Российский университет дружбы народов

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Отчёт по лабораторной работе №5

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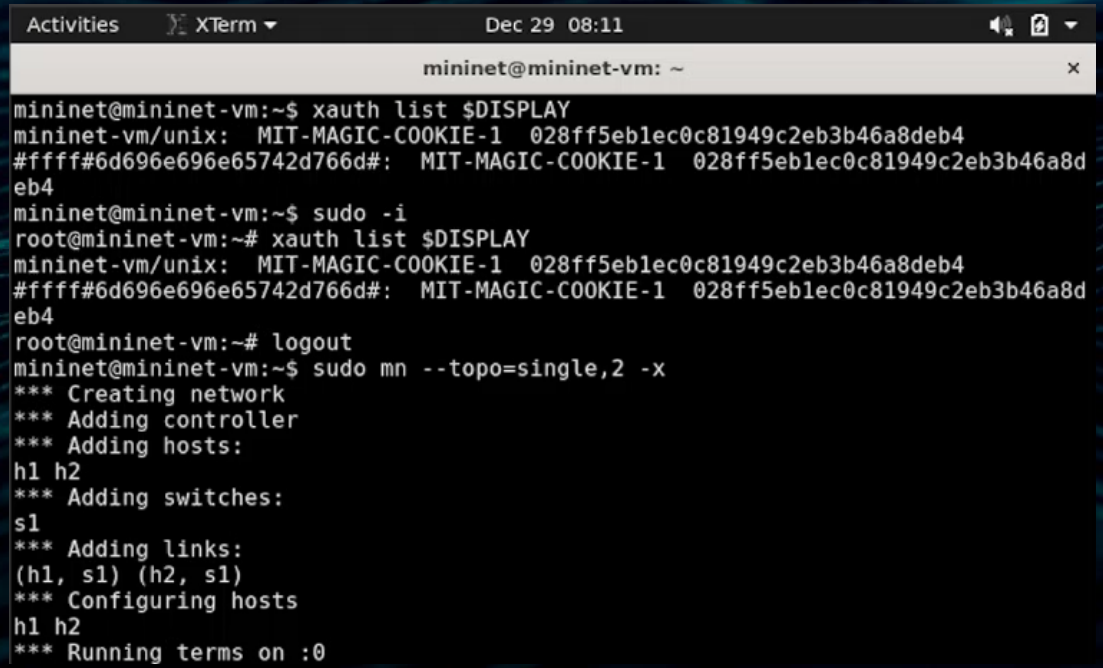
Цель работы (задание)

- 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.

Задачи (метод выполнения)

- Запуск лабораторной топологии




```
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=2.54 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.260 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.045 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.063 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.060 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.048 ms

--- 10.0.0.2 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5096ms
rtt min/avg/max/mdev = 0.045/0.502/2.538/0.913 ms
```

Задачи (метод выполнения)

- Добавление потери пакетов на интерфейс, подключённый к эмулируемой глобальной сети

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

```
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=0.305 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.055 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.056 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.050 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.051 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.053 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.054 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.122 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.102 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.092 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=0.053 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=0.119 ms
```

```
root@mininet-vm:/home/mininet# sudo tc qdisc del dev h1-eth0 root nete
m
```

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h2-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=2 ttl=64 time=1.03 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.916 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.166 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.049 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.125 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.077 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.052 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.050 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.054 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.053 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=0.124 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=0.050 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=0.050 ms
```

```
root@mininet-vm:/home/mininet# sudo tc qdisc del dev h2-eth0 root netem
root@mininet-vm:/home/mininet#
```

Задачи (метод выполнения)

- Добавление значения корреляции для потери пакетов в эмулируемой глобальной сети

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root nete
m 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.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.382 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.051 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.050 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.076 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.055 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.079 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.062 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.051 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.091 ms
```

```
root@mininet-vm:/home/mininet# sudo tc qdisc del dev h1-eth0 root nete
m
```

Задачи (метод выполнения)

- Добавление повреждения пакетов в эмулируемой глобальной сети

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root nete
m corrupt 0.01%
root@mininet-vm:/home/mininet#
```

```
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 53422 connected to 10.0.0.2 port 5201
[ ID] Interval           Transfer     Bitrate         Retr  Cwnd
[  7]   0.00-1.00   sec  1.36 GBytes  11.7 Gbits/sec    4    813 KBytes

[  7]   1.00-2.00   sec  1.49 GBytes  12.8 Gbits/sec    4   1.23 MBytes

[  7]   2.00-3.00   sec  1.41 GBytes  12.1 Gbits/sec    5    799 KBytes

[  7]   3.00-4.02   sec  1.45 GBytes  12.2 Gbits/sec    2   1.16 MBytes
```

```
Server listening on 5201
-----------------------------------------------------------
Accepted connection from 10.0.0.1, port 53420
[  7] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 53422
[ ID] Interval           Transfer     Bitrate
[  7]   0.00-1.00   sec  1.32 GBytes  11.4 Gbits/sec
[  7]   1.00-2.00   sec  1.50 GBytes  12.9 Gbits/sec
[  7]   2.00-3.00   sec  1.40 GBytes  12.0 Gbits/sec
[  7]   3.00-4.00   sec  1.47 GBytes  12.6 Gbits/sec
[  7]   4.00-5.00   sec  1.45 GBytes  12.5 Gbits/sec
[  7]   5.00-6.00   sec  1.43 GBytes  12.3 Gbits/sec
[  7]   6.00-7.00   sec  1.50 GBytes  12.9 Gbits/sec
[  7]   7.00-8.00   sec  1.43 GBytes  12.3 Gbits/sec
[  7]   8.00-9.00   sec  1.49 GBytes  12.8 Gbits/sec
[  7]   9.00-10.00  sec  1.40 GBytes  12.0 Gbits/sec
[  7]  10.00-10.01  sec  15.9 MBytes  10.4 Gbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bitrate
[  7]   0.00-10.01  sec  14.4 GBytes  12.4 Gbits/sec
ceiver
```

Задачи (метод выполнения)

- Добавление переупорядочивания пакетов в интерфейс подключения к эмулируемой глобальной сети

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root nete
m delay 10ms reorder 25% 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=13.6 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=11.1 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=10.9 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=10.2 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=10.3 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=10.4 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=10.8 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=10.9 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=10.8 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=10.2 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=10.2 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=10.8 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=10.3 ms

root@mininet-vm:/home/mininet# sudo tc qdisc del dev h1-eth0 root nete
m
```

Задачи (метод выполнения)

- Добавление дублирования пакетов в интерфейс подключения к эмулируемой глобальной сети

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root nete
m duplicate 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=1.52 ms
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.55 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.910 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.167 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.056 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.052 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.052 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.207 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.211 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.054 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.054 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.058 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.059 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.058 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.081 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.081 ms (DUP!)
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.104 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.105 ms (DUP!)
```

Задачи (метод выполнения)

- Добавление потери пакетов на интерфейс, подключённый к эмулируемой глобальной сети

```
#!/usr/bin/env python

"""
Simple experiment.
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' )
```

```
mininet@mininet-vm:~/work/lab_netem_ii/simple_drop$ sudo python analyze_ping.py
Total packets: 100
Lost packets: 4
Lost packet numbers: [19, 26, 44, 81]
```

Задачи (метод выполнения)

- Самостоятельная работа

```
def analyze(file_path='ping.dat', total_packets=100):
        with open(file_path, 'r') as f:
                lines = f.readlines()

        received_packets = set()
        duplicated_packets = set()
        packet_numbers = []

        for line in lines:
                packet_number = float(line.split()[0])

                if packet_number in received_packets:
                        duplicated_packets.add(packet_number)
                else:
                        received_packets.add(packet_number)

                packet_numbers.append(packet_number)

        duplicated_packet_count = len(duplicated_packets)
        received_packets = set(int(line.split()[0]) for line in lines)
        lost_packets = set(range(1, total_packets + 1)) - received_packets

        lost_packet_count = len(lost_packets)

        print(f'Total packets: {total_packets}')
        print(f'Lost packets: {lost_packet_count}')
        print(f'Lost packet numbers: {sorted(list(lost_packets))}')
        print(f'Duplicated packets: {duplicated_packet_count}')
        print(f'Duplicated packet numbers: {sorted(list(duplicated_packets))}')

if __name__ == '__main__':
        analyze()
```

```
mininet@mininet-vm:~/work/lab_netem_ii/simple_drop$ sudo python analyze_ping.py
Total packets: 100
Lost packets: 4
Lost packet numbers: [19, 26, 44, 81]
Duplicated packets: 51
Duplicated packet numbers: [2.0, 3.0, 4.0, 6.0, 9.0, 12.0, 13.0, 14.0, 17.0, 21
.0, 22.0, 23.0, 25.0, 30.0, 31.0, 32.0, 34.0, 35.0, 36.0, 39.0, 40.0, 42.0, 43.
0, 47.0, 53.0, 55.0, 57.0, 58.0, 59.0, 60.0, 61.0, 62.0, 63.0, 64.0, 66.0, 67.0
, 70.0, 72.0, 74.0, 77.0, 82.0, 84.0, 86.0, 87.0, 88.0, 90.0, 91.0, 95.0, 96.0,
 99.0, 100.0]
```

Результаты и их анализ

- получил навыки проведения интерактивных экспериментов в среде Mininet по исследованию параметров сети, связанных с потерей, дублированием, изменением порядка и повреждением пакетов при передаче данных.

Благодарю за внимание