

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

- Амуничников Антон Игоревич
- Группа: НПИбд-01-22
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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

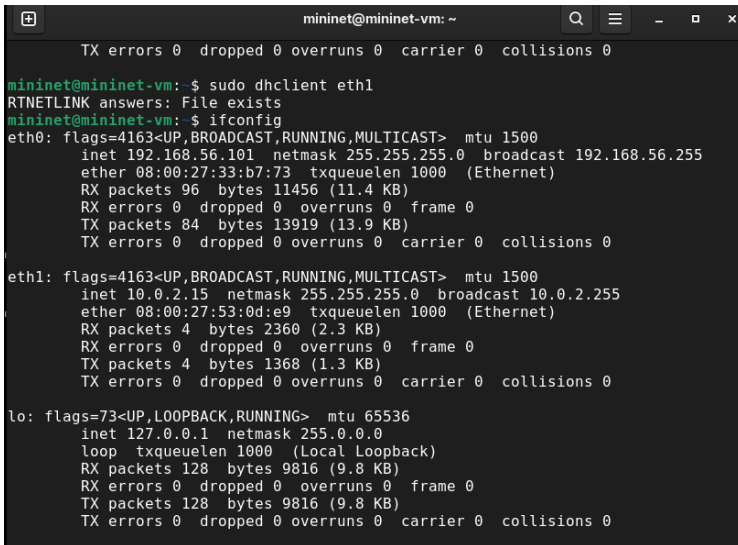
1. Установить на виртуальную машину mininet iPerf3 и дополнительное программное обеспечения для визуализации и обработки данных.

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 three interfaces: eth0 (192.168.56.101), eth1 (10.0.2.15), and lo (127.0.0.1), including their MTU, flags, and statistics.

```
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

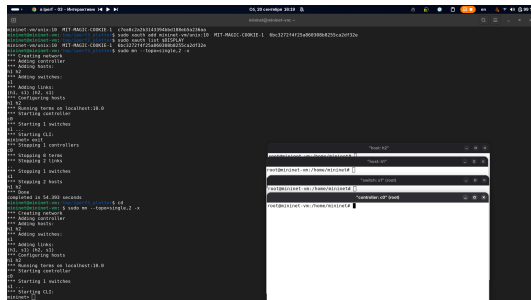
```
mininet@mininet-vm:~$ sudo apt-get update --fix-missing
Hit:1 http://us.archive.ubuntu.com/ubuntu focal InRelease
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [128 kB]
Get:3 http://security.ubuntu.com/ubuntu focal-security InRelease [128 kB]
Get:4 http://security.ubuntu.com/ubuntu 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

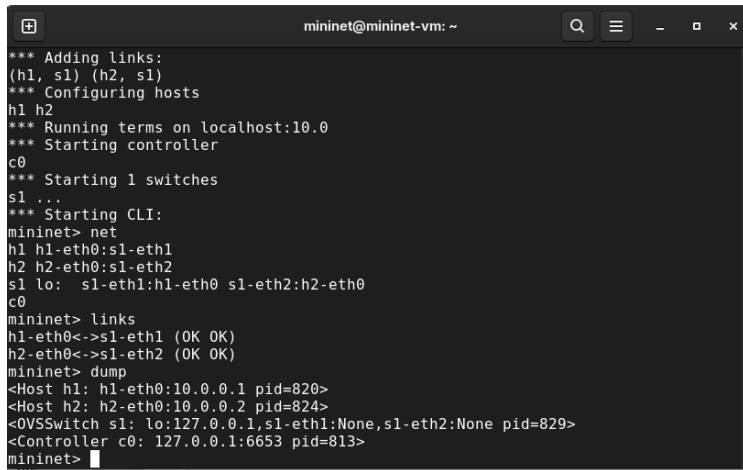
3.4 Интерактивные эксперименты



```
root@mininet-vn:/mnt/1$ ./topology.py
Creating network
Adding controller
Adding hosts
Adding switches
Adding links
Running tests on localhost:18.0
Starting controller
Starting 1 switches
Starting 1 switch
Starting CLI
mininet exit
Stopping 1 controllers
Stopping 0 terms
Stopping 2 links
Stopping 1 switches
Stopping 2 hosts
Done
Completed in 54.202 seconds
root@mininet-vn:/mnt/1$ ./topology.py
Creating network
Adding controller
Adding hosts
Adding switches
Adding links
Running tests on localhost:18.0
Starting controller
Starting 1 switches
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  90b
ab8d5e7c4d197633a22e325718d38
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/.Xauthority
```

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