

Part A

1) 1. Print the list of network interfaces, their MAC addresses and their assigned IP addresses, if any.

The different interfaces available in mininet VM are shown in the below picture including their IP and MAC address

```
mininet@mininet-vm:~$ ifconfig
eth0      Link encap:Ethernet  HWaddr 08:00:27:78:1e:6f
          inet addr:10.0.2.15  Bcast:10.0.2.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:655 errors:0 dropped:0 overruns:0 frame:0
          TX packets:497 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:189162 (189.1 KB)  TX bytes:52368 (52.3 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:340 errors:0 dropped:0 overruns:0 frame:0
          TX packets:340 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:17000 (17.0 KB)  TX bytes:17000 (17.0 KB)

mininet@mininet-vm:~$
```

IP address

MAC address

2. Calculate the latency between mininet vm and www.rutgers.edu for 10 packets. Repeat the result for stanford.edu and www.google.co.in and compare the difference in latency.

```

mininet@mininet-vm: ~
mininet@mininet-vm:~$ ping www.rutgers.edu -c 10
PING www.rutgers.edu (128.6.46.88) 56(84) bytes of data.
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=1 ttl=235 time=227 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=2 ttl=235 time=293 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=3 ttl=235 time=334 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=4 ttl=235 time=221 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=5 ttl=235 time=221 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=6 ttl=235 time=229 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=7 ttl=235 time=220 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=8 ttl=235 time=221 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=9 ttl=235 time=221 ms
64 bytes from www-new.rutgers.edu (128.6.46.88): icmp_seq=10 ttl=235 time=221 ms

--- www.rutgers.edu ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9016ms
rtt min/avg/max/mdev = 220.271/241.215/334.856/37.710 ms
mininet@mininet-vm:~$ ping www.stanford.edu -c 10
PING pantheon-systems.map.fastly.net (199.232.102.133) 56(84) bytes of data.
64 bytes from 199.232.102.133: icmp_seq=1 ttl=55 time=222 ms
64 bytes from 199.232.102.133: icmp_seq=2 ttl=55 time=52.2 ms
64 bytes from 199.232.102.133: icmp_seq=3 ttl=55 time=52.6 ms
64 bytes from 199.232.102.133: icmp_seq=4 ttl=55 time=52.8 ms
64 bytes from 199.232.102.133: icmp_seq=5 ttl=55 time=51.7 ms
64 bytes from 199.232.102.133: icmp_seq=6 ttl=55 time=51.3 ms
64 bytes from 199.232.102.133: icmp_seq=7 ttl=55 time=51.4 ms
64 bytes from 199.232.102.133: icmp_seq=8 ttl=55 time=52.4 ms
64 bytes from 199.232.102.133: icmp_seq=9 ttl=55 time=51.2 ms
64 bytes from 199.232.102.133: icmp_seq=10 ttl=55 time=51.8 ms

--- pantheon-systems.map.fastly.net ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9020ms
rtt min/avg/max/mdev = 51.206/69.059/222.758/51.235 ms
mininet@mininet-vm:~$ ping www.google.co.in -c 10
PING www.google.co.in (142.250.199.131) 56(84) bytes of data.
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=1 ttl=56 time=50.7 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=2 ttl=56 time=33.1 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=3 ttl=56 time=34.3 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=4 ttl=56 time=33.0 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=5 ttl=56 time=32.4 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=6 ttl=56 time=45.3 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=7 ttl=56 time=36.9 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=8 ttl=56 time=36.7 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=9 ttl=56 time=50.0 ms
64 bytes from bom07s36-in-f3.1e100.net (142.250.199.131): icmp_seq=10 ttl=56 time=33.5 ms

--- www.google.co.in ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9015ms
rtt min/avg/max/mdev = 32.426/38.630/50.712/6.870 ms
mininet@mininet-vm:~$

```

- The Avg latency of Rutgers.edu is 241.215ms and The avg latency of Stanford.edu is 69.059 ms and The Avg latency of google.co.in is 38.630ms ..
- The difference between google.co.in and Rutgers.edu is 202.585ms
- The difference between google.co.in and standford.edu is 30.429ms

Part 2:

1)

Create a simple two node network using "sudo mn" and do the following

- Print the MAC address of host h1. Print the MAC addresses of switch s1.
- Explain the different interfaces that s1 has.

```
"Node: h1"
root@1798:/home/jithendra# 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
    inet6 fe80::5ce1:35ff:fef0:a759 prefixlen 64 scopeid 0x20<link>
    ether 5e:e1:35:f0:a7:59 txqueuelen 1000 (Ethernet)
    RX packets 74 bytes 8183 (8.1 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 42 bytes 3540 (3.5 KB)
    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 32 bytes 2488 (2.4 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 32 bytes 2488 (2.4 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

root@1798:/home/jithendra#
```

Ip address of host h1

MAC Address of host h1

The different network interfaces in the switch

```
"Node: s1" (root)
root@1798:/home/jithendra# ifconfig
eno1: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    ether 38:22:e2:bb:7b:38 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
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 20314 bytes 6330591 (6.3 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 20314 bytes 6330591 (6.3 MB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

s1-eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet6 fe80::6c38:4ff:fe2e:21d3 prefixlen 64 scopeid 0x20<link>
    ether 6e:38:04:2e:21:d3 txqueuelen 1000 (Ethernet)
    RX packets 42 bytes 3540 (3.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 74 bytes 8183 (8.1 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

s1-eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet6 fe80::a0ce:38ff:fe8b:c4f0 prefixlen 64 scopeid 0x20<link>
    ether a2:ce:38:8b:c4:f0 txqueuelen 1000 (Ethernet)
    RX packets 42 bytes 3540 (3.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 74 bytes 8183 (8.1 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

wlo1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.241.197 netmask 255.255.255.0 broadcast 192.168.241.255
    inet6 2401:4900:4fb5:bded:5d5f:3521:6c9b:a2b3 prefixlen 64 scopeid 0x0
    <global>
    inet6 2401:4900:4fb5:bded:3cc2:c45e:c5f7:85ee prefixlen 64 scopeid 0x0
    <global>
    inet6 fe80::e40b:11f2:caa7:2cff prefixlen 64 scopeid 0x20<link>
    ether 90:78:41:bf:4a:73 txqueuelen 1000 (Ethernet)
    RX packets 1097897 bytes 945119339 (945.1 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 885694 bytes 295151711 (295.1 MB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

root@1798:/home/jithendra#
```

MAC address of switch

Details of connection switch and host 1

Details of connection switch
and host 2

b) Ping h1 from h2 and view the ARP entries stored at hosts h1 and h2. 3. Measure the TCP throughput from h1 to h2 using iperf

```
mininet> h1 ping -c 10 h2
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=0.540 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.082 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.078 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=0.121 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.123 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.080 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.078 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.077 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.106 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9225ms
rtt min/avg/max/mdev = 0.050/0.133/0.540/0.137 ms
mininet>
```

"Node: h1"	"Node: h2"
<pre>root@1798:/home/jithendra# iperf -s ----- Server listening on TCP port 5001 TCP window size: 85.3 KByte (default) ----- [12] local 10.0.0.1 port 5001 connected with 10.0.0.2 port 33994 [ID] Interval Transfer Bandwidth [12] 0.0- 5.0 sec 22.7 GBytes 39.0 Gbits/sec </pre>	<pre>root@1798:/home/jithendra# iperf -c 10.0.0.1 -t 5 ----- Client connecting to 10.0.0.1, TCP port 5001 TCP window size: 298 KByte (default) ----- [11] local 10.0.0.2 port 33994 connected with 10.0.0.1 port 5001 [ID] Interval Transfer Bandwidth [11] 0.0- 5.0 sec 22.7 GBytes 39.0 Gbits/sec root@1798:/home/jithendra#</pre>

Measure the TCP throughput from h1 to h2 using iperf