Task1

What is the output of "nodes" and "net"?

```
mininet> nodes
available nodes are:
h1 h2 h3 h4 h5 h6 h7 h8 s1 s2 s3 s4 s5 s6 s7
```

```
mininet> net
h1 h1-eth0:s3-eth2
h2 h2-eth0:s3-eth3
h3 h3-eth0:s4-eth2
h4 h4-eth0:s4-eth3
h5 h5-eth0:s6-eth2
h6 h6-eth0:s6-eth3
h7 h7-eth0:s7-eth2
h8 h8-eth0:s7-eth3
s1 lo:  s1-eth1:s2-eth1 s1-eth2:s5-eth1
s2 lo:  s2-eth1:s1-eth1 s2-eth2:s3-eth1 s2-eth3:s4-eth1
s3 lo:  s3-eth1:s2-eth2 s3-eth2:h1-eth0 s3-eth3:h2-eth0
s4 lo:  s4-eth1:s2-eth3 s4-eth2:h3-eth0 s4-eth3:h4-eth0
s5 lo:  s5-eth1:s1-eth2 s5-eth2:s6-eth1 s5-eth3:s7-eth1
s6 lo:  s6-eth1:s5-eth2 s6-eth2:h5-eth0 s6-eth3:h6-eth0
s7 lo:  s7-eth1:s5-eth3 s7-eth2:h7-eth0 s7-eth3:h8-eth0
c0
```

What is the output of "h7 ifconfig"

```
mininet> h7 ifconfig
h7-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.0.7  netmask 255.0.0.0  broadcast 10.255.255.255
        inet6 fe80::6c08:14ff:fe17:59c3  prefixlen 64  scopeid 0x20<link>
        ether 6e:08:14:17:59:c3  txqueuelen 1000  (Ethernet)
        RX packets 61  bytes 4722 (4.7 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 10  bytes 796 (796.0 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
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        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
```

Task2

1. Draw the function call graph of this controller. For example, once a packet comes to the controller, which function is the first to be called, which one is the second, and so forth?
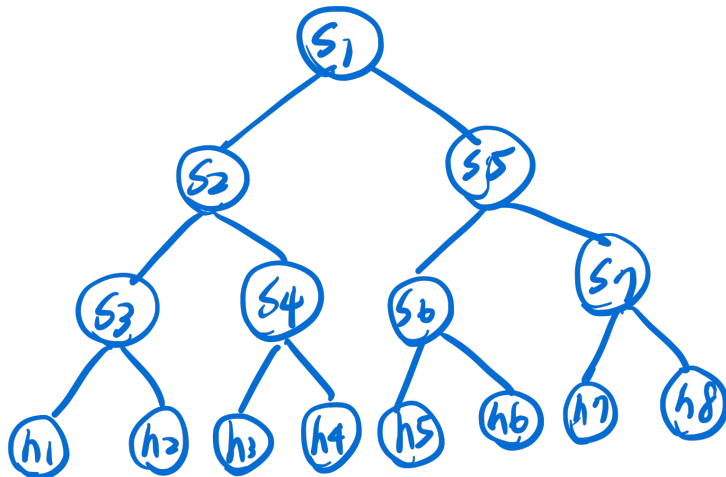
2. Have h1 ping h2, and h1 ping h8 for 100 times (e.g., h1 ping -c100 p2).

h1 ping -c100 h2

```
--- 10.0.0.2 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101084ms
rtt min/avg/max/mdev = 0.037/0.108/5.173/0.509 ms
```

h1 ping -c100 h8

```
--- 10.0.0.8 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101245ms
rtt min/avg/max/mdev = 0.063/0.208/13.141/1.300 ms
```

   a. How long does it take (on average) to ping for each case?
   For h1 ping h2, it takes 0.108ms for avg.
   For h1 ping h8, it takes 0.208ms for avg

   b. What is the minimum and maximum ping you have observed?
   For h1 ping h2, min is 0.037ms, max is 5.173ms.
   For h1 ping h8, min is 0.063ms, max is 13.141ms.

   c. What is the difference, and why?
   For h1, h8 is far than h2, so the running time data for h1 ping h8 is larger.

3. Run "iperf h1 h2" and "iperf h1 h8"

   a. What is "iperf" used for?

Testing TCP bandwidth between two nodes.

b. What is the throughput for each case?

```
mininet> iperf h1 h2
*** Iperf: testing TCP bandwidth between h1 and h2
.*** Results: ['13.7 Gbits/sec', '13.7 Gbits/sec']
```

```
mininet> iperf h1 h8
*** Iperf: testing TCP bandwidth between h1 and h8
*** Results: ['11.2 Gbits/sec', '11.2 Gbits/sec']
```

c. What is the difference, and explain the reasons for the difference.

The bandwidth between h1&h8 is larger than h1&h2.

4. Which of the switches observe traffic? Please describe your way for observing such traffic on switches (e.g., adding some functions in the "of_tutorial" controller).

Use pingall to make sure that ping is reachable.

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5 h6 h7 h8
h2 -> h1 h3 h4 h5 h6 h7 h8
h3 -> h1 h2 h4 h5 h6 h7 h8
h4 -> h1 h2 h3 h5 h6 h7 h8
h5 -> h1 h2 h3 h4 h6 h7 h8
h6 -> h1 h2 h3 h4 h5 h7 h8
h7 -> h1 h2 h3 h4 h5 h6 h8
h8 -> h1 h2 h3 h4 h5 h6 h7
*** Results: 0% dropped (56/56 received)
```

Task3

1. Describe how the above code works, such as how the "MAC to Port" map is established. You could use a 'ping' example to describe the establishment process (e.g., h1 ping h2).

2. (Comment out all prints before doing this experiment) Have h1 ping h2, and h1 ping h8 for 100 times (e.g., h1 ping -c100 p2).

h1 ping -c100 h2

```
--- 10.0.0.2 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101120ms
rtt min/avg/max/mdev = 0.046/0.058/0.249/0.021 ms
```

h1 ping -c100 h8

```
--- 10.0.0.8 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101198ms
rtt min/avg/max/mdev = 0.041/0.312/23.643/2.345 ms
```

a. How long did it take (on average) to ping for each case?

For h1 ping h2, it takes 0.058ms for avg.

For h1 ping h8, it takes 0.312ms for avg

b. What is the minimum and maximum ping you have observed?
    For h1 ping h2, min is 0.046ms, max is 0.249ms.
    For h1 ping h8, min is 0.041ms, max is 23.643ms.

c. Any difference from Task 2 and why do you think there is a change if there is?
        Yes, the data of avg and max of h1 ping h2 are all smaller than task2. But for h1 ping h8, they are almost twice. I think that's because h1 & h8 is under different switch but h1 and h2 are under the same switch.

3. Q.3 Run "iperf h1 h2" and "iperf h1 h8".
   a. What is the throughput for each case?

```
mininet> iperf h1 h2
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['13.7 Gbits/sec', '13.6 Gbits/sec']
```

```
mininet> iperf h1 h8
*** Iperf: testing TCP bandwidth between h1 and h8
*** Results: ['11.2 Gbits/sec', '11.2 Gbits/sec']
```

b. What is the difference from Task 2 and why do you think there is a change if there is?

The bandwidth of both h1&h2 and h1&h8 are quite same.

// code for running container : sudo docker exec -it 074691e3f66f /ENTRYPOINT.sh