

Лабораторная работа №2

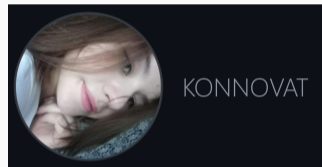
Моделирование сетей передачи данных

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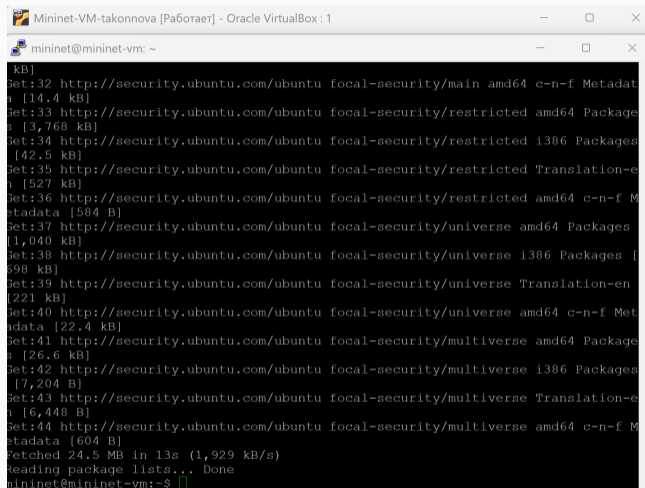
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- Познакомиться с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получить навыки проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.

Выполнение лабораторной работы

Установка необходимого программного обеспечения



```
Mininet-VM-takonnova [Работает] - Oracle VirtualBox : 1
mininet@mininet-vm: ~
kB]
Get:32 http://security.ubuntu.com/ubuntu focal-security/main amd64 c-n-f Metadata [14.4 kB]
Get:33 http://security.ubuntu.com/ubuntu focal-security/restricted amd64 Packages [3,768 kB]
Get:34 http://security.ubuntu.com/ubuntu focal-security/restricted i386 Packages [42.5 kB]
Get:35 http://security.ubuntu.com/ubuntu focal-security/restricted Translation-en [527 kB]
Get:36 http://security.ubuntu.com/ubuntu focal-security/restricted amd64 c-n-f Metadata [584 B]
Get:37 http://security.ubuntu.com/ubuntu focal-security/universe amd64 Packages [1,040 kB]
Get:38 http://security.ubuntu.com/ubuntu focal-security/universe i386 Packages [698 kB]
Get:39 http://security.ubuntu.com/ubuntu focal-security/universe Translation-en [221 kB]
Get:40 http://security.ubuntu.com/ubuntu focal-security/universe amd64 c-n-f Metadata [22.4 kB]
Get:41 http://security.ubuntu.com/ubuntu focal-security/multiverse amd64 Packages [26.6 kB]
Get:42 http://security.ubuntu.com/ubuntu focal-security/multiverse i386 Packages [7,204 B]
Get:43 http://security.ubuntu.com/ubuntu focal-security/multiverse Translation-en [6,448 B]
Get:44 http://security.ubuntu.com/ubuntu focal-security/multiverse amd64 c-n-f Metadata [604 B]
Fetched 24.5 MB in 13s (1,929 kB/s)
Reading package lists... Done
mininet@mininet-vm:~$
```

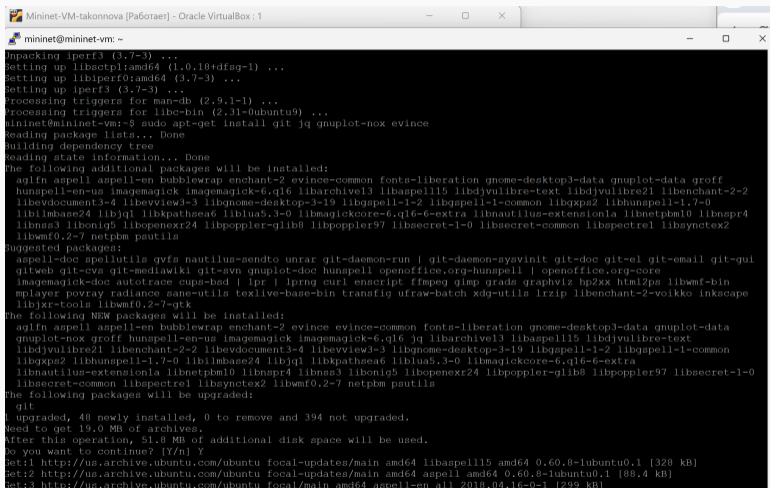
Рис. 1: Обновление репозитиев программного обеспечения

Установка необходимого программного обеспечения

```
Mininet-VM-takonnova [Работает] - Oracle VirtualBox : 1
mininet@mininet-vm: ~
Try: sudo apt install <deb name>

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 (127 kB/s)
Selecting previously unselected package libsctp1:amd64.
(Reading database ... 102146 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) ...
```

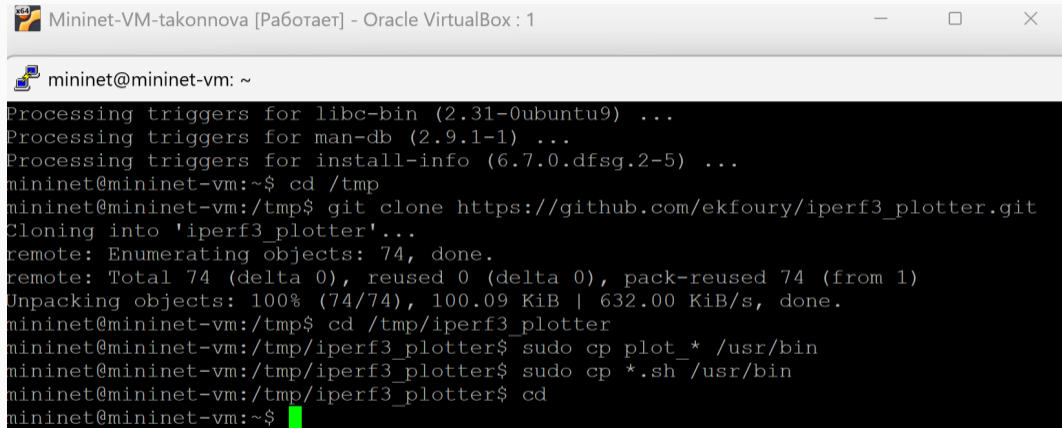
Установка необходимого программного обеспечения



```
Mininet-VM-takonnova [Работаer] - Oracle VirtualBox : 1
mininet@mininet-vm: ~
Unpacking iperf3 (3.7-3) ...
Setting up libctpl: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:~$ 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 libenchanted-2-2
  libevdocument3-4 libevview3-3 libgnome-desktop-3-19 libgspell-1-2 libgspell-1-common libgxps2 libhunspell-1.7-0
  liblmbase24 libjq1 libkpathsea6 liblua5.3-0 libmagickcore-6.q16-6-extra libnautilus-extensionla libnetpbm10 libnspr4
  libnss3 libonig5 libopenexr24 libpoppler-glib8 libpoppler97 libsecret-1-0 libsecret-common libspectrel libsynctex2
  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 libenchanted-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 libenchanted-2-2 libevdocument3-4 libevview3-3 libgnome-desktop-3-19 libgspell-1-2 libgspell-1-common
  libgxps2 libhunspell-1.7-0 liblmbase24 libjq1 libkpathsea6 liblua5.3-0 libmagickcore-6.q16-6-extra
  libnautilus-extensionla libnetpbm10 libnss3 libonig5 libopenexr24 libpoppler-glib8 libpoppler97 libsecret-1-0
  libsecret-common libspectrel libsynctex2 libwmf0.2-7 netpbm psutils
The following packages will be upgraded:
  git
1 upgraded, 48 newly installed, 0 to remove and 394 not upgraded.
Need to get 19.0 MB of archives.
After this operation, 51.8 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libaspell15 amd64 0.60.8-1ubuntu0.1 [328 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 aspell amd64 0.60.8-1ubuntu0.1 [88.4 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/main amd64 aspell-en all 2018.04.16-0-1 [299 kB]
```

Рис. 3: Установка необходимого дополнительного программного обеспечения на виртуальную машину

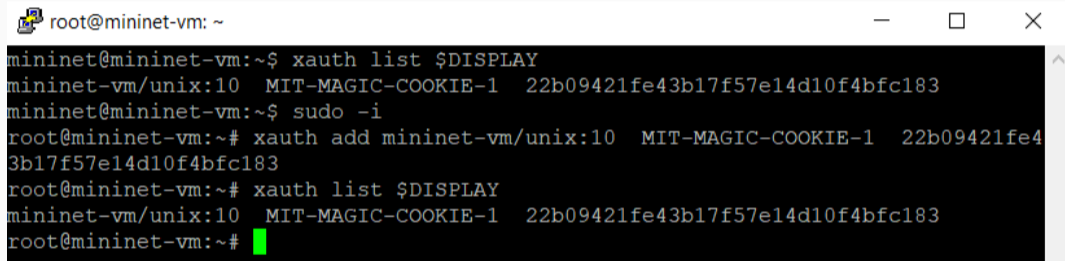
Установка необходимого программного обеспечения



The screenshot shows a terminal window titled "Mininet-VM-takonnova [Работает] - Oracle VirtualBox : 1". The terminal prompt is "mininet@mininet-vm: ~". The output shows the installation of various triggers, followed by the cloning of the "iperf3_plotter" repository from GitHub. The repository is cloned into "/tmp", and its contents are copied to "/usr/bin".

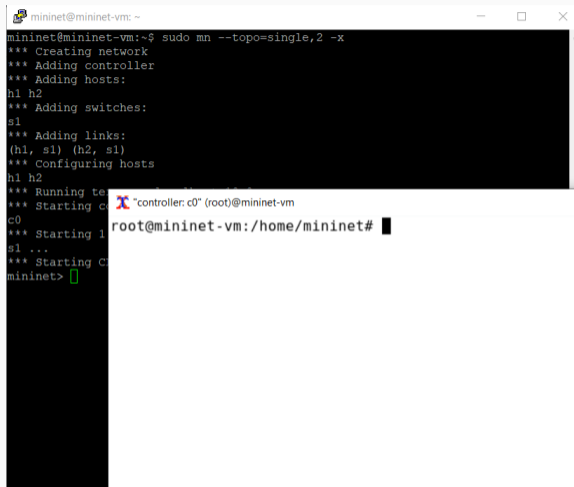
```
Processing triggers for libc-bin (2.31-0ubuntu9) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for install-info (6.7.0.dfsg.2-5) ...
mininet@mininet-vm:~$ cd /tmp
mininet@mininet-vm:/tmp$ git clone https://github.com/ekfoury/iperf3_plotter.git
Cloning into 'iperf3_plotter'...
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 | 632.00 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$ cd
mininet@mininet-vm:~$
```

Рис. 4: Развертывание iperf3_plotter

A terminal window titled 'root@mininet-vm: ~' with standard window controls. The terminal output shows a sequence of commands and their results. The first command 'xauth list \$DISPLAY' shows a single entry for 'mininet-vm/unix:10'. The second command 'sudo -i' switches to root. The third command 'xauth add mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 22b09421fe43b17f57e14d10f4bfc183' adds a new entry. The final 'xauth list \$DISPLAY' command shows both the original and the newly added entries.

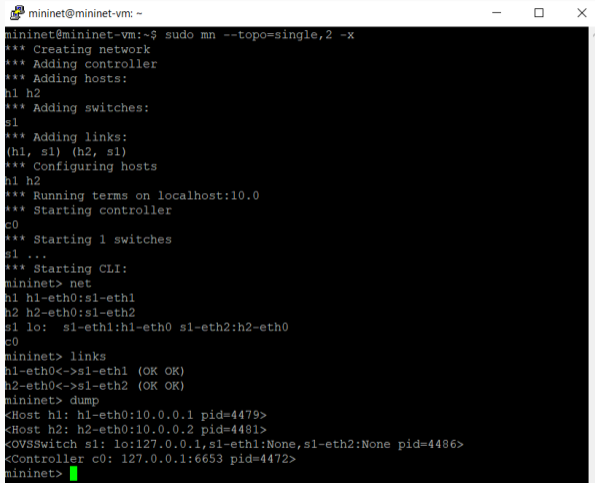
```
root@mininet-vm: ~  
mininet@mininet-vm:~$ xauth list $DISPLAY  
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  22b09421fe43b17f57e14d10f4bfc183  
mininet@mininet-vm:~$ sudo -i  
root@mininet-vm:~# xauth add mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  22b09421fe4  
3b17f57e14d10f4bfc183  
root@mininet-vm:~# xauth list $DISPLAY  
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  22b09421fe43b17f57e14d10f4bfc183  
root@mininet-vm:~#
```

Рис. 5: Исправление прав запуска X-соединения



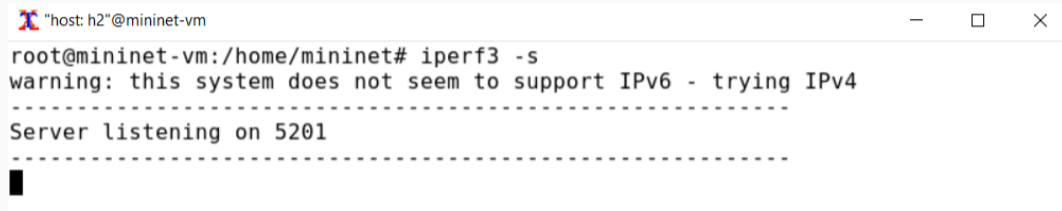
```
mininet@mininet-vm: ~  
mininet@mininet-vm:~$ sudo mn --topo=single,2 -x  
*** Creating network  
*** Adding controller  
*** Adding hosts:  
h1 h2  
*** Adding switches:  
s1  
*** Adding links:  
(h1, s1) (h2, s1)  
*** Configuring hosts  
h1 h2  
*** Running tests  
*** Starting controller: c0 (root@mininet-vm)  
c0  
*** Starting 1 hosts  
s1 ...  
*** Starting C  
mininet>
```

Рис. 6: Создание простейшей топологии, состоящей из двух хостов и коммутатора



```
mininet@mininet-vm: ~  
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=4479>  
<Host h2: h2-eth0:10.0.0.2 pid=4481>  
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=4486>  
<Controller c0: 127.0.0.1:6653 pid=4472>  
mininet>
```

Рис. 7: Просмотр параметров топологии



```
"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
-----
█
```

Рис. 8: Запуск сервера iperf3 в терминале h2

```
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 45660 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr    Cwnd
[ 7]  0.00-1.00      sec  1.94 GBytes  16.7 Gbits/sec    0   3.59 MBytes
[ 7]  1.00-2.00      sec  1.97 GBytes  16.9 Gbits/sec    0   4.58 MBytes
[ 7]  2.00-3.00      sec  1.08 GBytes  9.24 Gbits/sec    0   4.58 MBytes
[ 7]  3.00-4.00      sec  1.80 GBytes  15.5 Gbits/sec    0   4.58 MBytes
[ 7]  4.00-5.00      sec  2.01 GBytes  17.2 Gbits/sec    0   4.58 MBytes
[ 7]  5.00-6.00      sec  2.01 GBytes  17.3 Gbits/sec    0   4.80 MBytes
[ 7]  6.00-7.00      sec  1.93 GBytes  16.6 Gbits/sec    0   8.21 MBytes
[ 7]  7.00-8.00      sec  1.96 GBytes  16.9 Gbits/sec    0   8.21 MBytes
[ 7]  8.00-9.00      sec  1.98 GBytes  17.0 Gbits/sec    0   8.21 MBytes
[ 7]  9.00-10.00     sec  1.98 GBytes  17.0 Gbits/sec    0   8.21 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-10.00      sec  18.7 GBytes  16.0 Gbits/sec    0
[ 7]  0.00-10.00      sec  18.6 GBytes  16.0 Gbits/sec    0
sender
receiver

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

Рис. 9: Запуск клиента iperf3 в терминале хоста h1

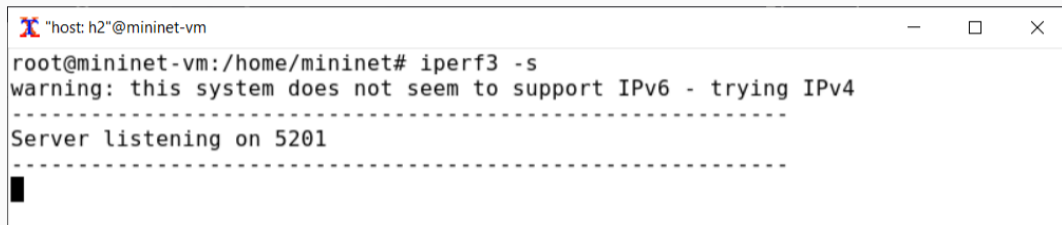
```
host: h2"@"mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 45658
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 45660
[ ID] Interval           Transfer     Bitrate
[ 7] 0.00-1.00    sec   1.92 GBytes  16.5 Gbits/sec
[ 7] 1.00-2.00    sec   1.97 GBytes  16.9 Gbits/sec
[ 7] 2.00-3.00    sec   1.08 GBytes   9.21 Gbits/sec
[ 7] 3.00-4.00    sec   1.80 GBytes  15.5 Gbits/sec
[ 7] 4.00-5.00    sec   2.01 GBytes  17.2 Gbits/sec
[ 7] 5.00-6.00    sec   2.01 GBytes  17.3 Gbits/sec
[ 7] 6.00-7.00    sec   1.95 GBytes  16.8 Gbits/sec
[ 7] 7.00-8.00    sec   1.94 GBytes  16.7 Gbits/sec
[ 7] 8.00-9.00    sec   1.98 GBytes  17.0 Gbits/sec
[ 7] 9.00-10.00   sec   1.98 GBytes  17.0 Gbits/sec
-----
[ ID] Interval           Transfer     Bitrate
[ 7] 0.00-10.00   sec  18.6 GBytes  16.0 Gbits/sec
-----
Server listening on 5201
█
```

receiver

Рис. 10: Остановка сервера iPerf3 в терминале хоста h2

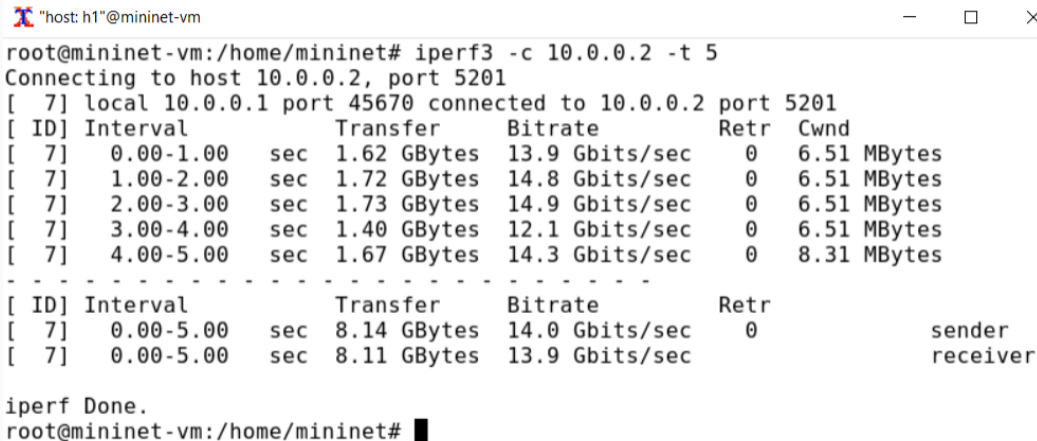
```
mininet@mininet-vmx -  
mininet> h2 iperf3 -s &  
-----  
Server listening on TCP port 5001  
TCP window size: 85.3 KByte (default)  
-----  
mininet> h1 iperf3 -c h2  
Connecting to host 10.0.0.2, port 5201  
[ 5] local 10.0.0.1 port 45666 connected to 10.0.0.2 port 5201  
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd  
[ 5] 0.00-1.00    sec 2.00 GBytes 17.2 Gbits/sec  0    3.21 Mbytes  
[ 5] 1.00-2.00    sec 2.05 GBytes 17.6 Gbits/sec  0    3.21 Mbytes  
[ 5] 2.00-3.00    sec 1.99 GBytes 17.1 Gbits/sec  0    8.11 Mbytes  
[ 5] 3.00-4.00    sec 1.89 GBytes 16.2 Gbits/sec  0    8.11 Mbytes  
[ 5] 4.00-5.00    sec 1.58 GBytes 13.6 Gbits/sec  0    8.11 Mbytes  
[ 5] 5.00-6.00    sec 1.32 GBytes 11.4 Gbits/sec  0    8.11 Mbytes  
[ 5] 6.00-7.00    sec 1.94 GBytes 16.7 Gbits/sec  0    8.11 Mbytes  
[ 5] 7.00-8.00    sec 2.01 GBytes 17.3 Gbits/sec  0    8.11 Mbytes  
[ 5] 8.00-9.00    sec 1.94 GBytes 16.7 Gbits/sec  0    8.11 Mbytes  
[ 5] 9.00-10.00   sec 1.97 GBytes 16.9 Gbits/sec  0    8.11 Mbytes  
-----  
[ ID] Interval      Transfer    Bitrate      Retr  
[ 5] 0.00-10.00   sec 18.7 GBytes 16.1 Gbits/sec  0  
[ 5] 0.00-10.00   sec 18.7 GBytes 16.1 Gbits/sec  0  
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 45664  
[ 5] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 45664  
[ ID] Interval      Transfer    Bitrate  
[ 5] 0.00-1.01    sec 1.99 GBytes 17.0 Gbits/sec  
[ 5] 1.01-2.00    sec 2.04 GBytes 17.6 Gbits/sec  
[ 5] 2.00-3.00    sec 2.01 GBytes 17.3 Gbits/sec  
[ 5] 3.00-4.00    sec 1.87 GBytes 16.0 Gbits/sec  
[ 5] 4.00-5.00    sec 1.58 GBytes 13.6 Gbits/sec  
[ 5] 5.00-6.00    sec 1.32 GBytes 11.3 Gbits/sec  
[ 5] 6.00-7.00    sec 1.94 GBytes 16.7 Gbits/sec  
[ 5] 7.00-8.00    sec 2.01 GBytes 17.3 Gbits/sec  
[ 5] 8.00-9.00    sec 1.94 GBytes 16.7 Gbits/sec  
[ 5] 9.00-10.00   sec 1.99 GBytes 17.1 Gbits/sec  
[ 5] 10.00-10.00  sec 832 KBytes 13.1 Gbits/sec  
-----  
[ ID] Interval      Transfer    Bitrate  
[ 5] 0.00-10.00   sec 18.7 GBytes 16.1 Gbits/sec  
-----
```

Рис. 11: Запуск сервера iperf3 на хосте h2, запуск клиента iperf3 на хосте h1, остановка серверного процесса



```
"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
-----
█
```

Рис. 12: Запуск сервера iperf3 в терминале h2

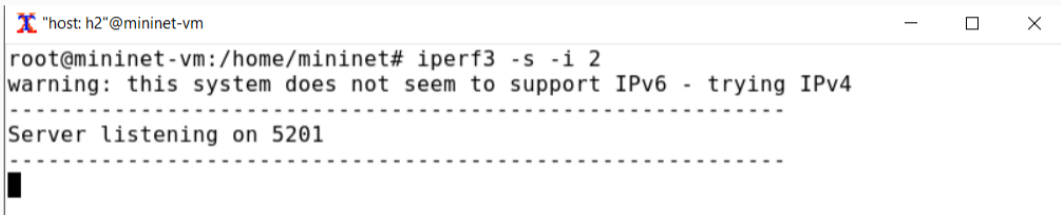


A terminal window titled "host: h1"@mininet-vm. The user runs the command `iperf3 -c 10.0.0.2 -t 5`. The output shows a connection to host 10.0.0.2 on port 5201. A table of results for five 1-second intervals is displayed, showing transfer rates between 12.1 and 14.9 Gbits/sec. A summary row shows an average of 14.0 Gbits/sec. The test ends with "iperf Done."

```
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 45670 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr    Cwnd
[ 7]  0.00-1.00    sec   1.62 GBytes  13.9 Gbits/sec    0   6.51 MBytes
[ 7]  1.00-2.00    sec   1.72 GBytes  14.8 Gbits/sec    0   6.51 MBytes
[ 7]  2.00-3.00    sec   1.73 GBytes  14.9 Gbits/sec    0   6.51 MBytes
[ 7]  3.00-4.00    sec   1.40 GBytes  12.1 Gbits/sec    0   6.51 MBytes
[ 7]  4.00-5.00    sec   1.67 GBytes  14.3 Gbits/sec    0   8.31 MBytes
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-5.00    sec   8.14 GBytes  14.0 Gbits/sec    0
[ 7]  0.00-5.00    sec   8.11 GBytes  13.9 Gbits/sec
sender
receiver

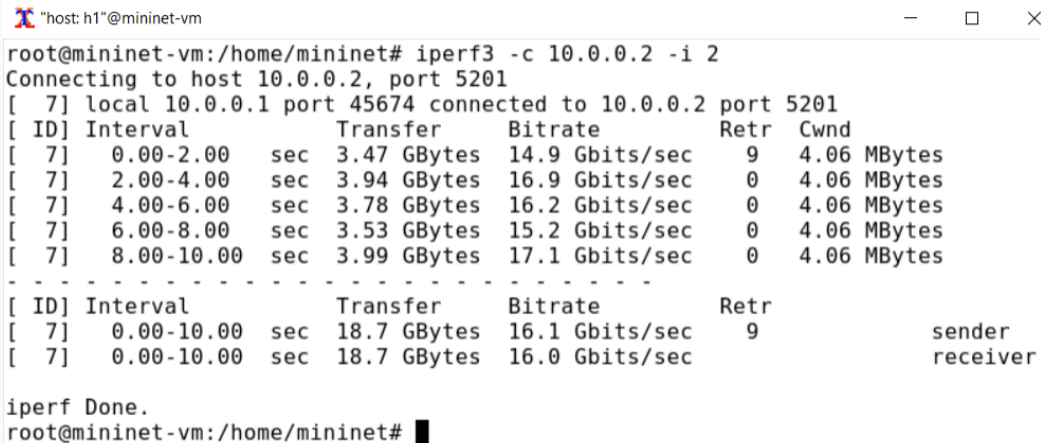
iperf Done.
root@mininet-vm:/home/mininet#
```

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



```
"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
-----
█
```

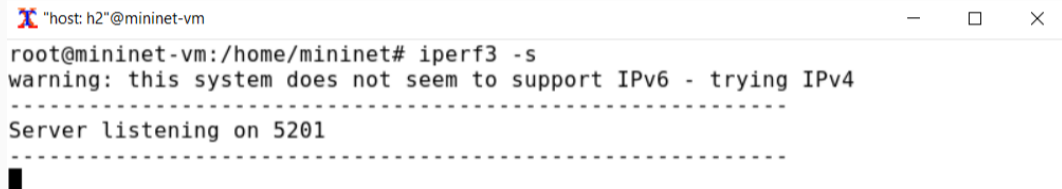
Рис. 14: Запуск сервера iperf3 в терминале h2 с 2-секундным интервалом времени отсчёта

A terminal window titled '"host: h1"@mininet-vm' with standard window controls. It displays the execution of the iperf3 client on host h1, connecting to 10.0.0.2. The output shows five 2-second intervals of data transfer, followed by a summary table and the command completion message.

```
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 45674 connected to 10.0.0.2 port 5201
[ ID] Interval            Transfer          Bitrate          Retr   Cwnd
[ 7]  0.00-2.00    sec   3.47 GBytes    14.9 Gbits/sec     9   4.06 MBytes
[ 7]  2.00-4.00    sec   3.94 GBytes    16.9 Gbits/sec     0   4.06 MBytes
[ 7]  4.00-6.00    sec   3.78 GBytes    16.2 Gbits/sec     0   4.06 MBytes
[ 7]  6.00-8.00    sec   3.53 GBytes    15.2 Gbits/sec     0   4.06 MBytes
[ 7]  8.00-10.00   sec   3.99 GBytes    17.1 Gbits/sec     0   4.06 MBytes
- - - - -
[ ID] Interval            Transfer          Bitrate          Retr
[ 7]  0.00-10.00   sec   18.7 GBytes    16.1 Gbits/sec     9
[ 7]  0.00-10.00   sec   18.7 GBytes    16.0 Gbits/sec
sender
receiver

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

Рис. 15: Запуск клиента iperf3 в терминале h1 с 2-секундным интервалом времени отсчёта



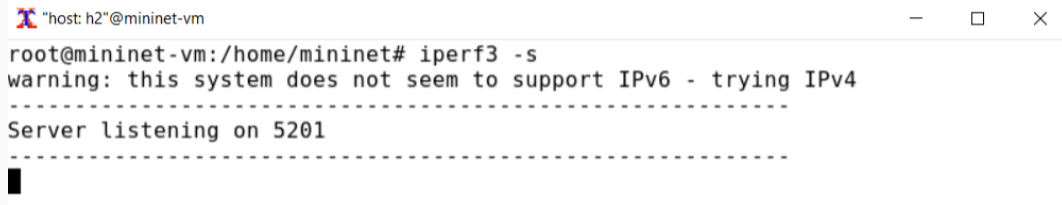
```
"host: h2"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
█
```

Рис. 16: Запуск сервера iperf3 в терминале h2

```
"host: h1"@mininet-vm
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 45678 connected to 10.0.0.2 port 5201
[ ID] Interval            Transfer          Bitrate          Retr  Cwnd
[ 7]  0.00-1.00      sec   1.93 GBytes     16.6 Gbits/sec      0   3.47 MBytes
[ 7]  1.00-2.00      sec   1.97 GBytes     16.9 Gbits/sec      0   3.47 MBytes
[ 7]  2.00-3.00      sec   2.02 GBytes     17.3 Gbits/sec      0   3.47 MBytes
[ 7]  3.00-4.00      sec   2.00 GBytes     17.2 Gbits/sec      0   3.47 MBytes
[ 7]  4.00-5.00      sec   2.02 GBytes     17.4 Gbits/sec      0   3.47 MBytes
[ 7]  5.00-6.00      sec   1.97 GBytes     17.0 Gbits/sec      0   4.42 MBytes
[ 7]  6.00-7.00      sec   2.00 GBytes     17.2 Gbits/sec      0   4.42 MBytes
[ 7]  7.00-8.00      sec   1.97 GBytes     17.0 Gbits/sec      1   4.42 MBytes
[ 7]  8.00-8.05      sec    110 MBytes     17.6 Gbits/sec      0   4.42 MBytes
- - - - -
[ ID] Interval            Transfer          Bitrate          Retr
[ 7]  0.00-8.05      sec   16.0 GBytes     17.1 Gbits/sec      1
[ 7]  0.00-8.05      sec   16.0 GBytes     17.0 Gbits/sec
sender
receiver

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

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



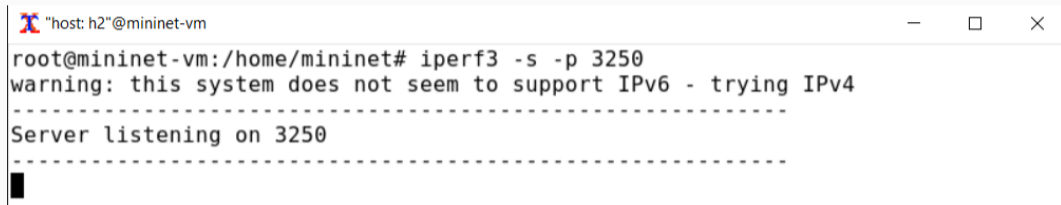
```
"host: h2"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
█
```

Рис. 18: Запуск сервера iperf3 в терминале h2

```
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 48290 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      127 KBytes  1.04 Mbits/sec  90
[ 7] 4.00-5.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 5.00-6.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 6.00-7.00 sec      127 KBytes  1.04 Mbits/sec  90
[ 7] 7.00-8.00 sec      129 KBytes  1.05 Mbits/sec  91
[ 7] 8.00-9.00 sec      127 KBytes  1.04 Mbits/sec  90
[ 7] 9.00-10.00 sec     129 KBytes  1.05 Mbits/sec  91
- - - - -
[ ID] Interval           Transfer     Bitrate      Jitter      Lost/Total Datagrams
[ 7] 0.00-10.00 sec     1.25 MBytes  1.05 Mbits/sec  0.000 ms    0/906 (0%) sender
[ 7] 0.00-10.00 sec     1.25 MBytes  1.05 Mbits/sec  0.027 ms    0/906 (0%) receiver

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

Рис. 19: Запуск клиента iperf3 в терминале h1 с протоколом UDP



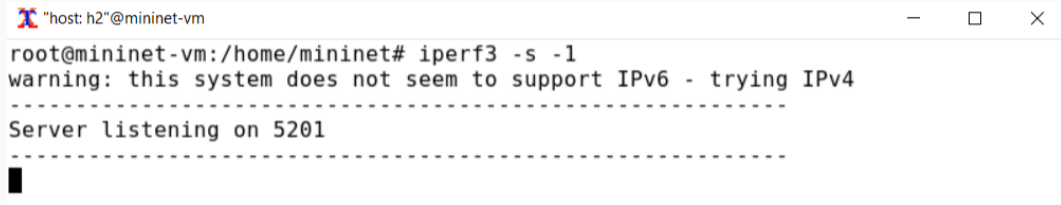
```
"host: h2"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s -p 3250
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 3250
-----
█
```

Рис. 20: Запуск сервера `iperf3` в терминале `h2` с портом прослушивания

```
"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 56094 connected to 10.0.0.2 port 3250
[ ID] Interval            Transfer          Bitrate          Retr   Cwnd
[ 7]  0.00-1.00      sec   1.59 GBytes    13.7 Gbits/sec     0    4.30 MBytes
[ 7]  1.00-2.00      sec   1.79 GBytes    15.4 Gbits/sec     0    4.30 MBytes
[ 7]  2.00-3.00      sec   1.70 GBytes    14.6 Gbits/sec     0    4.74 MBytes
[ 7]  3.00-4.00      sec   2.02 GBytes    17.4 Gbits/sec     0    4.74 MBytes
[ 7]  4.00-5.00      sec   1.91 GBytes    16.4 Gbits/sec     0    4.74 MBytes
[ 7]  5.00-6.00      sec   2.01 GBytes    17.3 Gbits/sec     0    4.74 MBytes
[ 7]  6.00-7.00      sec   2.02 GBytes    17.3 Gbits/sec     0    8.10 MBytes
[ 7]  7.00-8.00      sec   1.97 GBytes    16.9 Gbits/sec     0    8.10 MBytes
[ 7]  8.00-9.00      sec   1.95 GBytes    16.7 Gbits/sec     0    8.10 MBytes
[ 7]  9.00-10.00     sec   1.98 GBytes    17.1 Gbits/sec     0    8.10 MBytes
- - - - -
[ ID] Interval            Transfer          Bitrate          Retr
[ 7]  0.00-10.00     sec   18.9 GBytes    16.3 Gbits/sec     0
[ 7]  0.00-10.00     sec   18.9 GBytes    16.2 Gbits/sec
sender
receiver

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

Рис. 21: Запуск клиента iperf3 в терминале h1 с портом



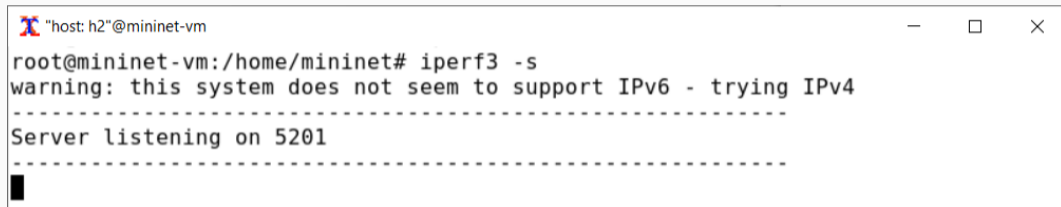
```
"host: h2"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s -1
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
█
```

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

```
"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 45686
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 45688
[ ID] Interval           Transfer     Bitrate
[ 7] 0.00-1.00    sec   1.97 GBytes  16.9 Gbits/sec
[ 7] 1.00-2.00    sec   2.00 GBytes  17.2 Gbits/sec
[ 7] 2.00-3.00    sec   1.97 GBytes  16.9 Gbits/sec
[ 7] 3.00-4.00    sec   1.54 GBytes  13.2 Gbits/sec
[ 7] 4.00-5.00    sec   1.59 GBytes  13.7 Gbits/sec
[ 7] 5.00-6.00    sec   1.84 GBytes  15.8 Gbits/sec
[ 7] 6.00-7.00    sec   1.91 GBytes  16.4 Gbits/sec
[ 7] 7.00-8.00    sec   1.98 GBytes  17.1 Gbits/sec
[ 7] 8.00-9.00    sec   1.60 GBytes  13.8 Gbits/sec
[ 7] 9.00-10.00   sec   1.53 GBytes  13.1 Gbits/sec
-----
[ ID] Interval           Transfer     Bitrate
[ 7] 0.00-10.00   sec  17.9 GBytes  15.4 Gbits/sec
root@mininet-vm:/home/mininet#
```

receiver

Рис. 23: Запуск клиента iperf3 в терминале h1



```
"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
-----
█
```

Рис. 24: Запуск сервера iperf3 в терминале h2



```
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": 45692,
      "remote_host": "10.0.0.2",
      "remote_port": 5201
    },
    "version": "iperf 3.7",
    "system_info": "Linux mininet-vm 5.4.0-42-generic #46-Ubuntu SMP Fri Jul 10 00:24:02 UTC 2020 x86_64",
    "timestamp": {
      "time": "Mon, 18 Nov 2024 11:40:20 GMT",
      "timesecs": 1731930020
    },
    "connecting_to": {
      "host": "10.0.0.2",
      "port": 5201
    },
    "cookie": "rgvirntfmik26rw5cj2sifmh6wwcxazcz27s",
    "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,

```

Рис. 25: Запуск клиента iperf3 в терминале h1 с параметром -J (отображение вывода в формате JSON)

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

Рис. 26: Экспортирование вывода результатов теста в файл

```
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 8 terms
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 1783.296 seconds
mininet@mininet-vm:~$
```

Рис. 27: Завершение работы mininet в интерактивном режиме

Вывод

- В ходе выполнения лабораторной работы познакомились с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получили навыки проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.

Список литературы. Библиография

[1] Mininet: <https://mininet.org/>