

Лабораторная работа №2

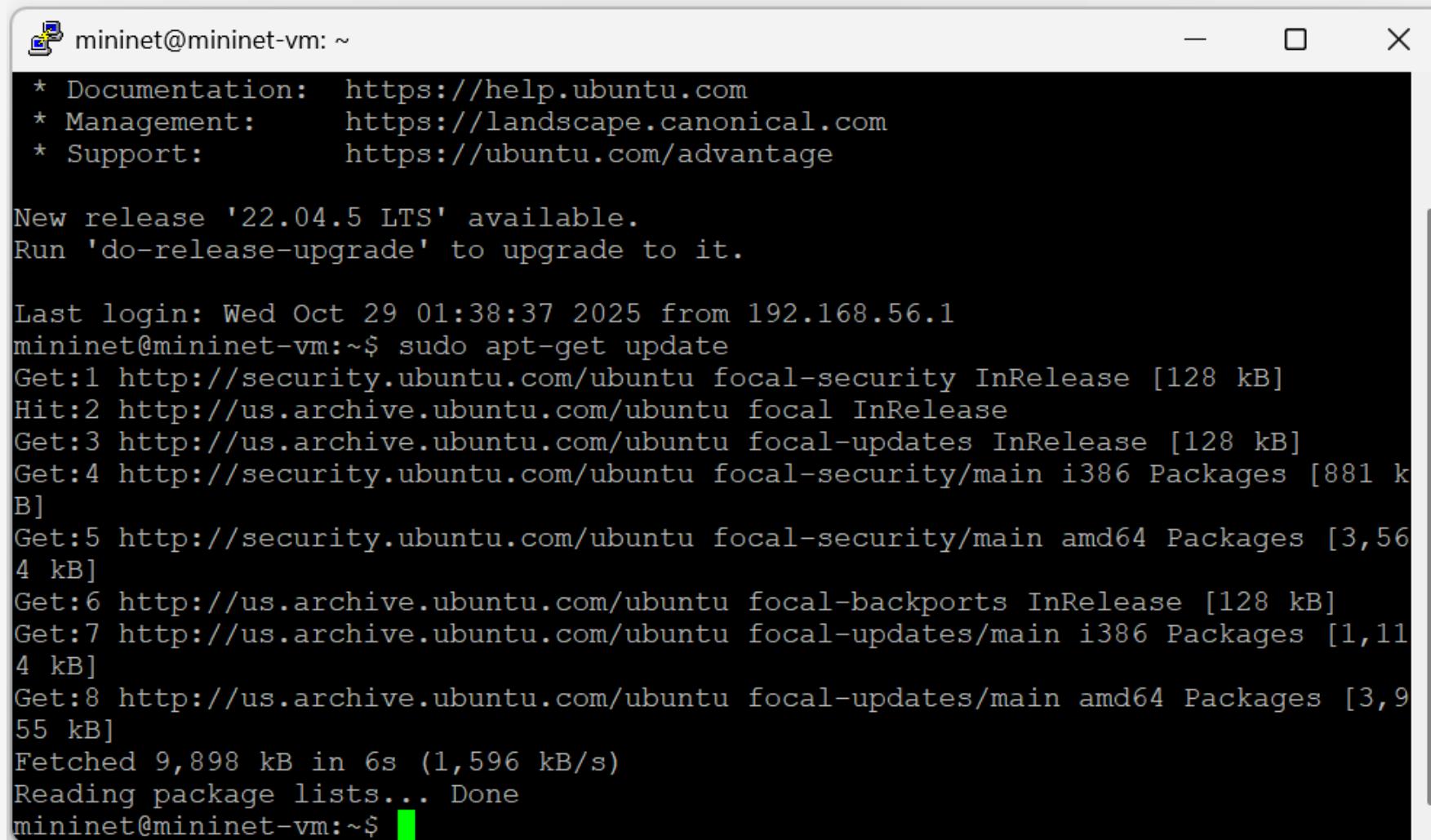
Моделирование сетей передачи данных

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Установка необходимого программного обеспечения



```
mininet@mininet-vm: ~
* Documentation: https://help.ubuntu.com
* Management: https://landscape.canonical.com
* Support: https://ubuntu.com/advantage

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

Last login: Wed Oct 29 01:38:37 2025 from 192.168.56.1
mininet@mininet-vm:~$ sudo apt-get update
Get:1 http://security.ubuntu.com/ubuntu focal-security InRelease [128 kB]
Hit:2 http://us.archive.ubuntu.com/ubuntu focal InRelease
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [128 kB]
Get:4 http://security.ubuntu.com/ubuntu focal-security/main i386 Packages [881 kB]
Get:5 http://security.ubuntu.com/ubuntu focal-security/main amd64 Packages [3,564 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease [128 kB]
Get:7 http://us.archive.ubuntu.com/ubuntu focal-updates/main i386 Packages [1,114 kB]
Get:8 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 Packages [3,955 kB]
Fetched 9,898 kB in 6s (1,596 kB/s)
Reading package lists... Done
mininet@mininet-vm:~$ █
```

Рис. 1: Обновление репозиториев программного обеспечения

Установка необходимого программного обеспечения

```
mininet@mininet-vm:~$ sudo apt-get install iperf3
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.
mininet@mininet-vm:~$ █
```

Рис. 2: Установка iperf3

Установка необходимого 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
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 (1:2.25.1-1ubuntu3.14).
jq is already the newest version (1.6-1ubuntu0.20.04.1).
0 upgraded, 0 newly installed, 0 to remove and 394 not upgraded.
mininet@mininet-vm:~$
```

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

Установка необходимого программного обеспечения

```
mininet@mininet-vm:~$ cd /tmp/
mininet@mininet-vm:/tmp$ git clone https://github.com/ekfouri/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 | 915.00 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$ █
```

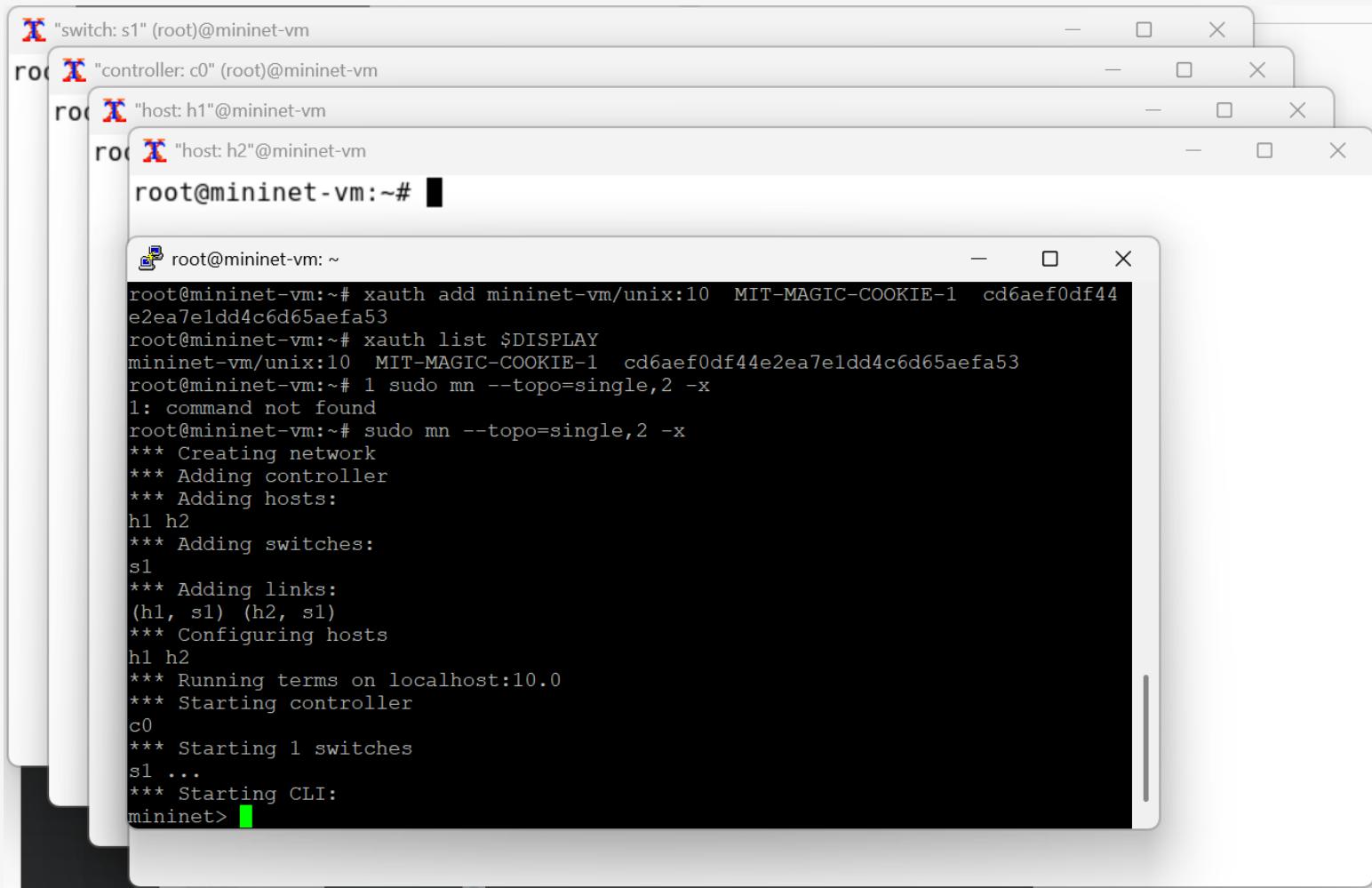
Рис. 4: Развёртывание iperf3_plotter

Интерактивные эксперименты

```
mininet@mininet-vm:~$ xauth list $DISPLAY
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  cd6aef0df44e2ea7e1dd4c6d65aefa53
mininet@mininet-vm:~$ sudo -i
root@mininet-vm:~# xauth add mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  cd6aef0df44
e2ea7e1dd4c6d65aefa53
root@mininet-vm:~# xauth list $DISPLAY
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  cd6aef0df44e2ea7e1dd4c6d65aefa53
root@mininet-vm:~#
```

Рис. 5: Исправление прав запуска X-соединения

Интерактивные эксперименты



The screenshot shows a terminal window with multiple tabs, each displaying a different node's command-line interface (CLI). The tabs are:

- "switch: s1" (root)@mininet-vm
- "controller: c0" (root)@mininet-vm
- "host: h1" (root)@mininet-vm
- "host: h2" (root)@mininet-vm
- root@mininet-vm:~# (active tab)

The active tab (root@mininet-vm:~#) contains the following command-line session:

```
root@mininet-vm:~# xauth add mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 cd6aef0df44e2ea7e1dd4c6d65aefa53
root@mininet-vm:~# xauth list $DISPLAY
mininet-vm/unix:10 MIT-MAGIC-COOKIE-1 cd6aef0df44e2ea7e1dd4c6d65aefa53
root@mininet-vm:~# 1 sudo mn --topo=single,2 -x
1: command not found
root@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>
```

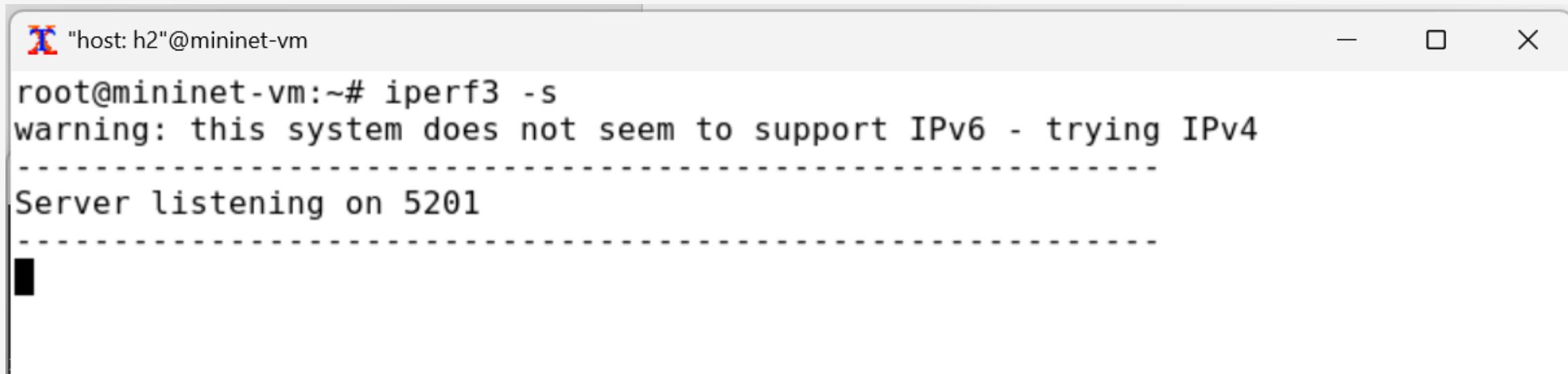
Рис. 6: Создание простейшей топологии, состоящей из двух хостов и коммутатора

Интерактивные эксперименты

```
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=1202>
<Host h2: h2-eth0:10.0.0.2 pid=1206>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=1211>
<Controller c0: 127.0.0.1:6653 pid=1195>
mininet> █
```

Рис. 7: Просмотр параметров топологии

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". The output indicates a warning that the system does not support IPv6 and is trying IPv4. It then shows a dashed line separator followed by the message "Server listening on 5201". Below this message is another dashed line separator and a small black square icon.

```
"host: h2"@mininet-vm
root@mininet-vm:~# 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

```
X "host: h1"@mininet-vm
root@mininet-vm:~# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 58386 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00   sec   1.81 GBytes   15.5 Gbits/sec    0  8.35 MBytes
[ 7]  1.00-2.00   sec   1.89 GBytes   16.3 Gbits/sec    0  8.35 MBytes
[ 7]  2.00-3.00   sec   1.85 GBytes   15.9 Gbits/sec    0  8.35 MBytes
[ 7]  3.00-4.01   sec   1.72 GBytes   14.8 Gbits/sec    0  8.35 MBytes
[ 7]  4.01-5.00   sec   1.75 GBytes   15.1 Gbits/sec    0  8.35 MBytes
[ 7]  5.00-6.00   sec   1.02 GBytes   8.80 Gbits/sec    0  8.35 MBytes
[ 7]  6.00-7.00   sec   914 MBytes    7.68 Gbits/sec    0  8.35 MBytes
[ 7]  7.00-8.00   sec   986 MBytes    8.26 Gbits/sec    0  8.35 MBytes
[ 7]  8.00-9.00   sec   949 MBytes    7.97 Gbits/sec    0  8.35 MBytes
[ 7]  9.00-10.00  sec   1.01 GBytes   8.64 Gbits/sec   0  8.35 MBytes
[ 7]  0.00-10.00  sec  13.8 GBytes   11.9 Gbits/sec   0
[ 7]  0.00-10.00  sec  13.8 GBytes   11.9 Gbits/sec
                                         sender
                                         receiver
iperf Done.
root@mininet-vm:~#
```

Рис. 9: Запуск клиента iperf3 в терминале хоста h1

Интерактивные эксперименты

```
X "host: h2"@mininet-vm
root@mininet-vm:~# 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 58384
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 58386
[ ID] Interval          Transfer     Bitrate
[ 7]  0.00-1.00   sec  1.81 GBytes  15.5 Gbits/sec
[ 7]  1.00-2.00   sec  1.89 GBytes  16.1 Gbits/sec
[ 7]  2.00-3.00   sec  1.86 GBytes  16.0 Gbits/sec
[ 7]  3.00-4.00   sec  1.72 GBytes  14.7 Gbits/sec
[ 7]  4.00-5.00   sec  1.75 GBytes  15.0 Gbits/sec
[ 7]  5.00-6.00   sec  1.03 GBytes  8.90 Gbits/sec
[ 7]  6.00-7.01   sec  905 MBytes  7.53 Gbits/sec
[ 7]  7.01-8.00   sec  996 MBytes  8.41 Gbits/sec
[ 7]  8.00-9.01   sec  949 MBytes  7.87 Gbits/sec
[ 7]  9.01-10.00  sec  1.01 GBytes  8.75 Gbits/sec
[ 7] 10.00-10.00  sec   704 KBytes  1.46 Gbits/sec
-----
[ ID] Interval          Transfer     Bitrate
[ 7]  0.00-10.00  sec  13.8 GBytes  11.9 Gbits/sec
-----                                         receiver
-----
Server listening on 5201
-----
```

Рис. 10: Остановка сервера iPerf3 в терминале хоста h2

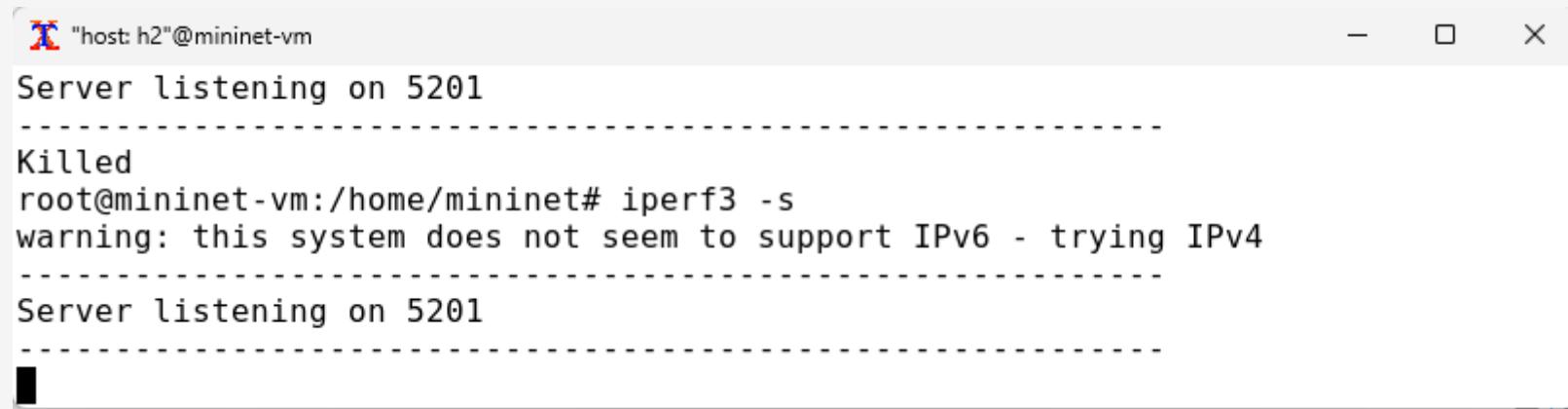
Интерактивные эксперименты

```
mininet> h2 iperf3 -s &
mininet> h1 iperf -c h2
connect failed: Connection refused
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 58416 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate    Retr  Cwnd
[ 5]  0.00-1.00   sec  1.65 GBytes  14.2 Gbits/sec  0  8.37 MBytes
[ 5]  1.00-2.00   sec  1.63 GBytes  13.9 Gbits/sec  0  8.37 MBytes
[ 5]  2.00-3.00   sec  1.61 GBytes  13.9 Gbits/sec  0  8.37 MBytes
[ 5]  3.00-4.00   sec   978 MBytes  8.20 Gbits/sec  0  8.37 MBytes
[ 5]  4.00-5.01   sec   801 MBytes  6.65 Gbits/sec  0  8.37 MBytes
[ 5]  5.01-6.00   sec   849 MBytes  7.19 Gbits/sec  0  8.37 MBytes
[ 5]  6.00-7.01   sec   818 MBytes  6.82 Gbits/sec  0  8.37 MBytes
[ 5]  7.01-8.00   sec   981 MBytes  8.28 Gbits/sec  0  8.37 MBytes
[ 5]  8.00-9.00   sec   1.43 GBytes 12.3 Gbits/sec  0  8.37 MBytes
[ 5]  9.00-10.00  sec   889 MBytes  7.43 Gbits/sec  0  8.37 MBytes
- - - - - [ ID] Interval           Transfer     Bitrate    Retr
[ 5]  0.00-10.00  sec  11.5 GBytes  9.89 Gbits/sec  0                     sender
[ 5]  0.00-10.01  sec  11.5 GBytes  9.88 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
mininet> h2 killall iperf3
iperf3: no process found
mininet>
Interrupt
mininet> h2 killall -9 iperf3
iperf3: no process found
mininet> h2 iperf3 -s &
mininet>
Interrupt
mininet>
```

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

Интерактивные эксперименты



```
"host: h2"@mininet-vm
Server listening on 5201
-----
Killed
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

Интерактивные эксперименты

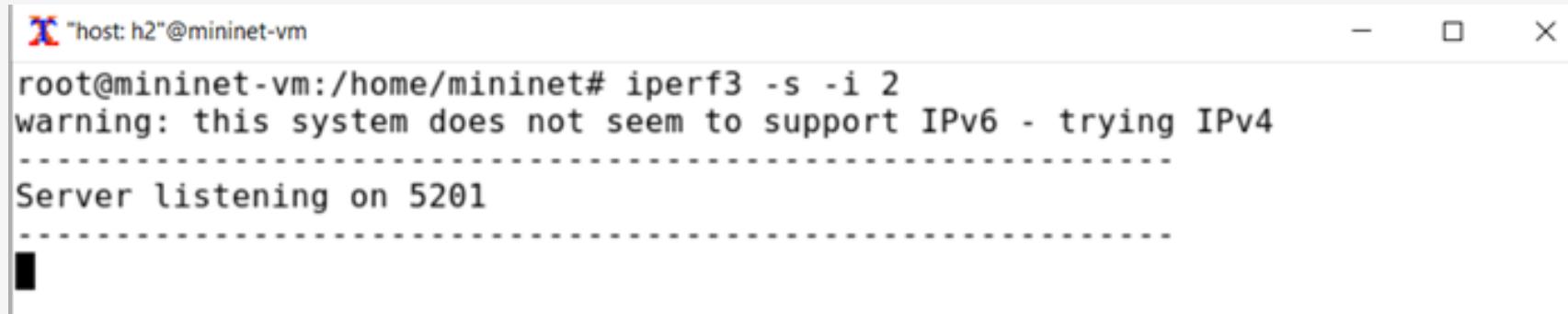
```
X "host: h1"@mininet-vm
[ 7] 8.00-9.01  sec 1.00 GBytes 8.60 Gbits/sec 1 8.04 MBytes
[ 7] 9.01-10.00 sec 1.38 GBytes 11.9 Gbits/sec 0 8.04 MBytes
[ ID] Interval      Transfer     Bitrate      Retr
[ 7] 0.00-10.00   sec 13.0 GBytes 11.2 Gbits/sec 2
[ 7] 0.00-10.00   sec 13.0 GBytes 11.2 Gbits/sec

iperf Done.
root@mininet-vm:~# iperf3 -c 10.0.0.2 -t 5
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 58420 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer     Bitrate      Retr  Cwnd
[ 7] 0.00-1.01    sec 1.78 GBytes 15.1 Gbits/sec 0 8.04 MBytes
[ 7] 1.01-2.00    sec 1.84 GBytes 15.9 Gbits/sec 0 8.04 MBytes
[ 7] 2.00-3.01    sec 1.76 GBytes 15.1 Gbits/sec 0 8.04 MBytes
[ 7] 3.01-4.00    sec 1005 MBytes 8.45 Gbits/sec 1 8.04 MBytes
[ 7] 4.00-5.01    sec 946 MBytes 7.88 Gbits/sec 0 8.04 MBytes
[ ID] Interval      Transfer     Bitrate      Retr
[ 7] 0.00-5.01    sec 7.28 GBytes 12.5 Gbits/sec 1
[ 7] 0.00-5.01    sec 7.28 GBytes 12.5 Gbits/sec

iperf Done.
root@mininet-vm:~#
```

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 and has run the command "iperf3 -s -i 2". The output indicates a warning about IPv6 support and switching to IPv4, followed by a message that the server is listening on port 5201. A small black square icon is visible in the bottom-left corner of the terminal window.

```
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 отчёта

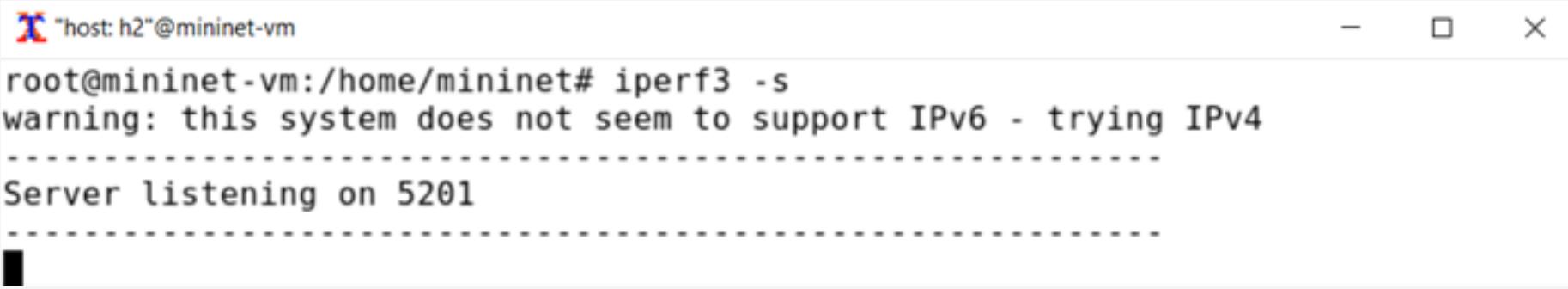
Интерактивные эксперименты

```
X "host: h1"@mininet-vm
iperf Done.
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 58540 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-2.00   sec   1.50 GBytes   6.44 Gbits/sec    0  8.09 MBytes
[ 7]  2.00-4.00   sec   1.64 GBytes   7.07 Gbits/sec    1  8.09 MBytes
[ 7]  4.00-6.01   sec   1.87 GBytes   8.00 Gbits/sec    0  8.09 MBytes
[ 7]  6.01-8.00   sec   1.72 GBytes   7.40 Gbits/sec    0  8.09 MBytes
[ 7]  8.00-10.00  sec   1.69 GBytes   7.26 Gbits/sec    0  8.09 MBytes
[ 7]  0.00-10.00  sec  8.42 GBytes   7.23 Gbits/sec    1
[ 7]  0.00-10.02  sec  8.42 GBytes   7.22 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

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". The output indicates a warning: "warning: this system does not seem to support IPv6 - trying IPv4". It then shows a dashed line followed by the text "Server listening on 5201". Below this, there is another dashed line and a small black square icon.

```
"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 58544 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.01   sec  870 MBytes  7.24 Gbits/sec   1  8.24 MBytes
[ 7]  1.01-2.01   sec  749 MBytes  6.29 Gbits/sec   0  8.24 MBytes
[ 7]  2.01-3.00   sec  810 MBytes  6.83 Gbits/sec   0  8.24 MBytes
[ 7]  3.00-4.00   sec  789 MBytes  6.63 Gbits/sec   0  8.24 MBytes
[ 7]  4.00-5.00   sec  972 MBytes  8.15 Gbits/sec   0  8.24 MBytes
[ 7]  5.00-6.00   sec  785 MBytes  6.58 Gbits/sec   1  8.24 MBytes
[ 7]  6.00-7.00   sec  795 MBytes  6.67 Gbits/sec   1  8.24 MBytes
[ 7]  7.00-8.00   sec  702 MBytes  5.88 Gbits/sec   0  8.24 MBytes
[ 7]  8.00-9.00   sec  1.13 GBytes  9.71 Gbits/sec   0  8.24 MBytes
[ 7]  9.00-10.00  sec  808 MBytes  6.76 Gbits/sec   1  8.24 MBytes
[ 7] 10.00-11.00  sec  801 MBytes  6.70 Gbits/sec   2  8.24 MBytes
[ 7] 11.00-12.00  sec  795 MBytes  6.70 Gbits/sec   0  8.24 MBytes
[ 7] 12.00-13.00  sec  861 MBytes  7.20 Gbits/sec   0  8.24 MBytes
[ 7] 13.00-14.00  sec  886 MBytes  7.46 Gbits/sec   0  8.24 MBytes
[ 7] 14.00-15.01  sec  746 MBytes  6.20 Gbits/sec   0  8.24 MBytes
[ 7] 15.01-16.00  sec  782 MBytes  6.61 Gbits/sec   0  8.24 MBytes
[ 7] 16.00-17.01  sec  898 MBytes  7.49 Gbits/sec   0  8.24 MBytes
[ 7] 17.01-18.00  sec  882 MBytes  7.44 Gbits/sec   0  8.24 MBytes
[ 7] 18.00-19.00  sec  925 MBytes  7.77 Gbits/sec   0  8.24 MBytes
[ 7] 19.00-19.46  sec  374 MBytes  6.79 Gbits/sec   0  8.24 MBytes
[ ID] Interval      Transfer     Bitrate      Retr
[ 7]  0.00-19.46   sec  16.0 GBytes  7.06 Gbits/sec   6                     sender
[ 7]  0.00-19.49   sec  16.0 GBytes  7.05 Gbits/sec                    receiver

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

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

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
-----
```

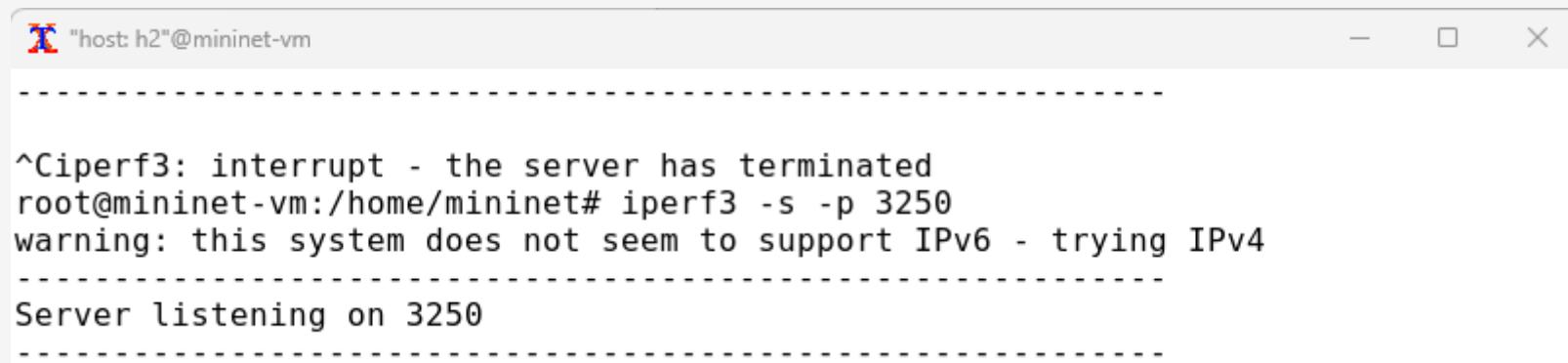
Рис. 18: Запуск сервера iperf3 в терминале h2

Интерактивные эксперименты

```
X "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 34762 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   127 KBytes  1.04 Mbits/sec  90
[ 7]  8.00-9.00  sec   129 KBytes  1.06 Mbits/sec  91
[ 7]  9.00-10.00 sec   127 KBytes  1.04 Mbits/sec  90
[ 7]  0.00-10.00 sec  1.25 MBytes  1.05 Mbits/sec  0.000 ms  0/905 (0%)  sender
[ 7]  0.00-10.00 sec  1.25 MBytes  1.05 Mbits/sec  0.011 ms  0/905 (0%)  receiver
iperf Done.
root@mininet-vm:/home/mininet# █
```

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

Интерактивные эксперименты



A screenshot of a terminal window titled "host h2"@"mininet-vm". The window contains the following text:

```
^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
-----
```

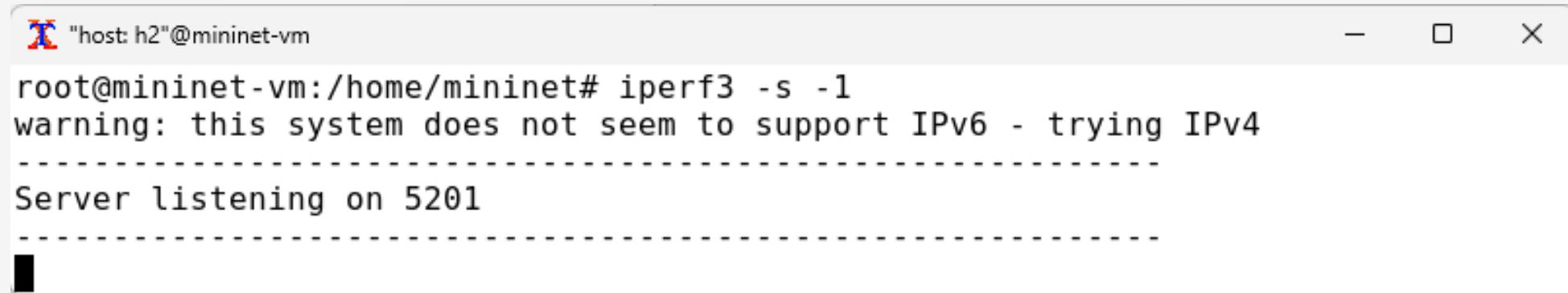
Рис. 20: Запуск сервера iperf3 в терминале h2 с портом прослушивания

Интерактивные эксперименты

```
X "host: h1"@mininet-vm
iperf Done.
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -p 3250
iperf3: error - unable to connect to server: Connection refused
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 52176 connected to 10.0.0.2 port 3250
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00   sec    916 MBytes   7.68 Gbits/sec    0  8.26 MBytes
[ 7]  1.00-2.01   sec    871 MBytes   7.27 Gbits/sec    0  8.26 MBytes
[ 7]  2.01-3.00   sec    826 MBytes   6.97 Gbits/sec    1  8.26 MBytes
[ 7]  3.00-4.01   sec    818 MBytes   6.82 Gbits/sec    0  8.26 MBytes
[ 7]  4.01-5.01   sec    772 MBytes   6.47 Gbits/sec    1  8.26 MBytes
[ 7]  5.01-6.00   sec    888 MBytes   7.49 Gbits/sec    1  8.26 MBytes
[ 7]  6.00-7.01   sec    990 MBytes   8.21 Gbits/sec    0  8.26 MBytes
[ 7]  7.01-8.01   sec    879 MBytes   7.36 Gbits/sec    0  8.26 MBytes
[ 7]  8.01-9.00   sec    954 MBytes   8.09 Gbits/sec    0  8.26 MBytes
[ 7]  9.00-10.01  sec   885 MBytes   7.40 Gbits/sec   0  8.26 MBytes
[ 7]  0.00-10.01  sec   8.59 GBytes  7.38 Gbits/sec   3
[ 7]  0.00-10.01  sec   8.59 GBytes  7.37 Gbits/sec
iperf Done.
root@mininet-vm:/home/mininet#
```

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

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 -1". The output indicates a warning about IPv6 support and switching to IPv4, followed by a message that the server is listening on port 5201.

```
"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)

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 58554
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 58556
[ ID] Interval          Transfer     Bitrate
[ 7]  0.00-1.01  sec   829 MBytes  6.91 Gbits/sec
[ 7]  1.01-2.01  sec   862 MBytes  7.23 Gbits/sec
[ 7]  2.01-3.00  sec   781 MBytes  6.58 Gbits/sec
[ 7]  3.00-4.01  sec   949 MBytes  7.93 Gbits/sec
[ 7]  4.01-5.00  sec   774 MBytes  6.53 Gbits/sec
[ 7]  5.00-6.00  sec   994 MBytes  8.34 Gbits/sec
[ 7]  6.00-7.00  sec   840 MBytes  7.04 Gbits/sec
[ 7]  7.00-8.00  sec   858 MBytes  7.21 Gbits/sec
[ 7]  8.00-9.00  sec   1.05 GBytes  8.99 Gbits/sec
[ 7]  9.00-10.01 sec   918 MBytes  7.62 Gbits/sec
-----
[ ID] Interval          Transfer     Bitrate
[ 7]  0.00-10.01 sec  8.67 GBytes  7.44 Gbits/sec
root@mininet-vm:/home/mininet# receiver
```

Рис. 23: Запуск клиента iperf3 в терминале h1

Интерактивные эксперименты

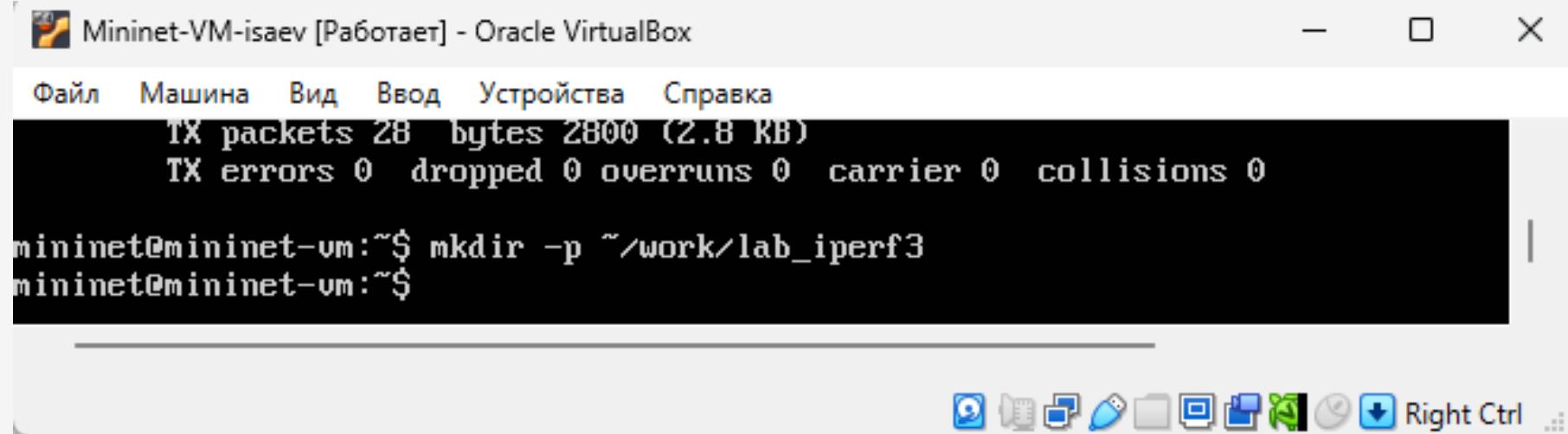
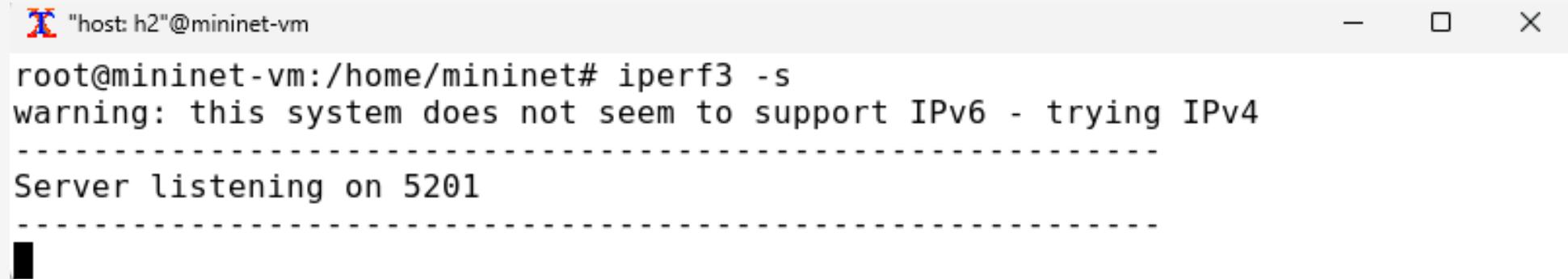


Рис. 24: Создание каталога для работы над проектом

Интерактивные эксперименты

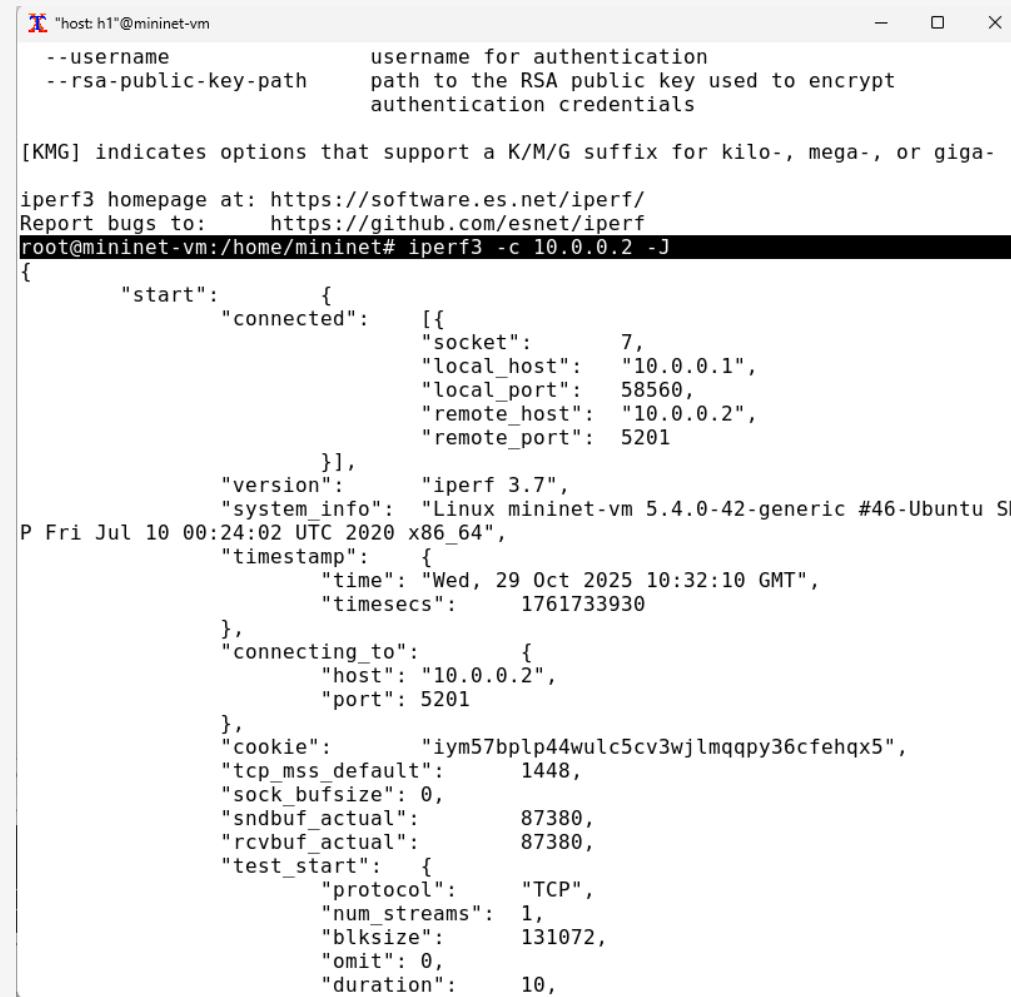


The screenshot shows a terminal window with a red header bar containing a red 'X' icon and the text "host: h2" followed by "@mininet-vm". The main area of the terminal displays the following command and its output:

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

Рис. 25: Запуск сервера iperf3 в терминале h2

Интерактивные эксперименты



```
"host h1"@mininet-vm
--username          username for authentication
--rsa-public-key-path  path to the RSA public key used to encrypt
                       authentication credentials

[KMG] indicates options that support a K/M/G suffix for kilo-, mega-, or giga-
iperf3 homepage at: https://software.es.net/iperf/
Report bugs to:     https://github.com/esnet/iperf
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -J
{
    "start": {
        "connected": [
            {
                "socket": 7,
                "local_host": "10.0.0.1",
                "local_port": 58560,
                "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": "Wed, 29 Oct 2025 10:32:10 GMT",
            "timesecs": 1761733930
        },
        "connecting_to": {
            "host": "10.0.0.2",
            "port": 5201
        },
        "cookie": "iym57bplp44wulc5cv3wjlmqqpy36cfhqx5",
        "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,
```

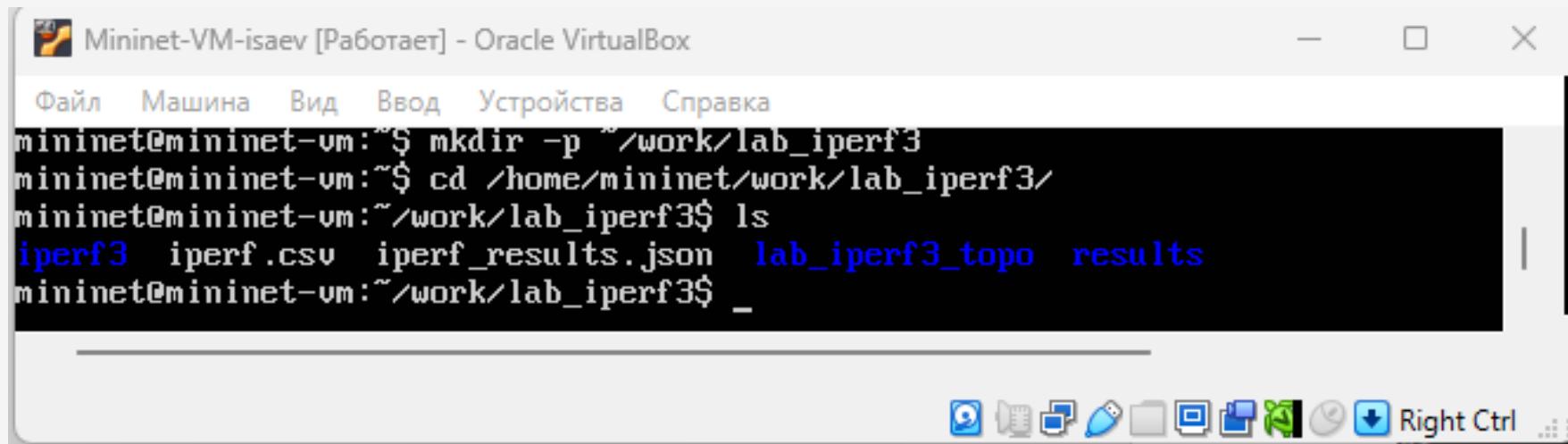
Рис. 26: Запуск клиента iperf3 в терминале h1 с параметром -J (отображение вывода в формате JSON)

Интерактивные эксперименты

```
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. 27: Экспортирование вывода результатов теста в файл

Интерактивные эксперименты



The screenshot shows a terminal window titled "Mininet-VM-isaev [Работает] - Oracle VirtualBox". The window contains a command-line interface with the following text:

```
Файл  Машина  Вид  Ввод  Устройства  Справка
mininet@mininet-vm:~$ mkdir -p ~/work/lab_iperf3
mininet@mininet-vm:~$ cd /home/mininet/work/lab_iperf3/
mininet@mininet-vm:~/work/lab_iperf3$ ls
iperf3  iperf.csv  iperf_results.json  lab_iperf3_topo  results
mininet@mininet-vm:~/work/lab_iperf3$ _
```

The terminal window has a standard Linux-style menu bar at the top. Below the menu is a scrollable text area containing the command history and output. At the bottom of the window is a toolbar with various icons, including a magnifying glass, a folder, a file, a pencil, a square, a triangle, a green checkmark, a blue arrow, and a right control key icon.

Рис. 28: Проверка создания файла

Интерактивные эксперименты

```
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 8 terms
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 1423.250 seconds
mininet@mininet-vm:~$
```

Рис. 29: Завершение работы mininet в интерактивном режиме

Интерактивные эксперименты

```
mininet@mininet-vm:~$ cd ~/work/lab_iperf3/
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
iperf3
iperf.csv
iperf_results.json
lab_iperf3_topo
results
mininet@mininet-vm:~/work/lab_iperf3$ sudo chown -R mininet:mininet ~/work
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 24
drwxrwxr-x 3 mininet mininet 4096 Oct  9 08:52 iperf3
-rw-rw-r-- 1 mininet mininet   949 Sep 27 12:14 iperf.csv
-rw-r--r-- 1 mininet mininet 7805 Oct 29 03:33 iperf_results.json
drwxrwxr-x 2 mininet mininet 4096 Oct 10 07:26 lab_iperf3_topo
drwxrwxr-x 2 mininet mininet 4096 Sep 27 12:14 results
mininet@mininet-vm:~/work/lab_iperf3$ █
```

Рис. 30: Корректирование прав доступа к файлу JSON

Интерактивные эксперименты

```
mininet@mininet-vm: ~/work/lab_iperf3/results
-rw-rw-r-- 1 mininet mininet 949 Sep 27 12:14 iperf.csv
-rw-r--r-- 1 mininet mininet 7805 Oct 29 03:33 iperf_results.json
drwxrwxr-x 2 mininet mininet 4096 Oct 10 07:26 lab_iperf3_topo
drwxrwxr-x 2 mininet mininet 4096 Sep 27 12:14 results
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3/
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 24
drwxrwxr-x 3 mininet mininet 4096 Oct  9 08:52 iperf3
-rw-rw-r-- 1 mininet mininet 949 Sep 27 12:14 iperf.csv
-rw-r--r-- 1 mininet mininet 7805 Oct 29 03:33 iperf_results.json
drwxrwxr-x 2 mininet mininet 4096 Oct 10 07:26 lab_iperf3_topo
drwxrwxr-x 2 mininet mininet 4096 Sep 27 12:14 results
mininet@mininet-vm:~/work/lab_iperf3$ plot_iperf.sh iperf_results.json
mininet@mininet-vm:~/work/lab_iperf3$ cd results
mininet@mininet-vm:~/work/lab_iperf3/results$ ls -l
1.dat
bytes.pdf
cwnd.pdf
MTU.pdf
retransmits.pdf
RTT.pdf
RTT_Var.pdf
throughput.pdf
mininet@mininet-vm:~/work/lab_iperf3/results$
```

Рис. 31: Генерация выходных данных и последующая проверка

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/>