Com uso de linha de comando padrão do Mininet, crie a topologia considerando o endereço MAC padronizado, larguras de banda bw de 5Mbps e controlador do Mininet

```
mininet@mininet-vm:~$ sudo mn --topo=linear,6 --link tc,bw=5 --mac
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6
*** Adding switches:
s1 s2 s3 s4 s5 s6
*** Adding links:
(5.00Mbit) (5.00Mbit) (h1, s1) (5.00Mbit) (5.00Mbit) (h2, s2) (5.00Mbit) (5.00Mbit) (h3, s3) (5.00Mb
it) (5.00Mbit) (h4, s4) (5.00Mbit) (5.00Mbit) (h5, s5) (5.00Mbit) (5.00Mbit) (h6, s6) (5.00Mbit) (5.
00Mbit) (s2, s1) (5.00Mbit) (5.00Mbit) (s3, s2) (5.00Mbit) (5.00Mbit) (s4, s3) (5.00Mbit) (5.00Mbit)
 (s5, s4) (5.00Mbit) (5.00Mbit) (s6, s5)
*** Configuring hosts
h1 h2 h3 h4 h5 h6
*** Starting controller
c0
*** Starting 6 switches
s1 s2 s3 s4 s5 s6 ...(5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5
.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit) (5.00Mbit)
*** Starting CLI:
```

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

Inspecione informações das interfaces, endereços MAC, IP e portas através de linhas de comando

```
mininet> h1 ifconfig
h1-eth0   Link encap:Ethernet   HWaddr 00:00:00:00:00:01
          inet addr:10.0.0.1  Bcast:10.255.255.255  Mask:255.0.0.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

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:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

```
mininet> h2 ifconfig
h2-eth0    Link encap:Ethernet   HWaddr 00:00:00:00:00:02
           inet addr:10.0.0.2  Bcast:10.255.255.255  Mask:255.0.0.0
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)


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:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:0
           RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

Inspecione informações das interfaces, endereços MAC, IP e portas através de linhas de comando

```
mininet> h5 ifconfig
h5-eth0   Link encap:Ethernet   HWaddr 00:00:00:00:00:05
          inet addr:10.0.0.5   Bcast:10.255.255.255   Mask:255.0.0.0
          UP BROADCAST RUNNING MULTICAST   MTU:1500   Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)   TX bytes:0 (0.0 B)

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:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)   TX bytes:0 (0.0 B)
```

```
mininet> h1 ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: h1-eth0@if9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc htb state UP group default qlen 100
0
    link/ether 00:00:00:00:00:01 brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.1/8 brd 10.255.255.255 scope global h1-eth0
       valid_lft forever preferred_lft forever
mininet> h2 ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: h2-eth0@if10: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc htb state UP group default qlen 10
00
    link/ether 00:00:00:00:00:02 brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.2/8 brd 10.255.255.255 scope global h2-eth0
       valid_lft forever preferred_lft forever
mininet> h3 ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: h3-eth0@if11: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc htb state UP group default qlen 10
00
    link/ether 00:00:00:00:00:03 brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.3/8 brd 10.255.255.255 scope global h3-eth0
       valid_lft forever preferred_lft forever
```
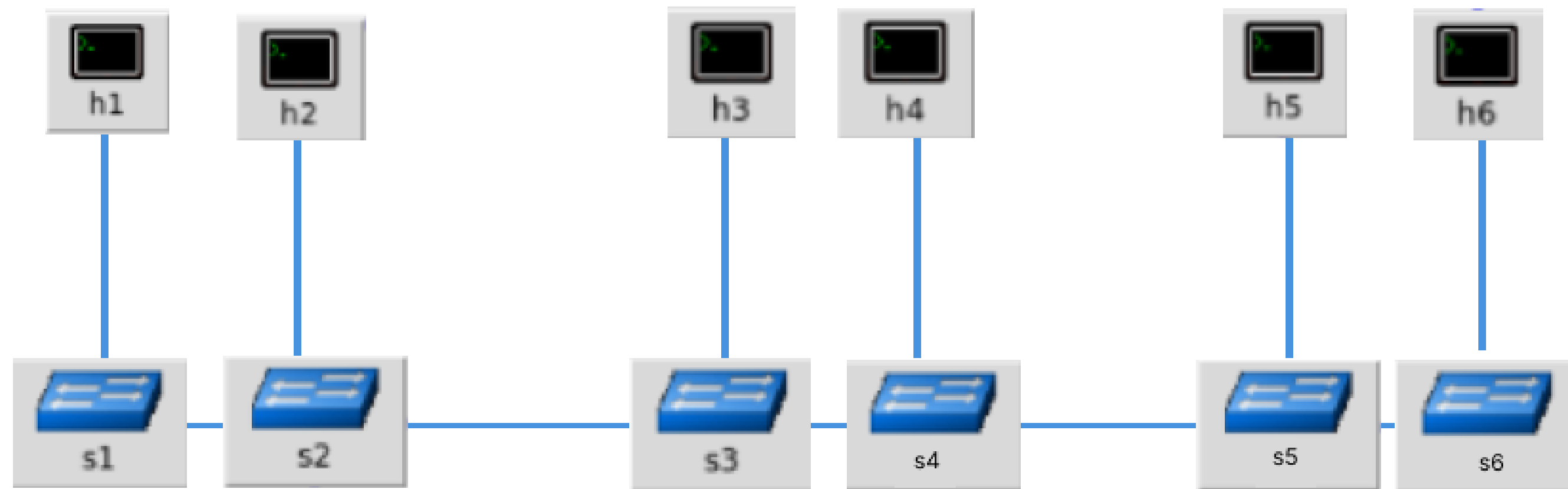
Execute testes de ping entre os diferentes nós, mostre os pacotes chegando nos nós com uso do comando tcpdump

```
mininet> h1 ping h4
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
64 bytes from 10.0.0.4: icmp_seq=1 ttl=64 time=0.219 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=0.047 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=0.056 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=0.058 ms
64 bytes from 10.0.0.4: icmp_seq=5 ttl=64 time=0.061 ms
64 bytes from 10.0.0.4: icmp_seq=6 ttl=64 time=0.064 ms
^C
--- 10.0.0.4 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 4996ms
rtt min/avg/max/mdev = 0.047/0.084/0.219/0.060 ms
mininet> h2 ping h5
PING 10.0.0.5 (10.0.0.5) 56(84) bytes of data.
64 bytes from 10.0.0.5: icmp_seq=1 ttl=64 time=7.63 ms
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.318 ms
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.060 ms
64 bytes from 10.0.0.5: icmp_seq=4 ttl=64 time=0.061 ms
64 bytes from 10.0.0.5: icmp_seq=5 ttl=64 time=0.325 ms
64 bytes from 10.0.0.5: icmp_seq=6 ttl=64 time=0.066 ms
^V64 bytes from 10.0.0.5: icmp_seq=7 ttl=64 time=0.329 ms
64 bytes from 10.0.0.5: icmp_seq=8 ttl=64 time=0.059 ms
^C64 bytes from 10.0.0.5: icmp_seq=9 ttl=64 time=0.061 ms
64 bytes from 10.0.0.5: icmp_seq=10 ttl=64 time=0.048 ms
^C
--- 10.0.0.5 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9000ms
rtt min/avg/max/mdev = 0.048/0.896/7.637/2.250 ms
mininet> h3 ping h6
PING 10.0.0.6 (10.0.0.6) 56(84) bytes of data.
64 bytes from 10.0.0.6: icmp_seq=1 ttl=64 time=7.22 ms
64 bytes from 10.0.0.6: icmp_seq=2 ttl=64 time=0.321 ms
64 bytes from 10.0.0.6: icmp_seq=3 ttl=64 time=0.059 ms
64 bytes from 10.0.0.6: icmp_seq=4 ttl=64 time=0.061 ms
64 bytes from 10.0.0.6: icmp_seq=5 ttl=64 time=0.063 ms
64 bytes from 10.0.0.6: icmp_seq=6 ttl=64 time=0.061 ms
^C
--- 10.0.0.6 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5000ms
rtt min/avg/max/mdev = 0.059/1.297/7.220/2.650 ms
```

Especifique que o host 1 na porta 5555 vai ser um servidor TCP e o host 2 um cliente e execute testes de iperf, considere um relatório por segundo com teste de 15segundos Faça os testes para larguras de banda bw de 2,10,15e 20Mbps.

```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i -t 15
WARNING: interval too small, increasing from 0.00 to 0.5 seconds.
iperf: ignoring extra argument -- 15
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 31] local 10.0.0.2 port 46994 connected with 10.0.0.1 port 5555
[ ID] Interval       Transfer     Bandwidth
[ 31]  0.0- 0.5 sec   640 KBytes  10.5 Mbits/sec
[ 31]  0.5- 1.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  1.0- 1.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  1.5- 2.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  2.0- 2.5 sec   384 KBytes  6.29 Mbits/sec
[ 31]  2.5- 3.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  3.0- 3.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  3.5- 4.0 sec   384 KBytes  6.29 Mbits/sec
[ 31]  4.0- 4.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  4.5- 5.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  5.0- 5.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  5.5- 6.0 sec   384 KBytes  6.29 Mbits/sec
[ 31]  6.0- 6.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  6.5- 7.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  7.0- 7.5 sec   384 KBytes  6.29 Mbits/sec
[ 31]  7.5- 8.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  8.0- 8.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  8.5- 9.0 sec   384 KBytes  6.29 Mbits/sec
[ 31]  9.0- 9.5 sec   256 KBytes  4.19 Mbits/sec
[ 31]  9.5-10.0 sec   256 KBytes  4.19 Mbits/sec
[ 31]  0.0-10.3 sec  6.12 MBytes  4.99 Mbits/sec
root@mininet-vm:~# []
```

X "Node: h1"

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
------------------------------------------------------------
Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 32] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 46994
[ ID] Interval       Transfer     Bandwidth
[ 32]  0.0- 1.0 sec   591 KBytes  4.84 Mbits/sec
[ 32]  1.0- 2.0 sec   578 KBytes  4.74 Mbits/sec
[ 32]  2.0- 3.0 sec   585 KBytes  4.80 Mbits/sec
[ 32]  3.0- 4.0 sec   583 KBytes  4.77 Mbits/sec
[ 32]  4.0- 5.0 sec   587 KBytes  4.81 Mbits/sec
[ 32]  5.0- 6.0 sec   583 KBytes  4.77 Mbits/sec
[ 32]  6.0- 7.0 sec   584 KBytes  4.78 Mbits/sec
[ 32]  7.0- 8.0 sec   584 KBytes  4.78 Mbits/sec
[ 32]  8.0- 9.0 sec   581 KBytes  4.76 Mbits/sec
[ 32]  9.0-10.0 sec   585 KBytes  4.80 Mbits/sec
[ 32]  0.0-10.7 sec  6.12 MBytes  4.78 Mbits/sec
```

Especifique que o host 1 na porta 5555 vai ser um servidor TCP e o host 2 um cliente e execute testes de iperf, considere um relatório por segundo com teste de 15segundos Faça os testes para larguras de banda bw de 2,10,15e 20Mbps.

"Node: h2"

```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i -t 15
WARNING: interval too small, increasing from 0.00 to 0.5 seconds.
iperf: ignoring extra argument -- 15
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 31] local 10.0.0.2 port 47018 connected with 10.0.0.1 port 5555
[ ID] Interval        Transfer     Bandwidth
[ 31]  0.0- 0.5 sec   384 KBytes   6.29 Mbits/sec
[ 31]  0.5- 1.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  1.0- 1.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  1.5- 2.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  2.0- 2.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  2.5- 3.0 sec   0.00 Bytes   0.00 bits/sec
[ 31]  3.0- 3.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  3.5- 4.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  4.0- 4.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  4.5- 5.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  5.0- 5.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  5.5- 6.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  6.0- 6.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  6.5- 7.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  7.0- 7.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  7.5- 8.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  8.0- 8.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  8.5- 9.0 sec   0.00 Bytes   0.00 bits/sec
[ 31]  9.0- 9.5 sec   128 KBytes   2.10 Mbits/sec
[ 31]  9.5-10.0 sec   128 KBytes   2.10 Mbits/sec
[ 31]  0.0-10.6 sec   2.62 MBytes  2.07 Mbits/sec
root@mininet-vm:~# []
```

"Node: h1"

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
------------------------------------------------------------
Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 32] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 47018
[ ID] Interval        Transfer     Bandwidth
[ 32]  0.0- 1.0 sec   236 KBytes   1.93 Mbits/sec
[ 32]  1.0- 2.0 sec   233 KBytes   1.91 Mbits/sec
[ 32]  2.0- 3.0 sec   235 KBytes   1.92 Mbits/sec
[ 32]  3.0- 4.0 sec   232 KBytes   1.90 Mbits/sec
[ 32]  4.0- 5.0 sec   233 KBytes   1.91 Mbits/sec
[ 32]  5.0- 6.0 sec   235 KBytes   1.92 Mbits/sec
[ 32]  6.0- 7.0 sec   232 KBytes   1.90 Mbits/sec
[ 32]  7.0- 8.0 sec   236 KBytes   1.93 Mbits/sec
[ 32]  8.0- 9.0 sec   232 KBytes   1.90 Mbits/sec
[ 32]  9.0-10.0 sec   235 KBytes   1.92 Mbits/sec
[ 32] 10.0-11.0 sec   233 KBytes   1.91 Mbits/sec
[ 32]  0.0-11.5 sec   2.62 MBytes  1.92 Mbits/sec
```

Especifique que o host 1 na porta 5555 vai ser um servidor TCP e o host 2 um cliente e execute testes de iperf, considere um relatório por segundo com teste de 15segundos Faça os testes para larguras de banda bw de 2,10,15e 20Mbps.

"Node: h1"

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
------------------------------------------------------------
Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 32] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 47054
[ ID] Interval       Transfer     Bandwidth
[ 32]  0.0- 1.0 sec  1.14 MBytes  9.59 Mbits/sec
[ 32]  1.0- 2.0 sec  1.14 MBytes  9.57 Mbits/sec
[ 32]  2.0- 3.0 sec  1.14 MBytes  9.58 Mbits/sec
[ 32]  3.0- 4.0 sec  1.14 MBytes  9.57 Mbits/sec
[ 32]  4.0- 5.0 sec  1.14 MBytes  9.52 Mbits/sec
[ 32]  5.0- 6.0 sec  1.14 MBytes  9.58 Mbits/sec
[ 32]  6.0- 7.0 sec  1.14 MBytes  9.57 Mbits/sec
[ 32]  7.0- 8.0 sec  1.14 MBytes  9.58 Mbits/sec
[ 32]  8.0- 9.0 sec  1.14 MBytes  9.57 Mbits/sec
[ 32]  9.0-10.0 sec  1.14 MBytes  9.57 Mbits/sec
[ 32]  0.0-10.3 sec  11.8 MBytes  9.57 Mbits/sec
```

"Node: h2"

```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i -t 15
WARNING: interval too small, increasing from 0.00 to 0.5 seconds.
iperf: ignoring extra argument -- 15
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 31] local 10.0.0.2 port 47054 connected with 10.0.0.1 port 5555
[ ID] Interval       Transfer     Bandwidth
[ 31]  0.0- 0.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  0.5- 1.0 sec   512 KBytes  8.39 Mbits/sec
[ 31]  1.0- 1.5 sec   640 KBytes  10.5 Mbits/sec
[ 31]  1.5- 2.0 sec   512 KBytes  8.39 Mbits/sec
[ 31]  2.0- 2.5 sec   640 KBytes  10.5 Mbits/sec
[ 31]  2.5- 3.0 sec   640 KBytes  10.5 Mbits/sec
[ 31]  3.0- 3.5 sec   512 KBytes  8.39 Mbits/sec
[ 31]  3.5- 4.0 sec   640 KBytes  10.5 Mbits/sec
[ 31]  4.0- 4.5 sec   512 KBytes  8.39 Mbits/sec
[ 31]  4.5- 5.0 sec   640 KBytes  10.5 Mbits/sec
[ 31]  5.0- 5.5 sec   640 KBytes  10.5 Mbits/sec
[ 31]  5.5- 6.0 sec   512 KBytes  8.39 Mbits/sec
[ 31]  6.0- 6.5 sec   640 KBytes  10.5 Mbits/sec
[ 31]  6.5- 7.0 sec   512 KBytes  8.39 Mbits/sec
[ 31]  7.0- 7.5 sec   512 KBytes  8.39 Mbits/sec
[ 31]  7.5- 8.0 sec   640 KBytes  10.5 Mbits/sec
[ 31]  8.0- 8.5 sec   512 KBytes  8.39 Mbits/sec
[ 31]  8.5- 9.0 sec   640 KBytes  10.5 Mbits/sec
[ 31]  9.0- 9.5 sec   512 KBytes  8.39 Mbits/sec
[ 31]  9.5-10.0 sec   640 KBytes  10.5 Mbits/sec
[ 31]  0.0-10.2 sec  11.8 MBytes  9.68 Mbits/sec
root@mininet-vm:~#
```

Especifique que o host 1 na porta 5555 vai ser um servidor TCP e o host 2 um cliente e execute testes de iperf, considere um relatório por segundo com teste de 15segundos Faça os testes para larguras de banda bw de 2,10,15e 20Mbps.

"Node: h1"

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
------------------------------------------------------------
Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 32] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 47082
[ ID] Interval       Transfer     Bandwidth
[ 32]  0.0- 1.0 sec  1.72 MBytes  14.4 Mbits/sec
[ 32]  1.0- 2.0 sec  1.71 MBytes  14.3 Mbits/sec
[ 32]  2.0- 3.0 sec  1.71 MBytes  14.3 Mbits/sec
[ 32]  3.0- 4.0 sec  1.72 MBytes  14.4 Mbits/sec
[ 32]  4.0- 5.0 sec  1.71 MBytes  14.3 Mbits/sec
[ 32]  5.0- 6.0 sec  1.71 MBytes  14.4 Mbits/sec
[ 32]  6.0- 7.0 sec  1.71 MBytes  14.4 Mbits/sec
[ 32]  7.0- 8.0 sec  1.71 MBytes  14.3 Mbits/sec
[ 32]  8.0- 9.0 sec  1.71 MBytes  14.3 Mbits/sec
[ 32]  9.0-10.0 sec  1.71 MBytes  14.4 Mbits/sec
[ 32]  0.0-10.2 sec  17.5 MBytes  14.4 Mbits/sec
```

"Node: h2"

```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i -t 15
WARNING: interval too small, increasing from 0.00 to 0.5 seconds.
iperf: ignoring extra argument -- 15
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 31] local 10.0.0.2 port 47082 connected with 10.0.0.1 port 5555
[ ID] Interval       Transfer     Bandwidth
[ 31]  0.0- 0.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  0.5- 1.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  1.0- 1.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  1.5- 2.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  2.0- 2.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  2.5- 3.0 sec   768 KBytes  12.6 Mbits/sec
[ 31]  3.0- 3.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  3.5- 4.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  4.0- 4.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  4.5- 5.0 sec   768 KBytes  12.6 Mbits/sec
[ 31]  5.0- 5.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  5.5- 6.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  6.0- 6.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  6.5- 7.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  7.0- 7.5 sec   768 KBytes  12.6 Mbits/sec
[ 31]  7.5- 8.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  8.0- 8.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  8.5- 9.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  9.0- 9.5 sec   896 KBytes  14.7 Mbits/sec
[ 31]  9.5-10.0 sec   896 KBytes  14.7 Mbits/sec
[ 31]  0.0-10.1 sec  17.5 MBytes  14.5 Mbits/sec
root@mininet-vm:~# []
```

Especifique que o host 1 na porta 5555 vai ser um servidor TCP e o host 2 um cliente e execute testes de iperf, considere um relatório por segundo com teste de 15segundos Faça os testes para larguras de banda bw de 2,10,15e 20Mbps.

"Node: h1"   — □ ✕

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
------------------------------------------------------------
Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 32] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 47106
[ ID] Interval       Transfer     Bandwidth
[ 32]  0.0- 1.0 sec  2.29 MBytes  19.2 Mbits/sec
[ 32]  1.0- 2.0 sec  2.28 MBytes  19.1 Mbits/sec
[ 32]  2.0- 3.0 sec  2.28 MBytes  19.1 Mbits/sec
[ 32]  3.0- 4.0 sec  2.28 MBytes  19.1 Mbits/sec
[ 32]  4.0- 5.0 sec  2.28 MBytes  19.1 Mbits/sec
[ 32]  5.0- 6.0 sec  2.28 MBytes  19.1 Mbits/sec
[ 32]  6.0- 7.0 sec  2.28 MBytes  19.1 Mbits/sec
[ 32]  7.0- 8.0 sec  2.30 MBytes  19.3 Mbits/sec
[ 32]  8.0- 9.0 sec  2.26 MBytes  19.0 Mbits/sec
[ 32]  9.0-10.0 sec  2.29 MBytes  19.2 Mbits/sec
[ 32]  0.0-10.5 sec  23.9 MBytes  19.1 Mbits/sec
```

"Node: h2"

```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i -t 15
WARNING: interval too small, increasing from 0.00 to 0.5 seconds.
iperf: ignoring extra argument -- 15
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 31] local 10.0.0.2 port 47106 connected with 10.0.0.1 port 5555
[ ID] Interval       Transfer     Bandwidth
[ 31]  0.0- 0.5 sec  2.38 MBytes  39.8 Mbits/sec
[ 31]  0.5- 1.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  1.0- 1.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  1.5- 2.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  2.0- 2.5 sec  1.00 MBytes  16.8 Mbits/sec
[ 31]  2.5- 3.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  3.0- 3.5 sec  1.25 MBytes  21.0 Mbits/sec
[ 31]  3.5- 4.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  4.0- 4.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  4.5- 5.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  5.0- 5.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  5.5- 6.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  6.0- 6.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  6.5- 7.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  7.0- 7.5 sec  1.00 MBytes  16.8 Mbits/sec
[ 31]  7.5- 8.0 sec  1.25 MBytes  21.0 Mbits/sec
[ 31]  8.0- 8.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  8.5- 9.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  9.0- 9.5 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  9.5-10.0 sec  1.12 MBytes  18.9 Mbits/sec
[ 31]  0.0-10.0 sec  23.9 MBytes  19.9 Mbits/sec
root@mininet-vm:~# []
```

Com uso de linha de comando padrão do Mininet, crie a topologia customizada considerando o endereço MAC padronizado e controlador manual

```
mininet@mininet-vm:~/C115/TrabalhoFinal$ sudo mn --custom topology.py --topo top
ology --controller=none --mac
Tolopogy created
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Adding switches:
s1 s2 s3 s4
*** Adding links:
(h1, s1) (h2, s1) (h3, s2) (h4, s2) (h5, s3) (h6, s3) (h7, s4) (h8, s4) (h9, s4)
 (s1, s2) (s2, s3) (s3, s4)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Starting controller

*** Starting 4 switches
s1 s2 s3 s4 ...
*** Starting CLI:
```

Inspecione informações das interfaces, endereços MAC, IP e portas através de linhas de comando

```
mininet> h1 ifconfig -a
h1-eth0    Link encap:Ethernet   HWaddr 00:00:00:00:00:01
           inet addr:10.0.0.1  Bcast:10.255.255.255  Mask:255.0.0.0
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)


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:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1
           RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

Inspecione informações das interfaces, endereços MAC, IP e portas através de linhas de comando

```
mininet> h2 ifconfig -a
h2-eth0    Link encap:Ethernet   HWaddr 00:00:00:00:00:02
           inet addr:10.0.0.2   Bcast:10.255.255.255   Mask:255.0.0.0
           UP BROADCAST RUNNING MULTICAST   MTU:1500   Metric:1
           RX packets:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:0 (0.0 B)   TX bytes:0 (0.0 B)

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:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1
           RX bytes:0 (0.0 B)   TX bytes:0 (0.0 B)
```

```
s3          Link encap:Ethernet  HWaddr ee:18:a6:c0:ff:45
            BROADCAST MULTICAST  MTU:1500  Metric:1
            RX packets:0 errors:0 dropped:36 overruns:0 frame:0
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

s4          Link encap:Ethernet  HWaddr 32:02:0f:17:34:43
            BROADCAST MULTICAST  MTU:1500  Metric:1
            RX packets:0 errors:0 dropped:36 overruns:0 frame:0
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

s1-eth1     Link encap:Ethernet  HWaddr e2:63:13:66:05:34
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:32 errors:0 dropped:0 overruns:0 frame:0
            TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)

s1-eth2     Link encap:Ethernet  HWaddr fa:7b:f5:6e:3f:31
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:32 errors:0 dropped:0 overruns:0 frame:0
            TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)

s1-eth3     Link encap:Ethernet  HWaddr 76:bc:f8:4d:17:b6
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:77 errors:0 dropped:0 overruns:0 frame:0
            TX packets:57 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:4802 (4.8 KB)  TX bytes:3962 (3.9 KB)

s2-eth1     Link encap:Ethernet  HWaddr 96:cd:1e:ca:a3:91
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:32 errors:0 dropped:0 overruns:0 frame:0
            TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)

s2-eth2     Link encap:Ethernet  HWaddr de:7b:9c:c7:ae:32
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:32 errors:0 dropped:0 overruns:0 frame:0
            TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)
```

Com uso de linha de comando padrão do Mininet, crie a topologia customizada considerando o endereço MAC padronizado e controlador manual

```
s3-eth3    Link encap:Ethernet    HWaddr ca:27:28:45:73:fb
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:86 errors:0 dropped:0 overruns:0 frame:0
           TX packets:90 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:5852 (5.8 KB)  TX bytes:6020 (6.0 KB)

s3-eth4    Link encap:Ethernet    HWaddr 2a:3d:d8:7d:53:d8
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:75 errors:0 dropped:0 overruns:0 frame:0
           TX packets:87 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:5166 (5.1 KB)  TX bytes:5670 (5.6 KB)

s4-eth1    Link encap:Ethernet    HWaddr 66:f5:6d:a0:13:fb
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:32 errors:0 dropped:0 overruns:0 frame:0
           TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)

s4-eth2    Link encap:Ethernet    HWaddr d6:11:90:0d:2f:92
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:32 errors:0 dropped:0 overruns:0 frame:0
           TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)

s4-eth3    Link encap:Ethernet    HWaddr d2:4b:eb:81:d0:fd
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:32 errors:0 dropped:0 overruns:0 frame:0
           TX packets:60 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:2240 (2.2 KB)  TX bytes:3416 (3.4 KB)

s4-eth4    Link encap:Ethernet    HWaddr 76:f7:42:36:ee:3e
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:87 errors:0 dropped:0 overruns:0 frame:0
           TX packets:75 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:5670 (5.6 KB)  TX bytes:5166 (5.1 KB)
```

Com uso de linha de comando padrão do Mininet, crie a topologia customizada considerando o endereço MAC padronizado e controlador manual

```
mininet> s1 ifconfig -a
eth0        Link encap:Ethernet   HWaddr 08:00:27:08:8c:ca
            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:14361 errors:0 dropped:0 overruns:0 frame:0
            TX packets:6032 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:20607956 (20.6 MB)  TX bytes:414037 (414.0 KB)

eth1        Link encap:Ethernet   HWaddr 08:00:27:94:d2:41
            inet addr:192.168.56.102  Bcast:192.168.56.255  Mask:255.255.255.0
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:4657 errors:0 dropped:0 overruns:0 frame:0
            TX packets:3573 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:762590 (762.5 KB)  TX bytes:523272 (523.2 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:46398 errors:0 dropped:0 overruns:0 frame:0
            TX packets:46398 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1
            RX bytes:2699424 (2.6 MB)  TX bytes:2699424 (2.6 MB)

ovs-system Link encap:Ethernet   HWaddr de:66:6a:70:a3:5e
            BROADCAST MULTICAST  MTU:1500  Metric:1
            RX packets:0 errors:0 dropped:0 overruns:0 frame:0
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

s1          Link encap:Ethernet   HWaddr 06:6a:c2:e3:a0:43
            BROADCAST MULTICAST  MTU:1500  Metric:1
            RX packets:0 errors:0 dropped:36 overruns:0 frame:0
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

s2          Link encap:Ethernet   HWaddr 0a:1c:58:d6:a2:48
            BROADCAST MULTICAST  MTU:1500  Metric:1
            RX packets:0 errors:0 dropped:36 overruns:0 frame:0
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

Com uso de linha de comando padrão do Mininet, crie a topologia customizada considerando o endereço MAC padronizado e controlador manual

Faça testes de ping considerando os switchesnormais

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5 h6 h7 h8 h9
h2 -> h1 h3 h4 h5 h6 h7 h8 h9
h3 -> h1 h2 h4 h5 h6 h7 h8 h9
h4 -> h1 h2 h3 h5 h6 h7 h8 h9
h5 -> h1 h2 h3 h4 h6 h7 h8 h9
h6 -> h1 h2 h3 h4 h5 h7 h8 h9
h7 -> h1 h2 h3 h4 h5 h6 h8 h9
h8 -> h1 h2 h3 h4 h5 h6 h7 h9
h9 -> h1 h2 h3 h4 h5 h6 h7 h8
*** Results: 0% dropped (72/72 received)
```

Desenho Topologia
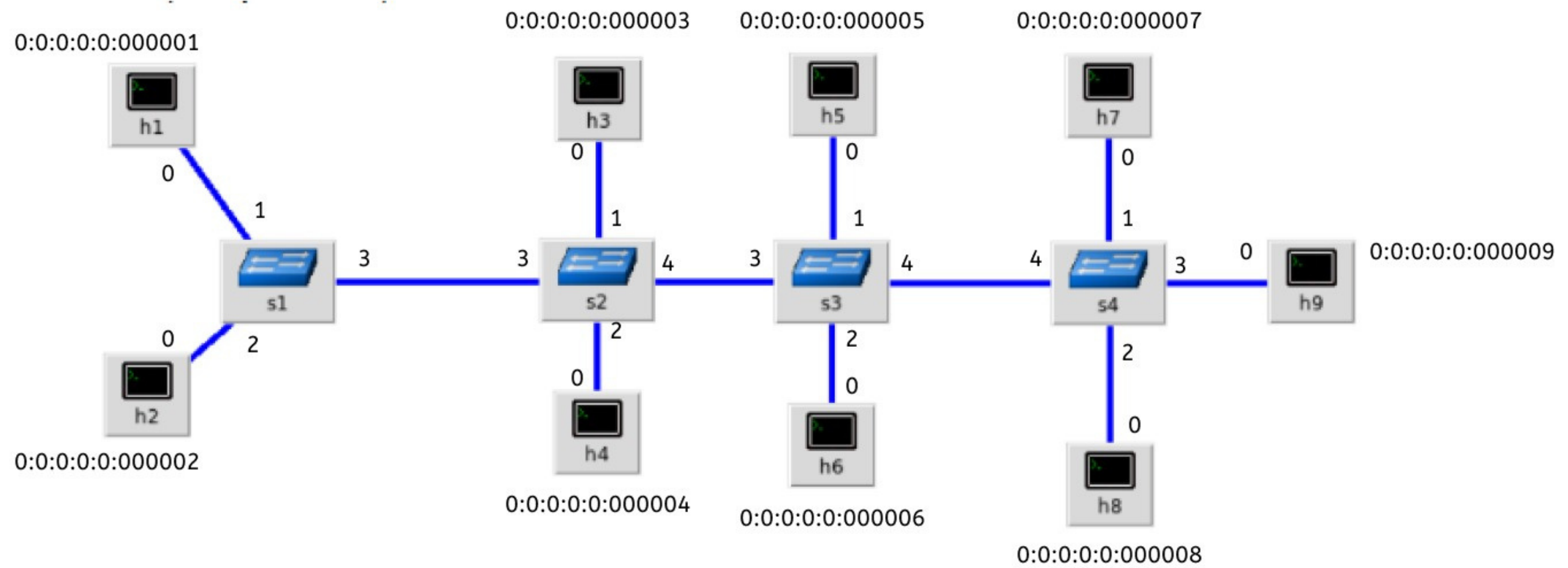
Apague as regras anteriores e
crie regras baseadas em
endereços MAC para algunsnós

```
// Ver flows
sudo ovs-ofctl show s1

// Apagar flows
sudo ovs-ofctl del-flows s1

/// A cada switch
sudo ovs-ofctl add-flow s1 dl_type=0x806,nw_proto=1,action=flood

// HOST1 - HOST2
sudo ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:02,actions=output:2
sudo ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:01,actions=output:1

// HOST5 - HOST2
sudo ovs-ofctl add-flow s3 dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:02,actions=output:3
sudo ovs-ofctl add-flow s2 dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:02,actions=output:3
sudo ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:02,actions=output:2

sudo ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05,actions=output:3
sudo ovs-ofctl add-flow s2 dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05,actions=output:4
sudo ovs-ofctl add-flow s3 dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05,actions=output:1

// HOST6 - HOST7
sudo ovs-ofctl add-flow s3 dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:07,actions=output:4
sudo ovs-ofctl add-flow s4 dl_src=00:00:00:00:00:06,dl_dst=00:00:00:00:00:07,actions=output:1

sudo ovs-ofctl add-flow s4 dl_src=00:00:00:00:00:07,dl_dst=00:00:00:00:00:06,actions=output:4
sudo ovs-ofctl add-flow s3 dl_src=00:00:00:00:00:07,dl_dst=00:00:00:00:00:06,actions=output:2
```

Faça testes de ping para demonstrar que as regras foram bem implementadas.

```
root@mininet-vm:~/C115/TrabalhoFinal# ping 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=0.143 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.027 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.064 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.045 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.049 ms
```

Faça testes de ping para demonstrar que as regras foram bem implementadas.

```
root@mininet-vm:~/C115/TrabalhoFinal# ping 10.0.0.5
PING 10.0.0.5 (10.0.0.5) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.145 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.017 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.064 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.045 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.019 ms
```

Faça testes de ping para demonstrar que as regras foram bem implementadas.

```
root@mininet-vm:~/C115/TrabalhoFinal# ping 10.0.0.7
PING 10.0.0.7 (10.0.0.7) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.153 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.077 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.054 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.045 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.049 ms
```