

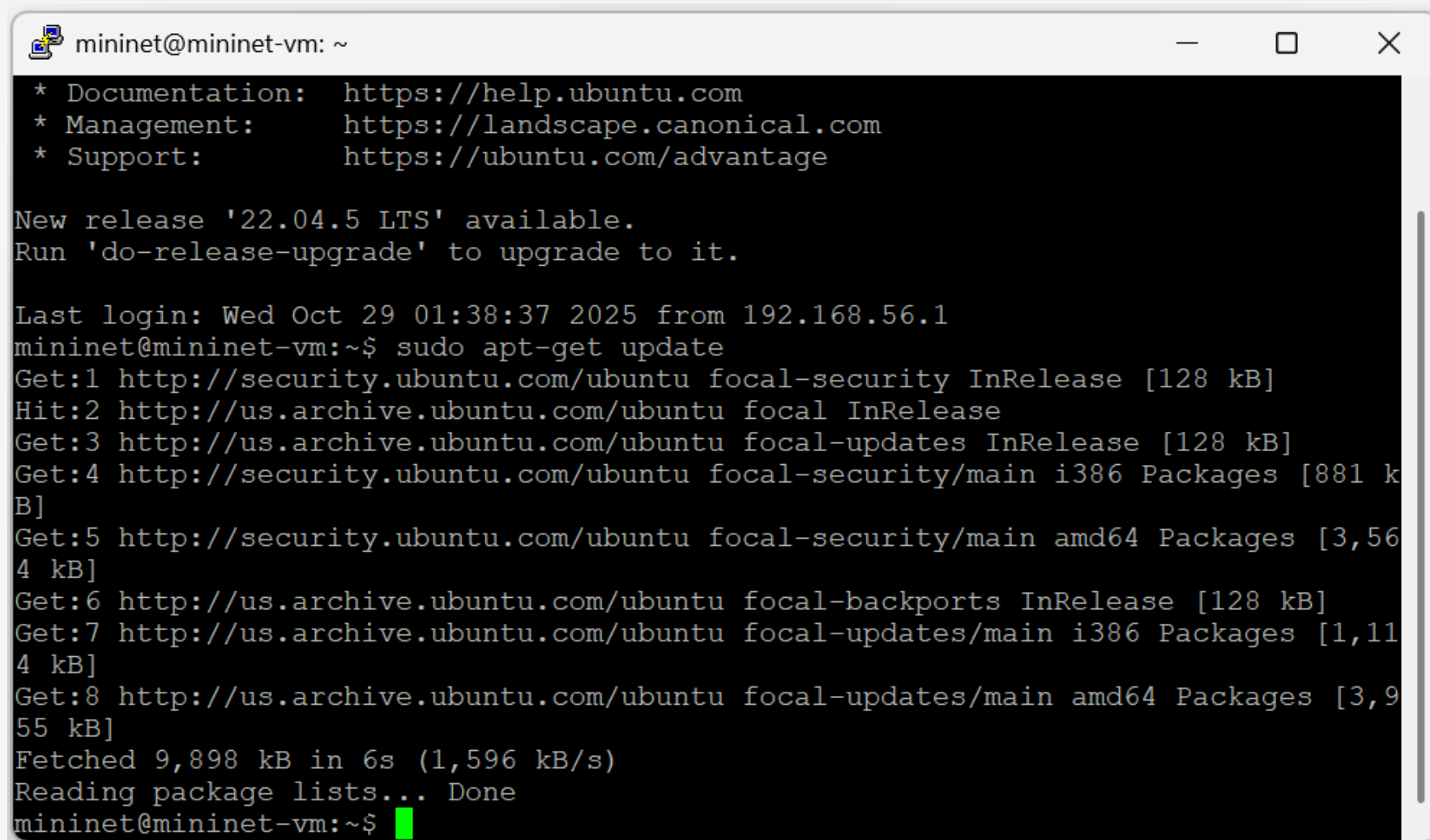
Лабораторная работа №2
Моделирование сетей передачи данных

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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 репозитория 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/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 | 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$
```

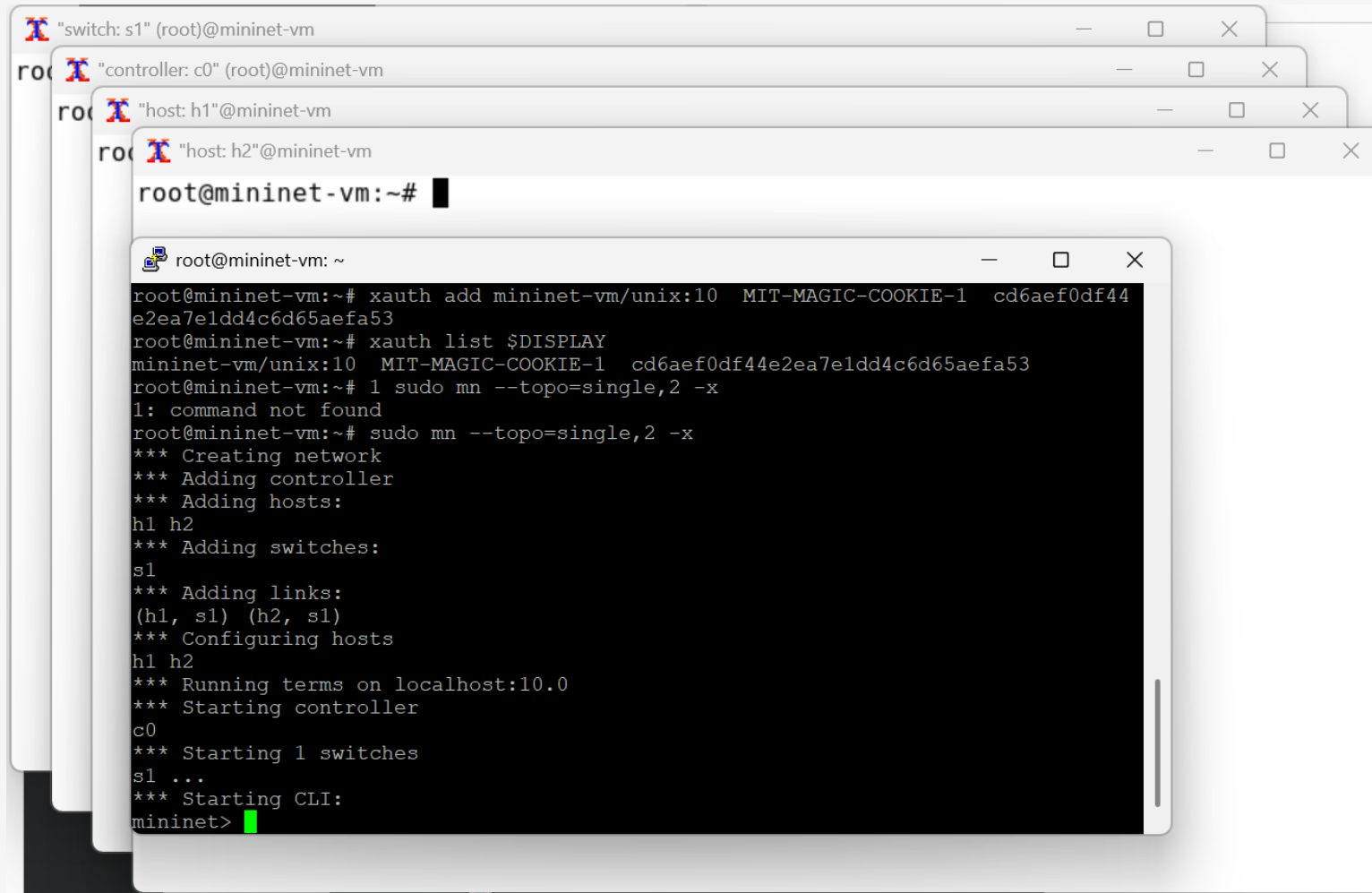
Рис. 4: Развертывание iperf3_plotter

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 image shows four overlapping terminal windows from the Mininet environment. The top-most window is titled "switch: s1" (root)@mininet-vm. Below it is "controller: c0" (root)@mininet-vm, then "host: h1" (root)@mininet-vm, and finally "host: h2" (root)@mininet-vm. The bottom-most window is titled "root@mininet-vm: ~" and contains the following commands and output:

```
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
l: 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>
```

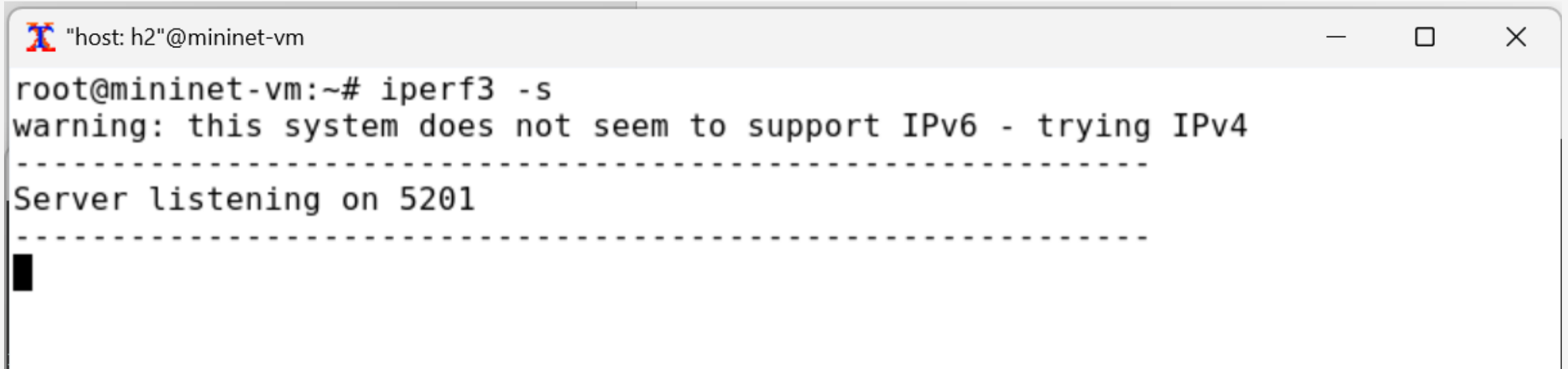
Рис. 6: Создание простейшей топологии, состоящей из двух хостов и коммутатора

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

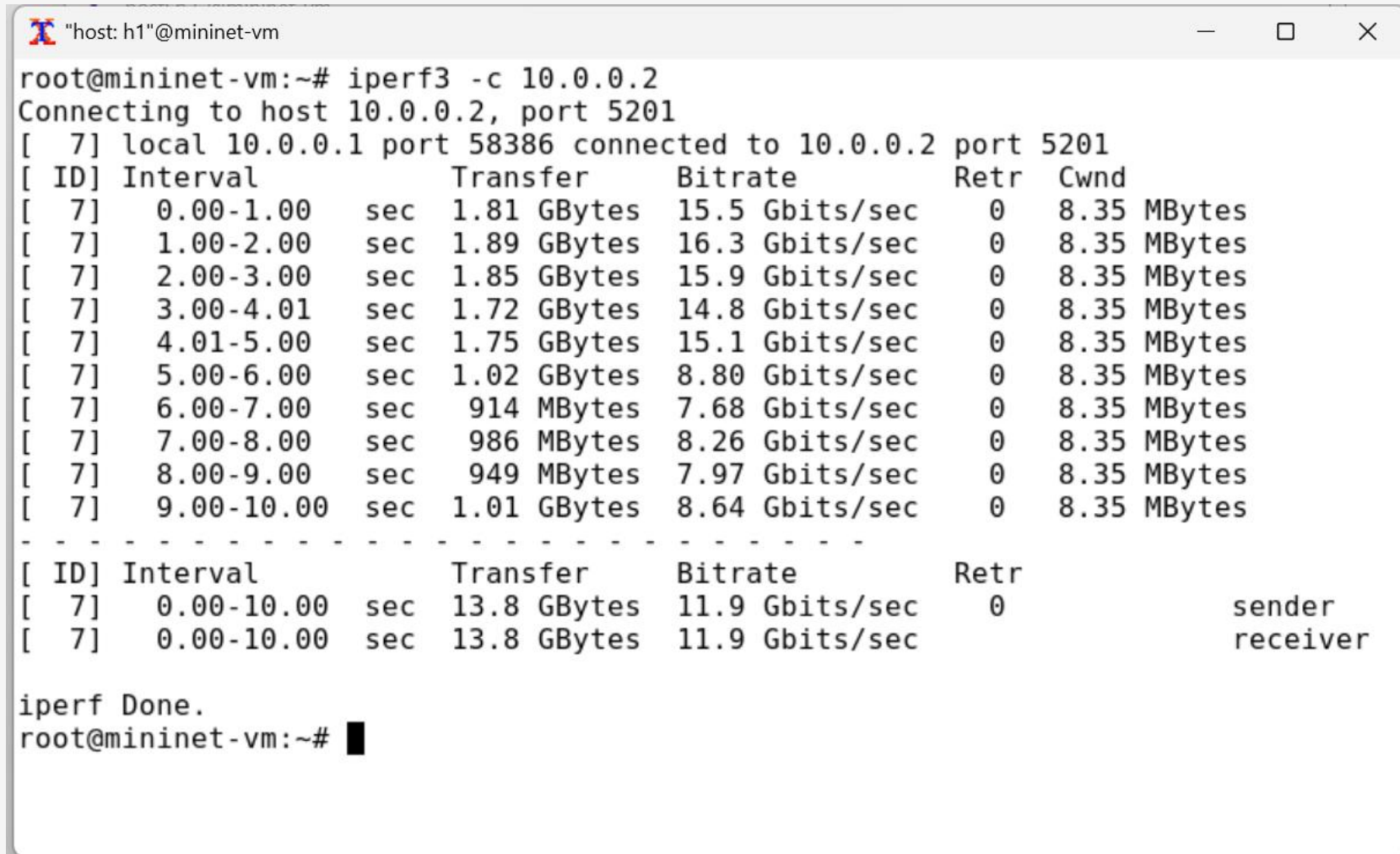
Интерактивные эксперименты

A terminal window titled '"host: h2"@mininet-vm' with standard window controls (minimize, maximize, close). The terminal shows the command 'root@mininet-vm:~# iperf3 -s' being executed. The output includes a warning about IPv6 support, dashed lines, and the message 'Server listening on 5201'. A cursor is visible on the line following the dashed lines.

```
"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

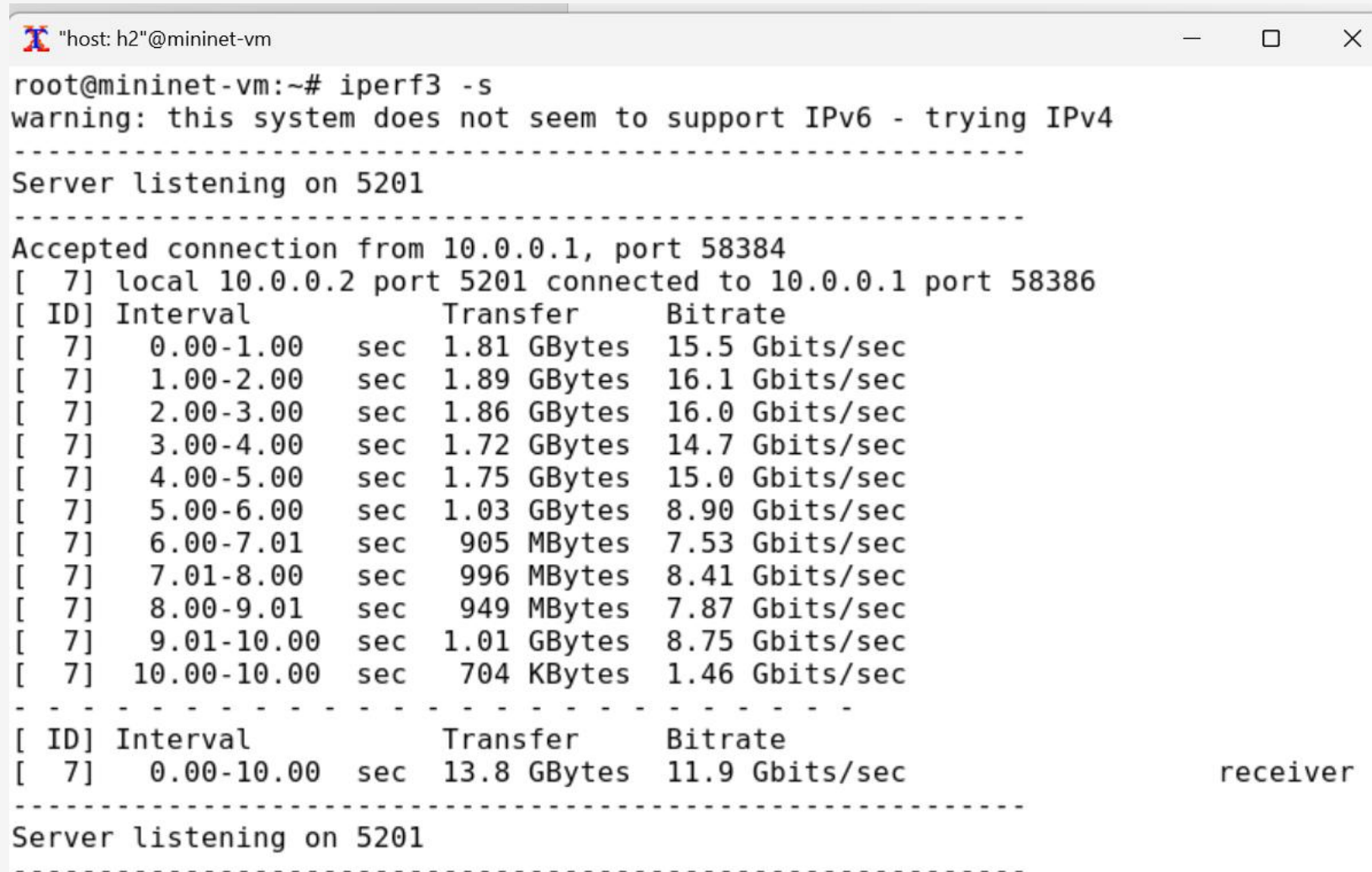
A terminal window titled '"host: h1"@mininet-vm' showing the execution of the iperf3 client. The user runs 'iperf3 -c 10.0.0.2', and the terminal displays connection details and a table of performance metrics over 10 intervals. The final summary shows a total transfer of 13.8 GBytes at 11.9 Gbits/sec. The terminal ends with 'iperf Done.' and the root prompt.

```
"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
- - - - -
[ ID] Interval            Transfer        Bitrate        Retr
[ 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    0
                                     sender
                                     receiver

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

Рис. 9: Запуск клиента iperf3 в терминале хоста h1

Интерактивные эксперименты



```
"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
-----
Server listening on 5201
-----
```

receiver

Рис. 10: Остановка сервера iPerf3 в терминале хоста h2

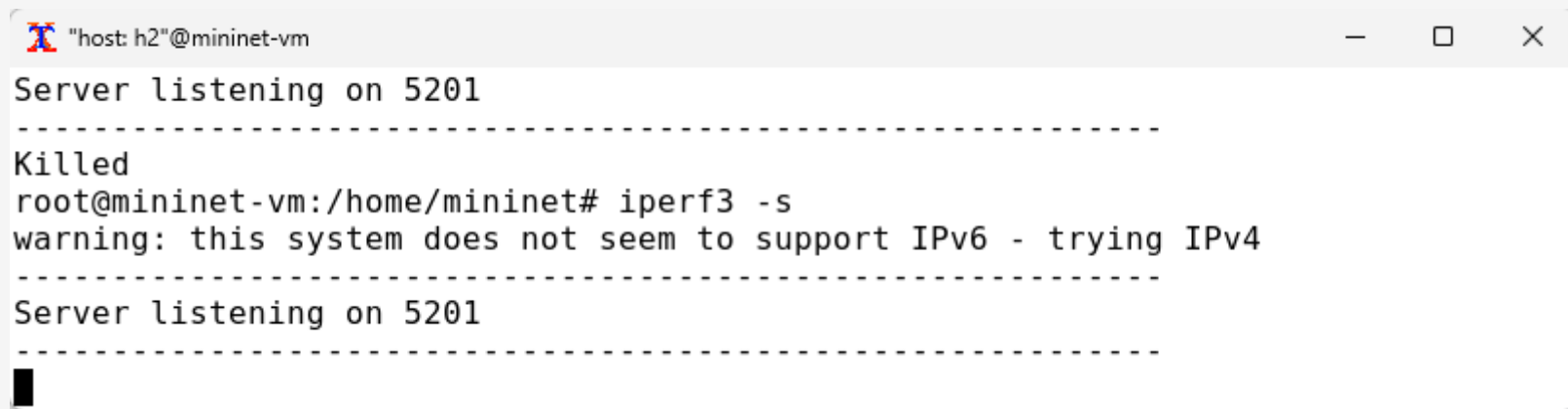
Интерактивные эксперименты

```
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
[ 5]  0.00-10.01   sec  11.5 GBytes 9.88 Gbits/sec  0
                                     sender
                                     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

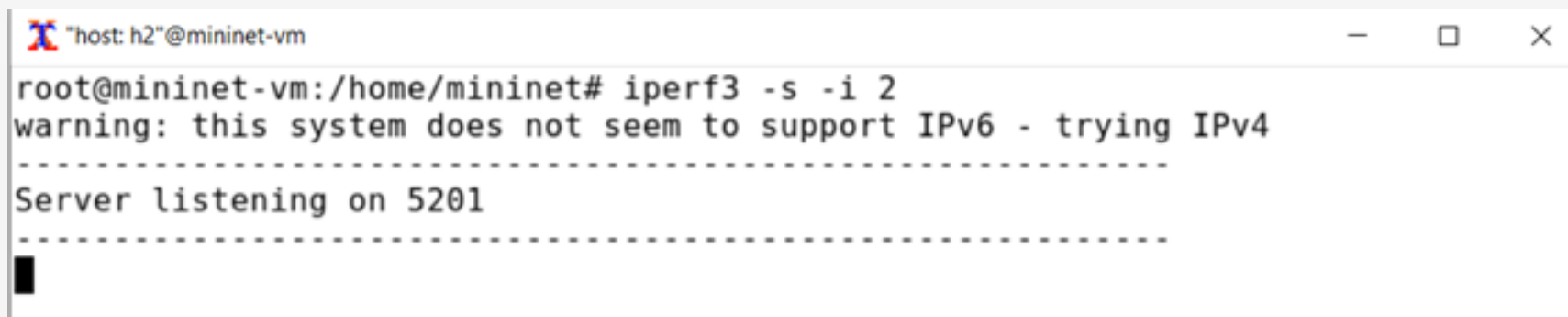
```
"host: h1"@mininet-vm
[ 7] 8.00-9.01 sec 1.00 GBytes 8.60 Gbits/sec 1 8.04 MBytes
[ 7] 9.01-10.00 sec 1.38 GBytes 11.9 Gbits/sec 0 8.04 MBytes
- - - - -
[ ID] Interval          Transfer      Bitrate      Retr
[ 7] 0.00-10.00 sec 13.0 GBytes 11.2 Gbits/sec 2
[ 7] 0.00-10.00 sec 13.0 GBytes 11.2 Gbits/sec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

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
sender
receiver

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

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

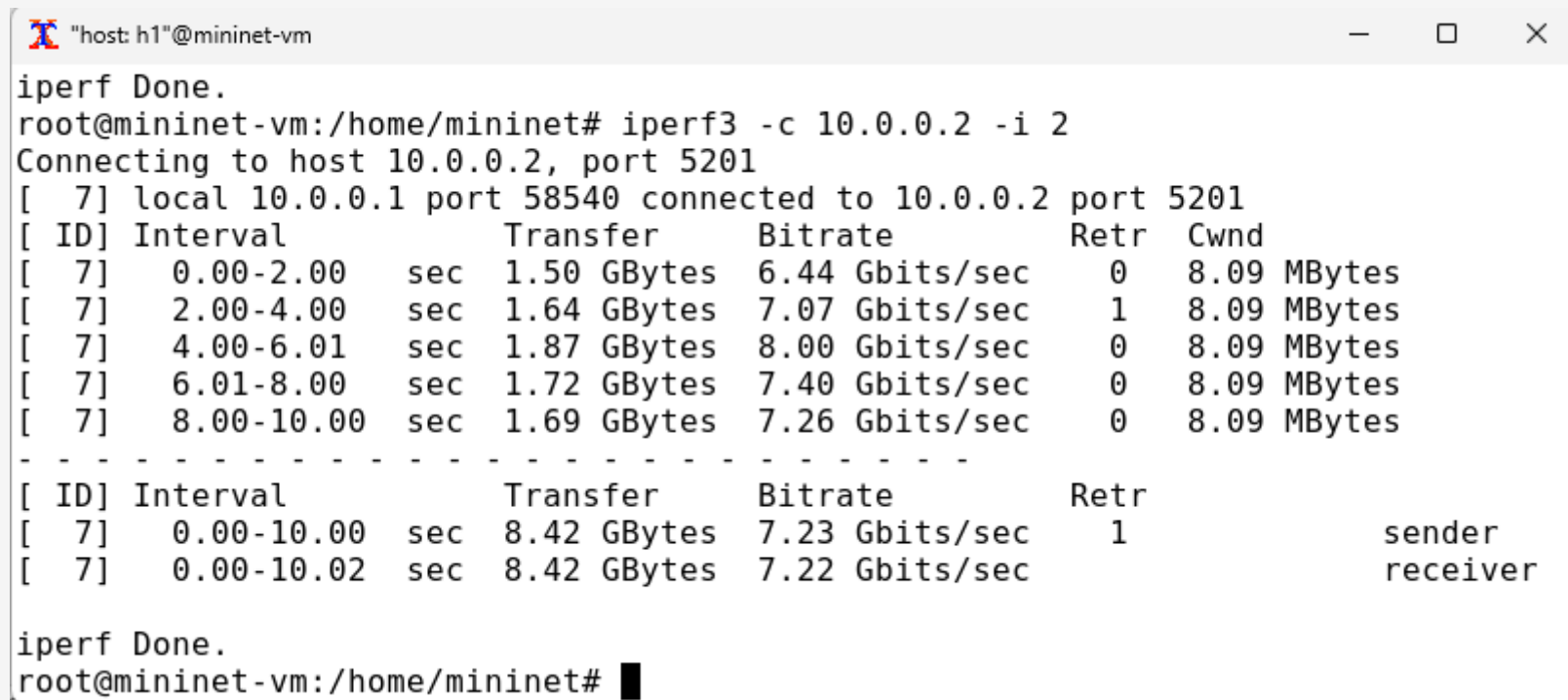
Интерактивные эксперименты



```
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

Интерактивные эксперименты



```
"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
- - - - -
[ ID] Interval            Transfer        Bitrate        Retr
[ 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



```
"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

```
"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
[ 7]  0.00-19.49  sec   16.0 GBytes  7.05 Gbits/sec
                                     sender
                                     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

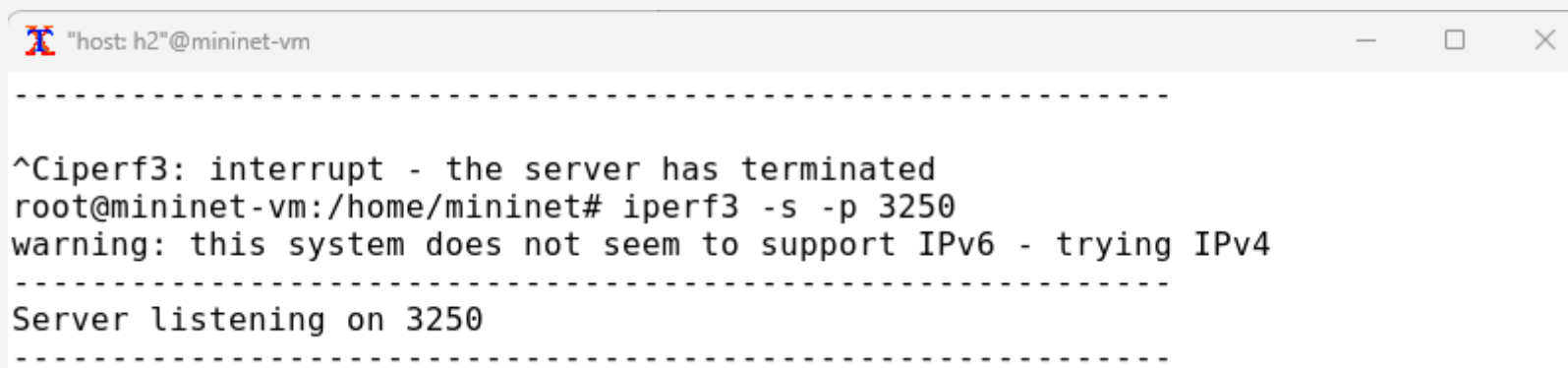
Интерактивные эксперименты

```
"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
- - - - -
[ 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  0/905 (0%)  send
er
[ 7] 0.00-10.00     sec    1.25 MBytes    1.05 Mbits/sec    0.011 ms  0/905 (0%)  rece
iver

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

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

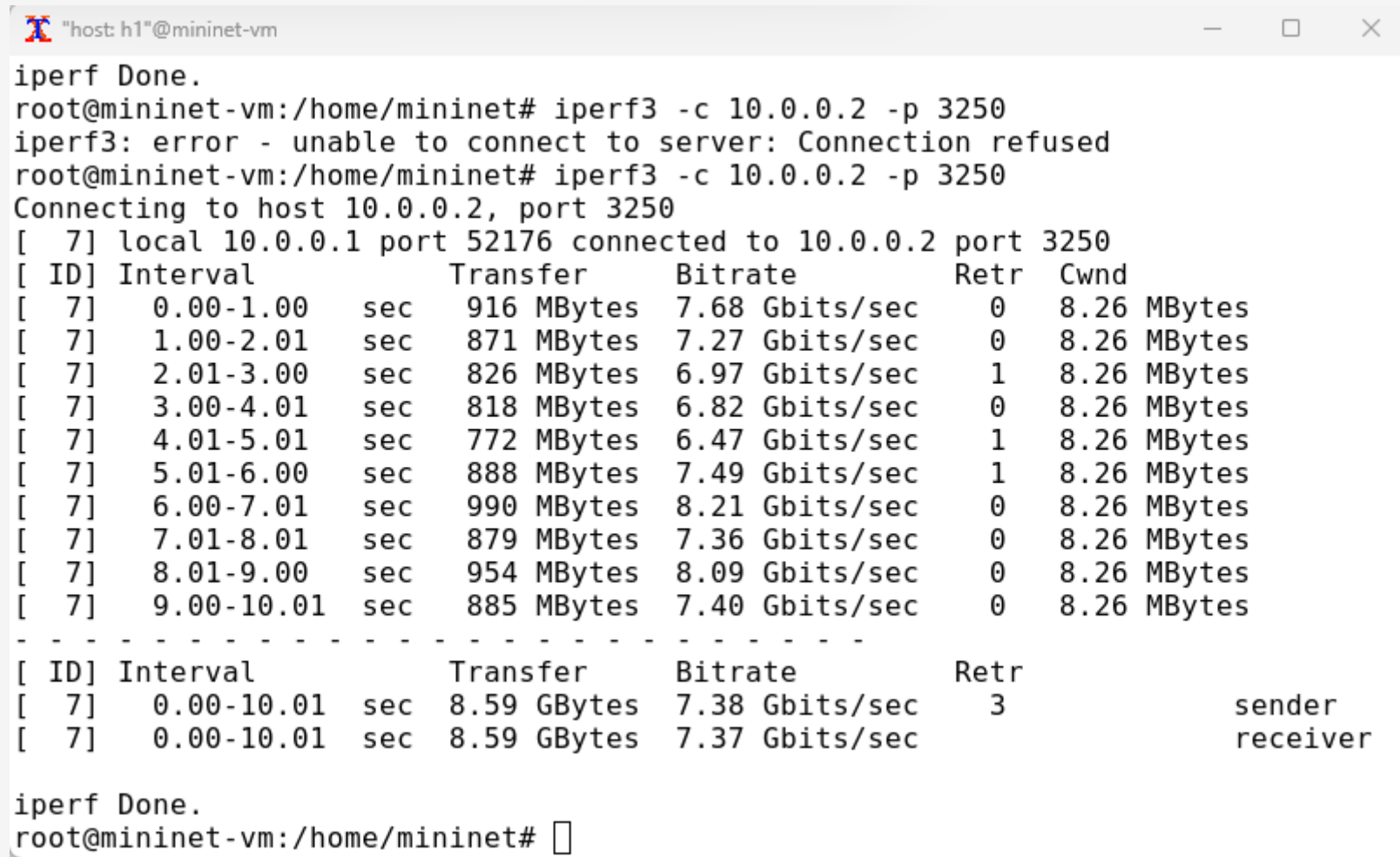
Интерактивные эксперименты



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

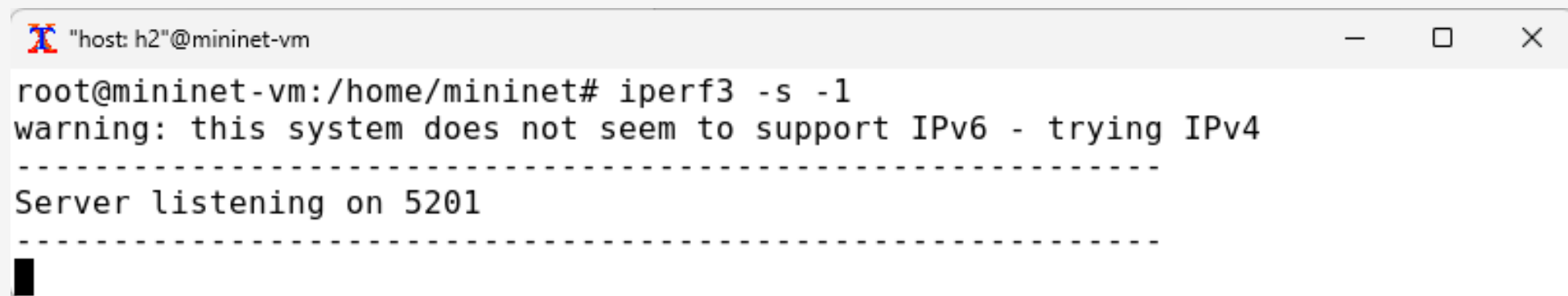


```
host: h1@mininet-vm
iperf Done.
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -p 3250
iperf3: error - unable to connect to server: Connection refused
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -p 3250
Connecting to host 10.0.0.2, port 3250
[ 7] local 10.0.0.1 port 52176 connected to 10.0.0.2 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
- - - - -
[ ID] Interval           Transfer     Bitrate      Retr
[ 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
                                     sender
                                     receiver

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

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

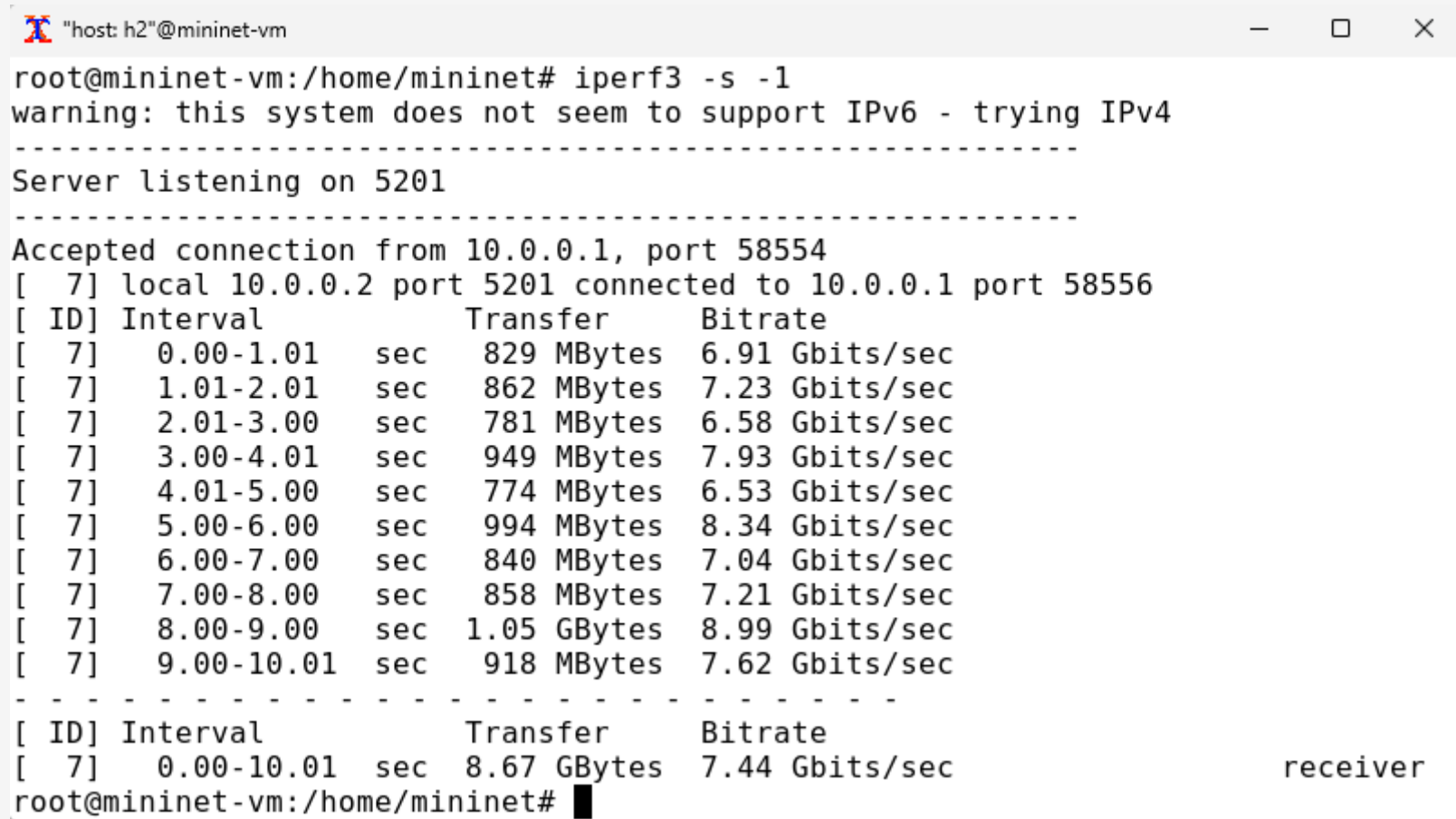
Интерактивные эксперименты



```
"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 приять только 1 клиента)

Интерактивные эксперименты

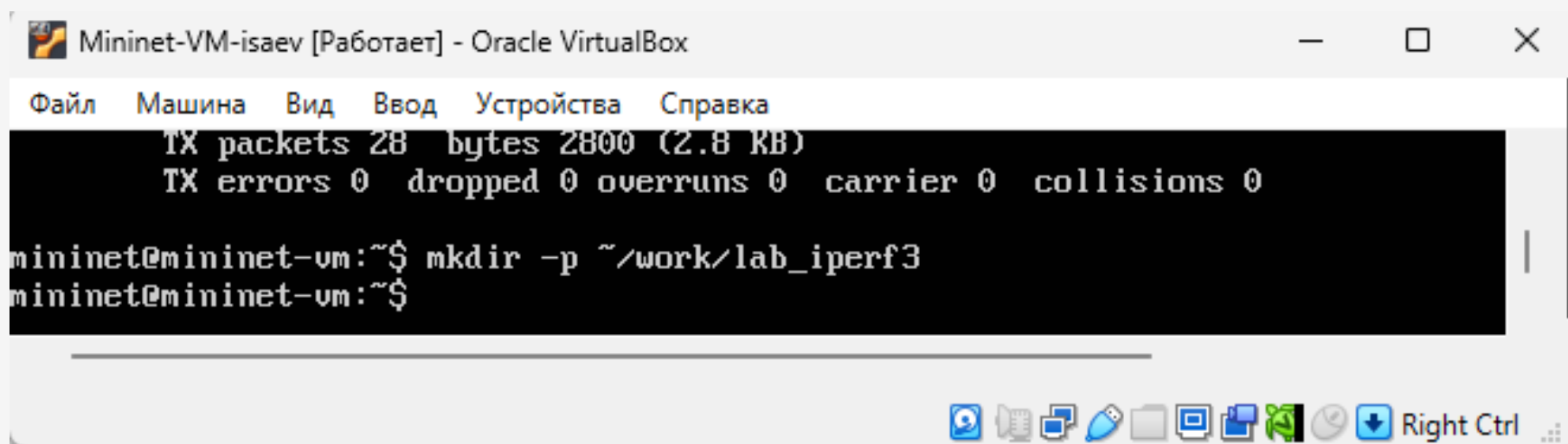
A terminal window titled '"host: h2"@mininet-vm' with standard window controls. The terminal shows the execution of 'iperf3 -s -1' as a server. It receives a connection from 10.0.0.1:58554 and reports performance metrics for 10 intervals. The final summary shows a total transfer of 8.67 GBytes at 7.44 Gbits/sec. The word 'receiver' is printed on the right side of the terminal.

```
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

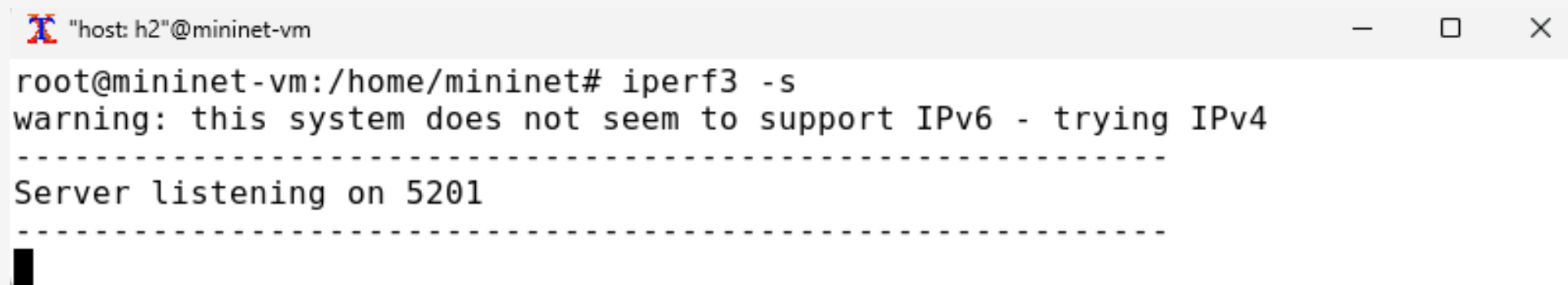
Интерактивные эксперименты



```
Mininet-VM-isaev [Работает] - Oracle VirtualBox
Файл  Машина  Вид  Ввод  Устройства  Справка
TX packets 28 bytes 2800 (2.8 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
mininet@mininet-vm:~$ mkdir -p ~/work/lab_iperf3
mininet@mininet-vm:~$
```

Рис. 24: Создание каталога для работы над проектом

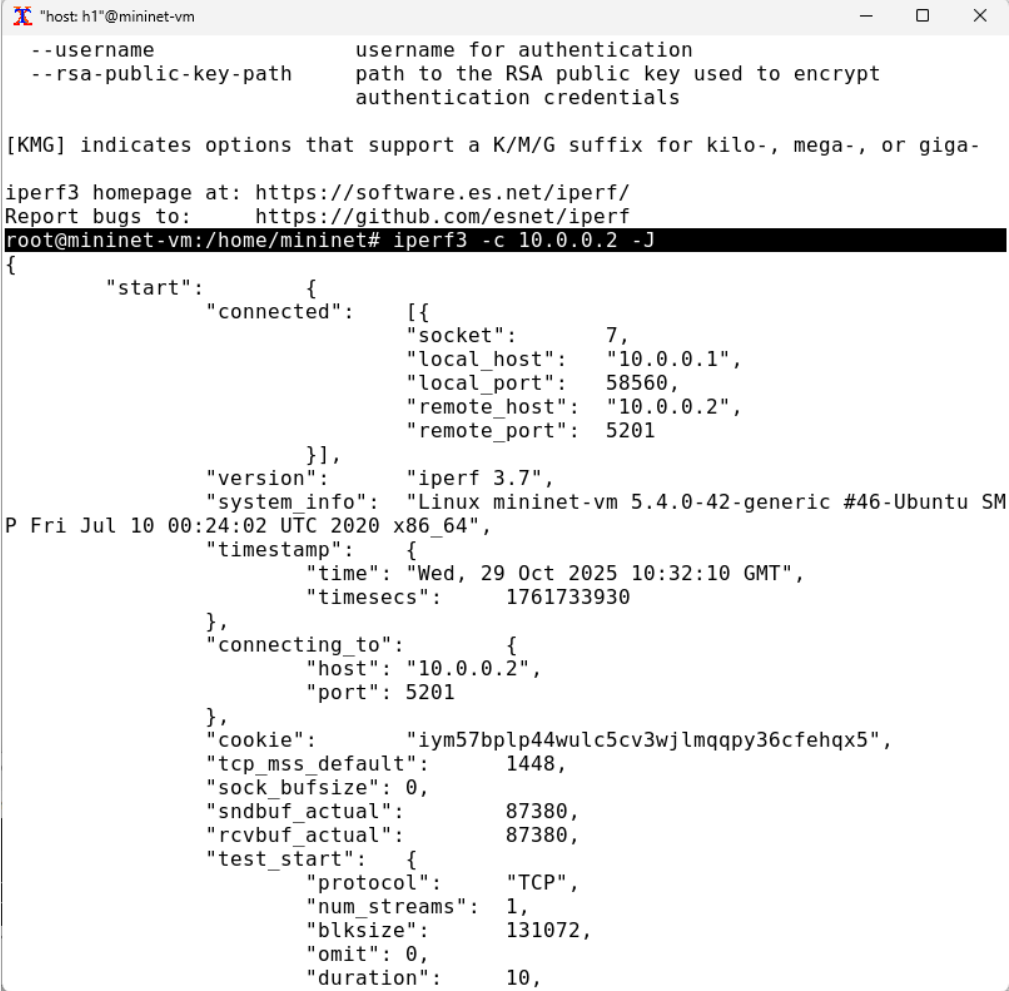
Интерактивные эксперименты

A terminal window titled '"host: h2"@mininet-vm' with standard window controls (minimize, maximize, close). The terminal content shows the command 'iperf3 -s' being executed, followed by a warning about IPv6 support and the message 'Server listening on 5201'.

```
"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. 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 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": "iym57bplp44wulc5cv3wjlmqqpy36cfehqx5",
    "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,

```

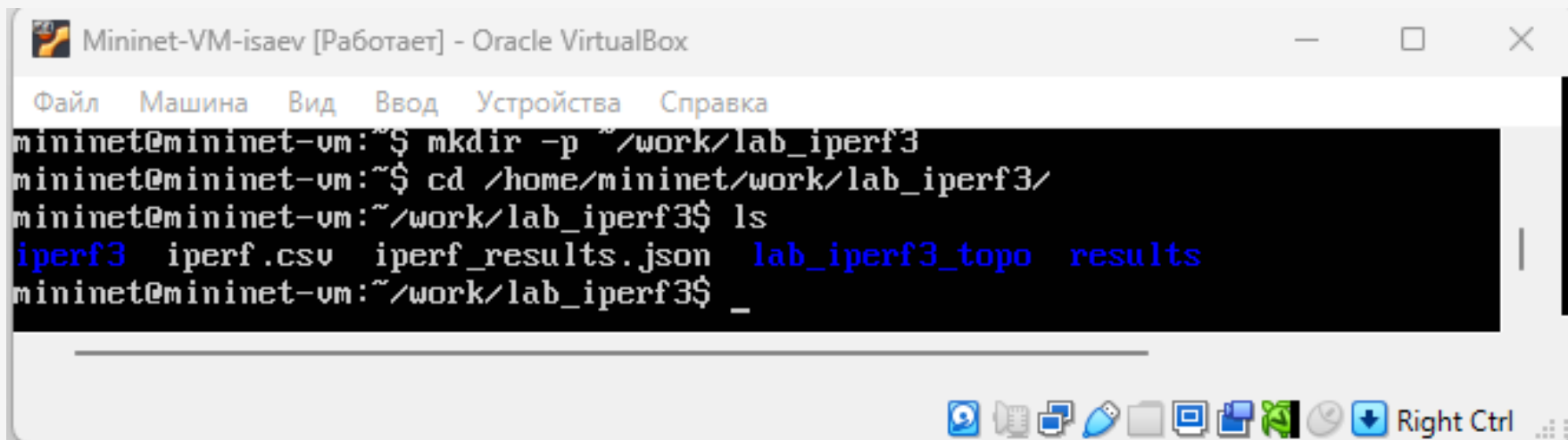
Рис. 26: Запуск клиента iperf3 в терминале h1 с параметром -J (отображение вывода в формате JSON)

Интерактивные эксперименты

```
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2 -J > /home/mininet/work/lab_i  
perf3/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 terminal displays the following commands and output:

```
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 includes a menu bar with "Файл", "Машина", "Вид", "Ввод", "Устройства", and "Справка". At the bottom, there is a toolbar with various icons and a "Right Ctrl" button.

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:~$
```

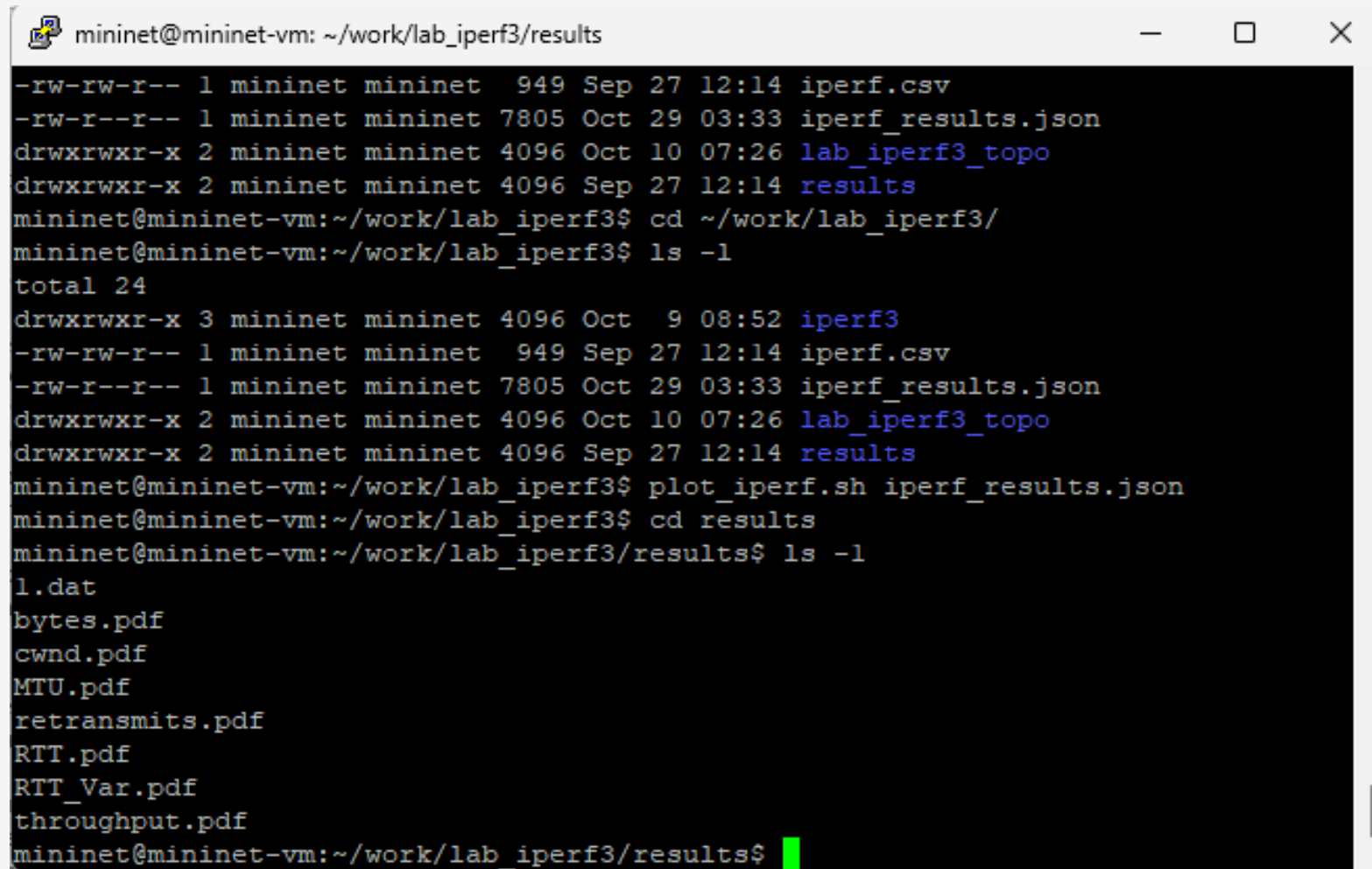
Рис. 29: Завершение работы mininet в интерактивном режиме

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
l.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/>