TRABALHO MININET [C115-L1]

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QUESTÃO 1

Considere uma topologia linear com oito hosts. Com uso de linha de comando padrão do Mininet, crie a topologia considerando o endereço MAC padronizado, larguras de banda bw de 6 Mbps e controlador do Mininet.

COMANDO: sudo mn --mac --topo=linear,8 --link=tc,bw=6

```
mininet@mininet-vm:~$ sudo 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) (6.00Mb
it) (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, s
5) (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) (6.00Mb
it) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbi
t) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit) (6.00Mbit)
*** Starting CLI:
mininet>
```

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

HOST 1

```
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
```

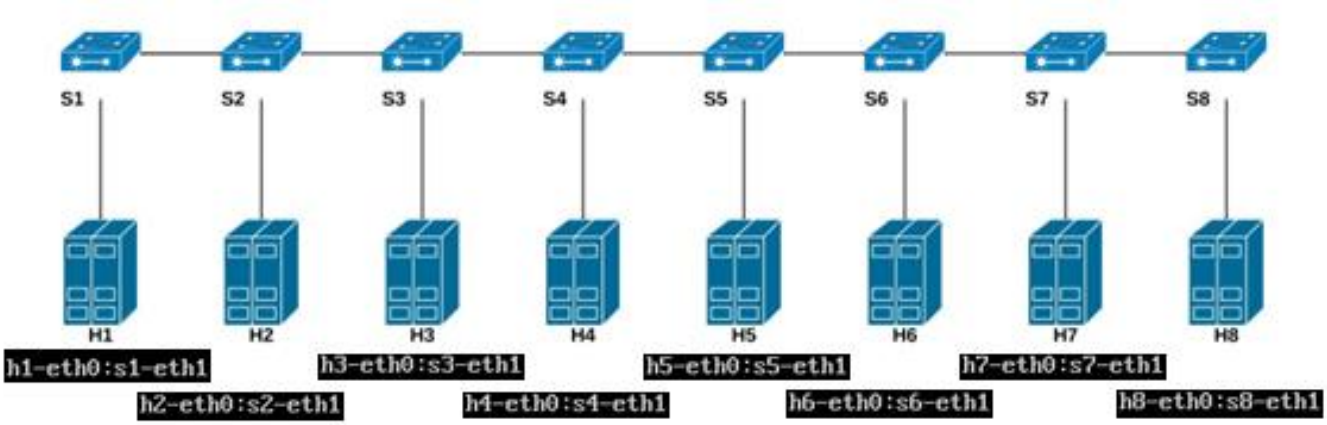
HOST 8

```
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.

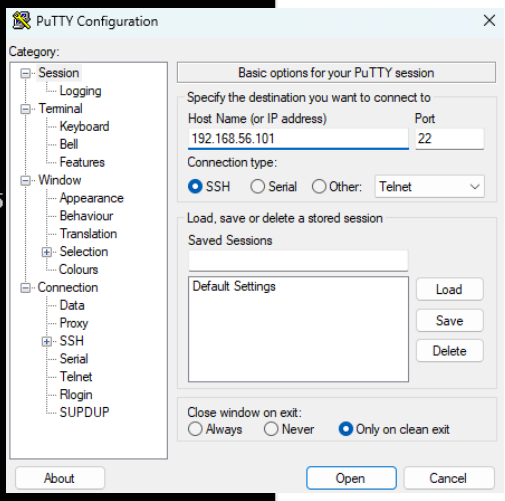
INFORMAÇÕES DETALHADAS SOBRE AS INTERFACES DE REDE DO SISTEMA:

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:~$
```

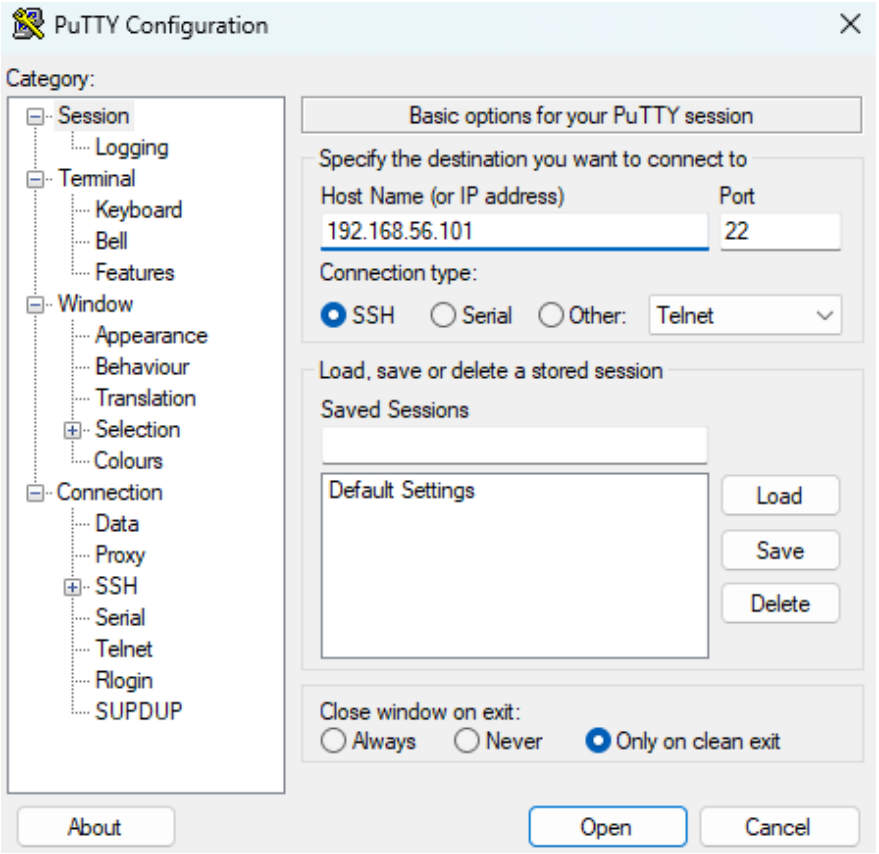
A INTERFACE ETH1 NÃO TEM IP ATRIBUÍDO. PARA ATRIBUIR UM IP A ESTÁ INTERFACE, DIGITE O SEGUINTE COMANDO: SUDO DHCLIENT ETH1

```
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:~$
```

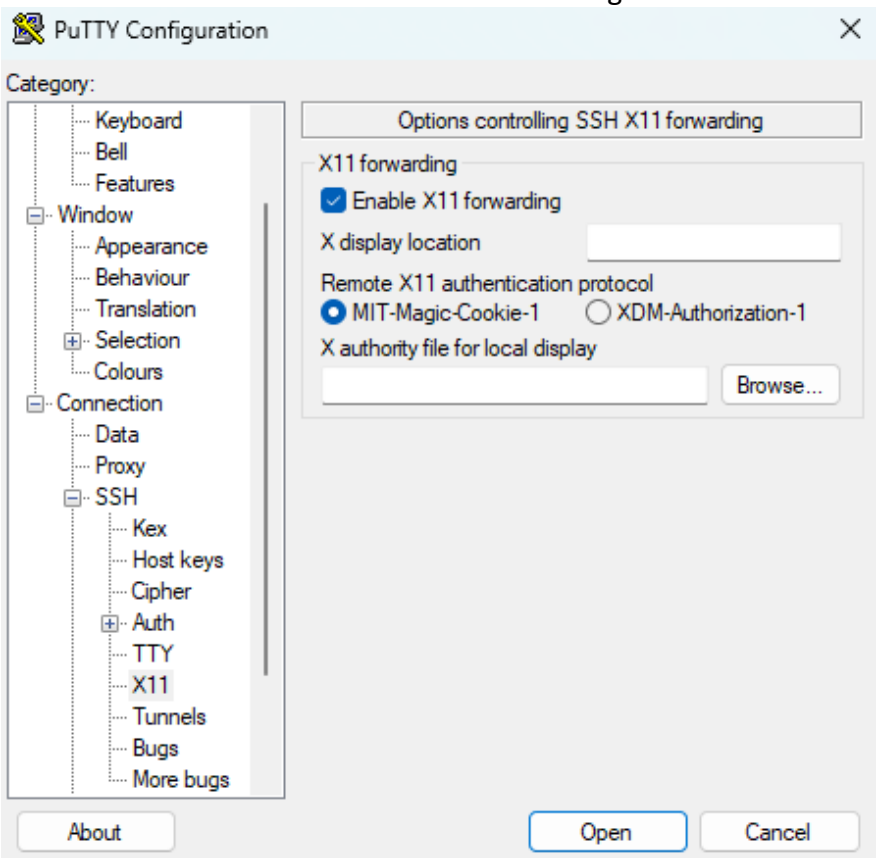


Configuração do Software PuTTY

- Inserindo o endereço IP



- Habilitando o comando Enable X11 forwarding no PuTTY

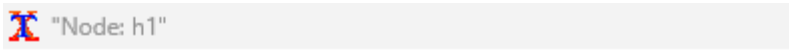


Execução do Software PuTTY:

```
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) (6.00Mb
it) (h3, s3) (6.00Mbit) (6.00Mbit) (h4, s4) (6.00Mbit) (6.00Mbit) (h5, s5) (6.00
Mbit) (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, s
5) (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) (6.0
0Mbit) (6.00Mbit) (6.00Mbit)
*** Starting CLI:
mininet>
```

Execução do Software Xming:

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




```
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)
------------------------------------------------------------
[  6] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 34244
[ 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)
------------------------------------------------------------
[  5] local 10.0.0.2 port 34244 connected with 10.0.0.1 port 5555
[ 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
root@mininet-vm:~#
```

BANDA 25 MBPS

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

"Node: h1"

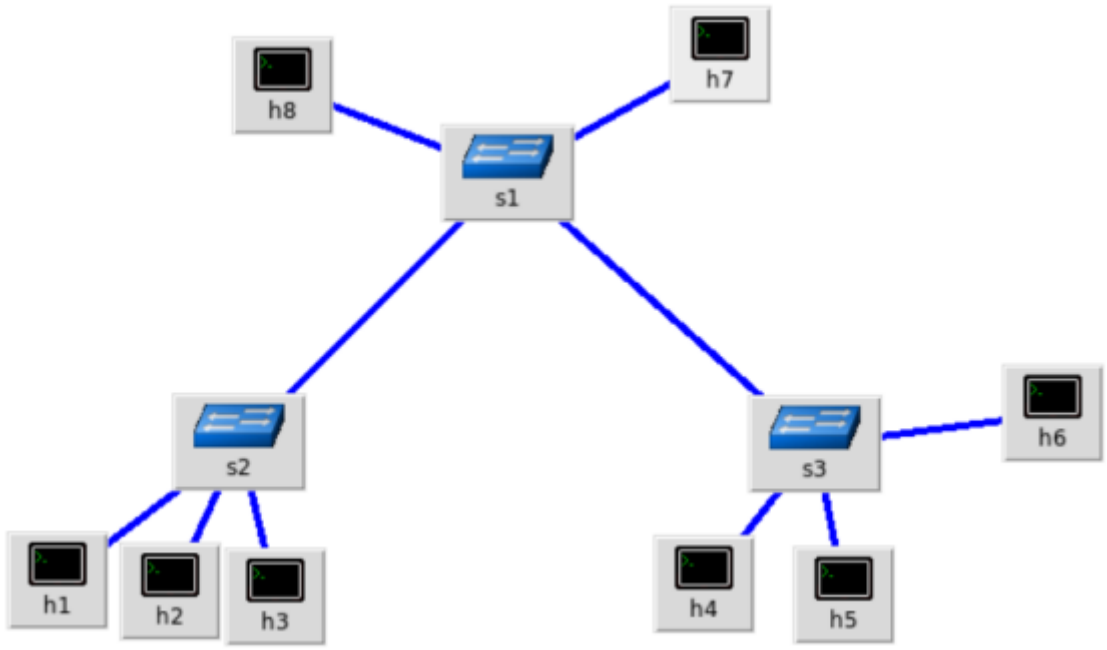
```
root@mininet-vm:~# iperf -s -p 5555 -i 1
------------------------------------------------------------
Server listening on TCP port 5555
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  6] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 34272
[ 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)
------------------------------------------------------------
[  5] local 10.0.0.2 port 34272 connected with 10.0.0.1 port 5555
[ 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
root@mininet-vm:~#
```

QUESTÃO 2

Crie um código Python para a topologia customizada abaixo:



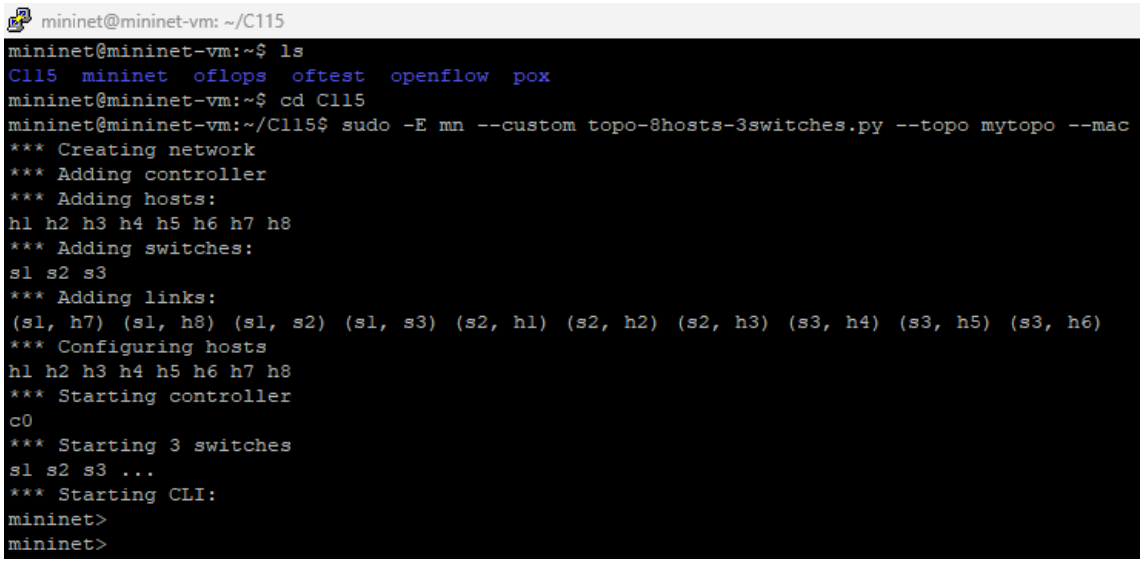
CÓDIGO PYTHON

https://github.com/Matheuwss/C115

topo-8hosts-3switches.py

```python
from mininet.topo import Topo

class MyTopo( Topo ):
    "8 hosts and 3 switches - custom topology"

    def __init__( self ):
        "Create custom topo."

        # Initialize topology
        Topo.__init__( self )

        # Add hosts and switches
        h1 = self.addHost('h1')
        h2 = self.addHost('h2')
        h3 = self.addHost('h3')
        h4 = self.addHost('h4')
        h5 = self.addHost('h5')
        h6 = self.addHost('h6')
        h7 = self.addHost('h7')
        h8 = self.addHost('h8')
        s1 = self.addSwitch('s1')
        s2 = self.addSwitch('s2')
        s3 = self.addSwitch('s3')

        # Add links
        self.addLink(s1, s2)
        self.addLink(s1, s3)
        self.addLink(s1, h7)
        self.addLink(s1, h8)

        self.addLink(s2, h1)
        self.addLink(s2, h2)
        self.addLink(s2, h3)

        self.addLink(s3, h4)
        self.addLink(s3, h5)
        self.addLink(s3, h6)

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.



b) Inspecione 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
```

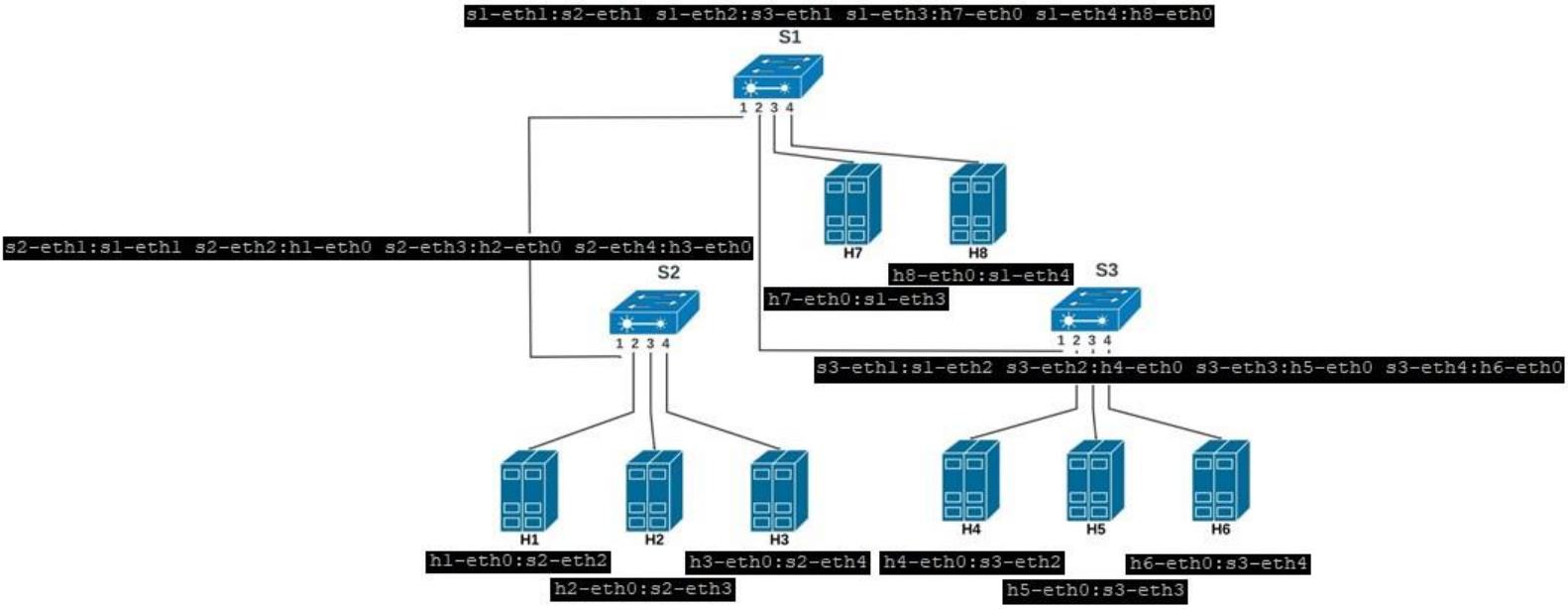
HOSTS 7, 8

```
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.

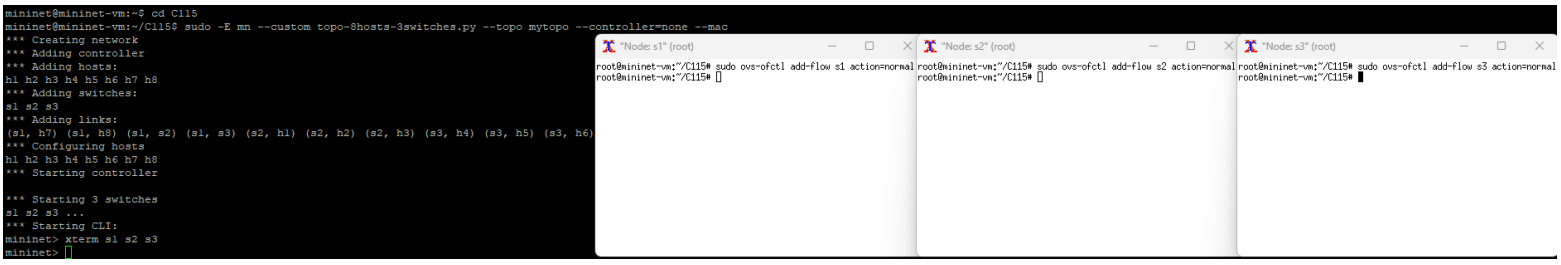
Linhas de comando:

xterm s1 s2 s3

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

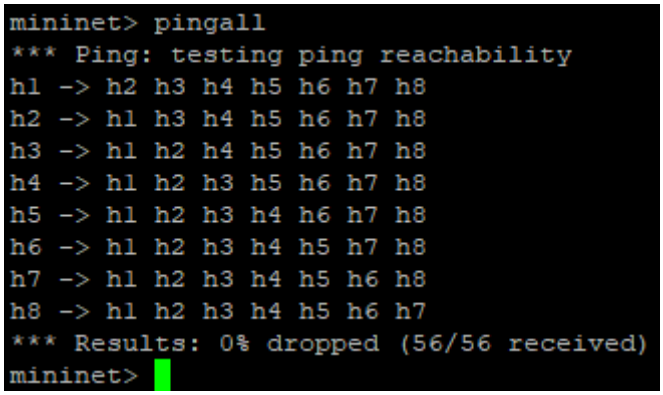
S2: sudo ovs-ofctl add-flow s2 action=normal

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



Teste de ping

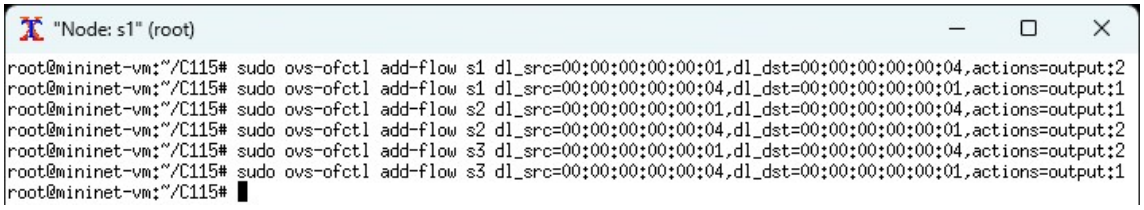
Comando: pingall



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)



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