

رامتین احسانی - ۹۷۵۲۱۰۱۸

تمرین پنجم - مهندسی اینترنت

(۱) ابتدا موارد گفته شده در لینک به اشتراک گذاشته شده در تمرین را نصب کردم:

- Vagrant
- VirtualBox
- Wireshark

بعد از نصب پیش نیاز ها و راه اندازی **vagrant**، سراغ بخش اول تمرین رفتیم.

برای بالا آوردن **vagrant**، از دستورات زیر در محیط ترمینال باید استفاده کرد:

- `vagrant up`
- `vagrant ssh`

برای توپولوژی اول باید دستور زیر را وارد کرد:

- `sudo mn --topo minimal`

پس از اجرای این دستور خروجی زیر بدست می آید:

```
vagrant@ubuntu-bionic:~$ sudo mn --topo minimal
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
```

اجرای دستور **net**:

```
mininet> net
h1 h1-eth0:s1-eth1
h2 h2-eth0:s1-eth2
s1 lo: s1-eth1:h1-eth0 s1-eth2:h2-eth0
c0
mininet> 
```

برای توپولوژی دوم دستور زیر مورد نیاز است:

- `sudo mn --topo linear,2,2`

پس از اجرای این دستور خروجی زیر بدست می آید:

```
vagrant@ubuntu-bionic:~$ sudo mn --topo linear,2,2
*** Creating network
*** Adding controller
*** Adding hosts:
h1s1 h1s2 h2s1 h2s2
*** Adding switches:
s1 s2
*** Adding links:
(h1s1, s1) (h1s2, s2) (h2s1, s1) (h2s2, s2) (s2, s1)
*** Configuring hosts
h1s1 h1s2 h2s1 h2s2
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ...
*** Starting CLI:
```

اجرای دستور `net`:

```
mininet> net
h1s1 h1s1-eth0:s1-eth1
h1s2 h1s2-eth0:s2-eth1
h2s1 h2s1-eth0:s1-eth2
h2s2 h2s2-eth0:s2-eth2
s1 lo: s1-eth1:h1s1-eth0 s1-eth2:h2s1-eth0 s1-eth3:s2-eth3
s2 lo: s2-eth1:h1s2-eth0 s2-eth2:h2s2-eth0 s2-eth3:s1-eth3
c0
mininet>
```

برای توپولوژی سوم دستور زیر مورد نیاز است:

- `sudo mn --topo tree,2,3`

پس از اجرای این دستور خروجی زیر بدست می آید:

```
vagrant@ubuntu-bionic:~$ sudo mn --topo tree,2,3
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Adding switches:
s1 s2 s3 s4
*** Adding links:
(s1, s2) (s1, s3) (s1, s4) (s2, h1) (s2, h2) (s2, h3) (s3, h4) (s3, h5) (s3, h6)
(s4, h7) (s4, h8) (s4, h9)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Starting controller
c0
*** Starting 4 switches
s1 s2 s3 s4 ...
*** Starting CLI:
mininet>
```

اجرای دستور net:

```
mininet> net
h1 h1-eth0:s2-eth1
h2 h2-eth0:s2-eth2
h3 h3-eth0:s2-eth3
h4 h4-eth0:s3-eth1
h5 h5-eth0:s3-eth2
h6 h6-eth0:s3-eth3
h7 h7-eth0:s4-eth1
h8 h8-eth0:s4-eth2
h9 h9-eth0:s4-eth3
s1 lo: s1-eth1:s2-eth4 s1-eth2:s3-eth4 s1-eth3:s4-eth4
s2 lo: s2-eth1:h1-eth0 s2-eth2:h2-eth0 s2-eth3:h3-eth0 s2-eth4:s1-eth1
s3 lo: s3-eth1:h4-eth0 s3-eth2:h5-eth0 s3-eth3:h6-eth0 s3-eth4:s1-eth2
s4 lo: s4-eth1:h7-eth0 s4-eth2:h8-eth0 s4-eth3:h9-eth0 s4-eth4:s1-eth3
c0
mininet>
```

۲) در قسمت اول، پهنای باند را برابر با مقدار ثابت 10Mb/s میگیرم و تاخیر را تغییر میدهم.  
تاخیر: 1ms

- sudo mn --topo minimal --link tc,bw=10,delay=1ms

iperf:

```
*** Starting CLI:
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['9.14 Mbits/sec', '11.5 Mbits/sec']
mininet>
```

Ping:

```
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3006ms
rtt min/avg/max/mdev = 7.243/9.705/16.074/3.683 ms
mininet>
```

تاخیر: 5ms

- sudo mn --topo minimal --link tc,bw=10,delay=5ms

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['9.26 Mbits/sec', '11.6 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3009ms
rtt min/avg/max/mdev = 21.444/26.282/35.994/5.727 ms
mininet> █
```

:10ms تاخير

- sudo mn --topo minimal --link tc,bw=10,delay=10ms

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['9.26 Mbits/sec', '11.8 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 43.855/46.693/52.905/3.624 ms
mininet>
```

:20ms تاخير

- sudo mn --topo minimal --link tc,bw=10,delay=20ms

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['9.21 Mbits/sec', '12.1 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3009ms
rtt min/avg/max/mdev = 82.326/90.522/108.715/10.585 ms
mininet>
```

:50ms تاخير

- sudo mn --topo minimal --link tc,bw=10,delay=50ms

.iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['8.47 Mbits/sec', '14.1 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 204.274/214.194/240.307/15.105 ms
mininet>
```

تاخير 100ms:

- sudo mn --topo minimal --link tc,bw=10,delay=100ms

.iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['7.98 Mbits/sec', '15.6 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3006ms
rtt min/avg/max/mdev = 405.819/422.129/467.093/26.012 ms
mininet>
```

تاخير 200ms:

- sudo mn --topo minimal --link tc,bw=10,delay=200ms

.iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['4.04 Mbits/sec', '6.10 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 807.928/815.750/837.997/12.849 ms
mininet>
```

تاخير 400ms:

- sudo mn --topo minimal --link tc,bw=10,delay=400ms

:iperf and ping

```
*** Starting CLI:
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['744 Kbits/sec', '973 Kbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3037ms
rtt min/avg/max/mdev = 1603.421/1610.121/1624.133/8.246 ms, pipe 2
mininet>
```

تاخیر 500ms:

- sudo mn --topo minimal --link tc,bw=10,delay=500ms

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['382 Kbits/sec', '522 Kbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3030ms
rtt min/avg/max/mdev = 2001.970/2007.969/2020.770/7.539 ms, pipe 2
mininet>
```

تاخیر 700ms:

- sudo mn --topo minimal --link tc,bw=10,delay=700ms

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['157 Kbits/sec', '252 Kbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3054ms
rtt min/avg/max/mdev = 2804.109/2810.807/2825.753/8.801 ms, pipe 3
mininet>
```

همانطور که مشخص است هر چقدر تاخیر بیشتر شود پهنای باند کاهش میابد و RTT افزایش میابد.

در قسمت دوم، تاخیر را مقدار ثابت 10 ms در نظر میگیرم و پهنای باند را تغییر میدهم.

پهنای باند 1Mb:

- `sudo mn --topo minimal --link tc,bw=1,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['947 Kbits/sec', '1.60 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 43.149/45.431/50.344/2.944 ms
mininet>
```

پهنای باند 5Mb:

- `sudo mn --topo minimal --link tc,bw=5,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['4.70 Mbits/sec', '6.00 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 43.870/47.197/55.692/4.929 ms
mininet>
```

پهنای باند 10Mb:

- `sudo mn --topo minimal --link tc,bw=10,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['9.25 Mbits/sec', '11.9 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 41.785/46.281/54.968/5.119 ms
mininet>
```

پهنای باند 20Mb:

- `sudo mn --topo minimal --link tc,bw=20,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['18.0 Mbits/sec', '22.3 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3003ms
rtt min/avg/max/mdev = 43.025/46.413/53.584/4.205 ms
mininet>
```

پهنای باند 50Mb:

- `sudo mn --topo minimal --link tc,bw=50,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['38.0 Mbits/sec', '48.7 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 43.601/46.125/50.556/2.645 ms
mininet>
```

پهنای باند 100Mb:

- `sudo mn --topo minimal --link tc,bw=100,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['65.2 Mbits/sec', '82.3 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 42.615/47.568/59.310/6.812 ms
mininet>
```



پهنای باند 200Mb:

- `sudo mn --topo minimal --link tc,bw=200,delay=10ms`

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['119 Mbits/sec', '136 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 44.240/47.271/53.897/3.893 ms
mininet>
```

پهنای باند 400Mb:

- `sudo mn --topo minimal --link tc,bw=400,delay=10ms`

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['189 Mbits/sec', '209 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 42.873/47.300/56.626/5.488 ms
mininet>
```

پهنای باند 500Mb:

- `sudo mn --topo minimal --link tc,bw=500,delay=10ms`

:iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['254 Mbits/sec', '270 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 43.448/47.018/53.531/3.862 ms
mininet>
```

پهنای باند 700Mb:

- `sudo mn --topo minimal --link tc,bw=700,delay=10ms`

iperf and ping

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['309 Mbits/sec', '328 Mbits/sec']
mininet> h1 ping -qc 4 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 44.215/49.838/62.201/7.308 ms
mininet> █
```

از آن جایی که تاخیر یکسان است RTT تغییر چندانی نمیکنند و تقریباً بین این مثال‌ها یکسان است.

با افزایش پهنای باند هم پهنای باند بین دو host افزایش میابد.