GBytes 10.5 Gbits/sec
[ 5] 1.00-2.00    sec  1.26 GBytes 10.9 Gbits/sec
[ 5] 2.00-3.01    sec  1.31 GBytes 11.2 Gbits/sec
[ 5] 3.01-4.00    sec  1.13 GBytes 9.73 Gbits/sec
[ 5] 4.00-5.00    sec  1.33 GBytes 11.4 Gbits/sec
[ 5] 5.00-6.00    sec  1.12 GBytes 9.59 Gbits/sec
[ 5] 6.00-7.00    sec  1.11 GBytes 9.52 Gbits/sec
[ 5] 7.00-8.00    sec  1.14 GBytes 9.74 Gbits/sec
[ 5] 8.00-9.02    sec  1.22 GBytes 10.4 Gbits/sec
[ 5] 9.02-10.00   sec  1.15 GBytes 10.0 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 5] 0.00-10.02   sec  12.0 GBytes 10.3 Gbits/sec
                                     receiver
-----
Server listening on 5201
-----
iperf3: interrupt - the server has terminated
mininet> 
```

**Figure 11:** Запуск сервера iperf3 на хосте h2, запуск клиента iperf3 на хосте h1, остановка серверного процесса

## Запуск сервера iperf3 в терминале h2

```
.....
^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
.....
Server listening on 5201
.....
█
```

**Figure 12:** Запуск сервера iperf3 в терминале h2

# Запуск клиента iperf3

```
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 60124 connected to 10.0.0.2 port 5201
[ ID] Interval          Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-1.00      sec  1.23 GBytes 10.5 Gbits/sec    0   8.31 MBytes
[ 7]  1.00-2.00      sec  1.18 GBytes10.2 Gbits/sec    1   8.31 MBytes
[ 7]  2.00-3.00      sec  1.09 GBytes 9.37 Gbits/sec    0   8.31 MBytes
[ 7]  3.00-4.00      sec  1.27 GBytes11.0 Gbits/sec    0   8.31 MBytes
[ 7]  4.00-5.00      sec  1.15 GBytes 9.84 Gbits/sec    0   8.31 MBytes
- - - - -
[ ID] Interval          Transfer    Bitrate      Retr
[ 7]  0.00-5.00      sec  5.93 GBytes10.2 Gbits/sec    1
[ 7]  0.00-5.02      sec  5.91 GBytes10.1 Gbits/sec
                                     sender
                                     receiver

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

**Figure 13:** Запуск клиента iperf3 в терминале h1 с параметром -t (5 секунд)



## Запуск сервера iperf3

```
root@mininet-vm:/home/mininet# iperf3 -s -i 2
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
```

■

**Figure 14:** Запуск сервера iperf3 в терминале h2 с 2-секундным интервалом времени отсчёта

# Запуск клиента iperf3

```
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 60128 connected to 10.0.0.2 port 5201
[ ID] Interval            Transfer        Bitrate        Retr  Cwnd
[ 7]  0.00-2.01      sec  2.19 GBytes    9.36 Gbits/sec    0   8.33 MBytes
[ 7]  2.01-4.00      sec  2.25 GBytes    9.67 Gbits/sec    0   8.33 MBytes
[ 7]  4.00-6.00      sec  2.13 GBytes    9.17 Gbits/sec    0   8.33 MBytes
[ 7]  6.00-8.00      sec  2.62 GBytes   11.3 Gbits/sec    0   8.33 MBytes
[ 7]  8.00-10.00     sec  2.77 GBytes   11.9 Gbits/sec    0   8.33 MBytes
- - - - -
[ ID] Interval            Transfer        Bitrate        Retr
[ 7]  0.00-10.00     sec  12.0 GBytes   10.3 Gbits/sec    0
[ 7]  0.00-10.01     sec  12.0 GBytes   10.3 Gbits/sec    0
sender
receiver

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

27 сентября 202

**Figure 15:** Запуск клиента iperf3 в терминале h1 с 2-секундным интервалом времени отсчёта

## Запуск сервера iperf3 в терминале h2

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

**Figure 16:** Запуск сервера iperf3 в терминале h2

## Запуск клиента iperf3

```
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 60132 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00    sec   1.30 GBytes  11.1 Gbits/sec    0   8.33 MBytes
[ 7]  1.00-2.00    sec   994 MBytes   8.36 Gbits/sec    1   8.33 MBytes
[ 7]  2.00-3.00    sec   1.01 GBytes   8.63 Gbits/sec    0   8.33 MBytes
[ 7]  3.00-4.00    sec   1.01 GBytes   8.67 Gbits/sec    0   8.33 MBytes
[ 7]  4.00-5.00    sec   1.06 GBytes   9.14 Gbits/sec    0   8.33 MBytes
[ 7]  5.00-6.01    sec  1005 MBytes   8.39 Gbits/sec    0   8.33 MBytes
[ 7]  6.01-7.01    sec   889 MBytes   7.44 Gbits/sec    0   8.33 MBytes
[ 7]  7.01-8.01    sec   1.07 GBytes   9.22 Gbits/sec    0   8.33 MBytes
[ 7]  8.01-9.00    sec   965 MBytes   8.13 Gbits/sec    0   8.33 MBytes
[ 7]  9.00-10.01   sec   1.01 GBytes   8.58 Gbits/sec    0   8.33 MBytes
[ 7] 10.01-11.00   sec   1.08 GBytes   9.38 Gbits/sec    1   8.33 MBytes
[ 7] 11.00-12.00   sec   1.14 GBytes   9.82 Gbits/sec    0   8.33 MBytes
[ 7] 12.00-13.00   sec   1.10 GBytes   9.46 Gbits/sec    0   8.33 MBytes
[ 7] 13.00-14.00   sec   992 MBytes   8.33 Gbits/sec    0   8.33 MBytes
[ 7] 14.00-15.00   sec   1.01 GBytes   8.67 Gbits/sec    0   8.33 MBytes
[ 7] 15.00-15.47   sec   482 MBytes   8.63 Gbits/sec    0   8.33 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-15.47   sec  16.0 GBytes  8.88 Gbits/sec    2
[ 7]  0.00-15.47   sec  16.0 GBytes  8.88 Gbits/sec

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

Figure 17: Запуск клиента iperf3 в терминале h1 с объёмом данных 16 Гбайт

## Запуск сервера iperf3 в терминале h2

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

**Figure 18:** Запуск сервера iperf3 в терминале h2

# Запуск клиента iperf3 в терминале h1 с протоколом 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 54156 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]  | 4.00-5.01  | sec | 129 KBytes | 1.05 Mbits/sec | 91              |
| [ 7]  | 5.01-6.00  | sec | 127 KBytes | 1.05 Mbits/sec | 90              |
| [ 7]  | 6.00-7.00  | sec | 129 KBytes | 1.05 Mbits/sec | 91              |
| [ 7]  | 7.00-8.00  | sec | 129 KBytes | 1.05 Mbits/sec | 91              |
| [ 7]  | 8.00-9.00  | sec | 127 KBytes | 1.05 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]  | 0.00-10.01 | sec | 1.25 MBytes | 1.05 Mbits/sec | 0.046 ms | 0/906 (0%) receiver  |

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

**Figure 19:** Запуск клиента iperf3 в терминале h1 с протоколом UDP

## Запуск сервера iperf3 в терминале h2 с портом прослушивания

```
root@mininet-vm:/home/mininet# iperf3 -s -p 3250
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 3250
-----
_
```

**Figure 20:** Запуск сервера iperf3 в терминале h2 с портом прослушивания

## Запуск клиента iperf3 в терминале h1 с портом

```
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 48460 connected to 10.0.0.2 port 3250
[ ID] Interval           Transfer     Bitrate      Retr   Cwnd
[ 7]  0.00-1.00   sec  1.14 GBytes  9.81 Gbits/sec    0   8.29 MBytes
[ 7]  1.00-2.01   sec  1.18 GBytes 10.0 Gbits/sec    0   8.29 MBytes
[ 7]  2.01-3.01   sec  1.16 GBytes  9.97 Gbits/sec    0   8.29 MBytes
[ 7]  3.01-4.00   sec  1.12 GBytes  9.71 Gbits/sec    0   8.29 MBytes
[ 7]  4.00-5.00   sec  1.09 GBytes  9.37 Gbits/sec    0   8.29 MBytes
[ 7]  5.00-6.00   sec  1.16 GBytes  9.98 Gbits/sec    0   8.29 MBytes
[ 7]  6.00-7.00   sec  1.46 GBytes 12.6 Gbits/sec    1   8.29 MBytes
[ 7]  7.00-8.00   sec  1.16 GBytes  9.94 Gbits/sec    0   8.29 MBytes
[ 7]  8.00-9.00   sec  1.12 GBytes  9.62 Gbits/sec    0   8.29 MBytes
[ 7]  9.00-10.00  sec  1.24 GBytes 10.6 Gbits/sec    0   8.29 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-10.00  sec  11.8 GBytes 10.2 Gbits/sec    1
[ 7]  0.00-10.01  sec  11.8 GBytes 10.2 Gbits/sec    0
                                     sender
                                     receiver

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

**Figure 21:** Запуск клиента iperf3 в терминале h1 с портом



## Запуск сервера iperf3

```
-----  
root@mininet-vm:/home/mininet# iperf3 -s -1  
warning: this system does not seem to support IPv6 - trying IPv4  
-----  
server listening on 5201  
-----  
■
```

**Figure 22:** Запуск сервера iperf3 в терминале h2 с параметром -1 (чтобы принять только 1 клиента)

# Запуск клиента iperf3 в терминале h1

```
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 60142 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00    sec   1.18 GBytes  10.1 Gbits/sec    0   8.14 MBytes
[ 7]  1.00-2.00    sec   1.43 GBytes  12.3 Gbits/sec    0   8.14 MBytes
[ 7]  2.00-3.00    sec   1.24 GBytes  10.6 Gbits/sec    0   8.14 MBytes
[ 7]  3.00-4.00    sec   1.17 GBytes  10.1 Gbits/sec    1   8.14 MBytes
[ 7]  4.00-5.00    sec   1.12 GBytes   9.54 Gbits/sec    0   8.14 MBytes
[ 7]  5.00-6.01    sec   1.26 GBytes  10.9 Gbits/sec    0   8.14 MBytes
[ 7]  6.01-7.00    sec   1.25 GBytes  10.7 Gbits/sec    0   8.14 MBytes
[ 7]  7.00-8.00    sec   1.24 GBytes  10.7 Gbits/sec    0   8.14 MBytes
[ 7]  8.00-9.00    sec   1.10 GBytes   9.46 Gbits/sec    0   8.14 MBytes
[ 7]  9.00-10.01   sec   1.28 GBytes  10.9 Gbits/sec    0   8.14 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-10.01   sec   12.3 GBytes  10.5 Gbits/sec    1
[ 7]  0.00-10.01   sec   12.3 GBytes  10.5 Gbits/sec    0
                                     sender
                                     receiver

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

**Figure 23:** Запуск клиента iperf3 в терминале h1

## Создание каталога для работы над проектом

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

**Figure 24:** Создание каталога для работы над проектом

## Запуск сервера iperf3 в терминале h2

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

**Figure 25:** Запуск сервера iperf3 в терминале h2

# Запуск клиента iperf3

```
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -J
{
  "start": {
    "connected": [{
      "socket": 7,
      "local_host": "10.0.0.1",
      "local_port": 60146,
      "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 Fr
i Jul 10 00:24:02 UTC 2020 x86_64",
    "timestamp": {
      "time": "Sat, 27 Sep 2025 16:49:36 GMT",
      "timesecs": 1758991776
    },
    "connecting_to": {
      "host": "10.0.0.2",
      "port": 5201
    },
    "cookie": "fdfflfuj43d6b5a5b655ayzgk2qilh6rprlx",
    "tcp_mss_default": 1448,
    "sock_bufsize": 0,
    "sndbuf_actual": 87380,
    "rcvbuf_actual": 87380,
    "test_start": {
      "protocol": "TCP",
      "num_streams": 1,
      "blksize": 131072,
      "omit": 0,
      "duration": 10,
      "bytes": 0,
      "blocks": 0,
      "reverse": 0,
      "tos": 0
    }
  }
}
```

**Figure 26:** Запуск клиента iperf3 в терминале h1 с параметром -J (отображение вывода) <sup>29/35</sup>

## Экспортирование вывода результатов теста в файл

```
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -J > /home/mininet/work/lab_iperf  
3/iperf_results.json
```

**Figure 27:** Экспортирование вывода результатов теста в файл

## Проверка создания файла

```
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 root root 7790 Sep 27 09:52 iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$ |
```

Figure 28: Проверка создания файла

## Завершение работы mininet в интерактивном режиме

```
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 8 terms
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 1841.364 seconds
mininet@mininet-vm:~$
```

**Figure 29:** Завершение работы mininet в интерактивном режиме



# Корректирование прав доступа к файлу JSON

```
mininet@mininet-vm:~$ cd ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 8
-rw-r--r-- 1 root root 7790 Sep 27 09:52 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 7790 Sep 27 09:52 iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$
```

**Figure 30:** Корректирование прав доступа к файлу JSON

# Генерация выходных данных и последующая проверка

```
-rw-r--r-- 1 mininet mininet 7790 Sep 27 09:52 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  952 Sep 27 09:56 iperf.csv
-rw-r--r-- 1 mininet mininet 7790 Sep 27 09:52 iperf_results.json
drwxrwxr-x 2 mininet mininet 4096 Sep 27 09:56 results
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3/results
mininet@mininet-vm:~/work/lab_iperf3/results$ ls -l
total 88
-rw-rw-r-- 1 mininet mininet  491 Sep 27 09:56 1.dat
-rw-rw-r-- 1 mininet mininet 9853 Sep 27 09:56 bytes.pdf
-rw-rw-r-- 1 mininet mininet 9618 Sep 27 09:56 cwnd.pdf
-rw-rw-r-- 1 mininet mininet 9036 Sep 27 09:56 MTU.pdf
-rw-rw-r-- 1 mininet mininet 8978 Sep 27 09:56 retransmits.pdf
-rw-rw-r-- 1 mininet mininet 8946 Sep 27 09:56 RTT.pdf
-rw-rw-r-- 1 mininet mininet 9219 Sep 27 09:56 RTT_Var.pdf
-rw-rw-r-- 1 mininet mininet 9559 Sep 27 09:56 throughput.pdf
mininet@mininet-vm:~/work/lab_iperf3/results$
```

Figure 31: Генерация выходных данных и последующая проверка

В ходе выполнения лабораторной работы я познакомился 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.