# Лабораторная работа №3

Измерение и тестирование пропускной способности сети. Воспроизводимый эксперимент

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# Информация

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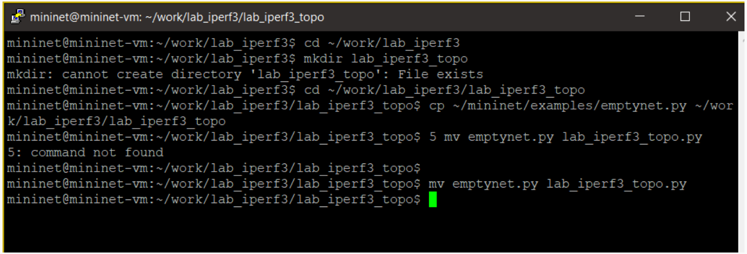
# Цель работы

# Цель работы

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

# Выполнение лабораторной работы

# Создание подкаталога, копирование файла с примером скрипта (описывающего стандартную простую топологию сети mininet)

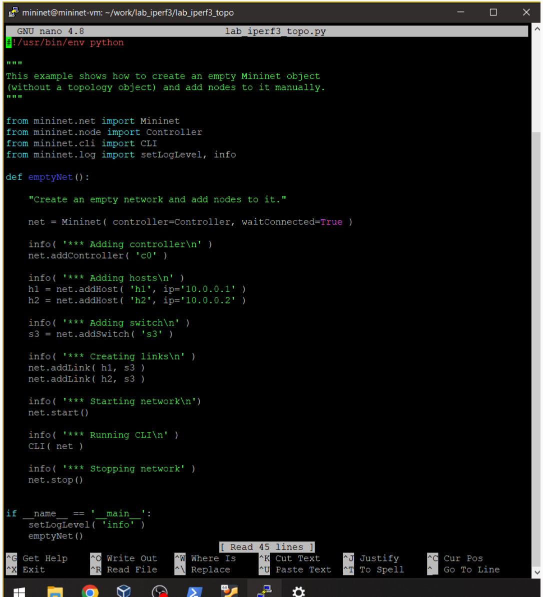


mininet@mininet-vm: ~/work/lab_iperf3/lab_iperf3_topo

```
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3
mininet@mininet-vm:~/work/lab_iperf3$ mkdir lab_iperf3_topo
mkdir: cannot create directory 'lab_iperf3_topo': File exists
mininet@mininet-vm:~/work/lab_iperf3$ cd ~/work/lab_iperf3/lab_iperf3_topo
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ cp ~/mininet/examples/emptynet.py ~/wor
k/lab_iperf3/lab_iperf3_topo
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ 5 mv emptynet.py lab_iperf3_topo.py
5: command not found
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ mv emptynet.py lab_iperf3_topo.py
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$
```

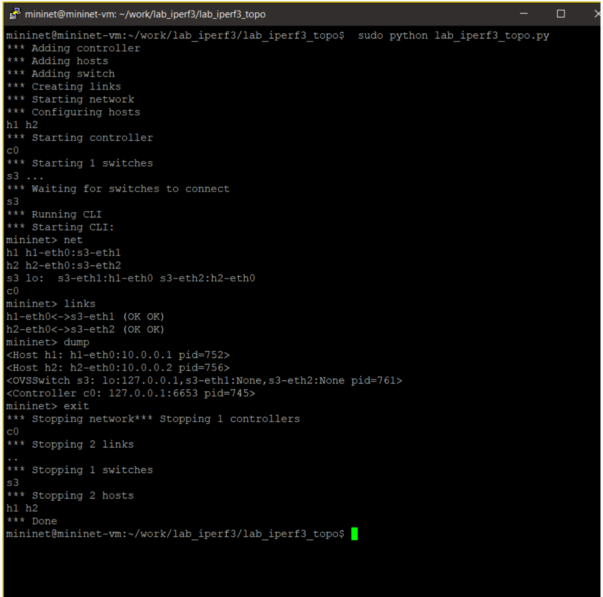
**Рис. 1:** Создание подкаталога, копирование файла с примером скрипта (описывающего стандартную простую топологию сети mininet)

# Содержание файла lab_iperf3_topo.py



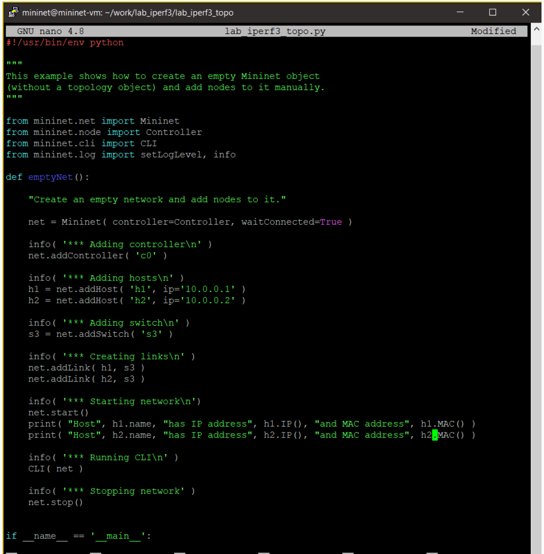
```
  GNU nano 4.8                          lab_iperf3_topo.py
#!/usr/bin/env python

"""
This example shows how to create an empty Mininet object
(without a topology object) and add nodes to it manually.
"""

from mininet.net import Mininet
from mininet.node import Controller
from mininet.cli import CLI
from mininet.log import setLogLevel, info

def emptyNet():

    "Create an empty network and add nodes to it."

    net = Mininet( controller=Controller, waitConnected=True )

    info( '*** Adding controller\n' )
    net.addController( 'c0' )

    info( '*** Adding hosts\n' )
    h1 = net.addHost( 'h1', ip='10.0.0.1' )
    h2 = net.addHost( 'h2', ip='10.0.0.2' )

    info( '*** Adding switch\n' )
    s3 = net.addSwitch( 's3' )

    info( '*** Creating links\n' )
    net.addLink( h1, s3 )
    net.addLink( h2, s3 )

    info( '*** Starting network\n')
    net.start()

    info( '*** Running CLI\n' )
    CLI( net )

    info( '*** Stopping network' )
    net.stop()


if __name__ == '__main__':
    setLogLevel( 'info' )
    emptyNet()
                                      [ Read 45 lines ]
^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify     ^C Cur Pos
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell    ^_ Go To Line
```

# Запуск скрипта создания топологии и дальнейший просмотр элементов



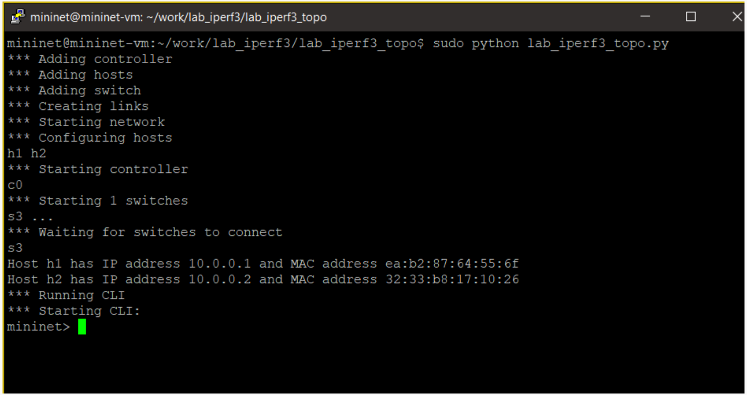
```
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$  sudo python lab_iperf3_topo.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
*** Starting network
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s3 ...
*** Waiting for switches to connect
s3
*** Running CLI
*** Starting CLI:
mininet> net
h1 h1-eth0:s3-eth1
h2 h2-eth0:s3-eth2
s3 lo:  s3-eth1:h1-eth0 s3-eth2:h2-eth0
c0
mininet> links
h1-eth0<->s3-eth1 (OK OK)
h2-eth0<->s3-eth2 (OK OK)
mininet> dump
<Host h1: h1-eth0:10.0.0.1 pid=752>
<Host h2: h2-eth0:10.0.0.2 pid=756>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None pid=761>
<Controller c0: 127.0.0.1:6653 pid=745>
mininet> exit
*** Stopping network*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s3
*** Stopping 2 hosts
h1 h2
*** Done
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$
```

# Внесение изменения в скрипт, позволяющего вывести на экран информацию о хостах h1 и h2 (имя, IP-адрес, MAC-адрес)



```
  GNU nano 4.8                     lab_iperf3_topo.py                    Modified
#!/usr/bin/env python

"""
This example shows how to create an empty Mininet object
(without a topology object) and add nodes to it manually.
"""

from mininet.net import Mininet
from mininet.node import Controller
from mininet.cli import CLI
from mininet.log import setLogLevel, info

def emptyNet():

    "Create an empty network and add nodes to it."

    net = Mininet( controller=Controller, waitConnected=True )

    info( '*** Adding controller\n' )
    net.addController( 'c0' )

    info( '*** Adding hosts\n' )
    h1 = net.addHost( 'h1', ip='10.0.0.1' )
    h2 = net.addHost( 'h2', ip='10.0.0.2' )

    info( '*** Adding switch\n' )
    s3 = net.addSwitch( 's3' )

    info( '*** Creating links\n' )
    net.addLink( h1, s3 )
    net.addLink( h2, s3 )

    info( '*** Starting network\n')
    net.start()
    print( "Host", h1.name, "has IP address", h1.IP(), "and MAC address", h1.MAC() )
    print( "Host", h2.name, "has IP address", h2.IP(), "and MAC address", h2.MAC() )

    info( '*** Running CLI\n' )
    CLI( net )

    info( '*** Stopping network' )
    net.stop()


if __name__ == '__main__':
```

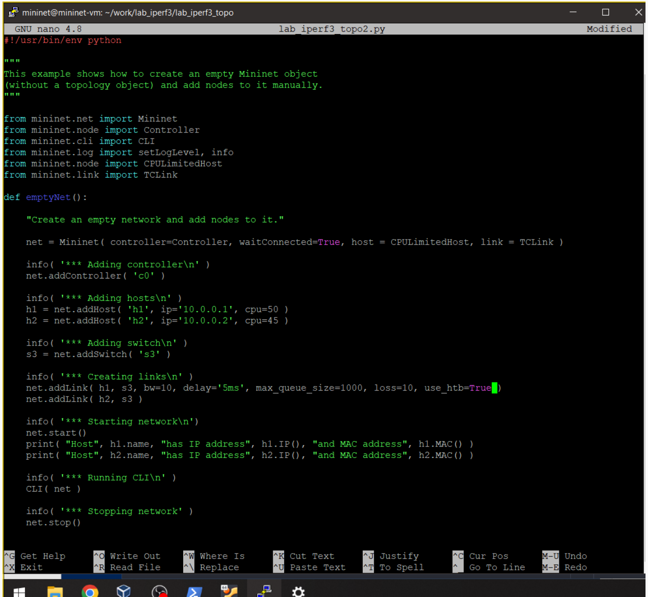
# Проверка корректности отработки скрипта



```
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ sudo python lab_iperf3_topo.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
*** Starting network
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s3 ...
*** Waiting for switches to connect
s3
Host h1 has IP address 10.0.0.1 and MAC address ea:b2:87:64:55:6f
Host h2 has IP address 10.0.0.2 and MAC address 32:33:b8:17:10:26
*** Running CLI
*** Starting CLI:
mininet>
```

**Рис. 5:** Проверка корректности отработки скрипта

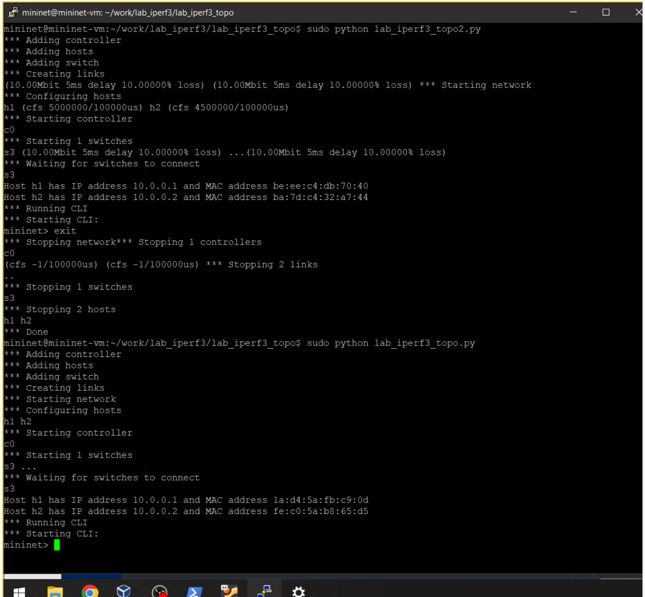
# Настройка параметров производительности



mininet@mininet-vm: ~/work/lab_iperf3/lab_iperf3_topo

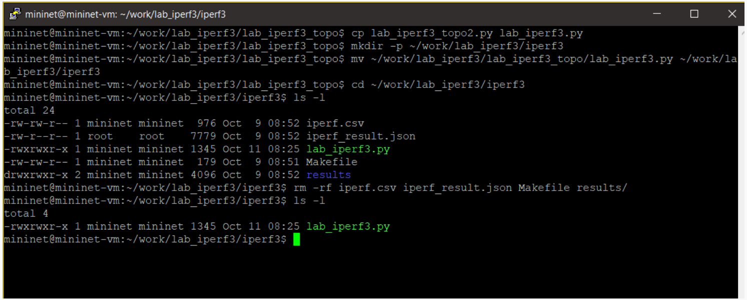
```
  GNU nano 4.8                              lab_iperf3_topo2.py                              Modified
#!/usr/bin/env python

"""
This example shows how to create an empty Mininet object
(without a topology object) and add nodes to it manually.
"""

from mininet.net import Mininet
from mininet.node import Controller
from mininet.cli import CLI
from mininet.log import setLogLevel, info
from mininet.node import CPULimitedHost
from mininet.link import TCLink

def emptyNet():

    "Create an empty network and add nodes to it."

    net = Mininet( controller=Controller, waitConnected=True, host = CPULimitedHost, link = TCLink )

    info( '*** Adding controller\n' )
    net.addController( 'c0' )

    info( '*** Adding hosts\n' )
    h1 = net.addHost( 'h1', ip='10.0.0.1', cpu=50 )
    h2 = net.addHost( 'h2', ip='10.0.0.2', cpu=45 )

    info( '*** Adding switch\n' )
    s3 = net.addSwitch( 's3' )

    info( '*** Creating links\n' )
    net.addLink( h1, s3, bw=10, delay='5ms', max_queue_size=1000, loss=10, use_htb=True )
    net.addLink( h2, s3 )

    info( '*** Starting network\n')
    net.start()
    print( "Host", h1.name, "has IP address", h1.IP(), "and MAC address", h1.MAC() )
    print( "Host", h2.name, "has IP address", h2.IP(), "and MAC address", h2.MAC() )

    info( '*** Running CLI\n' )
    CLI( net )

    info( '*** Stopping network' )
    net.stop()

^G Get Help     ^O Write Out    ^W Where Is     ^K Cut Text     ^J Justify      ^C Cur Pos      M-U Undo
^X Exit         ^R Read File    ^\ Replace      ^U Paste Text   ^T To Spell     ^_ Go To Line   M-E Redo
```

# Запуск скрипта с настройкой параметров производительности и без нее



```
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ sudo python lab_iperf3_topo2.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
(10.00Mbit 5ms delay 10.00000% loss) (10.00Mbit 5ms delay 10.00000% loss) *** Starting network
*** Configuring hosts
h1 (cfs 5000000/100000us) h2 (cfs 4500000/100000us)
*** Starting controller
c0
*** Starting 1 switches
s3 (10.00Mbit 5ms delay 10.00000% loss) ...(10.00Mbit 5ms delay 10.00000% loss)
*** Waiting for switches to connect
s3
Host h1 has IP address 10.0.0.1 and MAC address be:ee:c4:db:70:40
Host h2 has IP address 10.0.0.2 and MAC address ba:7d:c4:32:a7:44
*** Running CLI
*** Starting CLI:
mininet> exit
*** Stopping network*** Stopping 1 controllers
c0
(cfs -1/100000us) (cfs -1/100000us) *** Stopping 2 links
..
*** Stopping 1 switches
s3
*** Stopping 2 hosts
h1 h2
*** Done
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ sudo python lab_iperf3_topo.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
*** Starting network
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s3 ...
*** Waiting for switches to connect
s3
Host h1 has IP address 10.0.0.1 and MAC address 1a:d4:5a:fb:c9:0d
Host h2 has IP address 10.0.0.2 and MAC address fe:c0:5a:b8:65:d5
*** Running CLI
*** Starting CLI:
mininet>
```

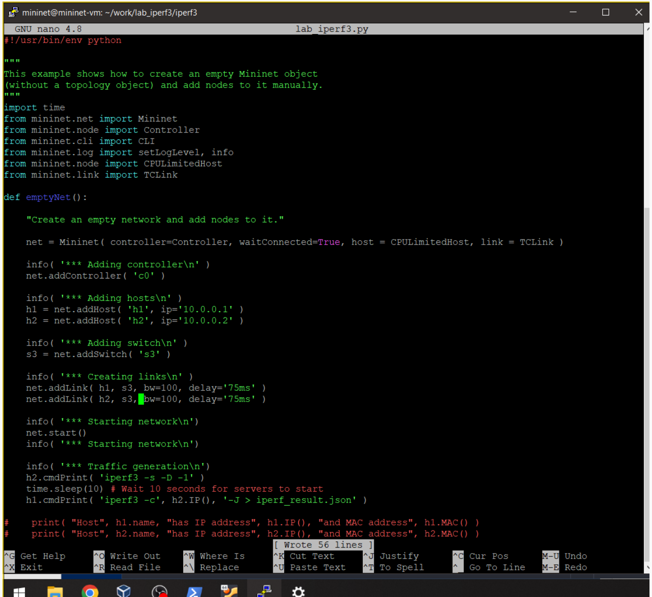
# Создание копии скрипта lab_iperf3_topo2.py



```
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ cp lab_iperf3_topo2.py lab_iperf3.py
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ mkdir -p ~/work/lab_iperf3/iperf3
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ mv ~/work/lab_iperf3/lab_iperf3_topo/lab_iperf3.py ~/work/la
b_iperf3/iperf3
mininet@mininet-vm:~/work/lab_iperf3/lab_iperf3_topo$ cd ~/work/lab_iperf3/iperf3
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ ls -l
total 24
-rw-rw-r-- 1 mininet mininet  976 Oct  9 08:52 iperf.csv
-rw-r--r-- 1 root    root    7779 Oct  9 08:52 iperf_result.json
-rwxrwxr-x 1 mininet mininet 1345 Oct 11 08:25 lab_iperf3.py
-rw-rw-r-- 1 mininet mininet  179 Oct  9 08:51 Makefile
drwxrwxr-x 2 mininet mininet 4096 Oct  9 08:52 results
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ rm -rf iperf.csv iperf_result.json Makefile results/
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ ls -l
total 4
-rwxrwxr-x 1 mininet mininet 1345 Oct 11 08:25 lab_iperf3.py
mininet@mininet-vm:~/work/lab_iperf3/iperf3$
```

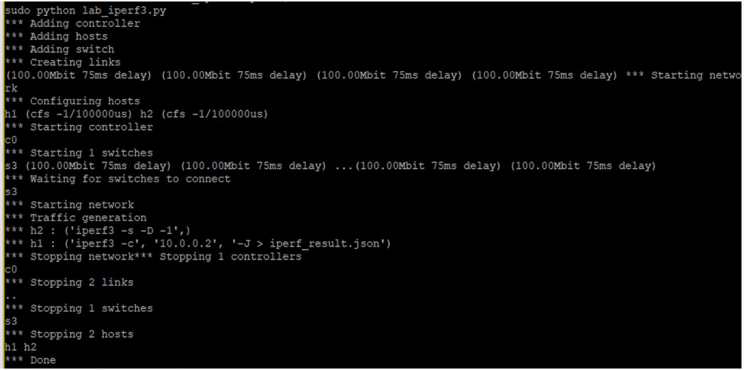
**Рис. 8:** Создание копии скрипта lab_iperf3_topo2.py

# Изменения кода в скрипте lab_iperf3.py



```
  GNU nano 4.8                                                  lab_iperf3.py
#!/usr/bin/env python

"""
This example shows how to create an empty Mininet object
(without a topology object) and add nodes to it manually.
"""
import time
from mininet.net import Mininet
from mininet.node import Controller
from mininet.cli import CLI
from mininet.log import setLogLevel, info
from mininet.node import CPULimitedHost
from mininet.link import TCLink

def emptyNet():

    "Create an empty network and add nodes to it."

    net = Mininet( controller=Controller, waitConnected=True, host = CPULimitedHost, link = TCLink )

    info( '*** Adding controller\n' )
    net.addController( 'c0' )

    info( '*** Adding hosts\n' )
    h1 = net.addHost( 'h1', ip='10.0.0.1' )
    h2 = net.addHost( 'h2', ip='10.0.0.2' )

    info( '*** Adding switch\n' )
    s3 = net.addSwitch( 's3' )

    info( '*** Creating links\n' )
    net.addLink( h1, s3, bw=100, delay='75ms' )
    net.addLink( h2, s3, bw=100, delay='75ms' )

    info( '*** Starting network\n')
    net.start()
    info( '*** Starting network\n')

    info( '*** Traffic generation\n')
    h2.cmdPrint( 'iperf3 -s -D -1' )
    time.sleep(10) # Wait 10 seconds for servers to start
    h1.cmdPrint( 'iperf3 -c', h2.IP(), '-J > iperf_result.json' )

#    print( "Host", h1.name, "has IP address", h1.IP(), "and MAC address", h1.MAC() )
#    print( "Host", h2.name, "has IP address", h2.IP(), "and MAC address", h2.MAC() )
                                                  [ Wrote 56 lines ]
^G Get Help     ^O Write Out    ^W Where Is     ^K Cut Text     ^J Justify      ^C Cur Pos      M-U Undo
^X Exit         ^R Read File    ^\ Replace      ^U Paste Text   ^T To Spell     ^_ Go To Line   M-E Redo
```

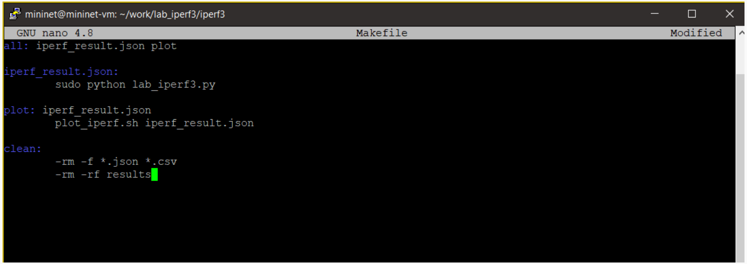
# Запуск скрипта lab_iperf3.py



```
sudo python lab_iperf3.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
(100.00Mbit 75ms delay) (100.00Mbit 75ms delay) (100.00Mbit 75ms delay) (100.00Mbit 75ms delay) *** Starting netwo
rk
*** Configuring hosts
h1 (cfs -1/100000us) h2 (cfs -1/100000us)
*** Starting controller
c0
*** Starting 1 switches
s3 (100.00Mbit 75ms delay) (100.00Mbit 75ms delay) ...(100.00Mbit 75ms delay) (100.00Mbit 75ms delay)
*** Waiting for switches to connect
s3
*** Starting network
*** Traffic generation
*** h2 : ('iperf3 -s -D -1',)
*** h1 : ('iperf3 -c', '10.0.0.2', '-J > iperf_result.json')
*** Stopping network*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s3
*** Stopping 2 hosts
h1 h2
*** Done
```

**Рис. 10:** Запуск скрипта lab_iperf3.py

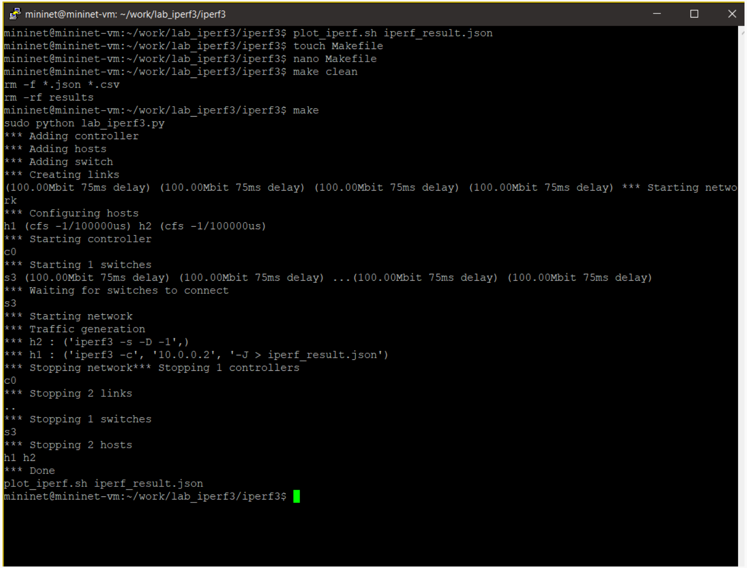
# Создание Makefile



```
all: iperf_result.json plot

iperf_result.json:
	sudo python lab_iperf3.py

plot: iperf_result.json
	plot_iperf.sh iperf_result.json

clean:
	-rm -f *.json *.csv
	-rm -rf results
```

**Рис. 11:** Создание Makefile

# Проверка работы Makefile



mininet@mininet-vm: ~/work/lab_iperf3/iperf3

```
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ plot_iperf.sh iperf_result.json
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ touch Makefile
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ nano Makefile
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ make clean
rm -f *.json *.csv
rm -rf results
mininet@mininet-vm:~/work/lab_iperf3/iperf3$ make
sudo python lab_iperf3.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
(100.00Mbit 75ms delay) (100.00Mbit 75ms delay) (100.00Mbit 75ms delay) (100.00Mbit 75ms delay) *** Starting netwo
rk
*** Configuring hosts
h1 (cfs -1/100000us) h2 (cfs -1/100000us)
*** Starting controller
c0
*** Starting 1 switches
s3 (100.00Mbit 75ms delay) (100.00Mbit 75ms delay) ...(100.00Mbit 75ms delay) (100.00Mbit 75ms delay)
*** Waiting for switches to connect
s3
*** Starting network
*** Traffic generation
*** h2 : ('iperf3 -s -D -1',)
*** h1 : ('iperf3 -c', '10.0.0.2', '-J > iperf_result.json')
*** Stopping network*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s3
*** Stopping 2 hosts
h1 h2
*** Done
plot_iperf.sh iperf_result.json
mininet@mininet-vm:~/work/lab_iperf3/iperf3$
```

# Выводы

# Выводы

В ходе выполнения лабораторной работы я познакомился 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.

# Список литературы

# Список литературы

1. Mininet [Электронный ресурс]. Mininet Project Contributors. URL: http://mini net.org/ (дата обращения: 06.10.2025).