

```
mininet> h1 ifconfig -a
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
    ether 00:00:00:00:00:01 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
    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
```

HOST 2

```
mininet> h2 ifconfig -a
h2-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.2 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:02 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
    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
```

HOST 3

```
mininet> h3 ifconfig -a
h3-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.3 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:03 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
    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
```

HOST 4

```
mininet> h4 ifconfig -a
h4-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.4 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:04 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
    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
```

HOST 5

```
mininet> h5 ifconfig -a
h5-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.5 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:05 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
    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
```

HOST 6

```
mininet> h6 ifconfig -a
h6-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.6 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:06 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
    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
```

HOST 7

```
mininet> h7 ifconfig -a
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
    ether 00:00:00:00:00:07 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
    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
```

HOST 8

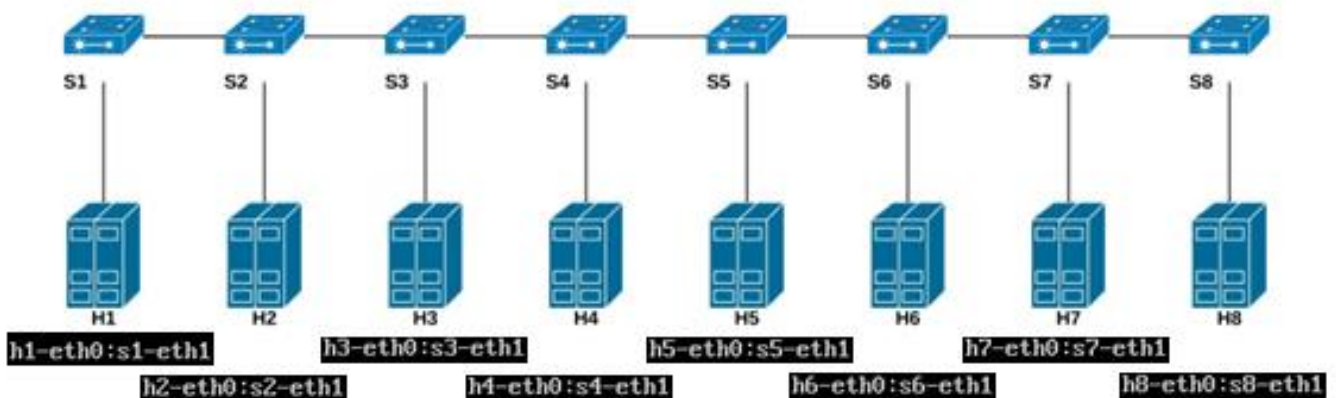
```
mininet> h8 ifconfig -a
h8-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.8 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:08 txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 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
    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
```

Informações Gerais

```
mininet> net
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
h7 h7-eth0:s7-eth1
h8 h8-eth0:s8-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 s6-eth3:s7-eth2
s7 lo: s7-eth1:h7-eth0 s7-eth2:s6-eth3 s7-eth3:s8-eth2
s8 lo: s8-eth1:h8-eth0 s8-eth2:s7-eth3
c0
mininet> dump
<Host h1: h1-eth0:10.0.0.1 pid=852>
<Host h2: h2-eth0:10.0.0.2 pid=856>
<Host h3: h3-eth0:10.0.0.3 pid=858>
<Host h4: h4-eth0:10.0.0.4 pid=860>
<Host h5: h5-eth0:10.0.0.5 pid=862>
<Host h6: h6-eth0:10.0.0.6 pid=864>
<Host h7: h7-eth0:10.0.0.7 pid=866>
<Host h8: h8-eth0:10.0.0.8 pid=868>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None pid=873>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None pid=876>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None pid=879>
<OVSSwitch s4: lo:127.0.0.1,s4-eth1:None,s4-eth2:None,s4-eth3:None pid=882>
<OVSSwitch s5: lo:127.0.0.1,s5-eth1:None,s5-eth2:None,s5-eth3:None pid=885>
<OVSSwitch s6: lo:127.0.0.1,s6-eth1:None,s6-eth2:None,s6-eth3:None pid=888>
<OVSSwitch s7: lo:127.0.0.1,s7-eth1:None,s7-eth2:None,s7-eth3:None pid=891>
<OVSSwitch s8: lo:127.0.0.1,s8-eth1:None,s8-eth2:None pid=894>
<Controller c0: 127.0.0.1:6653 pid=845>
mininet>
```

c) Crie um desenho ilustrativo da topologia com todas as informações obtidas no item anterior.



d) Execute testes de ping entre os diferentes nós, mostre os pacotes chegando nos nós com uso do comando `tcpdump`.

INFORMAÇÕES DETALHADAS SOBRE AS INTERFACES DE REDE DO SISTEMA:

COMANDO: `IFCONFIG -A`

```
mininet@mininet-vm:~$ ifconfig -a
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
    ether 08:00:27:1c:bf:e0 txqueuelen 1000 (Ethernet)
    RX packets 408 bytes 47691 (47.6 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 406 bytes 36009 (36.0 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

eth1: flags=4098<BROADCAST,MULTICAST> mtu 1500
    ether 08:00:27:53:73:b5 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
    loop txqueuelen 1000 (Local Loopback)
    RX packets 7414 bytes 426508 (426.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 7414 bytes 426508 (426.5 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet@mininet-vm:~$
```

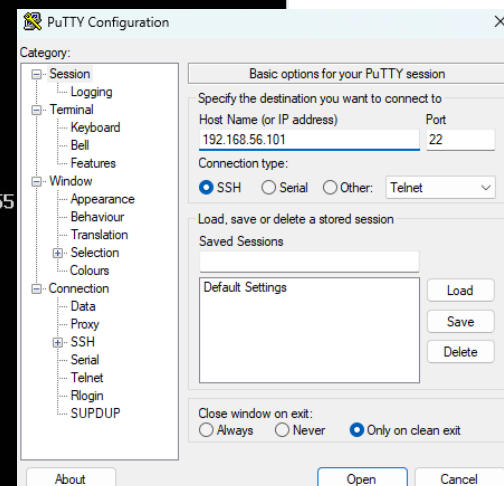
A INTERFACE `ETH1` NÃO TEM IP ATRIBUÍDO. PARA ATRIBUIR UM IP A ESTÁ INTERFACE, DIGITE O SEGUINTE COMANDO: `SUDO DHCPCLIENT ETH1`

```
mininet@mininet-vm:~$ sudo dhclient eth1
mininet@mininet-vm:~$ ifconfig -a
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
    ether 08:00:27:1c:bf:e0 txqueuelen 1000 (Ethernet)
    RX packets 435 bytes 49851 (49.8 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 433 bytes 38169 (38.1 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.56.101 netmask 255.255.255.0 broadcast 192.168.56.255
    ether 08:00:27:53:73:b5 txqueuelen 1000 (Ethernet)
    RX packets 100 bytes 9582 (9.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 2 bytes 684 (684.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

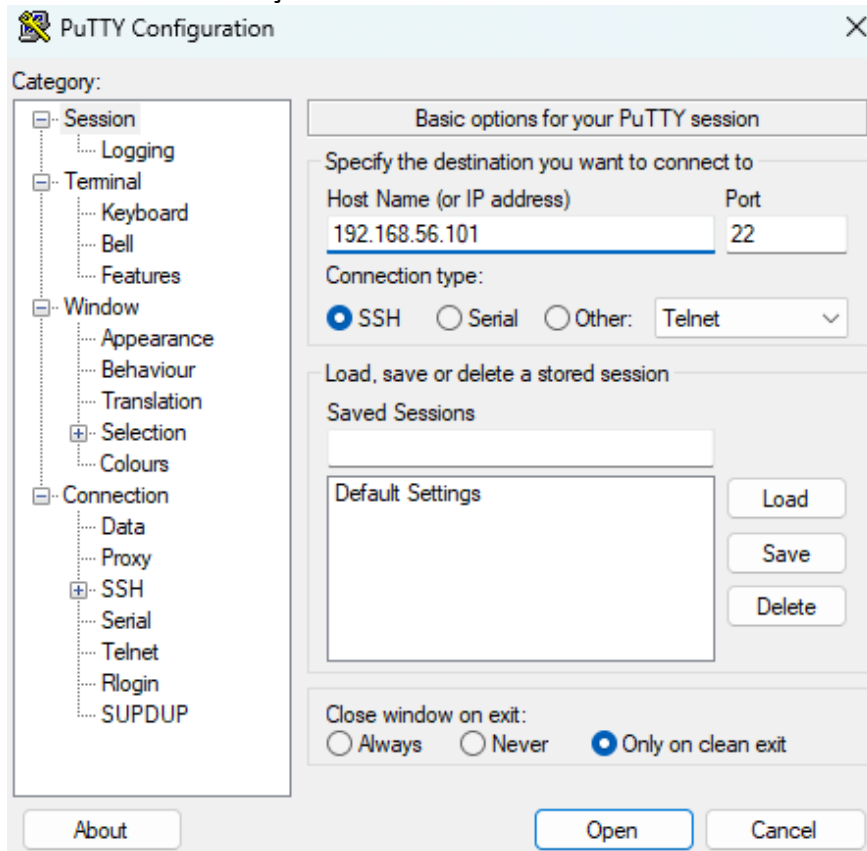
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    loop txqueuelen 1000 (Local Loopback)
    RX packets 7414 bytes 426508 (426.5 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 7414 bytes 426508 (426.5 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet@mininet-vm:~$
```

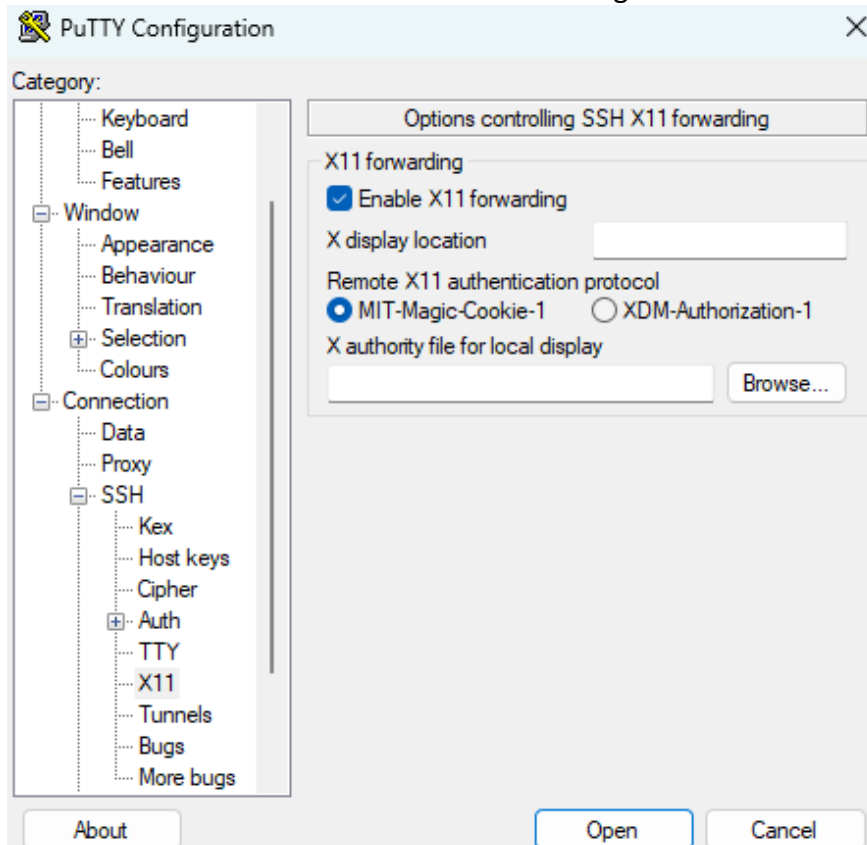


Configuração do Software PuTTY

- Inserindo o endereço IP



- Habilitando o comando Enable X11 forwarding no PuTTY




Execução do Software PuTTY:

```
mininet@mininet-vm: ~  
login as: mininet  
mininet@192.168.56.101's password:  
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-42-generic x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/advantage  
  
New release '22.04.2 LTS' available.  
Run 'do-release-upgrade' to upgrade to it.  
  
Last login: Mon Jun 12 11:03:17 2023 from 192.168.56.1  
mininet@mininet-vm:~$ sudo -E mn --mac --topo=linear,8 --link=tc,bw=6  
*** Creating network  
*** Adding controller  
*** Adding hosts:  
h1 h2 h3 h4 h5 h6 h7 h8  
*** Adding switches:  
s1 s2 s3 s4 s5 s6 s7 s8  
*** Adding links:  
(6.00Mbit) (6.00Mbit) (h1, s1) (6.00Mbit) (6.00Mbit) (h2, s2) (6.00Mbit) (6.00Mbit)  
(h3, s3) (6.00Mbit) (6.00Mbit) (h4, s4) (6.00Mbit) (6.00Mbit) (h5, s5) (6.00Mbit)  
(6.00Mbit) (h6, s6) (6.00Mbit) (6.00Mbit) (h7, s7) (6.00Mbit) (6.00Mbit) (h8, s8)  
(6.00Mbit) (6.00Mbit) (s2, s1) (6.00Mbit) (6.00Mbit) (s3, s2) (6.00Mbit) (6.00Mbit)  
(s4, s3) (6.00Mbit) (6.00Mbit) (s5, s4) (6.00Mbit) (6.00Mbit) (s6, s5) (6.00Mbit)  
(6.00Mbit) (s7, s6) (6.00Mbit) (6.00Mbit) (s8, s7)  
*** Configuring hosts  
h1 h2 h3 h4 h5 h6 h7 h8  
*** Starting controller  
c0  
*** Starting 8 switches  
s1 s2 s3 s4 s5 s6 s7 s8 ... (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit)  
(6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit)  
(6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit)  
(6.00Mbit) (6.00Mbit) (6.00Mbit)  
*** Starting CLI:  
mininet>
```

Execução do Software Xming:



Com tudo configurado e em execução, podemos fazer os testes de ping:

 "Node: h1"

```
root@mininet-vm:~# for i in {2..8}; do ping -c 4 10.0.0.$i; done
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=5.39 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.405 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.069 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.068 ms

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3031ms
rtt min/avg/max/mdev = 0.068/1.483/5.392/2.260 ms
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=3.70 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.552 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.073 ms
64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.048 ms

--- 10.0.0.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3032ms
rtt min/avg/max/mdev = 0.048/1.093/3.700/1.518 ms
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=4.02 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=0.309 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=0.087 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=0.078 ms

--- 10.0.0.4 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3037ms
rtt min/avg/max/mdev = 0.078/1.122/4.017/1.673 ms
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=4.76 ms
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.493 ms
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.056 ms
64 bytes from 10.0.0.5: icmp_seq=4 ttl=64 time=0.073 ms

--- 10.0.0.5 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3032ms
rtt min/avg/max/mdev = 0.056/1.346/4.764/1.980 ms
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=9.79 ms
64 bytes from 10.0.0.6: icmp_seq=2 ttl=64 time=0.394 ms
64 bytes from 10.0.0.6: icmp_seq=3 ttl=64 time=0.063 ms
64 bytes from 10.0.0.6: icmp_seq=4 ttl=64 time=0.065 ms

--- 10.0.0.6 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3033ms
rtt min/avg/max/mdev = 0.063/2.578/9.790/4.166 ms
PING 10.0.0.7 (10.0.0.7) 56(84) bytes of data.
64 bytes from 10.0.0.7: icmp_seq=1 ttl=64 time=7.62 ms
64 bytes from 10.0.0.7: icmp_seq=2 ttl=64 time=0.433 ms
64 bytes from 10.0.0.7: icmp_seq=3 ttl=64 time=0.079 ms
64 bytes from 10.0.0.7: icmp_seq=4 ttl=64 time=0.060 ms

--- 10.0.0.7 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3034ms
rtt min/avg/max/mdev = 0.060/2.047/7.618/3.219 ms
PING 10.0.0.8 (10.0.0.8) 56(84) bytes of data.
64 bytes from 10.0.0.8: icmp_seq=1 ttl=64 time=6.32 ms
64 bytes from 10.0.0.8: icmp_seq=2 ttl=64 time=0.438 ms
64 bytes from 10.0.0.8: icmp_seq=3 ttl=64 time=0.096 ms
64 bytes from 10.0.0.8: icmp_seq=4 ttl=64 time=0.074 ms

--- 10.0.0.8 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3035ms
rtt min/avg/max/mdev = 0.074/1.731/6.317/2.651 ms
```


e) 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 20 segundos. Faça os testes para larguras de banda bw de 1, 5, 20 e 25 Mbps.

BANDA 1 MBPS

```
mininet@mininet-vm:~$ sudo -E mn --mac --topo=linear,8 --link=tc,bw=1

"Node: h1"
root@mininet-vm:~# iperf -s -p 5555 -i 1

Server listening on TCP port 5555
TCP window size: 85,3 KByte (default)

[ 6] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 34188
[ ID] Interval      Transfer    Bandwidth
[ 6] 0.0- 1.0 sec   120 KBytes  985 Kbits/sec
[ 6] 1.0- 2.0 sec   120 KBytes  985 Kbits/sec
[ 6] 2.0- 3.0 sec   113 KBytes  927 Kbits/sec
[ 6] 3.0- 4.0 sec   120 KBytes  985 Kbits/sec
[ 6] 4.0- 5.0 sec   113 KBytes  927 Kbits/sec
[ 6] 5.0- 6.0 sec   120 KBytes  985 Kbits/sec
[ 6] 6.0- 7.0 sec   113 KBytes  927 Kbits/sec
[ 6] 7.0- 8.0 sec   120 KBytes  985 Kbits/sec
[ 6] 8.0- 9.0 sec   116 KBytes  950 Kbits/sec
[ 6] 9.0-10.0 sec   117 KBytes  961 Kbits/sec
[ 6] 10.0-11.0 sec   116 KBytes  950 Kbits/sec
[ 6] 11.0-12.0 sec   117 KBytes  961 Kbits/sec
[ 6] 12.0-13.0 sec   116 KBytes  950 Kbits/sec
[ 6] 13.0-14.0 sec   117 KBytes  961 Kbits/sec
[ 6] 14.0-15.0 sec   116 KBytes  950 Kbits/sec
[ 6] 15.0-16.0 sec   117 KBytes  961 Kbits/sec
[ 6] 16.0-17.0 sec   116 KBytes  950 Kbits/sec
[ 6] 17.0-18.0 sec   117 KBytes  961 Kbits/sec
[ 6] 18.0-19.0 sec   116 KBytes  950 Kbits/sec
[ 6] 19.0-20.0 sec   117 KBytes  961 Kbits/sec
[ 6] 20.0-21.0 sec   116 KBytes  950 Kbits/sec
[ 6] 0.0-21.2 sec   2,42 MBytes  957 Kbits/sec

"Node: h2"
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i 1 -t 20

Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 102 KByte (default)

[ 5] local 10.0.0.2 port 34188 connected with 10.0.0.1 port 5555
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.0- 1.0 sec   269 KBytes  2.20 Mbits/sec
[ 5] 1.0- 2.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 2.0- 3.0 sec   106 KBytes  869 Kbits/sec
[ 5] 3.0- 4.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 4.0- 5.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 5.0- 6.0 sec   106 KBytes  869 Kbits/sec
[ 5] 6.0- 7.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 7.0- 8.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 8.0- 9.0 sec   106 KBytes  869 Kbits/sec
[ 5] 9.0-10.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 10.0-11.0 sec   106 KBytes  869 Kbits/sec
[ 5] 11.0-12.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 12.0-13.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 13.0-14.0 sec   106 KBytes  869 Kbits/sec
[ 5] 14.0-15.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 15.0-16.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 16.0-17.0 sec   106 KBytes  869 Kbits/sec
[ 5] 17.0-18.0 sec   127 KBytes  1.04 Mbits/sec
[ 5] 18.0-19.0 sec   63,6 KBytes  521 Kbits/sec
[ 5] 19.0-20.0 sec   106 KBytes  869 Kbits/sec
[ 5] 0.0-20.0 sec   2,42 MBytes  1.01 Mbits/sec
root@mininet-vm:~#
```

BANDA 5 MBPS

```
mininet@mininet-vm:~$ sudo -E mn --mac --topo=linear,8 --link=tc,bw=5

"Node: h1"
root@mininet-vm:~# iperf -s -p 5555 -i 1

Server listening on TCP port 5555
TCP window size: 85,3 KByte (default)

[ 6] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 34216
[ ID] Interval      Transfer    Bandwidth
[ 6] 0.0- 1.0 sec   587 KBytes  4,81 Mbits/sec
[ 6] 1.0- 2.0 sec   587 KBytes  4,81 Mbits/sec
[ 6] 2.0- 3.0 sec   583 KBytes  4,77 Mbits/sec
[ 6] 3.0- 4.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 4.0- 5.0 sec   585 KBytes  4,80 Mbits/sec
[ 6] 5.0- 6.0 sec   578 KBytes  4,74 Mbits/sec
[ 6] 6.0- 7.0 sec   583 KBytes  4,77 Mbits/sec
[ 6] 7.0- 8.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 8.0- 9.0 sec   588 KBytes  4,82 Mbits/sec
[ 6] 9.0-10.0 sec   578 KBytes  4,74 Mbits/sec
[ 6] 10.0-11.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 11.0-12.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 12.0-13.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 13.0-14.0 sec   583 KBytes  4,77 Mbits/sec
[ 6] 14.0-15.0 sec   583 KBytes  4,77 Mbits/sec
[ 6] 15.0-16.0 sec   587 KBytes  4,81 Mbits/sec
[ 6] 16.0-17.0 sec   581 KBytes  4,76 Mbits/sec
[ 6] 17.0-18.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 18.0-19.0 sec   583 KBytes  4,77 Mbits/sec
[ 6] 19.0-20.0 sec   584 KBytes  4,78 Mbits/sec
[ 6] 0.0-20.4 sec   11,6 MBytes  4,78 Mbits/sec

"Node: h2"
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i 1 -t 20

Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 128 KByte (default)

[ 5] local 10.0.0.2 port 34216 connected with 10.0.0.1 port 5555
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.0- 1.0 sec   768 KBytes  6,29 Mbits/sec
[ 5] 1.0- 2.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 2.0- 3.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 3.0- 4.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 4.0- 5.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 5.0- 6.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 6.0- 7.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 7.0- 8.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 8.0- 9.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 9.0-10.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 10.0-11.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 11.0-12.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 12.0-13.0 sec   768 KBytes  6,29 Mbits/sec
[ 5] 13.0-14.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 14.0-15.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 15.0-16.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 16.0-17.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 17.0-18.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 18.0-19.0 sec   640 KBytes  5,24 Mbits/sec
[ 5] 19.0-20.0 sec   512 KBytes  4,19 Mbits/sec
[ 5] 0.0-20.0 sec   11,6 MBytes  4,86 Mbits/sec
root@mininet-vm:~#
```

BANDA 20 MBPS

```
mininet@mininet-vm:~$ sudo -E mn --mac --topo=linear,8 --link=tc,bw=20
```

"Node: h1"

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
```

Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)

ID	Interval	Transfer	Bandwidth
[6]	0.0- 1.0 sec	2.25 MBytes	18.9 Mbits/sec
[6]	1.0- 2.0 sec	2.25 MBytes	18.9 Mbits/sec
[6]	2.0- 3.0 sec	2.23 MBytes	18.7 Mbits/sec
[6]	3.0- 4.0 sec	2.24 MBytes	18.8 Mbits/sec
[6]	4.0- 5.0 sec	2.25 MBytes	18.9 Mbits/sec
[6]	5.0- 6.0 sec	2.24 MBytes	18.8 Mbits/sec
[6]	6.0- 7.0 sec	2.24 MBytes	18.8 Mbits/sec
[6]	7.0- 8.0 sec	2.26 MBytes	19.0 Mbits/sec
[6]	8.0- 9.0 sec	2.26 MBytes	18.9 Mbits/sec
[6]	9.0-10.0 sec	2.24 MBytes	18.8 Mbits/sec
[6]	10.0-11.0 sec	2.25 MBytes	18.9 Mbits/sec
[6]	11.0-12.0 sec	2.24 MBytes	18.8 Mbits/sec
[6]	12.0-13.0 sec	2.26 MBytes	19.0 Mbits/sec
[6]	13.0-14.0 sec	2.25 MBytes	18.8 Mbits/sec
[6]	14.0-15.0 sec	2.25 MBytes	18.8 Mbits/sec
[6]	15.0-16.0 sec	2.23 MBytes	18.7 Mbits/sec
[6]	16.0-17.0 sec	2.26 MBytes	18.9 Mbits/sec
[6]	17.0-18.0 sec	2.26 MBytes	19.0 Mbits/sec
[6]	18.0-19.0 sec	2.24 MBytes	18.8 Mbits/sec
[6]	19.0-20.0 sec	2.25 MBytes	18.9 Mbits/sec
[6]	0.0-20.1 sec	45.1 MBytes	18.8 Mbits/sec

"Node: h2"

```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i 1 -t 20
```

Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 187 KByte (default)

ID	Interval	Transfer	Bandwidth
[5]	0.0- 1.0 sec	2.50 MBytes	21.0 Mbits/sec
[5]	1.0- 2.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	2.0- 3.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	3.0- 4.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	4.0- 5.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	5.0- 6.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	6.0- 7.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	7.0- 8.0 sec	2.12 MBytes	17.8 Mbits/sec
[5]	8.0- 9.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	9.0-10.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	10.0-11.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	11.0-12.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	12.0-13.0 sec	2.38 MBytes	19.9 Mbits/sec
[5]	13.0-14.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	14.0-15.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	15.0-16.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	16.0-17.0 sec	2.12 MBytes	17.8 Mbits/sec
[5]	17.0-18.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	18.0-19.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	19.0-20.0 sec	2.25 MBytes	18.9 Mbits/sec
[5]	0.0-20.0 sec	45.1 MBytes	18.9 Mbits/sec

BANDA 25 MBPS

```
mininet@mininet-vm:~$ sudo -E mn --mac --topo=linear,8 --link=tc,bw=25
```

"Node: h1"

```
root@mininet-vm:~# iperf -s -p 5555 -i 1
```

Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)

ID	Interval	Transfer	Bandwidth
[6]	0.0- 1.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	1.0- 2.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	2.0- 3.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	3.0- 4.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	4.0- 5.0 sec	2.75 MBytes	23.1 Mbits/sec
[6]	5.0- 6.0 sec	2.76 MBytes	23.2 Mbits/sec
[6]	6.0- 7.0 sec	2.75 MBytes	23.1 Mbits/sec
[6]	7.0- 8.0 sec	2.75 MBytes	23.1 Mbits/sec
[6]	8.0- 9.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	9.0-10.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	10.0-11.0 sec	2.79 MBytes	23.4 Mbits/sec
[6]	11.0-12.0 sec	2.78 MBytes	23.4 Mbits/sec
[6]	12.0-13.0 sec	2.78 MBytes	23.4 Mbits/sec
[6]	13.0-14.0 sec	2.79 MBytes	23.4 Mbits/sec
[6]	14.0-15.0 sec	2.78 MBytes	23.3 Mbits/sec
[6]	15.0-16.0 sec	2.79 MBytes	23.4 Mbits/sec
[6]	16.0-17.0 sec	2.79 MBytes	23.4 Mbits/sec
[6]	17.0-18.0 sec	2.79 MBytes	23.4 Mbits/sec
[6]	18.0-19.0 sec	2.77 MBytes	23.3 Mbits/sec
[6]	19.0-20.0 sec	2.77 MBytes	23.2 Mbits/sec
[6]	0.0-20.1 sec	55.9 MBytes	23.3 Mbits/sec

"Node: h2"

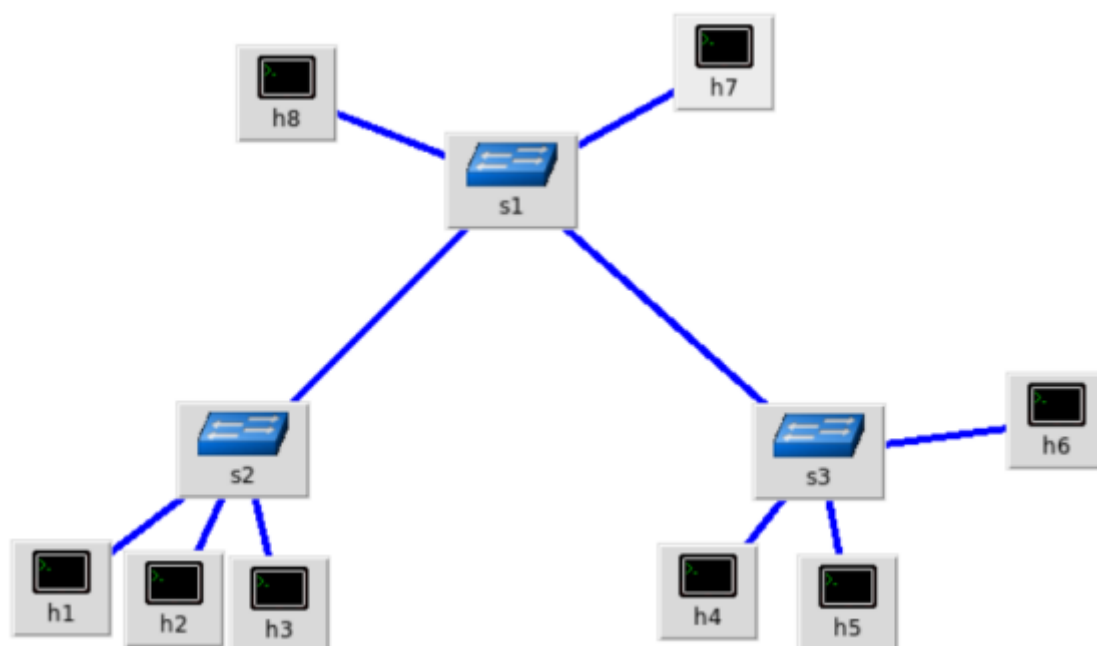
```
root@mininet-vm:~# iperf -c 10.0.0.1 -p 5555 -i 1 -t 20
```

Client connecting to 10.0.0.1, TCP port 5555
TCP window size: 136 KByte (default)

ID	Interval	Transfer	Bandwidth
[5]	0.0- 1.0 sec	3.00 MBytes	25.2 Mbits/sec
[5]	1.0- 2.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	2.0- 3.0 sec	2.88 MBytes	24.1 Mbits/sec
[5]	3.0- 4.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	4.0- 5.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	5.0- 6.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	6.0- 7.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	7.0- 8.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	8.0- 9.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	9.0-10.0 sec	2.88 MBytes	24.1 Mbits/sec
[5]	10.0-11.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	11.0-12.0 sec	2.88 MBytes	24.1 Mbits/sec
[5]	12.0-13.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	13.0-14.0 sec	2.62 MBytes	22.0 Mbits/sec
[5]	14.0-15.0 sec	2.88 MBytes	24.1 Mbits/sec
[5]	15.0-16.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	16.0-17.0 sec	2.88 MBytes	24.1 Mbits/sec
[5]	17.0-18.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	18.0-19.0 sec	2.75 MBytes	23.1 Mbits/sec
[5]	19.0-20.0 sec	2.88 MBytes	24.1 Mbits/sec
[5]	0.0-20.0 sec	55.9 MBytes	23.4 Mbits/sec

QUESTÃO 2

Crie um código Python para a topologia customizada abaixo:



CÓDIGO PYTHON

<https://github.com/Matheuwss/C115>

```
topo-8hosts-3switches.py
1  from mininet.topo import Topo
2
3  class MyTopo( Topo ):
4      "8 hosts and 3 switches - custom topology"
5
6      def __init__( self ):
7          "Create custom topo."
8
9          # Initialize topology
10         Topo.__init__( self )
11
12         # Add hosts and switches
13         h1 = self.addHost('h1')
14         h2 = self.addHost('h2')
15         h3 = self.addHost('h3')
16         h4 = self.addHost('h4')
17         h5 = self.addHost('h5')
18         h6 = self.addHost('h6')
19         h7 = self.addHost('h7')
20         h8 = self.addHost('h8')
21         s1 = self.addSwitch('s1')
22         s2 = self.addSwitch('s2')
23         s3 = self.addSwitch('s3')
24
25         # Add links
26         self.addLink(s1, s2)
27         self.addLink(s1, s3)
28         self.addLink(s1, h7)
29         self.addLink(s1, h8)
30
31         self.addLink(s2, h1)
32         self.addLink(s2, h2)
33         self.addLink(s2, h3)
34
35         self.addLink(s3, h4)
36         self.addLink(s3, h5)
37         self.addLink(s3, h6)
38
39     topos = { 'mytopo': ( lambda: MyTopo() ) }
```

a) 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
mininet@mininet-vm:~$ ls
C115  mininet  oflops  oftest  openflow  pox
mininet@mininet-vm:~$ cd C115
mininet@mininet-vm:~/C115$ sudo -E mn --custom topo-8hosts-3switches.py --topo mytopo --mac
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8
*** Adding switches:
s1 s2 s3
*** Adding links:
(s1, h7) (s1, h8) (s1, s2) (s1, s3) (s2, h1) (s2, h2) (s2, h3) (s3, h4) (s3, h5) (s3, h6)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
c0
*** Starting 3 switches
s1 s2 s3 ...
*** Starting CLI:
mininet>
mininet>
```

b) Inspeção informações das interfaces, endereços MAC, IP e portas através de linhas de comando.

HOSTS 1, 2, 3

```
mininet> h1 ifconfig -a
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
    ether 00:00:00:00:00:01 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
    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

mininet> h2 ifconfig -a
h2-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.2 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:02 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
    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

mininet> h3 ifconfig -a
h3-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.3 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:03 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
    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
```

HOSTS 4, 5, 6

```
mininet> h4 ifconfig -a
h4-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.4 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:04 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
    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

mininet> h5 ifconfig -a
h5-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.5 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:05 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
    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

mininet> h6 ifconfig -a
h6-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.6 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:06 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
    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
```

HOSTS 7, 8

```
mininet> h7 ifconfig -a
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
    ether 00:00:00:00:00:07 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
    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

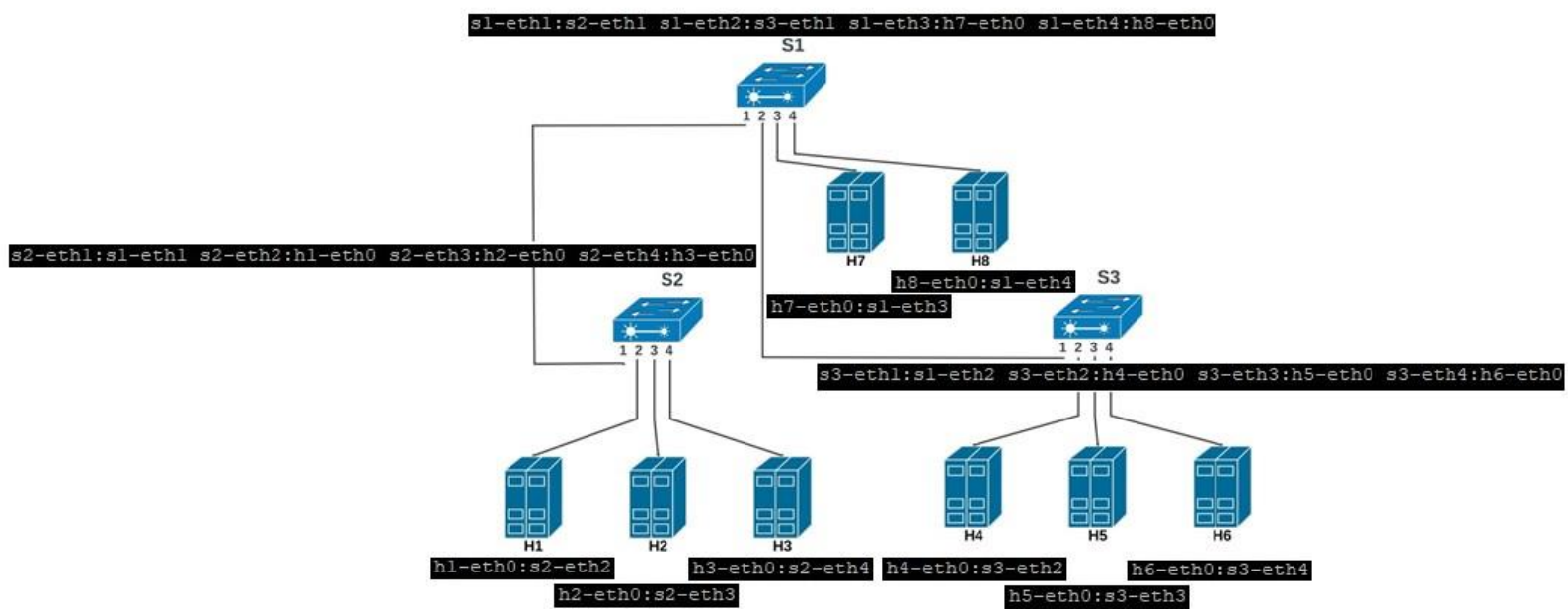
mininet> h8 ifconfig -a
h8-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.8 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 00:00:00:00:00:08 txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 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
    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
```

Informações Gerais

```
mininet> nodes
available nodes are:
c0 h1 h2 h3 h4 h5 h6 h7 h8 s1 s2 s3
mininet> net
h1 h1-eth0:s2-eth2
h2 h2-eth0:s2-eth3
h3 h3-eth0:s2-eth4
h4 h4-eth0:s3-eth2
h5 h5-eth0:s3-eth3
h6 h6-eth0:s3-eth4
h7 h7-eth0:s1-eth3
h8 h8-eth0:s1-eth4
s1 lo: s1-eth1:s2-eth1 s1-eth2:s3-eth1 s1-eth3:h7-eth0 s1-eth4:h8-eth0
s2 lo: s2-eth1:s1-eth1 s2-eth2:h1-eth0 s2-eth3:h2-eth0 s2-eth4:h3-eth0
s3 lo: s3-eth1:s1-eth2 s3-eth2:h4-eth0 s3-eth3:h5-eth0 s3-eth4:h6-eth0
c0
mininet> dump
<Host h1: h1-eth0:10.0.0.1 pid=1251>
<Host h2: h2-eth0:10.0.0.2 pid=1255>
<Host h3: h3-eth0:10.0.0.3 pid=1257>
<Host h4: h4-eth0:10.0.0.4 pid=1259>
<Host h5: h5-eth0:10.0.0.5 pid=1261>
<Host h6: h6-eth0:10.0.0.6 pid=1263>
<Host h7: h7-eth0:10.0.0.7 pid=1265>
<Host h8: h8-eth0:10.0.0.8 pid=1267>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None,s1-eth4:None pid=1272>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None,s2-eth4:None pid=1275>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None,s3-eth4:None pid=1278>
<Controller c0: 127.0.0.1:6653 pid=1244>
```


c) Crie um desenho ilustrativo da topologia com todas as informações obtidas no item anterior.



d) Faça testes de ping considerando os switches normais.

Linhas de comando:

xterm s1 s2 s3

S1: sudo ovs-ofctl add-flow s1 action=normal

S2: sudo ovs-ofctl add-flow s2 action=normal

S3: sudo ovs-ofctl add-flow s3 action=normal

```
mininet@mininet-vm:~$ cd C115
mininet@mininet-vm:~/C115$ sudo -E mn --custom topo-3hosts-3switches.py --topo mytopo --controller=none --mac
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8
*** Adding switches:
s1 s2 s3
*** Adding links:
(s1, h7) (s1, h8) (s1, s2) (s1, s3) (s2, h1) (s2, h2) (s2, h3) (s3, h4) (s3, h5) (s3, h6)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
mininet> xterm s1 s2 s3
mininet> 
```

Teste de ping

Comando: pingall

```
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)
mininet> 
```

e) Apague as regras anteriores e crie regras baseadas em endereços MAC para alguns nós. (Deve-se comunicar hosts dos diferentes switches).

Criando regras para os switches s1, s2 e s3

Usando 3 Switches (h1 – h4)

```
"Node: s1" (root)
root@mininet-virtual-machine:~$ sudo ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04,actions=output:2
root@mininet-virtual-machine:~$ sudo ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:01,actions=output:1
root@mininet-virtual-machine:~$ sudo ovs-ofctl add-flow s2 dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04,actions=output:1
root@mininet-virtual-machine:~$ sudo ovs-ofctl add-flow s2 dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:01,actions=output:2
root@mininet-virtual-machine:~$ sudo ovs-ofctl add-flow s3 dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04,actions=output:2
root@mininet-virtual-machine:~$ sudo ovs-ofctl add-flow s3 dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:01,actions=output:1
root@mininet-virtual-machine:~$
```

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

Usando 3 Switches (h1 – h4)

Linhas de comando:

xterm h1 h4

H1: ping 10.0.0.4

H4: tcpdump -XX -n -i h4-eth0

```
"Node: h1"
64 bytes from 10.0.0.4: icmp_seq=75 ttl=64 time=0.052 ms
64 bytes from 10.0.0.4: icmp_seq=76 ttl=64 time=0.051 ms
64 bytes from 10.0.0.4: icmp_seq=77 ttl=64 time=0.087 ms
64 bytes from 10.0.0.4: icmp_seq=78 ttl=64 time=0.076 ms
64 bytes from 10.0.0.4: icmp_seq=79 ttl=64 time=0.064 ms
64 bytes from 10.0.0.4: icmp_seq=80 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=81 ttl=64 time=0.040 ms
64 bytes from 10.0.0.4: icmp_seq=82 ttl=64 time=0.134 ms
64 bytes from 10.0.0.4: icmp_seq=83 ttl=64 time=0.077 ms
64 bytes from 10.0.0.4: icmp_seq=84 ttl=64 time=0.114 ms
64 bytes from 10.0.0.4: icmp_seq=85 ttl=64 time=0.089 ms
64 bytes from 10.0.0.4: icmp_seq=86 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=87 ttl=64 time=0.092 ms
64 bytes from 10.0.0.4: icmp_seq=88 ttl=64 time=0.077 ms
64 bytes from 10.0.0.4: icmp_seq=89 ttl=64 time=0.091 ms
64 bytes from 10.0.0.4: icmp_seq=90 ttl=64 time=0.103 ms
64 bytes from 10.0.0.4: icmp_seq=91 ttl=64 time=0.135 ms
64 bytes from 10.0.0.4: icmp_seq=92 ttl=64 time=0.084 ms
64 bytes from 10.0.0.4: icmp_seq=93 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=94 ttl=64 time=0.136 ms
64 bytes from 10.0.0.4: icmp_seq=95 ttl=64 time=0.115 ms
64 bytes from 10.0.0.4: icmp_seq=96 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=97 ttl=64 time=0.091 ms
64 bytes from 10.0.0.4: icmp_seq=98 ttl=64 time=0.123 ms
64 bytes from 10.0.0.4: icmp_seq=99 ttl=64 time=0.046 ms
64 bytes from 10.0.0.4: icmp_seq=100 ttl=64 time=0.042 ms
64 bytes from 10.0.0.4: icmp_seq=101 ttl=64 time=0.062 ms
64 bytes from 10.0.0.4: icmp_seq=102 ttl=64 time=0.033 ms
64 bytes from 10.0.0.4: icmp_seq=103 ttl=64 time=0.111 ms
64 bytes from 10.0.0.4: icmp_seq=104 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=105 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=106 ttl=64 time=0.057 ms
64 bytes from 10.0.0.4: icmp_seq=107 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=108 ttl=64 time=0.083 ms
64 bytes from 10.0.0.4: icmp_seq=109 ttl=64 time=0.039 ms
64 bytes from 10.0.0.4: icmp_seq=110 ttl=64 time=0.046 ms
64 bytes from 10.0.0.4: icmp_seq=111 ttl=64 time=0.046 ms
64 bytes from 10.0.0.4: icmp_seq=112 ttl=64 time=0.052 ms
64 bytes from 10.0.0.4: icmp_seq=113 ttl=64 time=0.078 ms
64 bytes from 10.0.0.4: icmp_seq=114 ttl=64 time=0.086 ms
64 bytes from 10.0.0.4: icmp_seq=115 ttl=64 time=0.051 ms
64 bytes from 10.0.0.4: icmp_seq=116 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=117 ttl=64 time=0.032 ms
64 bytes from 10.0.0.4: icmp_seq=118 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=119 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=120 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=121 ttl=64 time=0.046 ms
64 bytes from 10.0.0.4: icmp_seq=122 ttl=64 time=0.049 ms
64 bytes from 10.0.0.4: icmp_seq=123 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=124 ttl=64 time=0.077 ms
64 bytes from 10.0.0.4: icmp_seq=125 ttl=64 time=0.072 ms
64 bytes from 10.0.0.4: icmp_seq=126 ttl=64 time=0.041 ms
64 bytes from 10.0.0.4: icmp_seq=127 ttl=64 time=0.043 ms
64 bytes from 10.0.0.4: icmp_seq=128 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=129 ttl=64 time=0.046 ms
64 bytes from 10.0.0.4: icmp_seq=130 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=131 ttl=64 time=0.078 ms
64 bytes from 10.0.0.4: icmp_seq=132 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=133 ttl=64 time=0.083 ms
64 bytes from 10.0.0.4: icmp_seq=134 ttl=64 time=0.046 ms
64 bytes from 10.0.0.4: icmp_seq=135 ttl=64 time=0.063 ms
64 bytes from 10.0.0.4: icmp_seq=136 ttl=64 time=0.076 ms
64 bytes from 10.0.0.4: icmp_seq=137 ttl=64 time=0.045 ms
64 bytes from 10.0.0.4: icmp_seq=138 ttl=64 time=0.034 ms
II

"Node: h4"
18:16:31.251672 IP 10.0.0.1 > 10.0.0.4: ICMP echo request, id 1993, seq 135, length 64
0x0000: 0000 0000 0004 0000 0000 0001 0800 4500 .....E.
0x0010: 0054 2f05 4000 4001 f79f 0a00 0001 0a00 .T..@.....
0x0020: 0004 0800 41de 07c3 0087 6fc3 8764 0000 ....y...P.d.
0x0030: 0000 f4d6 0300 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:31.251692 IP 10.0.0.4 > 10.0.0.1: ICMP echo reply, id 1993, seq 135, length 64
0x0000: 0000 0000 0001 0000 0000 0004 0800 4500 .....E.
0x0010: 0054 a106 0000 4001 c59e 0a00 0004 0a00 .T..@.....
0x0020: 0001 0000 43de 07c3 0087 6fc3 8764 0000 ....y...P.d.
0x0030: 0000 f4d6 0300 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:32.277158 IP 10.0.0.1 > 10.0.0.4: ICMP echo request, id 1993, seq 136, length 64
0x0000: 0000 0000 0004 0000 0000 0001 0800 4500 .....E.
0x0010: 0054 2fe0 4000 4001 f6c4 0a00 0001 0a00 .T..@.....
0x0020: 0004 0800 b979 07c3 0088 70c3 8764 0000 ....y...P.d.
0x0030: 0000 7b3a 0400 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:32.277183 IP 10.0.0.4 > 10.0.0.1: ICMP echo reply, id 1993, seq 136, length 64
0x0000: 0000 0000 0001 0000 0000 0004 0800 4500 .....E.
0x0010: 0054 a1ad 0000 4001 c4f7 0a00 0004 0a00 .T..@.....
0x0020: 0001 0000 c179 07c3 0088 70c3 8764 0000 ....y...P.d.
0x0030: 0000 7b3a 0400 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:33.300264 IP 10.0.0.1 > 10.0.0.4: ICMP echo request, id 1993, seq 137, length 64
0x0000: 0000 0000 0004 0000 0000 0001 0800 4500 .....E.
0x0010: 0054 308a 4000 4001 f61a 0a00 0001 0a00 .T..@.....
0x0020: 0004 0800 561e 07c3 0088 71c3 8764 0000 ....f....q.d.
0x0030: 0000 c9d4 0400 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:33.300278 IP 10.0.0.4 > 10.0.0.1: ICMP echo reply, id 1993, seq 137, length 64
0x0000: 0000 0000 0001 0000 0000 0004 0800 4500 .....E.
0x0010: 0054 a25c 0000 4001 c448 0a00 0004 0a00 .T..@.....
0x0020: 0001 0000 5a1e 07c3 0088 71c3 8764 0000 ....f....q.d.
0x0030: 0000 c9d4 0400 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:34.324084 IP 10.0.0.1 > 10.0.0.4: ICMP echo request, id 1993, seq 138, length 64
0x0000: 0000 0000 0004 0000 0000 0001 0800 4500 .....E.
0x0010: 0054 30d4 4000 4001 f5d0 0a00 0001 0a00 .T..@.....
0x0020: 0004 0800 71c0 07c3 008a 72c3 8764 0000 ....y...f.d.
0x0030: 0000 c0f1 0400 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
18:16:34.324116 IP 10.0.0.4 > 10.0.0.1: ICMP echo reply, id 1993, seq 138, length 64
0x0000: 0000 0000 0001 0000 0000 0004 0800 4500 .....E.
0x0010: 0054 a23a 0000 4001 c40a 0a00 0004 0a00 .T..@.....
0x0020: 0001 0000 79c0 07c3 008a 72c3 8764 0000 ....y...f.d.
0x0030: 0000 c0f1 0400 0000 0000 1011 1213 1415 .....f....q.d.
0x0040: 1617 1819 1a1b 1c1d 1e1f 2021 2223 2425 .....!*"#$%
0x0050: 2627 2829 2a2b 2c2d 2e2f 3031 3233 3435 &'()*+,-./012345
0x0060: 3637 67
```