

# Лабораторная работа № 5

Эмуляция и измерение потерь пакетов в глобальных сетях

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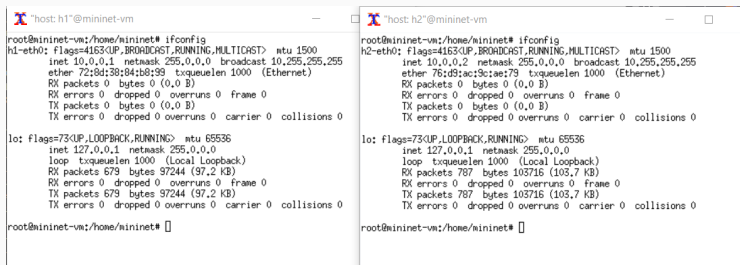
## Информация

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Основной целью работы является получение навыков проведения интерактивных экспериментов в среде Mininet по исследованию параметров сети, связанных с потерей, дублированием, изменением порядка и повреждением пакетов при передаче данных. Эти параметры влияют на производительность протоколов и сетей.

# Выполнение лабораторной работы



The image displays two terminal windows side-by-side, showing the output of the 'ifconfig' command for two hosts, h1 and h2, within a Mininet environment. Both hosts have a root user and are located at /home/mininet.

**Host h1:**

```
root@mininet-vm:/home/mininet# ifconfig
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.1 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 72:8d:38:84:b8:99 txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    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 679 bytes 97244 (97.2 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 679 bytes 97244 (97.2 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

root@mininet-vm:/home/mininet#
```

**Host h2:**

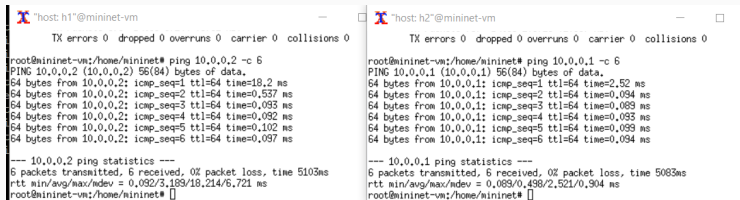
```
root@mininet-vm:/home/mininet# ifconfig
h2-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.2 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 76:d9:ac:3c:ae:79 txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    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 787 bytes 103716 (103.7 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 787 bytes 103716 (103.7 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

root@mininet-vm:/home/mininet#
```

Рис. 1: Информацию о сетевых интерфейсах и IP-адресах хостов

# Выполнение лабораторной работы



The image shows two terminal windows side-by-side. The left window is titled "host: h1"@mininet-vm and shows a ping command being executed from root@mininet-vm:/home/mininet# to 10.0.0.2 with 6 packets. The output shows successful pings with times ranging from 0.092 to 0.102 ms. The right window is titled "host: h2"@mininet-vm and shows a ping command being executed from root@mininet-vm:/home/mininet# to 10.0.0.1 with 6 packets. The output shows successful pings with times ranging from 0.089 to 0.094 ms. Both windows also display network statistics at the top, showing 0 errors, dropped packets, overruns, carrier errors, and collisions.

```
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

root@mininet-vm:/home/mininet# ping 10.0.0.2 -c 6
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.102 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.092 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.093 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.092 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.102 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.097 ms

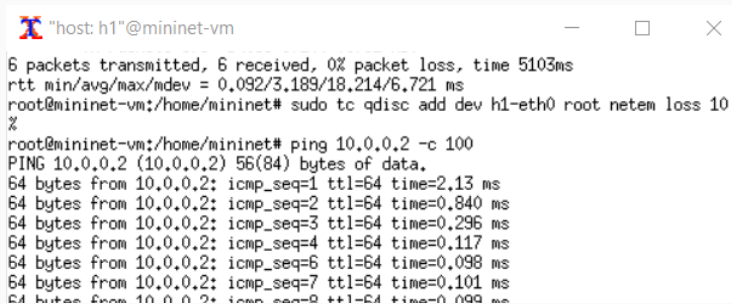
--- 10.0.0.2 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5103ms
rtt min/avg/max/mdev = 0.092/3.189/18.214/6.721 ms
root@mininet-vm:/home/mininet#
```

```
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

root@mininet-vm:/home/mininet# ping 10.0.0.1 -c 6
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.094 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.094 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.089 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.093 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.089 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.094 ms

--- 10.0.0.1 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5083ms
rtt min/avg/max/mdev = 0.089/0.498/2.521/0.904 ms
root@mininet-vm:/home/mininet#
```

Рис. 2: Проверка соединения между хостами

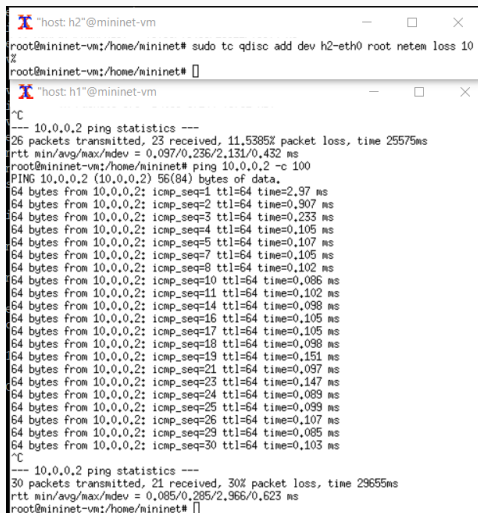


A terminal window titled "host: h1" @mininet-vm. The window shows the output of a ping command and the execution of a tc command to add packet loss. The ping command shows 6 packets transmitted, 6 received, 0% packet loss, and a time of 5103ms. The tc command is used to add 10% packet loss on the h1-eth0 interface. The ping command is then run again, showing 64 bytes from 10.0.0.2 with various icmp\_seq and time values.

```
"host: h1" @mininet-vm
6 packets transmitted, 6 received, 0% packet loss, time 5103ms
rtt min/avg/max/mdev = 0.092/3.189/18.214/6.721 ms
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem loss 10%
root@mininet-vm:/home/mininet# ping 10.0.0.2 -c 100
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=2.13 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.840 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.296 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.117 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.098 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.101 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.099 ms
```

Рис. 3: Добавление потери пакетов

## Выполнение лабораторной работы



The image shows two terminal windows. The top window, titled "host: h2"@mininet-vm, shows the execution of the command `sudo tc qdisc add dev h2-eth0 root netem loss 10 %` to configure packet loss on the interface. The bottom window, titled "host: h1"@mininet-vm, shows the execution of `ping 10.0.0.2 -c 100`. The output displays 30 ping attempts with a 30% packet loss rate and a total time of 29655ms.

```
"host: h2"@mininet-vm
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h2-eth0 root netem loss 10 %
root@mininet-vm:/home/mininet#

"host: h1"@mininet-vm
^C
--- 10.0.0.2 ping statistics ---
26 packets transmitted, 23 received, 11,5385% packet loss, time 25575ms
rtt min/avg/max/mdev = 0,097/0,236/2,131/0,432 ms
root@mininet-vm:/home/mininet# ping 10.0.0.2 -c 100
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=2,97 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0,907 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0,233 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0,105 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0,107 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0,105 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0,102 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0,086 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0,102 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=0,098 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=0,105 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=0,105 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=0,098 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=0,151 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=0,097 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=0,147 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=0,089 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=0,099 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=0,107 ms
64 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=0,085 ms
64 bytes from 10.0.0.2: icmp_seq=30 ttl=64 time=0,103 ms
^C
--- 10.0.0.2 ping statistics ---
30 packets transmitted, 21 received, 30% packet loss, time 29655ms
rtt min/avg/max/mdev = 0,085/0,285/2,966/0,623 ms
root@mininet-vm:/home/mininet#
```

Рис. 4: Добавление потери пакетов



## Выполнение лабораторной работы

```
root@mininet-vm:~# "host: h1"@mininet-vm
22 packets transmitted, 22 received, 0% packet loss, time 21486ms
rtt min/avg/max/mdev = 0.093/0.263/2.705/0.553 ms
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem loss 50%
50%
root@mininet-vm:/home/mininet# ping 10.0.0.2 -c 50
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
54 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.539 ms
54 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.127 ms
54 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.167 ms
54 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.116 ms
54 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.099 ms
54 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.098 ms
54 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.116 ms
54 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.104 ms
54 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=0.102 ms
54 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=0.100 ms
54 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=0.100 ms
54 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=0.103 ms
54 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=0.098 ms
54 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=0.099 ms
54 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=0.335 ms
54 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=0.130 ms
54 bytes from 10.0.0.2: icmp_seq=32 ttl=64 time=0.099 ms
54 bytes from 10.0.0.2: icmp_seq=40 ttl=64 time=0.099 ms
54 bytes from 10.0.0.2: icmp_seq=42 ttl=64 time=0.104 ms
54 bytes from 10.0.0.2: icmp_seq=43 ttl=64 time=0.090 ms

--- 10.0.0.2 ping statistics ---
50 packets transmitted, 20 received, 60% packet loss, time 50169ms
rtt min/avg/max/mdev = 0.090/0.141/0.539/0.105 ms
root@mininet-vm:/home/mininet# sudo tc qdisc del dev h1-eth0 root netem
root@mininet-vm:/home/mininet#
```

Рис. 5: Добавление значения корреляции для потери пакетов

# Выполнение лабораторной работы

```
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

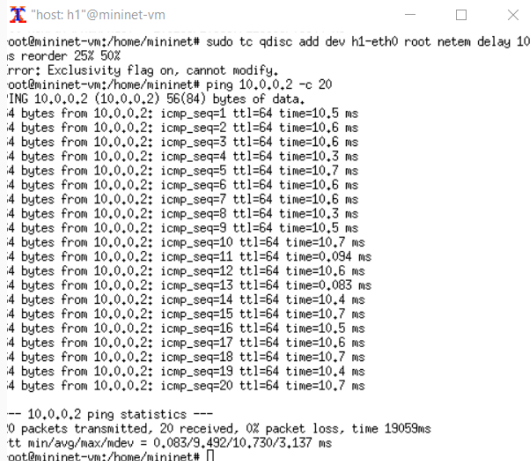
Accepted connection from 10.0.0.1, port 58764
[ 7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 58766
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-1.00 sec  1.33 GBytes  11.5 Gbits/sec
[ 7] 1.00-2.00 sec  1.53 GBytes  13.1 Gbits/sec
[ 7] 2.00-3.00 sec  1.60 GBytes  13.8 Gbits/sec
[ 7] 3.00-4.00 sec  1.35 GBytes  11.6 Gbits/sec
[ 7] 4.00-5.00 sec  1.44 GBytes  12.3 Gbits/sec
[ 7] 5.00-6.00 sec  1.55 GBytes  13.3 Gbits/sec
[ 7] 6.00-7.00 sec  1.39 GBytes  11.9 Gbits/sec
[ 7] 7.00-8.00 sec  1.57 GBytes  13.4 Gbits/sec
[ 7] 8.00-9.00 sec  1.43 GBytes  12.3 Gbits/sec
[ 7] 9.00-10.00 sec 1.63 GBytes  14.0 Gbits/sec
[ 7] 10.00-10.00 sec 320 KBytes   3.65 Gbits/sec
-----
[ ID] Interval      Transfer      Bitrate
[ 7] 0.00-10.00 sec 14.8 GBytes  12.7 Gbits/sec
-----
Server listening on 5201

host: h1" @mininet-vm
root@mininet-vm:/home/mininet# sudo tc qdisc del dev h1-eth0 root netem
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem corrupt
0.01%
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 58766 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Retr      Cwnd
[ 7] 0.00-1.00 sec  1.34 GBytes  11.5 Gbits/sec  3         506 KBytes
[ 7] 1.00-2.00 sec  1.53 GBytes  13.1 Gbits/sec  2         395 KBytes
[ 7] 2.00-3.00 sec  1.60 GBytes  13.8 Gbits/sec  2         402 KBytes
[ 7] 3.00-4.00 sec  1.35 GBytes  11.6 Gbits/sec  2         549 KBytes
[ 7] 4.00-5.00 sec  1.44 GBytes  12.4 Gbits/sec  4         1.43 MBytes
[ 7] 5.00-6.00 sec  1.55 GBytes  13.3 Gbits/sec  3         591 KBytes
[ 7] 6.00-7.00 sec  1.39 GBytes  11.9 Gbits/sec  2         871 KBytes
[ 7] 7.00-8.00 sec  1.56 GBytes  13.4 Gbits/sec  1         618 KBytes
[ 7] 8.00-9.00 sec  1.43 GBytes  12.3 Gbits/sec  4         535 KBytes
[ 7] 9.00-10.00 sec 1.63 GBytes  14.0 Gbits/sec  4         132 KBytes
-----
[ ID] Interval      Transfer      Bitrate      Retr      sender receiver
[ 7] 0.00-10.00 sec 14.8 GBytes  12.7 Gbits/sec  27
[ 7] 0.00-10.00 sec 14.8 GBytes  12.7 Gbits/sec

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

Рис. 6: Добавление повреждения пакетов

## Выполнение лабораторной работы



```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem delay 10
ms reorder 25% 50%
Error: Exclusivity flag on, cannot modify.
root@mininet-vm:/home/mininet# ping 10.0.0.2 -c 20
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
 4 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=10.5 ms
 4 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=10.6 ms
 4 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=10.6 ms
 4 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=10.3 ms
 4 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=10.7 ms
 4 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=10.6 ms
 4 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=10.6 ms
 4 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=10.3 ms
 4 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=10.5 ms
 4 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=10.7 ms
 4 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.094 ms
 4 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=10.6 ms
 4 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=0.083 ms
 4 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=10.4 ms
 4 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=10.7 ms
 4 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=10.5 ms
 4 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=10.6 ms
 4 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=10.7 ms
 4 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=10.4 ms
 4 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=10.7 ms

-- 10.0.0.2 ping statistics --
 0 packets transmitted, 20 received, 0% packet loss, time 19059ms
rtt min/avg/max/mdev = 0.083/9.492/10.730/3.137 ms
root@mininet-vm:/home/mininet#
```

Рис. 7: Добавление переупорядочивания пакетов

# Выполнение лабораторной работы

```
root@mininet-vm: /home/mininet# sudo tc qdisc add dev h1-eth0 root netem duplicat
e 50%
root@mininet-vm: /home/mininet# ping 10.0.0.2 -c 20
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.416 ms
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.437 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.076 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.098 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.099 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.121 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.114 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.115 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.109 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.110 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.096 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.105 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.106 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.104 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.105 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.106 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.106 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.107 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.106 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.107 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=0.106 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=0.108 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=0.097 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=0.105 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=0.106 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=0.107 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=0.109 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=0.099 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=0.099 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=0.098 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=0.097 ms

--- 10.0.0.2 ping statistics ---
20 packets transmitted, 20 received, +11 duplicates, 0% packet loss, time 19412ms
rtt min/avg/max/mdev = 0.076/0.124/0.437/0.079 ms
root@mininet-vm: /home/mininet#
```

Рис. 8: Добавление дублирования пакетов

```
GNU nano 4.8 lab netem ii.py Modified
Output: ping.dat
"""

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

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' )
    s1 = net.addSwitch( 's1' )

    info( '*** Creating links\n' )
    net.addLink( h1, s1 )
    net.addLink( h2, s1 )

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

    info( '*** Set delay\n' )
    h1.cmdPrint( 'tc qdisc add dev h1-eth0 root netem loss 10%' )
    h2.cmdPrint( 'tc qdisc add dev h2-eth0 root netem loss 10%' )

    time.sleep(10) # Wait 10 seconds

    info( '*** Ping\n' )
    h1.cmdPrint( 'ping -c 100', h2.IP(), '| grep "time=" | awk \'{print $5, $7}\'' | sed

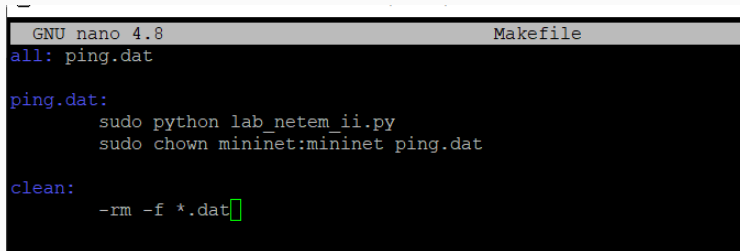
    info( '*** Stopping network' )
    net.stop()

if __name__ == '__main__':
    setLogLevel( 'info' )
    emptyNet()
```

Рис. 9: Создание скрипта для эксперимента lab\_netem\_ii.py

```
info( '*** Ping\n')  
h1.cmdPrint( 'ping -c 100', h2.IP(), '| grep "packet loss:" | awk \'{print $6, $7, $>
```

Рис. 10: Редактирование скрипта



```
GNU nano 4.8 Makefile
all: ping.dat

ping.dat:
    sudo python lab_netem_ii.py
    sudo chown mininet:mininet ping.dat

clean:
    rm -f *.dat
```

Рис. 11: Makefile

```
mininet@mininet-vm:~/work/lab_netem_ii/simple-drop$ make
sudo python lab_netem_ii.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
*** Starting network
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Waiting for switches to connect
s1
*** Set delay
*** h1 : ('tc qdisc add dev h1-eth0 root netem loss 10%,)
*** h2 : ('tc qdisc add dev h2-eth0 root netem loss 10%,)
*** Ping
*** h1 : ('ping -c 100', '10.0.0.2', '| grep "packet loss:" | awk \'{print $6, $7, $8}\'' > ping.dat')
*** Stopping network*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
sudo chown mininet:mininet ping.dat
mininet@mininet-vm:~/work/lab_netem_ii/simple-drop$ cat ping.dat
```

Рис. 12: Проведение эксперимента



В результате выполнения данной лабораторной работы я получила навыки проведения интерактивных экспериментов в среде Mininet по исследованию параметров сети, связанных с потерей, дублированием, изменением порядка и повреждением пакетов при передаче данных.

Спасибо за внимание!