

Лабораторная работа №2

Моделирование сетей передачи данных

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1. Информация

2. Вводная часть

3. Выполнение лабораторной работы

1. Информация

1.1 Докладчик

- Амуничников Антон Игоревич

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- Группа: НПИбд-01-22

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- Российский университет дружбы народов им. П. Лумумбы

1.1 Докладчик

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2. Вводная часть

2.1 Цель работы

- Основной целью работы является знакомство с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получение навыков проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.

2.2 Задание

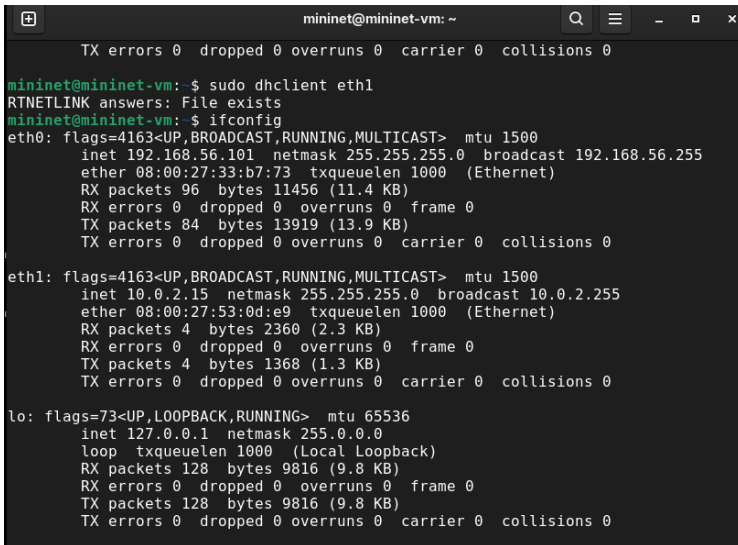
1. Установить на виртуальную машину mininet iPerf3 и дополнительное программное обеспечения для визуализации и обработки данных.

2.2 Задание

1. Установить на виртуальную машину mininet iPerf3 и дополнительное программное обеспечения для визуализации и обработки данных.
2. Провести ряд интерактивных экспериментов по измерению пропускной способности с помощью iPerf3 с построением графиков.

3. Выполнение лабораторной работы

3.1 Установка необходимого программного обеспечения

A terminal window titled 'mininet@mininet-vm: ~' with search, menu, and window control icons. It shows the execution of 'sudo dhclient eth1' and 'ifconfig' commands. The output for 'ifconfig' shows details for eth0, eth1, and lo interfaces, including IP addresses, netmasks, broadcast addresses, ether addresses, txqueuelen, and statistics for RX and TX packets, bytes, errors, dropped, overruns, carrier, and collisions.

```
mininet@mininet-vm: ~  
TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0  
  
mininet@mininet-vm:~$ sudo dhclient eth1  
RTNETLINK answers: File exists  
mininet@mininet-vm:~$ ifconfig  
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500  
    inet 192.168.56.101  netmask 255.255.255.0  broadcast 192.168.56.255  
    ether 08:00:27:33:b7:73  txqueuelen 1000  (Ethernet)  
    RX packets 96  bytes 11456 (11.4 KB)  
    RX errors 0  dropped 0  overruns 0  frame 0  
    TX packets 84  bytes 13919 (13.9 KB)  
    TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0  
  
eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500  
    inet 10.0.2.15  netmask 255.255.255.0  broadcast 10.0.2.255  
    ether 08:00:27:53:0d:e9  txqueuelen 1000  (Ethernet)  
    RX packets 4  bytes 2360 (2.3 KB)  
    RX errors 0  dropped 0  overruns 0  frame 0  
    TX packets 4  bytes 1368 (1.3 KB)  
    TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0  
  
lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536  
    inet 127.0.0.1  netmask 255.0.0.0  
    loop txqueuelen 1000  (Local Loopback)  
    RX packets 128  bytes 9816 (9.8 KB)  
    RX errors 0  dropped 0  overruns 0  frame 0  
    TX packets 128  bytes 9816 (9.8 KB)  
    TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0
```

3.2 Установка необходимого программного обеспечения

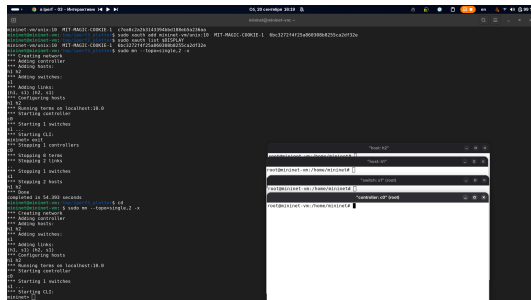
```
mininet@mininet-vm:~$ sudo apt-get update --fix-missing
Hit:1 http://us.archive.ubuntu.com/ubuntu focal InRelease
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [128 kB]
Get:3 http://security.ubuntu.com/ubuntu focal-security InRelease [128 kB]
Get:4 http://security.ubuntu.com/ubuntu focal-security/main amd64 Packages [3,564
Get:5 http://security.ubuntu.com/ubuntu focal-security/main i386 Packages [881 kB]
Get:6 http://security.ubuntu.com/ubuntu focal-security/main Translation-en [518 k
Get:7 http://security.ubuntu.com/ubuntu focal-security/main amd64 c-n-f Metadata
Get:8 http://security.ubuntu.com/ubuntu focal-security/restricted i386 Packages [
Get:9 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease [128 kB]
Get:10 http://security.ubuntu.com/ubuntu focal-security/restricted amd64 Packages
Get:11 http://security.ubuntu.com/ubuntu focal-security/restricted Translation-en
Get:12 http://security.ubuntu.com/ubuntu focal-security/restricted amd64 c-n-f Me
Get:13 http://security.ubuntu.com/ubuntu focal-security/universe amd64 Packages [
Get:14 http://security.ubuntu.com/ubuntu focal-security/universe i386 Packages [6
Get:15 http://security.ubuntu.com/ubuntu focal-security/universe Translation-en [
Get:16 http://security.ubuntu.com/ubuntu focal-security/universe amd64 c-n-f Meta
Get:17 http://security.ubuntu.com/ubuntu focal-security/multiverse amd64 Packages
Get:18 http://security.ubuntu.com/ubuntu focal-security/multiverse i386 Packages
Get:19 http://security.ubuntu.com/ubuntu focal-security/multiverse Translation-en
Get:20 http://security.ubuntu.com/ubuntu focal-security/multiverse amd64 c-n-f Me
Get:21 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 Packages [3,9
Get:22 http://us.archive.ubuntu.com/ubuntu focal-updates/main i386 Packages [1,11
Get:23 http://us.archive.ubuntu.com/ubuntu focal-updates/main Translation-en [600
Get:24 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 c-n-f Metadat
Get:25 http://us.archive.ubuntu.com/ubuntu focal-updates/restricted i386 Packages
Get:26 http://us.archive.ubuntu.com/ubuntu focal-updates/restricted amd64 Package
Get:27 http://us.archive.ubuntu.com/ubuntu focal-updates/restricted Translation-e
Get:28 http://us.archive.ubuntu.com/ubuntu focal-updates/restricted amd64 c-n-f M
Get:29 http://us.archive.ubuntu.com/ubuntu focal-updates/universe i386 Packages [
Get:30 http://us.archive.ubuntu.com/ubuntu focal-updates/universe amd64 Packages
```

3.3 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 | 776.00 KiB/s, done.
mininet@mininet-vm:/tmp$ cd iperf3_plotter
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo cd plot_* /usr/bin
sudo: cd: command not found
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo cp plot_* /usr/bin
mininet@mininet-vm:/tmp/iperf3_plotter$ sudo cp *.sh /usr/bin
```

Рисунок 3: Развертывание iperf3_plotter

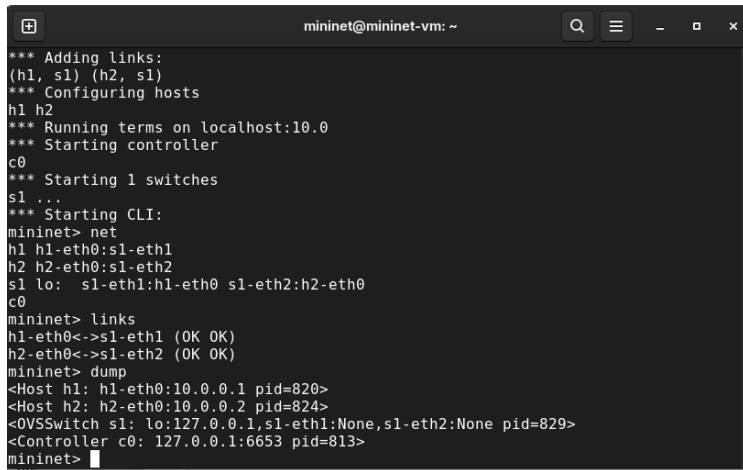
3.4 Интерактивные эксперименты



```
root@mininet-vn:/mnt/Mininet# ./topo.py
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Running tests on localhost:18.0
*** Starting controller
s0
*** Starting 1 switches
s1
*** Starting CLI:
mininet> exit
*** Stopping 1 controllers
s0
*** Stopping 0 terms
*** Stopping 2 links
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
Completed in 54.202 seconds
root@mininet-vn:/mnt/Mininet# ./topo.py
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Running tests on localhost:18.0
*** Starting controller
s0
*** Starting 1 switches
s1
*** Starting CLI:
mininet>
```

Рисунок 4: Задание простейшей топологии

3.5 Простой эксперимент



```
mininet@mininet-vm: ~  
*** 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=820>  
<Host h2: h2-eth0:10.0.0.2 pid=824>  
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=829>  
<Controller c0: 127.0.0.1:6653 pid=813>  
mininet> 
```

Рисунок 5: Тестовое соединение между хостами

3.6 Интерфейс mininet

```
"host: h2"
warning: this system does not seem to support IPv6 - trying IPv4
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 46690
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 46692
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-1.00 sec  2.39 GBytes  20.5 Gbits/sec
[ 7] 1.00-2.00 sec  2.18 GBytes  18.7 Gbits/sec
[ 7] 2.00-3.00 sec  2.26 GBytes  19.4 Gbits/sec
[ 7] 3.00-4.00 sec  2.34 GBytes  20.1 Gbits/sec
[ 7] 4.00-5.00 sec  2.36 GBytes  20.2 Gbits/sec
[ 7] 5.00-6.00 sec  2.40 GBytes  20.6 Gbits/sec
[ 7] 6.00-7.00 sec  2.39 GBytes  20.5 Gbits/sec
[ 7] 7.00-8.00 sec  2.40 GBytes  20.6 Gbits/sec
[ 7] 8.00-9.00 sec  2.30 GBytes  19.8 Gbits/sec
[ 7] 9.00-10.01 sec 2.32 GBytes  19.7 Gbits/sec
-----
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-10.01 sec 23.3 GBytes  20.0 Gbits/sec
-----
Server listening on 5201
receiver

"host: h1"
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 46692 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Retr  Cwnd
[ 7] 0.00-1.00 sec  2.39 GBytes  20.5 Gbits/sec    0   8.24 MBytes
[ 7] 1.00-2.00 sec  2.18 GBytes  18.8 Gbits/sec    3   8.24 MBytes
[ 7] 2.00-3.00 sec  2.27 GBytes  19.4 Gbits/sec    4   8.24 MBytes
[ 7] 3.00-4.00 sec  2.33 GBytes  20.1 Gbits/sec    1   8.24 MBytes
[ 7] 4.00-5.00 sec  2.36 GBytes  20.3 Gbits/sec    2   8.24 MBytes
[ 7] 5.00-6.00 sec  2.40 GBytes  20.6 Gbits/sec    1   8.24 MBytes
[ 7] 6.00-7.00 sec  2.40 GBytes  20.6 Gbits/sec    1   8.24 MBytes
[ 7] 7.00-8.00 sec  2.39 GBytes  20.6 Gbits/sec    1   8.24 MBytes
[ 7] 8.00-9.00 sec  2.32 GBytes  19.8 Gbits/sec    2   8.24 MBytes
[ 7] 9.00-10.00 sec 2.31 GBytes  19.9 Gbits/sec    2   8.24 MBytes
-----
[ ID] Interval      Transfer      Bitrate      Retr
[ 7] 0.00-10.00 sec 23.3 GBytes  20.1 Gbits/sec    17
[ 7] 0.00-10.01 sec 23.3 GBytes  20.0 Gbits/sec
-----
sender
receiver

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

3.7 Интерфейс mininet

```
mininet> h2 iperf3 -s &
mininet> h1 iperf3 -c h2
Connecting to host 10.0.0.2, port 5201
[ 5] local 10.0.0.1 port 46696 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 5]  0.00-1.00  sec     2.26 GBytes  19.4 Gbits/sec    0   8.11 MBytes
[ 5]  1.00-2.00  sec     2.30 GBytes  19.7 Gbits/sec    0   8.11 MBytes
[ 5]  2.00-3.00  sec     2.30 GBytes  19.8 Gbits/sec    0   8.11 MBytes
[ 5]  3.00-4.00  sec     2.42 GBytes  20.8 Gbits/sec    2   8.11 MBytes
[ 5]  4.00-5.00  sec     2.31 GBytes  19.9 Gbits/sec    0   8.11 MBytes
[ 5]  5.00-6.00  sec     2.34 GBytes  20.2 Gbits/sec    1   8.11 MBytes
[ 5]  6.00-7.00  sec     2.28 GBytes  19.6 Gbits/sec    0   8.11 MBytes
[ 5]  7.00-8.00  sec     2.15 GBytes  18.4 Gbits/sec    2   8.11 MBytes
[ 5]  8.00-9.00  sec     2.32 GBytes  20.0 Gbits/sec    1   8.11 MBytes
[ 5]  9.00-10.00 sec     2.38 GBytes  20.4 Gbits/sec    2   8.11 MBytes
- - - - -
[ ID] Interval      Transfer    Bitrate      Retr
[ 5]  0.00-10.00  sec     23.1 GBytes  19.8 Gbits/sec    8          sender
[ 5]  0.00-10.00  sec     23.1 GBytes  19.8 Gbits/sec                   receiver

iperf Done.
mininet>
```

Рисунок 7: Завершение процесса на сервере

3.8 -t — время в секундах для передачи

```
"host: h2"

Try: apt install <deb name>

root@mininet-vn:/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 46698
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 46700
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  2.39 GBytes 20.6 Gbits/sec
[ 7] 1.00-2.00 sec  2.41 GBytes 20.7 Gbits/sec
[ 7] 2.00-3.00 sec  2.36 GBytes 20.3 Gbits/sec
[ 7] 3.00-4.00 sec  2.34 GBytes 20.1 Gbits/sec
[ 7] 4.00-5.02 sec  2.34 GBytes 19.8 Gbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-5.02 sec  11.9 GBytes 20.3 Gbits/sec
Server listening on 5201

"host: h1"
[ 7] 8.00-9.00 sec  2.32 GBytes 19.8 Gbits/sec  2  8.24 MBytes
[ 7] 9.00-10.00 sec 2.31 GBytes 19.9 Gbits/sec  2  8.24 MBytes
[ ID] Interval      Transfer    Bitrate  Retr
[ 7] 0.00-10.00 sec 23.3 GBytes 20.1 Gbits/sec 17
[ 7] 0.00-10.01 sec 23.3 GBytes 20.0 Gbits/sec
iperf Done.
root@mininet-vn:/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 46700 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate  Retr  Cwnd
[ 7] 0.00-1.00 sec  2.40 GBytes 20.6 Gbits/sec  0  8.10 MBytes
[ 7] 1.00-2.00 sec  2.41 GBytes 20.7 Gbits/sec  1  8.10 MBytes
[ 7] 2.00-3.00 sec  2.37 GBytes 20.4 Gbits/sec  1  8.10 MBytes
[ 7] 3.00-4.00 sec  2.34 GBytes 20.1 Gbits/sec  1  8.10 MBytes
[ 7] 4.00-5.00 sec  2.34 GBytes 20.1 Gbits/sec  1  8.10 MBytes
[ ID] Interval      Transfer    Bitrate  Retr
[ 7] 0.00-5.00 sec  11.9 GBytes 20.4 Gbits/sec  4
[ 7] 0.00-5.02 sec  11.9 GBytes 20.3 Gbits/sec
iperf Done.
root@mininet-vn:/home/mininet#
```

Рисунок 8: Указание периода времени передачи

3.9 -i — интервал между отсчётами

```
"host: h2"
Server listening on 5201
-----
^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet# iperf3 -s -i 2
warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 46702
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 46704
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-2.00    sec 4.50 GBytes 19.3 Gbits/sec
[ 7] 2.00-4.00    sec 4.51 GBytes 19.4 Gbits/sec
[ 7] 4.00-6.00    sec 4.57 GBytes 19.6 Gbits/sec
[ 7] 6.00-8.00    sec 4.62 GBytes 19.9 Gbits/sec
[ 7] 8.00-10.01   sec 4.63 GBytes 19.8 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.01   sec 22.8 GBytes 19.6 Gbits/sec
-----
Server listening on 5201
-----
^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet#
```

```
"host: h1"
[ 7] 3.00-4.00    sec 2.34 GBytes 20.1 Gbits/sec 1 8.10 MBytes
[ 7] 4.00-5.00    sec 2.34 GBytes 20.1 Gbits/sec 1 8.10 MBytes
-----
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-5.00    sec 11.9 GBytes 20.4 Gbits/sec 4
[ 7] 0.00-5.02    sec 11.9 GBytes 20.3 Gbits/sec
-----
sender
receiver

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 46704 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr  Cwnd
[ 7] 0.00-2.00    sec 4.50 GBytes 19.3 Gbits/sec 2 8.33 MBytes
[ 7] 2.00-4.00    sec 4.51 GBytes 19.4 Gbits/sec 1 8.33 MBytes
[ 7] 4.00-6.00    sec 4.57 GBytes 19.6 Gbits/sec 9 8.33 MBytes
[ 7] 6.00-8.00    sec 4.63 GBytes 19.9 Gbits/sec 6 8.33 MBytes
[ 7] 8.00-10.00   sec 4.63 GBytes 19.9 Gbits/sec 2 8.33 MBytes
-----
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-10.00   sec 22.8 GBytes 19.6 Gbits/sec 20
[ 7] 0.00-10.01   sec 22.8 GBytes 19.6 Gbits/sec
-----
sender
receiver
```

3.10 -n — количество байт для передачи

```
"host: h2"
^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet# iperf3 -s
warning: this system does not seem to support IPv6 - trying IPv4
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 46706
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 46708
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  2.33 GBytes 20.0 Gbits/sec
[ 7] 1.00-2.00 sec  2.24 GBytes 19.2 Gbits/sec
[ 7] 2.00-3.00 sec  2.26 GBytes 19.4 Gbits/sec
[ 7] 3.00-4.00 sec  2.24 GBytes 19.2 Gbits/sec
[ 7] 4.00-5.00 sec  2.35 GBytes 20.2 Gbits/sec
[ 7] 5.00-6.00 sec  2.37 GBytes 20.3 Gbits/sec
[ 7] 6.00-6.95 sec  2.22 GBytes 20.1 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-6.95 sec  16.0 GBytes 19.8 Gbits/sec
-----
Server listening on 5201
-----

"host: h1"
-----
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-10.00 sec  22.8 GBytes 19.6 Gbits/sec    20
[ 7] 0.00-10.01 sec  22.8 GBytes 19.6 Gbits/sec
-----
iperf Done.
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 46708 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr  Cwnd
[ 7] 0.00-1.00 sec  2.33 GBytes 20.0 Gbits/sec    2   8.04 MBytes
[ 7] 1.00-2.00 sec  2.24 GBytes 19.2 Gbits/sec    1   8.04 MBytes
[ 7] 2.00-3.00 sec  2.27 GBytes 19.5 Gbits/sec    1   8.04 MBytes
[ 7] 3.00-4.00 sec  2.23 GBytes 19.2 Gbits/sec    2   8.04 MBytes
[ 7] 4.00-5.00 sec  2.36 GBytes 20.2 Gbits/sec    1   8.04 MBytes
[ 7] 5.00-6.00 sec  2.36 GBytes 20.3 Gbits/sec    3   8.04 MBytes
[ 7] 6.00-6.95 sec  2.22 GBytes 20.2 Gbits/sec    2   8.04 MBytes
-----
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-6.95 sec  16.0 GBytes 19.8 Gbits/sec    12
[ 7] 0.00-6.95 sec  16.0 GBytes 19.8 Gbits/sec
-----
iperf Done.
```

3.11 -u — протокол UDP

```
"host: h2"
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 60624
[ ID] Interval      Transfer      Bitrate      Jitter      Lost/Total Data
rams
[ 7] 0.00-1.00 sec    129 KBytes    1.05 Mbits/sec  0.024 ms    0/91 (0%)
[ 7] 1.00-2.00 sec    127 KBytes    1.04 Mbits/sec  0.023 ms    0/90 (0%)
[ 7] 2.00-3.00 sec    129 KBytes    1.05 Mbits/sec  0.015 ms    0/91 (0%)
[ 7] 3.00-4.00 sec    127 KBytes    1.04 Mbits/sec  0.026 ms    0/90 (0%)
[ 7] 4.00-5.00 sec    129 KBytes    1.05 Mbits/sec  0.019 ms    0/91 (0%)
[ 7] 5.00-6.00 sec    127 KBytes    1.04 Mbits/sec  0.021 ms    0/90 (0%)
[ 7] 6.00-7.00 sec    129 KBytes    1.05 Mbits/sec  0.035 ms    0/91 (0%)
[ 7] 7.00-8.00 sec    127 KBytes    1.04 Mbits/sec  0.024 ms    0/90 (0%)
[ 7] 8.00-9.00 sec    129 KBytes    1.05 Mbits/sec  0.025 ms    0/91 (0%)
[ 7] 9.00-10.00 sec   127 KBytes    1.04 Mbits/sec  0.025 ms    0/90 (0%)
[ 7] 10.00-10.00 sec  1.41 KBytes    5.58 Mbits/sec  0.025 ms    0/1 (0%)
-----
[ ID] Interval      Transfer      Bitrate      Jitter      Lost/Total Data
rams
[ 7] 0.00-10.00 sec  1.25 MBytes    1.05 Mbits/sec  0.025 ms    0/906 (0%)  rec
iver
-----
Server listening on 5201
-----
^Ciperf3: interrupt - the server has terminated
root@mininet-vm:/home/mininet#
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 60624 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] 4.00-5.00 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
er
[ 7] 0.00-10.00 sec  1.25 MBytes    1.05 Mbits/sec  0.025 ms    0/906 (0%)  rece
iver
iperf Done.
```

3.12 -p — номер порта

```
"host: h2"
-----
Server listening on 3250
-----
Accepted connection from 10.0.0.1, port 42114
[ 7] local 10.0.0.2 port 3250 connected to 10.0.0.1 port 42116
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  2.43 GBytes 20.9 Gbits/sec
[ 7] 1.00-2.00 sec  2.39 GBytes 20.5 Gbits/sec
[ 7] 2.00-3.00 sec  2.40 GBytes 20.6 Gbits/sec
[ 7] 3.00-4.00 sec  2.35 GBytes 20.2 Gbits/sec
[ 7] 4.00-5.00 sec  2.38 GBytes 20.4 Gbits/sec
[ 7] 5.00-6.00 sec  2.39 GBytes 20.5 Gbits/sec
[ 7] 6.00-7.00 sec  2.39 GBytes 20.5 Gbits/sec
[ 7] 7.00-8.00 sec  2.37 GBytes 20.4 Gbits/sec
[ 7] 8.00-9.00 sec  2.34 GBytes 20.1 Gbits/sec
[ 7] 9.00-10.00 sec 2.38 GBytes 20.5 Gbits/sec
[ 7] 10.00-10.00 sec 1.13 MBytes 8.55 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.00 sec 23.8 GBytes 20.5 Gbits/sec
-----
Server listening on 3250
receiver

"host: h1"
iver

iperf Done.
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 42116 connected to 10.0.0.2 port 3250
[ ID] Interval      Transfer    Bitrate  Retr  Cwnd
[ 7] 0.00-1.00 sec  2.43 GBytes 20.8 Gbits/sec    3   8.23 MBytes
[ 7] 1.00-2.00 sec  2.39 GBytes 20.5 Gbits/sec    0   8.23 MBytes
[ 7] 2.00-3.00 sec  2.40 GBytes 20.6 Gbits/sec    4   8.23 MBytes
[ 7] 3.00-4.00 sec  2.35 GBytes 20.2 Gbits/sec    1   8.23 MBytes
[ 7] 4.00-5.00 sec  2.38 GBytes 20.4 Gbits/sec    3   8.23 MBytes
[ 7] 5.00-6.00 sec  2.38 GBytes 20.5 Gbits/sec    2   8.23 MBytes
[ 7] 6.00-7.00 sec  2.39 GBytes 20.6 Gbits/sec    2   8.23 MBytes
[ 7] 7.00-8.00 sec  2.37 GBytes 20.4 Gbits/sec    0   8.23 MBytes
[ 7] 8.00-9.00 sec  2.35 GBytes 20.2 Gbits/sec    1   8.23 MBytes
[ 7] 9.00-10.00 sec 2.38 GBytes 20.4 Gbits/sec    3   8.23 MBytes
-----
[ ID] Interval      Transfer    Bitrate  Retr
[ 7] 0.00-10.00 sec 23.8 GBytes 20.5 Gbits/sec    19
[ 7] 0.00-10.00 sec 23.8 GBytes 20.5 Gbits/sec
-----
sender
receiver

iperf Done.
```


3.13 -1 — обработка данных только от одного клиента с остановкой сервера по завершении теста

```
"host: h2"
-----
^Ciperf3: interrupt - the server has terminated
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 46718
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 46720
[ ID] Interval           Transfer     Bitrate
[ 7] 0.00-1.00 sec      2.43 GBytes 20.9 Gbits/sec
[ 7] 1.00-2.00 sec      2.28 GBytes 19.6 Gbits/sec
[ 7] 2.00-3.00 sec      2.36 GBytes 20.2 Gbits/sec
[ 7] 3.00-4.00 sec      2.40 GBytes 20.6 Gbits/sec
[ 7] 4.00-5.00 sec      2.40 GBytes 20.6 Gbits/sec
[ 7] 5.00-6.00 sec      2.41 GBytes 20.7 Gbits/sec
[ 7] 6.00-7.00 sec      2.38 GBytes 20.4 Gbits/sec
[ 7] 7.00-8.00 sec      2.42 GBytes 20.8 Gbits/sec
[ 7] 8.00-9.00 sec      2.42 GBytes 20.8 Gbits/sec
[ 7] 9.00-10.01 sec     2.39 GBytes 20.3 Gbits/sec
-----
[ ID] Interval           Transfer     Bitrate
-----
"host: h1"
-----
iperf Done.
root@mininet-vm:/home/mininet# iperf3 -c 10.0.0.2
iperf3: error - unable to connect to server: Connection refused
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 46720 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7] 0.00-1.00 sec      2.43 GBytes 20.8 Gbits/sec    1   8.15 MBytes
[ 7] 1.00-2.00 sec      2.28 GBytes 19.6 Gbits/sec    4   8.15 MBytes
[ 7] 2.00-3.00 sec      2.36 GBytes 20.3 Gbits/sec    0   8.15 MBytes
[ 7] 3.00-4.00 sec      2.40 GBytes 20.6 Gbits/sec    2   8.15 MBytes
[ 7] 4.00-5.00 sec      2.40 GBytes 20.6 Gbits/sec    2   8.15 MBytes
[ 7] 5.00-6.00 sec      2.41 GBytes 20.7 Gbits/sec    5   8.15 MBytes
[ 7] 6.00-7.00 sec      2.38 GBytes 20.5 Gbits/sec    0   8.15 MBytes
[ 7] 7.00-8.00 sec      2.42 GBytes 20.8 Gbits/sec    0   8.15 MBytes
[ 7] 8.00-9.00 sec      2.42 GBytes 20.8 Gbits/sec    3   8.15 MBytes
[ 7] 9.00-10.00 sec     2.39 GBytes 20.6 Gbits/sec    1   8.15 MBytes
-----
[ ID] Interval           Transfer     Bitrate      Retr  sender
[ 7] 0.00-10.00 sec     23.9 GBytes 20.5 Gbits/sec   18
```

3.14 -J — результаты в JSON

```
"host: h2"
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 46722
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 46724
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  2.40 GBytes 20.6 Gbits/sec
[ 7] 1.00-2.00 sec  2.36 GBytes 20.3 Gbits/sec
[ 7] 2.00-3.00 sec  2.23 GBytes 19.1 Gbits/sec
[ 7] 3.00-4.00 sec  2.27 GBytes 19.5 Gbits/sec
[ 7] 4.00-5.00 sec  2.11 GBytes 18.1 Gbits/sec
[ 7] 5.00-6.00 sec  2.35 GBytes 20.2 Gbits/sec
[ 7] 6.00-7.00 sec  2.31 GBytes 19.9 Gbits/sec
[ 7] 7.00-8.00 sec  2.43 GBytes 20.8 Gbits/sec
[ 7] 8.00-9.00 sec  2.42 GBytes 20.8 Gbits/sec
[ 7] 9.00-10.00 sec 2.27 GBytes 19.5 Gbits/sec
[ 7] 10.00-10.00 sec 897 KBytes  8.16 Gbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.00 sec 23.1 GBytes 19.9 Gbits/sec
-----
receiver
Server listening on 5201

"host: h1"
-----
      "retransmits": 13,
      "sender":      true
    },
    "sum_received": {
      "start":        0,
      "end": 10.000917,
      "seconds": 10.000917,
      "bytes": 24851195776,
      "bits_per_second": 19879133704.239323,
      "sender":      true
    },
    "cpu_utilization_percent": {
      "host_total": 49.852238626193142,
      "host_user":  1.1546406184938729,
      "host_system": 48.697548152319754,
      "remote_total": 28.666099027183368,
      "remote_user": 1.612147945502004,
      "remote_system": 27.05392805371044
    },
    "sender_tcp_congestion": "cubic",
    "receiver_tcp_congestion": "cubic"
  }
}
```

3.15 -J — результаты в JSON

```
root@mininet-vm:~/work/lab_iperf3# cd /home/mininet/work/lab_iperf3
root@mininet-vm:~/work/lab_iperf3# iperf3 -c 10.0.0.2 -J > ~/work/lab_iperf3/iperf_result.json
root@mininet-vm:~/work/lab_iperf3# cd /home/mininet/work/lab_iperf3
bash: cd: /home/mininet/work/lab_iperf3: No such file or directory
root@mininet-vm:~/work/lab_iperf3# ls -l
total 4
-rw-r--r-- 1 root root 269 Sep 20 06:42 iperf_result.json
root@mininet-vm:~/work/lab_iperf3#
```

Рисунок 15: Проверка создания файла iperf_results.json

3.16 Права запуска X-соединения

```
mininet@mininet-vm:~$ xauth list $DISPLAY
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  90bab8d5e7c4d197633a22e325718d38
mininet@mininet-vm:~$ sudo xauth list $DISPLAY
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  6bc3272f4f25a860308b8255ca2df32e
mininet@mininet-vm:~$ sudo xauth add mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  90bab8d5e7c4d197633a22e325718d38
mininet@mininet-vm:~$ sudo xauth list $DISPLAY
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  90bab8d5e7c4d197633a22e325718d38
mininet@mininet-vm:~$ sudo xauth merge /tmp/.X11-unix/X0
```

Рисунок 16: Исправление прав запуска X-соединения

3.17 Генерация графиков

```
mininet@mininet-vm:~/work/lab_iperf3$ plot iperf.sh iperf result.json
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ ls -l
total 16
-rw-rw-r-- 1 mininet mininet 952 Sep 20 06:54 iperf.csv
-rw-r--r-- 1 mininet mininet 7797 Sep 20 06:51 iperf_result.json
drwxrwxr-x 2 mininet mininet 4096 Sep 20 06:54 results
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3/results
mininet@mininet-vm:~/work/lab_iperf3/results$ ls -l
total 88
-rw-rw-r-- 1 mininet mininet 482 Sep 20 06:54 1.dat
-rw-rw-r-- 1 mininet mininet 9752 Sep 20 06:54 bytes.pdf
-rw-rw-r-- 1 mininet mininet 9618 Sep 20 06:54 cwnd.pdf
-rw-rw-r-- 1 mininet mininet 9036 Sep 20 06:54 MTU.pdf
-rw-rw-r-- 1 mininet mininet 9095 Sep 20 06:54 retransmits.pdf
-rw-rw-r-- 1 mininet mininet 9001 Sep 20 06:54 RTT.pdf
-rw-rw-r-- 1 mininet mininet 9125 Sep 20 06:54 RTT_Var.pdf
-rw-rw-r-- 1 mininet mininet 9499 Sep 20 06:54 throughput.pdf
mininet@mininet-vm:~/work/lab_iperf3/results$
```

Рисунок 17: Визуализация результатов эксперимента

3.18 Выводы

- В результате выполнения данной лабораторной работы я познакомился с инструментом для измерения пропускной способности сети в режиме реального времени — iPerf3, а также получил навыки проведения интерактивного эксперимента по измерению пропускной способности моделируемой сети в среде Mininet.