

## Лабораторная работа № 6

### Настройка пропускной способности глобальной сети с помощью Token Bucket Filter

Старовойтов Е. С.

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#### Информация

##### Докладчик

- Старовойтов Егор Сергеевич
- студент кафедры ТВиК
- Российский университет дружбы народов
- [1032212281@pfur.ru](mailto:1032212281@pfur.ru)

#### Вводная часть

##### Цели и задачи

Основной целью работы является знакомство с принципами работы дисциплины очереди Token Bucket Filter, которая формирует входящий/исходящий трафик для ограничения пропускной способности, а также получение навыков моделирования и исследования поведения трафика посредством проведения интерактивного и воспроизводимого экспериментов в Mininet

1. Задайте топологию (рис. 6.3), состоящую из двух хостов и двух коммутаторов с назначенной по умолчанию mininet сетью 10.0.0.0/8.
2. Проведите интерактивные эксперименты по ограничению пропускной способности сети с помощью TBF в эмулируемой глобальной сети.

##### Результаты

Поставленные боевые задачи были выполнены, все цели достигнуты.

# Выполнение лабораторной работы

## 1. Запуск топологии, проверка соединения между хостами

```
mininet@mininet-vm:~$ sudo mn --topo=single,2 -x
** Creating network
** Adding controller
** Adding hosts:
1 h2
** Adding switches:
1
** Adding links:
h1, s1) (h2, s1)
** Configuring hosts
1 h2
** Running terms on localhost:10.0
** Starting controller
0
** Starting 1 switches
1 ...
** Starting CLI:
mininet>
mininet>

root@mininet-vm:/home/mininet# ifconfig
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 f6:a2:89:50:33:88 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 848 bytes 261596 (261.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 848 bytes 261596 (261.5 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
root@mininet-vm:/home/mininet#

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 d2:4c:f0:f8:3e:3d 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 785 bytes 249584 (249.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 785 bytes 249584 (249.5 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
root@mininet-vm:/home/mininet#
```

## 2. iperf без ограничений скорости передачи данных

```
root@mininet-virtual-machine:~# 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 f6:a2:89:50:33:88 txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame
me 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier
    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 848 bytes 261596 (261.5 KB)
    RX errors 0 dropped 0 overruns 0 frame
me 0
    TX packets 848 bytes 261596 (261.5 KB)
    TX errors 0 dropped 0 overruns 0 carrier
    collisions 0
root@mininet-virtual-machine:~# ping 10.0.0.2 -c 6
ping: c-6: Temporary failure in name resolution
root@mininet-virtual-machine:~# ping 10.0.0.2 -c 6
ping: socket: Address family not supported by protocol
root@mininet-virtual-machine:~# ping -c 6 10.0.0.2
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=0.659 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.099 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.034 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.022 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.023 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.027 ms
--- 10.0.0.2 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5105ms
rtt min/avg/max/mdev = 0.022/0.144/0.659/0.231 ms
root@mininet-virtual-machine:~#
```

```
root@mininet-virtual-machine:~# 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 d2:4c:f0:f8:3e:3d txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame
me 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier
    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 785 bytes 249584 (249.5 KB)
    RX errors 0 dropped 0 overruns 0 frame
me 0
    TX packets 785 bytes 249584 (249.5 KB)
    TX errors 0 dropped 0 overruns 0 carrier
    collisions 0
root@mininet-virtual-machine:~# ping -c 6 10.0.0.1
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=0.382 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.029 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.032 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.041 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.041 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.038 ms
--- 10.0.0.1 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5121ms
rtt min/avg/max/mdev = 0.029/0.093/0.382/0.128 ms
root@mininet-virtual-machine:~#
```

## 3. Ограничение скорости на конечных хостах

```
root@mininet-virtual-machine:~# sudo tc qdisc add dev h1-eth0 root netem loss 10%
root@mininet-virtual-machine:~# ping -c 6 10.0.0.2
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=0.239 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.164 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.039 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.036 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.033 ms
--- 10.0.0.2 ping statistics ---
6 packets transmitted, 5 received, 16.6667% packet loss, time 5105ms
rtt min/avg/max/mdev = 0.033/0.102/0.239/0.084 ms
root@mininet-virtual-machine:~#
```

#### 4. Ограничение на коммутаторах (test iperf3)

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem loss 50% 50%
root@mininet-vm:/home/mininet# ping -c 50 10.0.0.2
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=0.373 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.209 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.103 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.034 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.036 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.034 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.042 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=0.041 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=0.042 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=0.041 ms
64 bytes from 10.0.0.2: icmp_seq=22 ttl=64 time=0.035 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=0.024 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=0.044 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=0.022 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=0.040 ms
64 bytes from 10.0.0.2: icmp_seq=34 ttl=64 time=0.034 ms
64 bytes from 10.0.0.2: icmp_seq=35 ttl=64 time=0.045 ms
64 bytes from 10.0.0.2: icmp_seq=37 ttl=64 time=0.047 ms
64 bytes from 10.0.0.2: icmp_seq=38 ttl=64 time=0.041 ms
64 bytes from 10.0.0.2: icmp_seq=40 ttl=64 time=0.042 ms
64 bytes from 10.0.0.2: icmp_seq=41 ttl=64 time=0.045 ms
64 bytes from 10.0.0.2: icmp_seq=48 ttl=64 time=0.041 ms
64 bytes from 10.0.0.2: icmp_seq=49 ttl=64 time=0.280 ms
64 bytes from 10.0.0.2: icmp_seq=50 ttl=64 time=0.049 ms

--- 10.0.0.2 ping statistics ---
50 packets transmitted, 24 received, 52% packet loss, time 50158ms
rtt min/avg/max/mdev = 0.022/0.072/0.373/0.085 ms
root@mininet-vm:/home/mininet# sudo tc qdisc del dev h1-eth0 root netem
root@mininet-vm:/home/mininet#
```

## 5. Настройка ограничения на коммутаторе

```
Warning: this system does not seem to support IPv6 - trying IPv4
-----
Server listening on 5201
-----
Accepted connection from 10.0.0.1, port 51688
[ 5] local 10.0.0.2 port 5201 connected to 10.0.0.1 port 51690
[ ID] Interval      Transfer      Bitrate
[ 5] 0.00-1.00    sec  6.38 GBytes  54.8 Gbits/sec
[ 5] 1.00-2.00    sec  6.35 GBytes  54.5 Gbits/sec
[ 5] 2.00-3.00    sec  6.30 GBytes  54.2 Gbits/sec
[ 5] 3.00-4.00    sec  6.32 GBytes  54.3 Gbits/sec
[ 5] 4.00-5.00    sec  6.35 GBytes  54.5 Gbits/sec
[ 5] 5.00-6.00    sec  6.61 GBytes  56.8 Gbits/sec
[ 5] 6.00-7.00    sec  6.89 GBytes  59.2 Gbits/sec
[ 5] 7.00-8.00    sec  7.82 GBytes  67.1 Gbits/sec
[ 5] 8.00-9.00    sec  8.07 GBytes  69.3 Gbits/sec
[ 5] 9.00-10.00   sec  7.37 GBytes  63.3 Gbits/sec
[ 5] 10.00-10.00  sec   192 KBytes  447 Mbits/sec

[ ID] Interval      Transfer      Bitrate
[ 5] 0.00-10.00   sec  68.5 GBytes  58.8 Gbits/sec                                     receiver
-----
Server listening on 5201
-----
[
root@mininet-vn:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem corrupt 0.01%
root@mininet-vn:/home/mininet# iperf3 -c 10.0.0.2
iperf3 error - unable to connect to server: Connection refused
root@mininet-vn:/home/mininet# iperf3 -c 10.0.0.2
iperf3 error - unable to connect to server: Connection refused
root@mininet-vn:/home/mininet# sudo iperf3 -c 10.0.0.2
iperf3 error - unable to connect to server: Connection refused
root@mininet-vn:/home/mininet# iperf3 -c 10.0.0.2
Connecting to host 10.0.0.2, port 5201
[ 7] local 10.0.0.1 port 51690 connected to 10.0.0.2 port 5201
[ ID] Interval      Transfer      Bitrate      Retr  Cwnd
[ 7] 0.00-1.00    sec  6.40 GBytes  54.9 Gbits/sec  19  1.02 Mbytes
[ 7] 1.00-2.00    sec  6.35 GBytes  54.5 Gbits/sec  17  677 Kbytes
[ 7] 2.00-3.00    sec  6.30 GBytes  54.1 Gbits/sec  15  1.15 Mbytes
[ 7] 3.00-4.00    sec  6.32 GBytes  54.3 Gbits/sec  13  1.68 Mbytes
[ 7] 4.00-5.00    sec  6.34 GBytes  54.5 Gbits/sec  13  2.04 Mbytes
[ 7] 5.00-6.00    sec  6.61 GBytes  56.8 Gbits/sec  12  1.93 Mbytes
[ 7] 6.00-7.00    sec  6.90 GBytes  59.3 Gbits/sec  17  2.15 Mbytes
[ 7] 7.00-8.00    sec  7.82 GBytes  67.1 Gbits/sec  20  2.74 Mbytes
[ 7] 8.00-9.00    sec  8.07 GBytes  69.3 Gbits/sec  14  2.68 Mbytes
[ 7] 9.00-10.00   sec  7.36 GBytes  63.3 Gbits/sec  21  1.81 Mbytes

[ ID] Interval      Transfer      Bitrate      Retr
[ 7] 0.00-10.00   sec  68.5 GBytes  58.8 Gbits/sec  161
[ 7] 0.00-10.00   sec  68.5 GBytes  58.8 Gbits/sec                                     sender
                                                                    receiver

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

## 6. NETEM & TBF

```
root@mininet-vm:/home/mininet# sudo tc qdisc add dev h1-eth0 root netem delay 10ms reorder 25
50%
root@mininet-vm:/home/mininet#
root@mininet-vm:/home/mininet# ping -c 20 10.0.0.2
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=10.3 ms

64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=10.1 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=10.3 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=10.6 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.041 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=0.041 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=10.5 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=10.7 ms

--- 10.0.0.2 ping statistics ---
20 packets transmitted, 20 received, 0% packet loss, time 19115ms
rtt min/avg/max/mdev = 0.041/9.446/10.669/3.136 ms
root@mininet-vm:/home/mininet#
root@mininet-vm:/home/mininet#
```

## Выводы

Я познакомился с принципами работы дисциплины очереди Token Bucket Filter, которая формирует входящий/исходящий трафик для ограничения пропускной способности, а также получил навыки моделирования и исследования поведения трафика посредством проведения интерактивного и воспроизводимого экспериментов в Mininet