

## Лабораторная работа №2

Моделирование сетей передачи данных

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Коннова Т. А.

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Российский университет дружбы народов имени Патриса Лумумбы, Москва, Россия

- Коннова Татьяна Алексеевна
- Студентка группы НПИбд-01-22
- Студ. билет 1132221814
- Российский университет дружбы народов имени Патриса Лумумбы



## Цель лабораторной работы

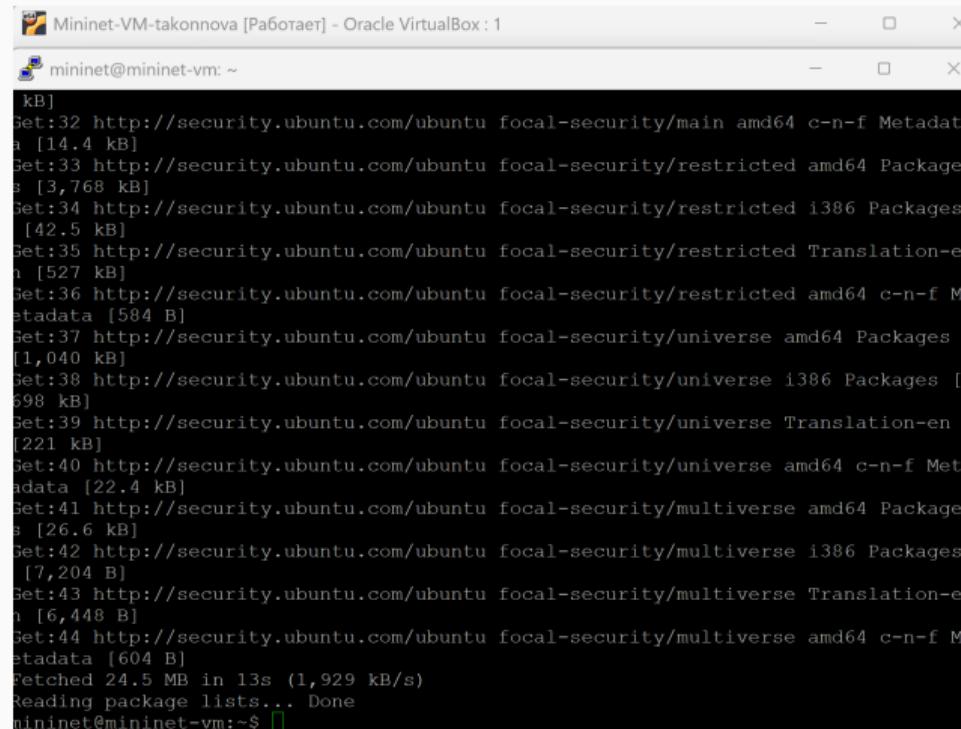
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- Познакомиться с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получить навыки проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.

## Выполнение лабораторной работы

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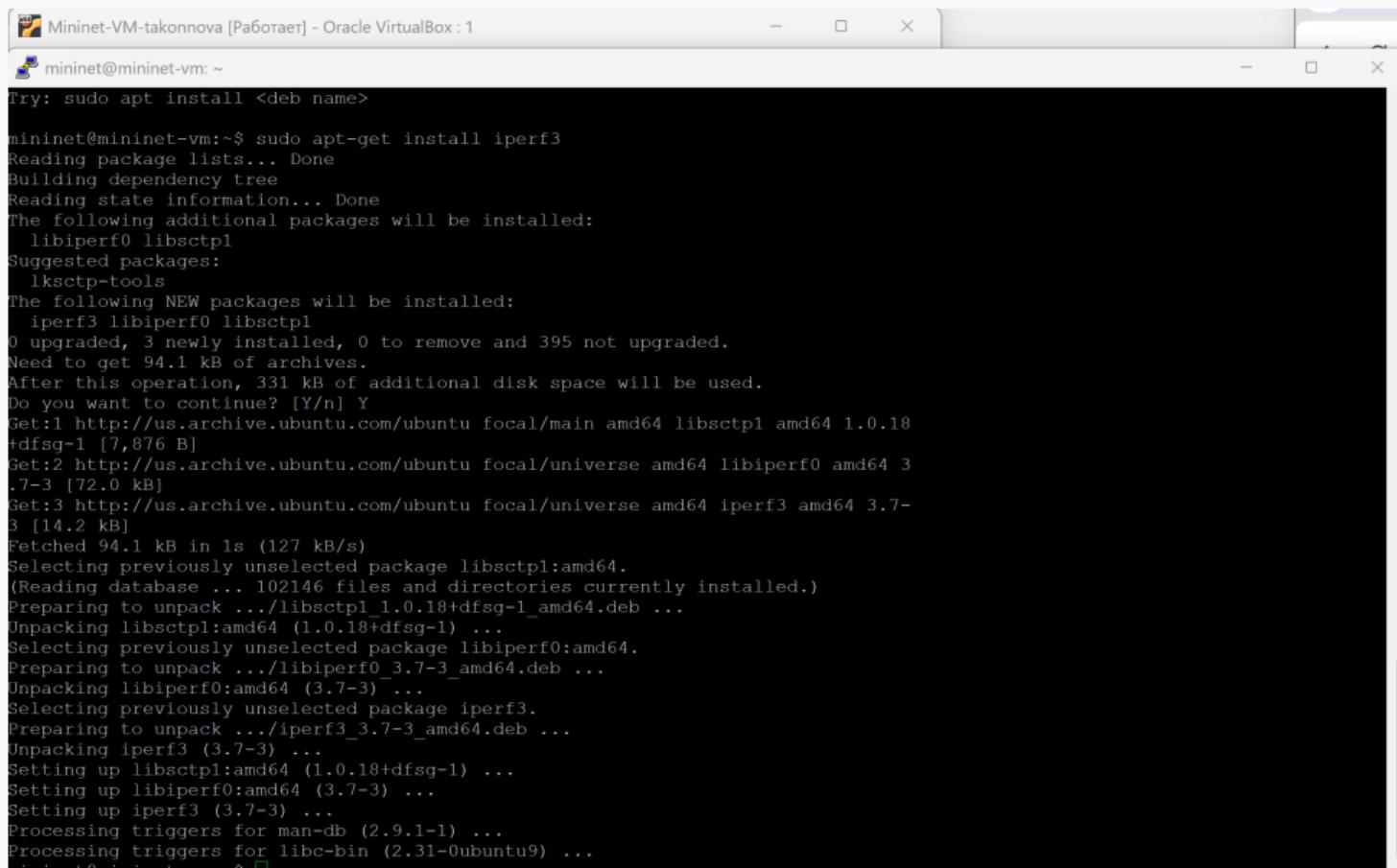
# Установка необходимого программного обеспечения



```
[22.4 kB]
Get:33 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:~$
```

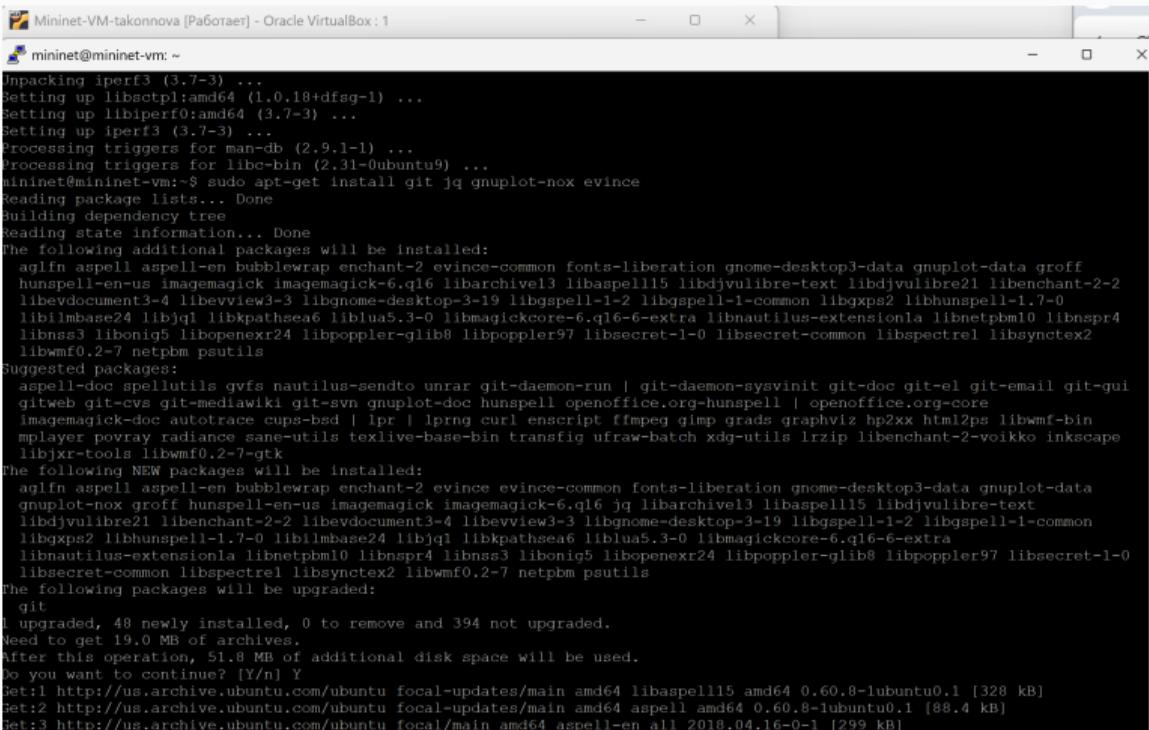
Рис. 1: Обновление репозиториев программного обеспечения

# Установка необходимого программного обеспечения



```
mininet@mininet-vm:~$ sudo apt 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) ...
```

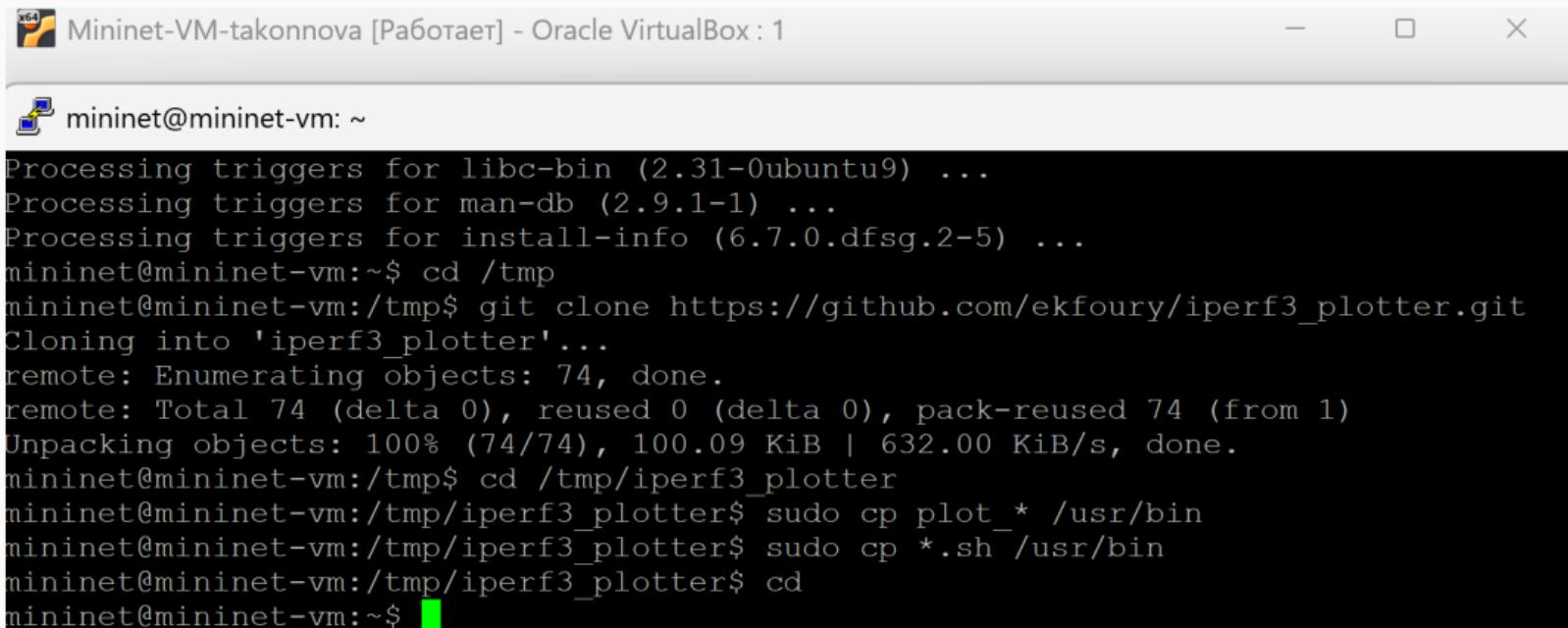
# Установка необходимого программного обеспечения



```
mininet@mininet-vm: ~
  unpacking iperf3 (3.7-3) ...
  setting up libstcpl1: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-en bubblewrap enchant-2 evince-common fonts-liberation gnome-desktop3-data gnuplot-data groff
  hunspell-en-us imagemagick imagemagick-6.q16 libarchivel3 libaspell15 libdjvuibre-text libdjvuibre21 libenchant-2
  libevdocument3-4 libevview3-3 libgnome-desktop-3-19 libgsPELL-1-2 libgsPELL-1-common libgxps2 libhunspell-1.7-0
  libilmbase24 libjqql libkpathsea6 liblubua5.3-0 libmagickcore-6.q16-6-extra libnautilus-extension1a libnetpbm10 libnspr4
  libnss3 libonig5 libopenexr24 libpoppler-glib8 libpoppler97 libsecret-1-0 libsecret-common libspectre1 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 radiane sane-utils texlive-base-bin transfig ufraw-batch xdg-utils lzzip libenchant-2-voikko inkscape
  libjxr-tools libwmf0.2-7-gtk
The following NEW packages will be installed:
  aglfn aspell-en bubblewrap enchant-2 evince-common fonts-liberation gnome-desktop3-data gnuplot-data
  gnuplot-nox groff hunspell-en-us imagemagick imagemagick-6.q16 jq libarchivel3 libaspell15 libdjvuibre-text
  libdjvuibre21 libenchant-2 libevdocument3-4 libevview3-3 libgnome-desktop-3-19 libgsSPELL-1-2 libgsSPELL-1-common
  libgxps2 libhunspell-1.7-0 libilmbase24 libjqql libkpathsea6 liblubua5.3-0 libmagickcore-6.q16-6-extra
  libnautilus-extension1a libnetpbm10 libnspr4 libnss3 libonig5 libopenexr24 libpoppler-glib8 libpoppler97 libsecret-1-0
  libsecret-common libspectre1 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

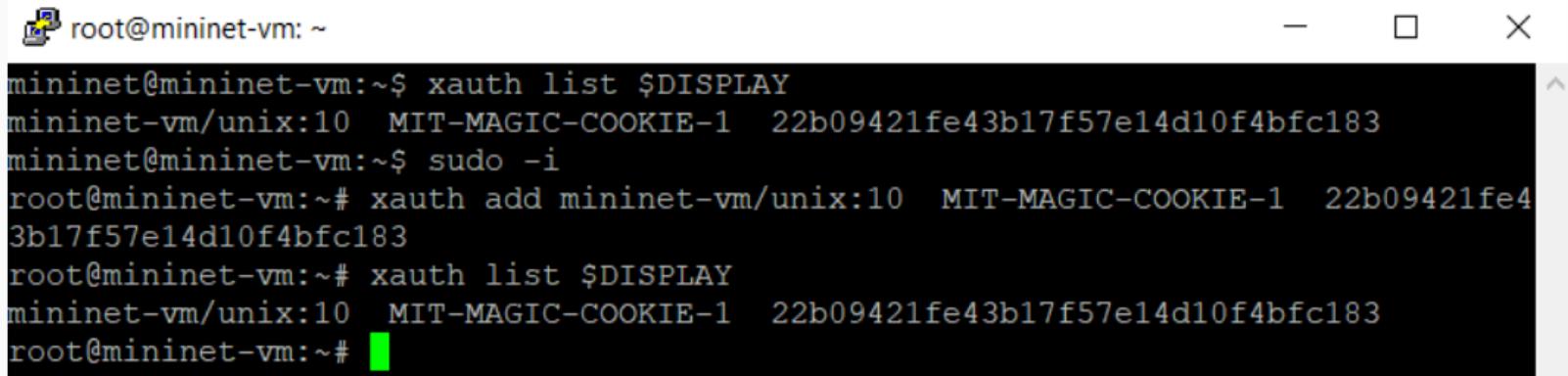
## Установка необходимого программного обеспечения



```
x64 Mininet-VM-takonna [Работает] - Oracle VirtualBox : 1
mininet@mininet-vm: ~
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: Развёртывание iperf3\_plotter

## Интерактивные эксперименты

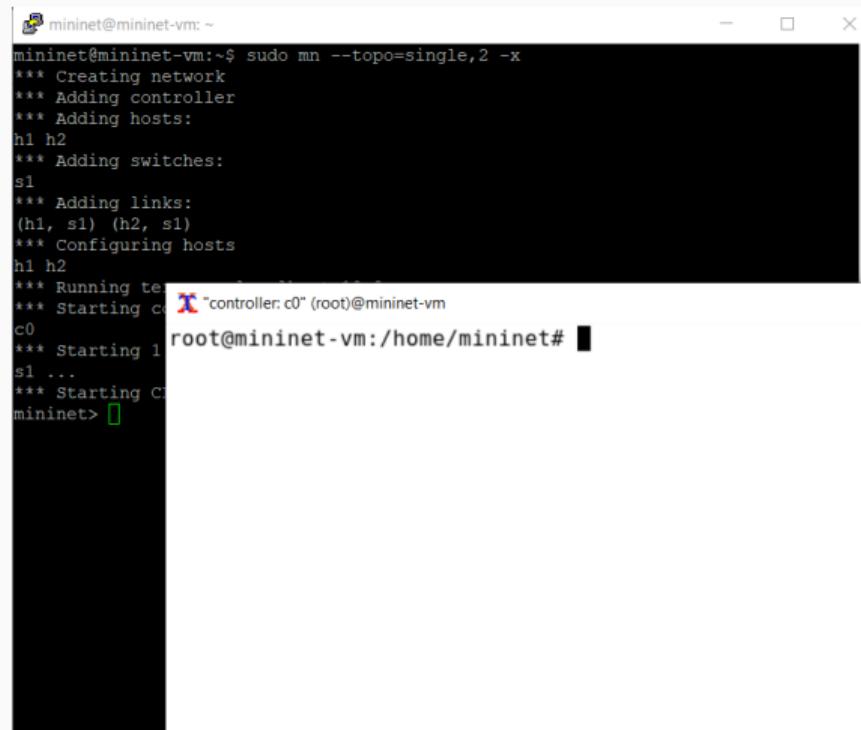


The screenshot shows a terminal window titled 'root@mininet-vm: ~'. The terminal displays the following command sequence:

```
root@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

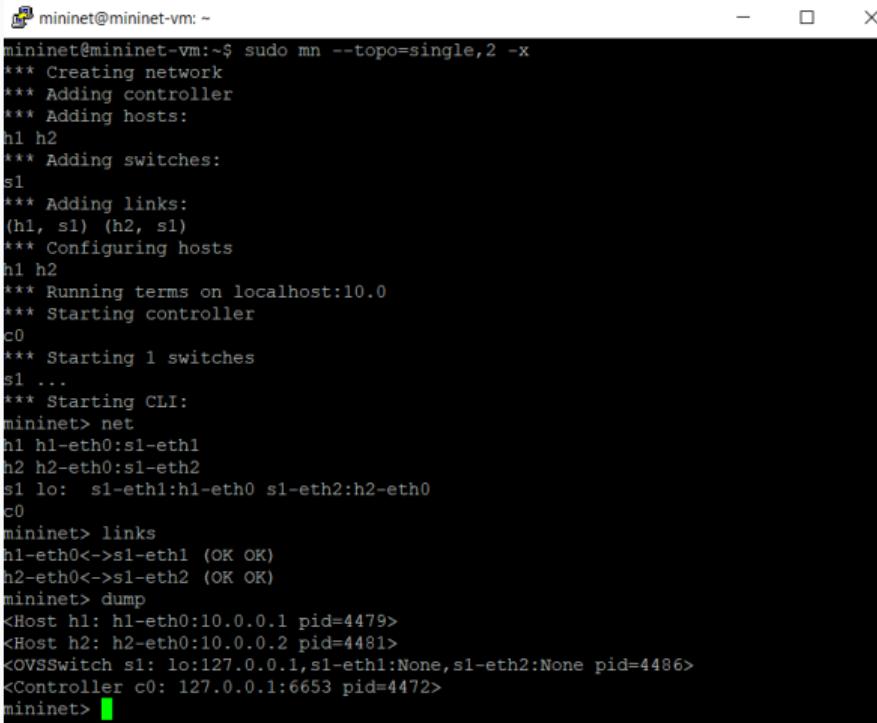
# Интерактивные эксперименты



```
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 test...
*** Starting controller "controller: c0" (root)@mininet-vm
c0
*** Starting 1
s1 ...
*** Starting Controller
mininet>
```

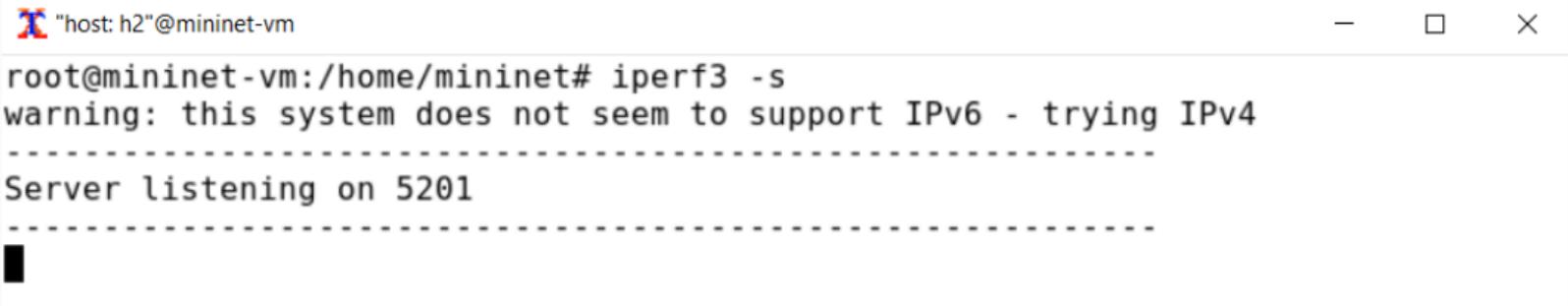
Рис. 6: Создание простейшей топологии, состоящей из двух хостов и коммутатора

# Интерактивные эксперименты



```
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>
```

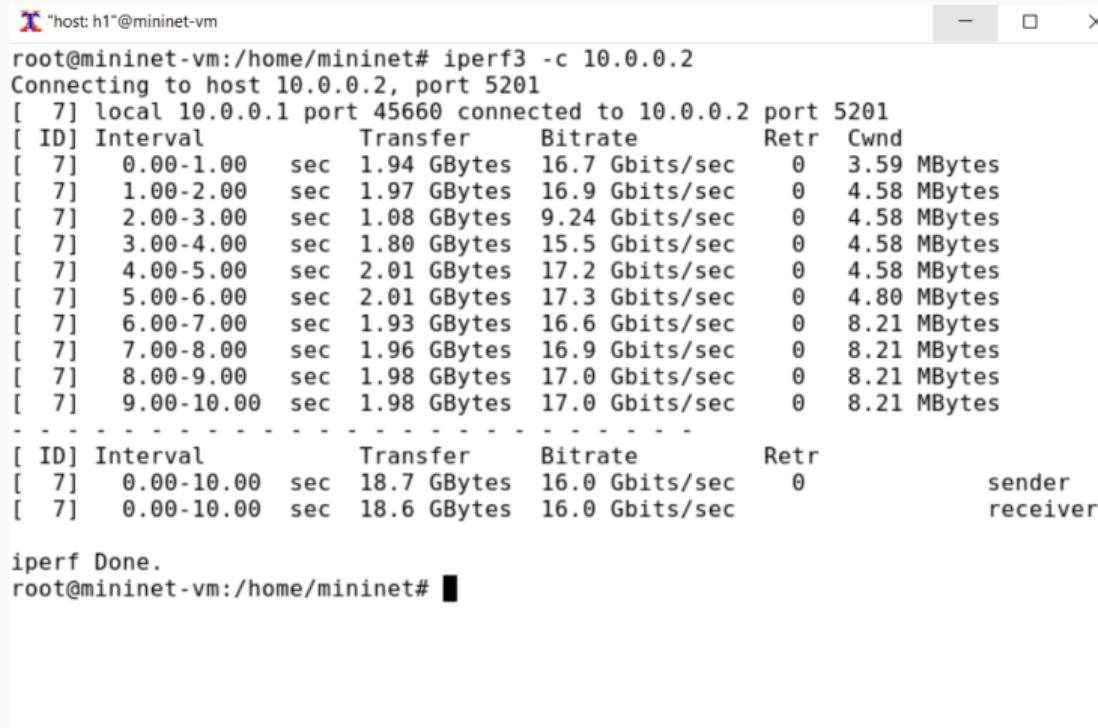
Рис. 7: Просмотр параметров топологии



```
"host: h2"@mininet-vm - X
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

## Интерактивные эксперименты



The screenshot shows a terminal window titled "host: h1" running on a host named mininet-vm. The user has run the command iperf3 -c 10.0.0.2, which connects to a host at 10.0.0.2 port 5201. The test results are displayed in a table format, showing transfer times from 0.00 to 10.00 seconds, transfer rates in GBytes/sec, and bitrates in Gbits/sec. The Cwnd values range from 3.59 to 8.21 MBytes. The last two rows show summary statistics for the sender and receiver.

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	sender
[ 7]	0.00-10.00	sec 18.6 GBytes	16.0 Gbits/sec		receiver

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

Рис. 9: Запуск клиента iperf3 в терминале хоста h1

## Интерактивные эксперименты

```
X "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
                                         receiver
-----
Server listening on 5201
-----
```

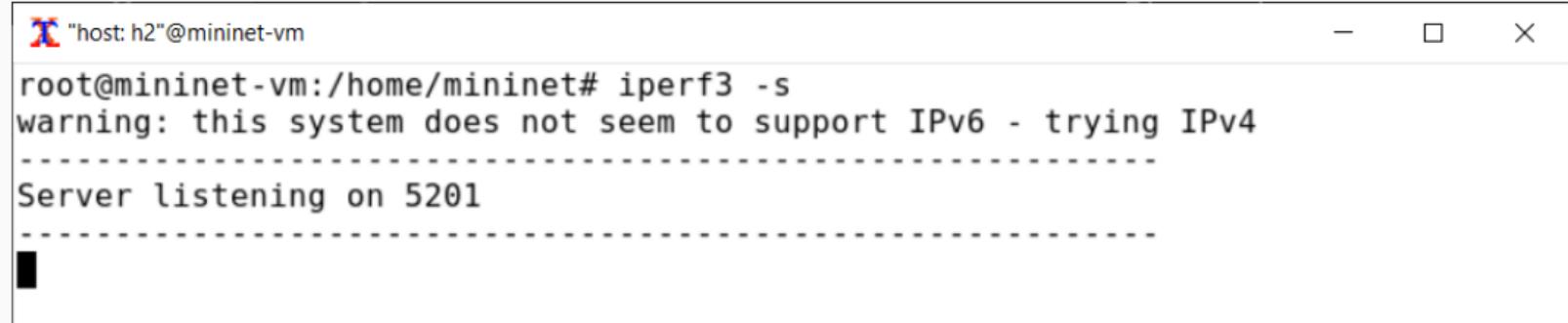
Рис. 10: Остановка сервера iPerf3 в терминале хоста h2

# Интерактивные эксперименты

```
mininet@mininet-vm: ~
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 Gbytes/sec  0  3.21 MBytes
[ 5]  1.00-2.00   sec   2.05 GBytes   17.6 Gbytes/sec  0  3.21 MBytes
[ 5]  2.00-3.00   sec   1.99 GBytes   17.1 Gbytes/sec  0  8.11 MBytes
[ 5]  3.00-4.00   sec   1.89 GBytes   16.2 Gbytes/sec  0  8.11 MBytes
[ 5]  4.00-5.00   sec   1.58 GBytes   13.6 Gbytes/sec  0  8.11 MBytes
[ 5]  5.00-6.00   sec   1.32 GBytes   11.4 Gbytes/sec  0  8.11 MBytes
[ 5]  6.00-7.00   sec   1.94 GBytes   16.7 Gbytes/sec  0  8.11 MBytes
[ 5]  7.00-8.00   sec   2.01 GBytes   17.3 Gbytes/sec  0  8.11 MBytes
[ 5]  8.00-9.00   sec   1.94 GBytes   16.7 Gbytes/sec  0  8.11 MBytes
[ 5]  9.00-10.00  sec   1.97 GBytes   16.9 Gbytes/sec  0  8.11 MBytes
[-----]
[ ID] Interval      Transfer     Bitrate      Retr
[ 5]  0.00-10.00  sec  18.7 GBytes   16.1 Gbits/sec  0           sender
[ 5]  0.00-10.00  sec  18.7 GBytes   16.1 Gbits/sec  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 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   632 KBytes   13.1 Gbits/sec
[-----]
[ ID] Interval      Transfer     Bitrate
[ 5]  0.00-10.00  sec  18.7 GBytes   16.1 Gbits/sec  receiver
```

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

## Интерактивные эксперименты



```
"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
-----"
```

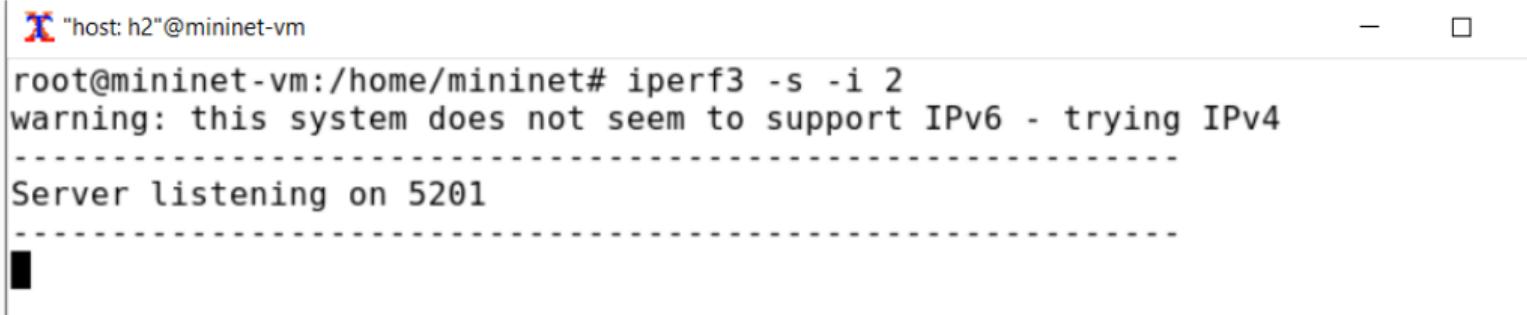
Рис. 12: Запуск сервера iperf3 в терминале h2

```
X "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 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
[ 7]  5.00-6.00   sec  8.14 GBytes  14.0 Gbits/sec    0
[ 7]  6.00-7.00   sec  8.11 GBytes  13.9 Gbits/sec    0
sender
receiver

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

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

## Интерактивные эксперименты



The screenshot shows a terminal window titled "host: h2" running on a host named "mininet-vm". The user is root. The command entered is "iperf3 -s -i 2". The output indicates a warning about IPv6 support and shows that the server is listening on port 5201.

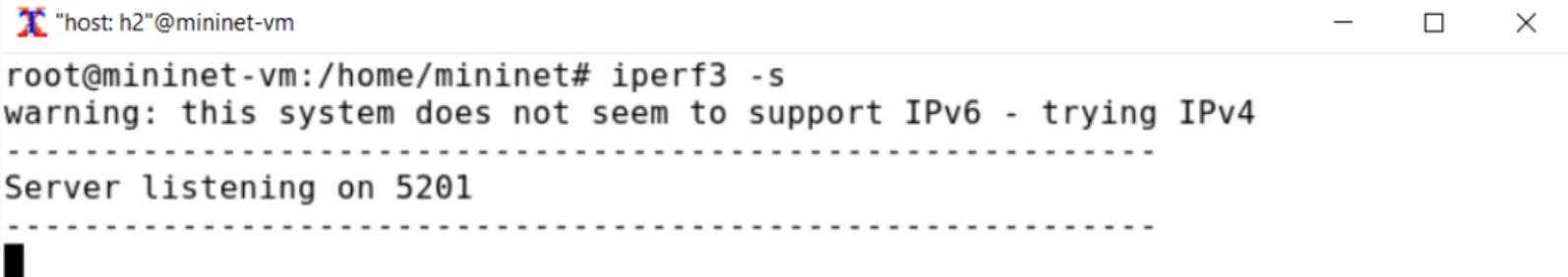
```
"host: h2"@mininet-vm
root@mininet-vm:/home/mininet# iperf3 -s -i 2
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
```

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

```
X "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 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 отчёта



```
"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
-----"
```

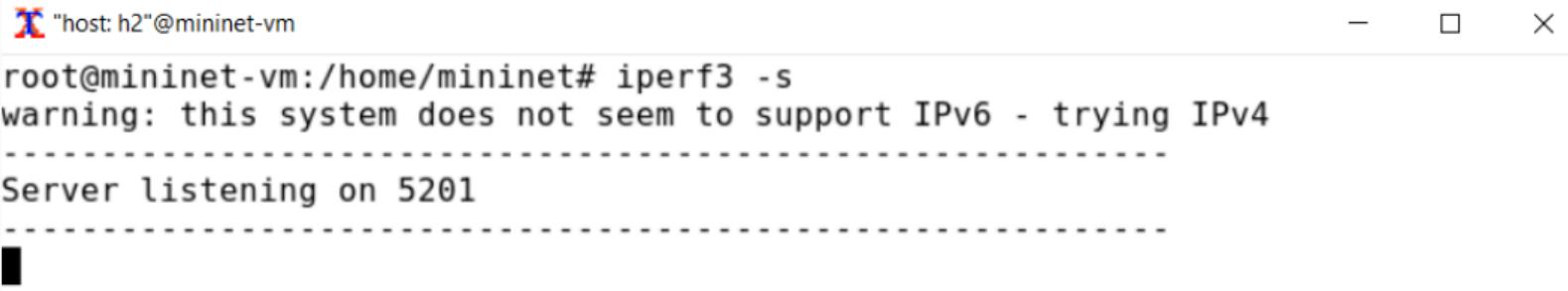
Рис. 16: Запуск сервера iperf3 в терминале h2

## Интерактивные эксперименты

```
X "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
[ 7]  8.00-8.05   sec   16.0 GBytes  17.1 Gbits/sec   1
[ 7]  0.00-8.05   sec   16.0 GBytes  17.0 Gbits/sec

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

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



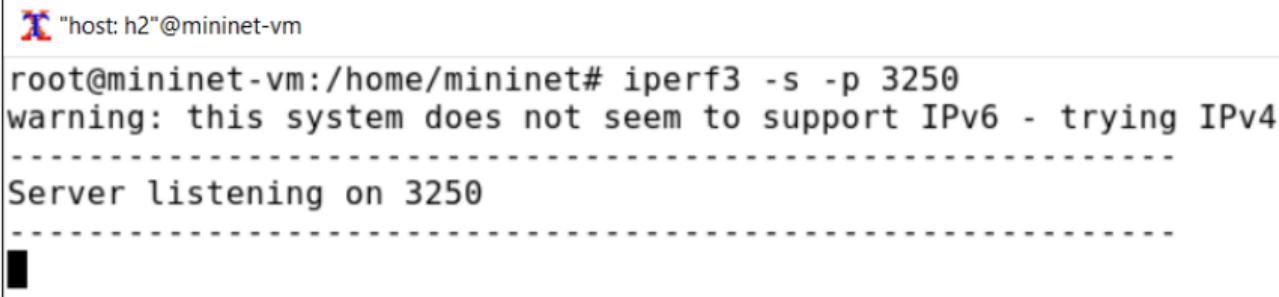
```
"host: h2"@"mininet-vm" - X - < > ×
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
```

Рис. 18: Запуск сервера iperf3 в терминале h2

## Интерактивные эксперименты

```
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 Datag
rams
[ 7]  0.00-10.00   sec   1.25 MBytes  1.05 Mbits/sec  0.000 ms  0/906 (0%)  send
[ 7]  0.00-10.00   sec   1.25 MBytes  1.05 Mbits/sec  0.027 ms  0/906 (0%)  rece
iver
iperf Done.
root@mininet-vm:/home/mininet# █
```

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



"host: h2" @mininet-vm

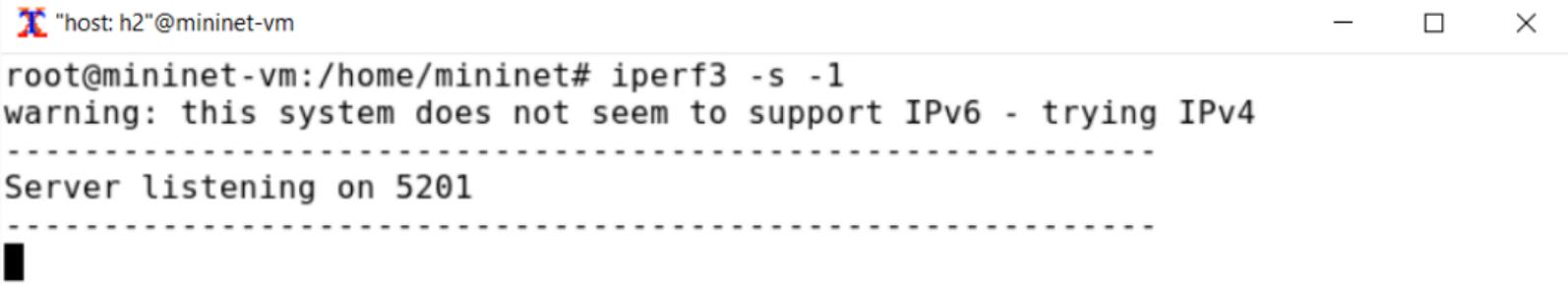
```
root@mininet-vm:/home/mininet# iperf3 -s -p 3250
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 3250
-----
```

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

## Интерактивные эксперименты

```
"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



The screenshot shows a terminal window titled "host: h2" running on a host named "mininet-vm". The user is root. The command entered is "iperf3 -s -1". The output indicates that the system does not support IPv6, so it is trying IPv4. A server is listening on port 5201. The terminal window has standard OS X-style controls (minimize, maximize, close) at the top right.

```
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)

## Интерактивные эксперименты

```
X "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

```
X "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

# Интерактивные эксперименты

```
X "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 P 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

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## Список литературы. Библиография

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