Shahin Mammadov
Computer Networks
Assignment #1

Problem 1.1

a)

```
shahin@shahin-GL503VM:~$ fping -C 10 -e -4 amazon.com www.amazon.com www.jacobs-university.de moodle.jacobs-university.
de
www.amazon.com              : [0], 84 bytes, 7.38 ms (7.38 avg, 0% loss)
moodle.jacobs-university.de : [0], 84 bytes, 0.48 ms (0.48 avg, 0% loss)
www.jacobs-university.de    : [0], 84 bytes, 26.1 ms (26.1 avg, 0% loss)
amazon.com                  : [0], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [1], 84 bytes, 7.47 ms (7.42 avg, 0% loss)
moodle.jacobs-university.de : [1], 84 bytes, 0.45 ms (0.46 avg, 0% loss)
www.jacobs-university.de    : [1], 84 bytes, 25.8 ms (25.9 avg, 0% loss)
amazon.com                  : [1], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [2], 84 bytes, 7.49 ms (7.44 avg, 0% loss)
moodle.jacobs-university.de : [2], 84 bytes, 0.49 ms (0.47 avg, 0% loss)
www.jacobs-university.de    : [2], 84 bytes, 25.7 ms (25.8 avg, 0% loss)
amazon.com                  : [2], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [3], 84 bytes, 7.32 ms (7.41 avg, 0% loss)
moodle.jacobs-university.de : [3], 84 bytes, 0.53 ms (0.48 avg, 0% loss)
www.jacobs-university.de    : [3], 84 bytes, 25.6 ms (25.8 avg, 0% loss)
amazon.com                  : [3], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [4], 84 bytes, 7.42 ms (7.41 avg, 0% loss)
moodle.jacobs-university.de : [4], 84 bytes, 0.51 ms (0.49 avg, 0% loss)
www.jacobs-university.de    : [4], 84 bytes, 25.7 ms (25.8 avg, 0% loss)
amazon.com                  : [4], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [5], 84 bytes, 7.36 ms (7.40 avg, 0% loss)
moodle.jacobs-university.de : [5], 84 bytes, 0.40 ms (0.47 avg, 0% loss)
www.jacobs-university.de    : [5], 84 bytes, 25.6 ms (25.7 avg, 0% loss)
amazon.com                  : [5], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [6], 84 bytes, 7.50 ms (7.42 avg, 0% loss)
moodle.jacobs-university.de : [6], 84 bytes, 0.40 ms (0.46 avg, 0% loss)
www.jacobs-university.de    : [6], 84 bytes, 25.7 ms (25.7 avg, 0% loss)
amazon.com                  : [6], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [7], 84 bytes, 7.58 ms (7.44 avg, 0% loss)
moodle.jacobs-university.de : [7], 84 bytes, 0.34 ms (0.45 avg, 0% loss)
www.jacobs-university.de    : [7], 84 bytes, 25.6 ms (25.7 avg, 0% loss)
amazon.com                  : [7], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [8], 84 bytes, 7.49 ms (7.44 avg, 0% loss)
moodle.jacobs-university.de : [8], 84 bytes, 0.42 ms (0.44 avg, 0% loss)
www.jacobs-university.de    : [8], 84 bytes, 25.7 ms (25.7 avg, 0% loss)
amazon.com                  : [8], 84 bytes, 113 ms (113 avg, 0% loss)
www.amazon.com              : [9], 84 bytes, 7.51 ms (7.45 avg, 0% loss)
moodle.jacobs-university.de : [9], 84 bytes, 0.71 ms (0.47 avg, 0% loss)
www.jacobs-university.de    : [9], 84 bytes, 25.8 ms (25.7 avg, 0% loss)
amazon.com                  : [9], 84 bytes, 113 ms (113 avg, 0% loss)

amazon.com                  : 113.71 113.37 113.38 113.23 113.20 113.17 113.32 113.15 113.39 113.19
www.amazon.com              : 7.38 7.47 7.49 7.32 7.42 7.36 7.50 7.58 7.49 7.51
www.jacobs-university.de    : 26.12 25.82 25.71 25.65 25.79 25.64 25.75 25.64 25.72 25.80
moodle.jacobs-university.de : 0.48 0.45 0.49 0.53 0.51 0.40 0.40 0.34 0.42 0.71
```

amazon.com	www.amazon.com	www.jacobs-university.de	moodle.jacobs-university.de
113.31 ms	7.45 ms	25.76 ms	0.43 ms

fping version 4.1. We see that moodle.jacobs-university.de is the fastest and amazon.com is the slowest. Even though www.amazon.com and amazon.com is owned by the same company, content delivery network makes www.amazon.com faster.

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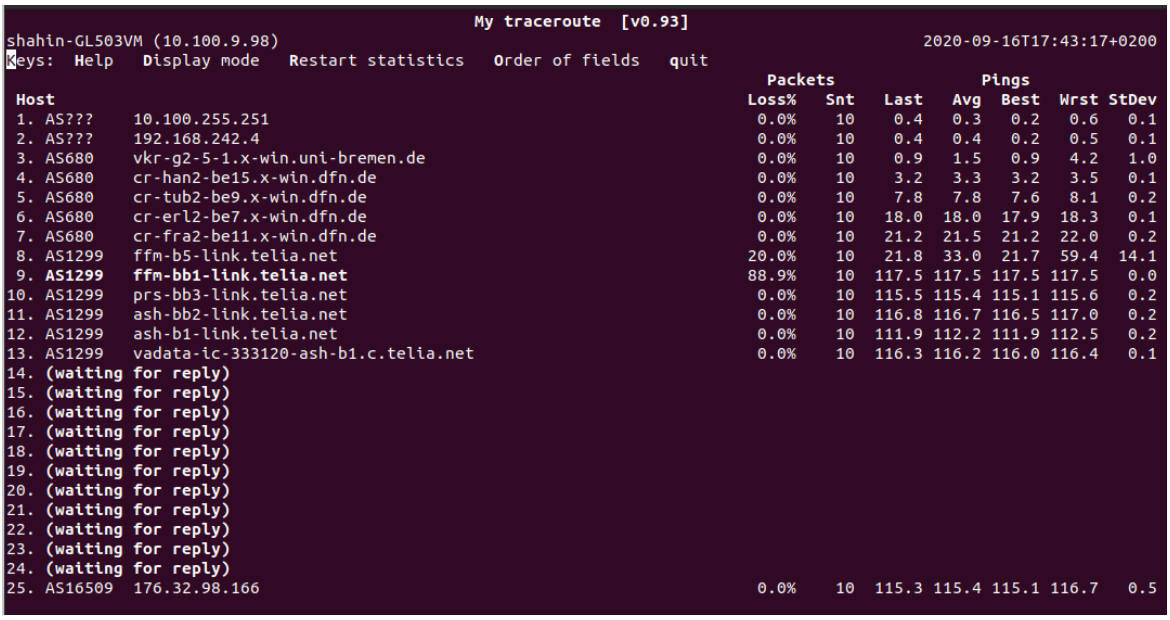
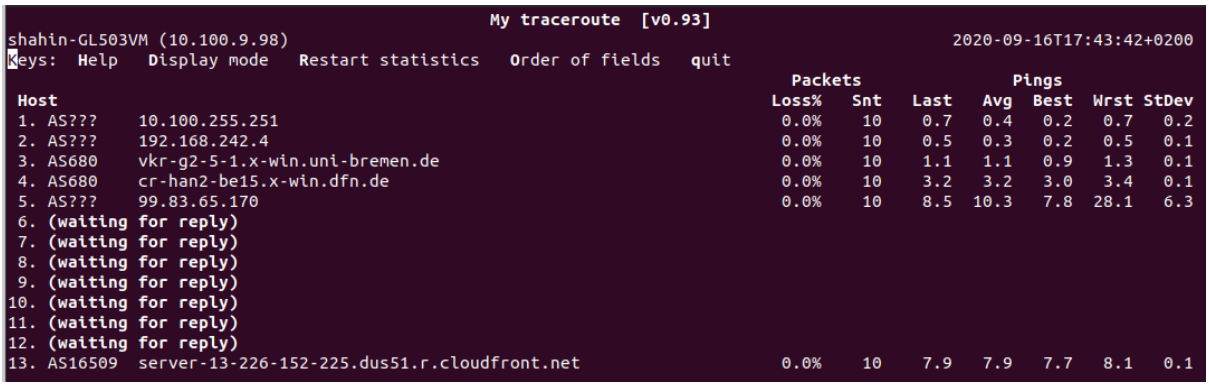
b) `mtr -z amazon.com report-cycles 10`



```
                                  My traceroute  [v0.93]
shahin-GL503VM (10.100.9.98)                                  2020-09-16T17:43:17+0200
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                  Packets               Pings
 Host                                          Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. AS???    10.100.255.251                     0.0%    10    0.4   0.3   0.2   0.6   0.1
 2. AS???    192.168.242.4                      0.0%    10    0.4   0.4   0.2   0.5   0.1
 3. AS680    vkr-g2-5-1.x-win.uni-bremen.de     0.0%    10    0.9   1.5   0.9   4.2   1.0
 4. AS680    cr-han2-be15.x-win.dfn.de          0.0%    10    3.2   3.3   3.2   3.5   0.1
 5. AS680    cr-tub2-be9.x-win.dfn.de           0.0%    10    7.8   7.8   7.6   8.1   0.2
 6. AS680    cr-erl2-be7.x-win.dfn.de           0.0%    10   18.0  18.0  17.9  18.3   0.1
 7. AS680    cr-fra2-be11.x-win.dfn.de          0.0%    10   21.2  21.5  21.2  22.0   0.2
 8. AS1299   ffm-b5-link.telia.net              20.0%    10   21.8  33.0  21.7  59.4  14.1
 9. AS1299   ffm-bb1-link.telia.net             88.9%    10  117.5 117.5 117.5 117.5   0.0
10. AS1299   prs-bb3-link.telia.net              0.0%    10  115.5 115.4 115.1 115.6   0.2
11. AS1299   ash-bb2-link.telia.net             0.0%    10  116.8 116.7 116.5 117.0   0.2
12. AS1299   ash-b1-link.telia.net              0.0%    10  111.9 112.2 111.9 112.5   0.2
13. AS1299   vadata-ic-333120-ash-b1.c.telia.net 0.0%    10  116.3 116.2 116.0 116.4   0.1
14. (waiting for reply)
15. (waiting for reply)
16. (waiting for reply)
17. (waiting for reply)
18. (waiting for reply)
19. (waiting for reply)
20. (waiting for reply)
21. (waiting for reply)
22. (waiting for reply)
23. (waiting for reply)
24. (waiting for reply)
25. AS16509  176.32.98.166                      0.0%    10  115.3 115.4 115.1 116.7   0.5
```

| AS-path | AS???-1 hop | AS680-2 hop | AS1299-5 hop | AS16509-0 hop |

`mtr -z www.amazon.com report-cycles 10`



```
                                  My traceroute  [v0.93]
shahin-GL503VM (10.100.9.98)                                  2020-09-16T17:43:42+0200
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                  Packets               Pings
 Host                                          Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. AS???    10.100.255.251                     0.0%    10    0.7   0.4   0.2   0.7   0.2
 2. AS???    192.168.242.4                      0.0%    10    0.5   0.3   0.2   0.5   0.1
 3. AS680    vkr-g2-5-1.x-win.uni-bremen.de     0.0%    10    1.1   1.1   0.9   1.3   0.1
 4. AS680    cr-han2-be15.x-win.dfn.de          0.0%    10    3.2   3.2   3.0   3.4   0.1
 5. AS???    99.83.65.170                       0.0%    10    8.5  10.3   7.8  28.1   6.3
 6. (waiting for reply)
 7. (waiting for reply)
 8. (waiting for reply)
 9. (waiting for reply)
10. (waiting for reply)
11. (waiting for reply)
12. (waiting for reply)
13. AS16509  server-13-226-152-225.dus51.r.cloudfront.net 0.0%  10    7.9   7.9   7.7   8.1   0.1
```

| AS-path | AS???-1 hop | AS680-1 hop | AS???-1 hop | AS16509-0 hop |

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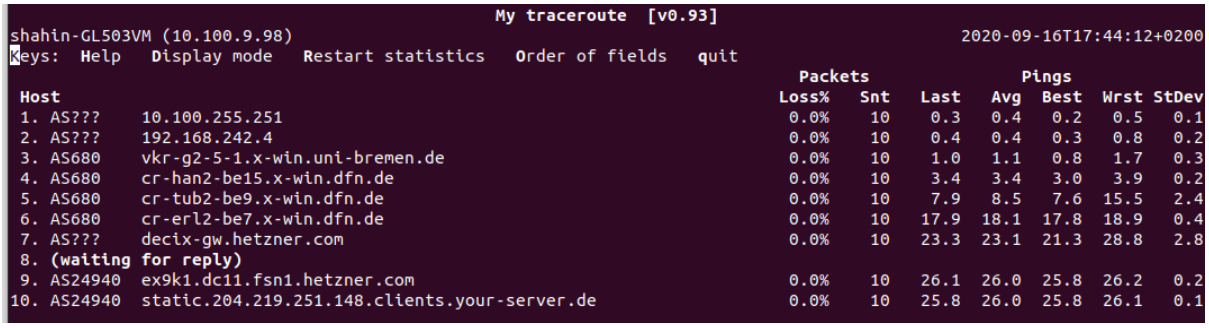
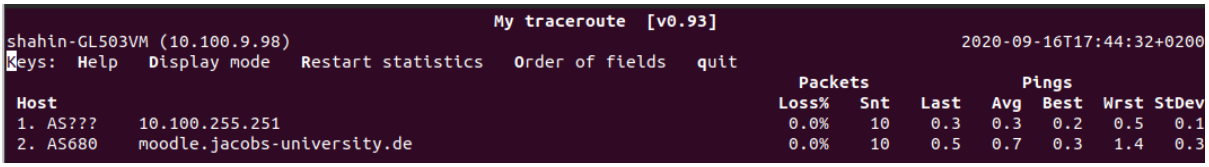
```
mtr -z www.jacobs-university.de report-cycles 10
```



```
                                    My traceroute  [v0.93]
shahin-GL503VM (10.100.9.98)                                    2020-09-16T17:44:12+0200
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                        Packets               Pings
 Host                                                 Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. AS???    10.100.255.251                            0.0%    10    0.3   0.4   0.2   0.5   0.1
 2. AS???    192.168.242.4                             0.0%    10    0.4   0.4   0.3   0.8   0.2
 3. AS680    vkr-g2-5-1.x-win.uni-bremen.de            0.0%    10    1.0   1.1   0.8   1.7   0.3
 4. AS680    cr-han2-be15.x-win.dfn.de                 0.0%    10    3.4   3.4   3.0   3.9   0.2
 5. AS680    cr-tub2-be9.x-win.dfn.de                  0.0%    10    7.9   8.5   7.6  15.5   2.4
 6. AS680    cr-erl2-be7.x-win.dfn.de                  0.0%    10   17.9  18.1  17.8  18.9   0.4
 7. AS???    decix-gw.hetzner.com                      0.0%    10   23.3  23.1  21.3  28.8   2.8
 8. (waiting for reply)
 9. AS24940  ex9k1.dc11.fsn1.hetzner.com               0.0%    10   26.1  26.0  25.8  26.2   0.2
10. AS24940  static.204.219.251.148.clients.your-server.de 0.0%  10   25.8  26.0  25.8  26.1   0.1
```

| AS-path | AS???-1 hop | AS680-3 hop | AS???-1 hop | AS24940-1 hop |

```
mtr -z moodle.jacobs-university.de report-cycles
```



```
                                    My traceroute  [v0.93]
shahin-GL503VM (10.100.9.98)                                    2020-09-16T17:44:32+0200
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                        Packets               Pings
 Host                                                 Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. AS???    10.100.255.251                            0.0%    10    0.3   0.3   0.2   0.5   0.1
 2. AS680    moodle.jacobs-university.de               0.0%    10    0.5   0.7   0.3   1.4   0.3
```

| AS-path | AS???-0 hop | AS680-0 hop|

We observe from our measurements that AS680 is in all the route packets tested meaning that all the outbound traffic path through AS680.

Moodle is hosted in the campus; hence it has the shortest route. www.jacobs-university.de is not hosted on the campus so it has longer route path.

First destination is 10.100.255.251.

Problem 1.2

a)

AS num	register
680	RIPE
16509	ARIN
1299	RIPE
24940	RIPE

b) 2001:638:709::/48 is not globally visible as exact match in BGP. It is announced by AS680 and netname is IUB-NET and description is “Campus Network of the International University Bremen”.

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Problem 1.3

a) After running the script, we first execute the command to start the server.

```
h2 iperf -s &
```

Then we run: `H1 iperf -c h2 -I 10 -t 60`

```
mininet> h2 iperf -s &
mininet> h1 iperf -c h2 -i 10 -t 60
------------------------------------------------------------
Client connecting to 10.0.0.2, TCP port 5001
TCP window size:  170 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.1 port 42196 connected with 10.0.0.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  12.0 MBytes  10.1 Mbits/sec
[  3] 10.0-20.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 20.0-30.0 sec  11.2 MBytes  9.44 Mbits/sec
[  3] 30.0-40.0 sec  11.6 MBytes  9.75 Mbits/sec
[  3] 40.0-50.0 sec  11.2 MBytes  9.44 Mbits/sec
[  3] 50.0-60.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3]  0.0-60.1 sec  68.9 MBytes  9.62 Mbits/sec
```

We see that bandwidth is averaging around 10Mbits/s and Transfer around 12Mbits/s. I expected the bandwidth to be higher and after looking at the code, inside the *class PointToPoint* we see that bw=10 meaning its limiting itself to 10Mbits/s.

```
h2 ping -c 10
```

b) First lets run.

```
--- 10.0.0.1 ping statistics ---
26 packets transmitted, 26 received, 0% packet loss, time 25599ms
rtt min/avg/max/mdev = 0.034/0.067/0.090/0.009 ms
mininet> h2 ping -c 10 h1
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=0.107 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.066 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.065 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.065 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.066 ms
64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=0.067 ms

--- 10.0.0.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9204ms
```

Current average without any background test is 0.070 ms. Now lets run measurement test in the background and test the ping.

The way I do this is by running the measurement in log file. The execution are visible in the screenshot attached below

```
h1 iperf -c h2 -I 10 -t 60
```

```
h2 ping -c 10 h1
```

```
mininet> h1 iperf -c 10.0.0.2 -i 10 -t 120 &> h1.log &
mininet> h2 ping -c 10 h1
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=15.6 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=18.0 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=10.7 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=15.7 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=16.7 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=18.2 ms
64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=18.4 ms
64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=17.3 ms
64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=16.9 ms
64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=15.2 ms

--- 10.0.0.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9012ms
rtt min/avg/max/mdev = 10.689/16.270/18.397/2.145 ms
```

As we see, the ping here is much higher. It is mainly due to queuing delay as it can't be the transmission delay because there are no data rate change and it's not propagation delay as we are on single machine. By running the test on the background we occupied the most of the bandwidth resulting in queue being built up to deliver the packets.

Problem 1.4

a) Lets first run ping between h3 and h4 without iperf in the background.

```
mininet> h4 ping -c 10 h3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=16.7 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.509 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.080 ms
64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.034 ms
64 bytes from 10.0.0.3: icmp_seq=5 ttl=64 time=0.051 ms
64 bytes from 10.0.0.3: icmp_seq=6 ttl=64 time=0.044 ms
64 bytes from 10.0.0.3: icmp_seq=7 ttl=64 time=0.097 ms
64 bytes from 10.0.0.3: icmp_seq=8 ttl=64 time=0.079 ms
64 bytes from 10.0.0.3: icmp_seq=9 ttl=64 time=0.107 ms
64 bytes from 10.0.0.3: icmp_seq=10 ttl=64 time=0.084 ms

--- 10.0.0.3 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9185ms
rtt min/avg/max/mdev = 0.034/1.774/16.664/4.964 ms
```

Now let's do with the measurement test in the background.

```
mininet> h1 iperf -c 10.0.0.2 -i 10 -t 120 &> h1.log &
mininet> h4 ping -c 10 h3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=9.35 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.471 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.070 ms
64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.076 ms
64 bytes from 10.0.0.3: icmp_seq=5 ttl=64 time=0.069 ms
64 bytes from 10.0.0.3: icmp_seq=6 ttl=64 time=0.092 ms
64 bytes from 10.0.0.3: icmp_seq=7 ttl=64 time=0.083 ms
64 bytes from 10.0.0.3: icmp_seq=8 ttl=64 time=0.024 ms
64 bytes from 10.0.0.3: icmp_seq=9 ttl=64 time=0.040 ms
64 bytes from 10.0.0.3: icmp_seq=10 ttl=64 time=0.049 ms

--- 10.0.0.3 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9176ms
rtt min/avg/max/mdev = 0.024/1.032/9.353/2.776 ms
```

As we can see in the bottom of each screenshots, there no big difference between the pings so it did not impact it.

b)

```
mininet> h2 iperf -s &>h2.log &
mininet> h1 iperf -c 10.0.0.2 -i 10 -t 120 &> h1.log &
mininet> h4 iperf -s &> h4.log &
mininet> h3 iperf -c 10.0.0.4 -i 10 -t 120 &> h3.log &
```

This is the execution commands to get the results. From h1 to h2:

```
 4 ------------------------------------------------------------
 5 [  3] local 10.0.0.1 port 42654 connected with 10.0.0.2 port 5001
 6 [ ID] Interval       Transfer     Bandwidth
 7 [  3]  0.0-10.0 sec  11.6 MBytes  9.75 Mbits/sec
 8 [  3] 10.0-20.0 sec  11.5 MBytes  9.65 Mbits/sec
 9 [  3] 20.0-30.0 sec  11.4 MBytes  9.54 Mbits/sec
10 [  3] 30.0-40.0 sec  11.4 MBytes  9.54 Mbits/sec
11 [  3] 40.0-50.0 sec  11.4 MBytes  9.54 Mbits/sec
12 [  3] 50.0-60.0 sec  11.5 MBytes  9.65 Mbits/sec
13 [  3] 60.0-70.0 sec  11.4 MBytes  9.54 Mbits/sec
14 [  3] 70.0-80.0 sec  11.4 MBytes  9.54 Mbits/sec
15 [  3] 80.0-90.0 sec  11.4 MBytes  9.54 Mbits/sec
16 [  3] 90.0-100.0 sec  11.4 MBytes  9.54 Mbits/sec
17 [  3] 100.0-110.0 sec  11.5 MBytes  9.65 Mbits/sec
18 [  3] 110.0-120.0 sec  11.4 MBytes  9.54 Mbits/sec
19 [  3]  0.0-120.1 sec   137 MBytes  9.58 Mbits/sec
```

From h3 to h4:

```
------------------------------------------------------------
[  3] local 10.0.0.3 port 40024 connected with 10.0.0.4 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  11.6 MBytes  9.75 Mbits/sec
[  3] 10.0-20.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 20.0-30.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 30.0-40.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 40.0-50.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 50.0-60.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 60.0-70.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 70.0-80.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 80.0-90.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 90.0-100.0 sec  11.2 MBytes  9.44 Mbits/sec
[  3] 100.0-110.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 110.0-120.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3]  0.0-120.0 sec   137 MBytes  9.58 Mbits/sec
```

Clearly there are no impact on each other.

Problem 1.5

a) From h1 to h4, from h3 to h2.

Data from h1 to h4:

```
------------------------------------------------------------
[  3] local 10.0.0.1 port 53678 connected with 10.0.0.4 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  11.8 MBytes  9.86 Mbits/sec
[  3] 10.0-20.0 sec  11.2 MBytes  9.44 Mbits/sec
[  3] 20.0-30.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 30.0-40.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 40.0-50.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 50.0-60.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3]  0.0-60.1 sec  68.6 MBytes  9.58 Mbits/sec
```

Data from h3 to h2:

```
[  3] local 10.0.0.3 port 39292 connected with 10.0.0.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 10.0-20.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 20.0-30.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 30.0-40.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 40.0-50.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 50.0-60.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3]  0.0-60.0 sec  68.5 MBytes  9.57 Mbits/sec
```

We can see the transfer and bandwidth rates are all similar.

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From h1 to h3, from h2 to h4:

Data from h1 to h3:

```
------------------------------------------------------------
Client connecting to 10.0.0.3, TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.1 port 36760 connected with 10.0.0.3 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  7.38 MBytes  6.19 Mbits/sec
[  3] 10.0-20.0 sec  5.88 MBytes  4.93 Mbits/sec
[  3] 20.0-30.0 sec  5.75 MBytes  4.82 Mbits/sec
[  3] 30.0-40.0 sec  5.88 MBytes  4.93 Mbits/sec
[  3] 40.0-50.0 sec  5.88 MBytes  4.93 Mbits/sec
[  3] 50.0-60.0 sec  5.75 MBytes  4.82 Mbits/sec
[  3]  0.0-60.1 sec  36.5 MBytes  5.09 Mbits/sec
```

Data from h2 to h4.

```
------------------------------------------------------------
Client connecting to 10.0.0.4, TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.2 port 51850 connected with 10.0.0.4 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  5.75 MBytes  4.82 Mbits/sec
[  3] 10.0-20.0 sec  5.62 MBytes  4.72 Mbits/sec
[  3] 20.0-30.0 sec  5.50 MBytes  4.61 Mbits/sec
[  3] 30.0-40.0 sec  5.62 MBytes  4.72 Mbits/sec
[  3] 40.0-50.0 sec  5.50 MBytes  4.61 Mbits/sec
[  3] 50.0-60.0 sec  7.38 MBytes  6.19 Mbits/sec
[  3]  0.0-60.1 sec  35.4 MBytes  4.94 Mbits/sec
```

We see that bandwidth and transfers are approximately halved because the two measurements consume the uplink from s1 to s2.

b) From h1 to h4:

```
------------------------------------------------------------
Client connecting to 10.0.0.4, TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.1 port 54042 connected with 10.0.0.4 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 10.0-20.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 20.0-30.0 sec  11.5 MBytes  9.65 Mbits/sec
[  3] 30.0-40.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 40.0-50.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3] 50.0-60.0 sec  11.4 MBytes  9.54 Mbits/sec
[  3]  0.0-60.0 sec  68.5 MBytes  9.57 Mbits/sec
```

From h3 to h6:

```
------------------------------------------------------------
Client connecting to 10.0.0.6, TCP port 5001
TCP window size:  110 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.3 port 42488 connected with 10.0.0.6 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  5.12 MBytes  4.30 Mbits/sec
[  3] 10.0-20.0 sec  4.25 MBytes  3.57 Mbits/sec
[  3] 20.0-30.0 sec  4.62 MBytes  3.88 Mbits/sec
[  3] 30.0-40.0 sec  5.12 MBytes  4.30 Mbits/sec
[  3] 40.0-50.0 sec  4.50 MBytes  3.77 Mbits/sec
[  3] 50.0-60.0 sec  8.12 MBytes  6.82 Mbits/sec
[  3]  0.0-60.0 sec  31.8 MBytes  4.44 Mbits/sec
```

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Explanation: Since h1 to h4 does not collide with h3 to h6, h1 to h4 reaches the 10Mbit/s. However for h3 to h6, bandwidth is getting limited by the link from h3 to s2 because of loss from s2 to s3.