

Trabalho final Mininet – C115

1) Considere uma topologia árvore com profundidade três e ramificação cinco

a) Com uso de linha de comando padrão do Mininet, crie a topologia considerando o endereço MAC padronizado, larguras de banda bw de 30 Mbps e controlador do Mininet (não precisa especificar)

[illegible]

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

1 - Dump

```
mininet@mininet-vm: ~  
*** Starting CLI:  
mininet> dump  
<Host h1: h1-eth0:10.0.0.1 pid=1856>  
<Host h2: h2-eth0:10.0.0.2 pid=1858>  
<Host h3: h3-eth0:10.0.0.3 pid=1860>  
<Host h4: h4-eth0:10.0.0.4 pid=1862>  
<Host h5: h5-eth0:10.0.0.5 pid=1864>  
<Host h6: h6-eth0:10.0.0.6 pid=1866>  
<Host h7: h7-eth0:10.0.0.7 pid=1868>  
<Host h8: h8-eth0:10.0.0.8 pid=1870>  
<Host h9: h9-eth0:10.0.0.9 pid=1872>  
<Host h10: h10-eth0:10.0.0.10 pid=1874>  
<Host h11: h11-eth0:10.0.0.11 pid=1876>  
<Host h12: h12-eth0:10.0.0.12 pid=1878>  
<Host h13: h13-eth0:10.0.0.13 pid=1880>  
<Host h14: h14-eth0:10.0.0.14 pid=1882>  
<Host h15: h15-eth0:10.0.0.15 pid=1884>  
<Host h16: h16-eth0:10.0.0.16 pid=1886>  
<Host h17: h17-eth0:10.0.0.17 pid=1888>  
<Host h18: h18-eth0:10.0.0.18 pid=1890>  
<Host h19: h19-eth0:10.0.0.19 pid=1892>  
<Host h20: h20-eth0:10.0.0.20 pid=1894>  
<Host h21: h21-eth0:10.0.0.21 pid=1896>  
<Host h22: h22-eth0:10.0.0.22 pid=1898>  
<Host h23: h23-eth0:10.0.0.23 pid=1900>  
<Host h24: h24-eth0:10.0.0.24 pid=1902>  
<Host h25: h25-eth0:10.0.0.25 pid=1904>  
<Host h26: h26-eth0:10.0.0.26 pid=1906>  
<Host h27: h27-eth0:10.0.0.27 pid=1908>  
<Host h28: h28-eth0:10.0.0.28 pid=1910>  
<Host h29: h29-eth0:10.0.0.29 pid=1912>  
<Host h30: h30-eth0:10.0.0.30 pid=1914>  
<Host h31: h31-eth0:10.0.0.31 pid=1916>  
<Host h32: h32-eth0:10.0.0.32 pid=1918>  
<Host h33: h33-eth0:10.0.0.33 pid=1920>  
<Host h34: h34-eth0:10.0.0.34 pid=1922>  
<Host h35: h35-eth0:10.0.0.35 pid=1924>  
<Host h36: h36-eth0:10.0.0.36 pid=1926>  
<Host h37: h37-eth0:10.0.0.37 pid=1928>  
<Host h38: h38-eth0:10.0.0.38 pid=1930>  
<Host h39: h39-eth0:10.0.0.39 pid=1932>  
<Host h40: h40-eth0:10.0.0.40 pid=1934>  
<Host h41: h41-eth0:10.0.0.41 pid=1936>  
<Host h42: h42-eth0:10.0.0.42 pid=1938>
```

```
mininet@mininet-vm: ~  
<Host h43: h43-eth0:10.0.0.43 pid=1940>  
<Host h44: h44-eth0:10.0.0.44 pid=1942>  
<Host h45: h45-eth0:10.0.0.45 pid=1944>  
<Host h46: h46-eth0:10.0.0.46 pid=1946>  
<Host h47: h47-eth0:10.0.0.47 pid=1948>  
<Host h48: h48-eth0:10.0.0.48 pid=1950>  
<Host h49: h49-eth0:10.0.0.49 pid=1952>  
<Host h50: h50-eth0:10.0.0.50 pid=1954>  
<Host h51: h51-eth0:10.0.0.51 pid=1956>  
<Host h52: h52-eth0:10.0.0.52 pid=1958>  
<Host h53: h53-eth0:10.0.0.53 pid=1960>  
<Host h54: h54-eth0:10.0.0.54 pid=1962>  
<Host h55: h55-eth0:10.0.0.55 pid=1964>  
<Host h56: h56-eth0:10.0.0.56 pid=1966>  
<Host h57: h57-eth0:10.0.0.57 pid=1968>  
<Host h58: h58-eth0:10.0.0.58 pid=1970>  
<Host h59: h59-eth0:10.0.0.59 pid=1972>  
<Host h60: h60-eth0:10.0.0.60 pid=1974>  
<Host h61: h61-eth0:10.0.0.61 pid=1976>  
<Host h62: h62-eth0:10.0.0.62 pid=1978>  
<Host h63: h63-eth0:10.0.0.63 pid=1980>  
<Host h64: h64-eth0:10.0.0.64 pid=1982>  
<Host h65: h65-eth0:10.0.0.65 pid=1984>  
<Host h66: h66-eth0:10.0.0.66 pid=1986>  
<Host h67: h67-eth0:10.0.0.67 pid=1988>  
<Host h68: h68-eth0:10.0.0.68 pid=1990>  
<Host h69: h69-eth0:10.0.0.69 pid=1992>  
<Host h70: h70-eth0:10.0.0.70 pid=1994>  
<Host h71: h71-eth0:10.0.0.71 pid=1996>  
<Host h72: h72-eth0:10.0.0.72 pid=1998>  
<Host h73: h73-eth0:10.0.0.73 pid=2000>  
<Host h74: h74-eth0:10.0.0.74 pid=2002>  
<Host h75: h75-eth0:10.0.0.75 pid=2004>  
<Host h76: h76-eth0:10.0.0.76 pid=2006>  
<Host h77: h77-eth0:10.0.0.77 pid=2008>  
<Host h78: h78-eth0:10.0.0.78 pid=2010>  
<Host h79: h79-eth0:10.0.0.79 pid=2012>  
<Host h80: h80-eth0:10.0.0.80 pid=2014>  
<Host h81: h81-eth0:10.0.0.81 pid=2016>  
<Host h82: h82-eth0:10.0.0.82 pid=2018>  
<Host h83: h83-eth0:10.0.0.83 pid=2020>  
<Host h84: h84-eth0:10.0.0.84 pid=2022>  
<Host h85: h85-eth0:10.0.0.85 pid=2024>  
<Host h86: h86-eth0:10.0.0.86 pid=2026>
```

```

mininet@mininet-vm: ~
<Host h87: h87-eth0:10.0.0.87 pid=2028>
<Host h88: h88-eth0:10.0.0.88 pid=2030>
<Host h89: h89-eth0:10.0.0.89 pid=2032>
<Host h90: h90-eth0:10.0.0.90 pid=2034>
<Host h91: h91-eth0:10.0.0.91 pid=2036>
<Host h92: h92-eth0:10.0.0.92 pid=2038>
<Host h93: h93-eth0:10.0.0.93 pid=2040>
<Host h94: h94-eth0:10.0.0.94 pid=2042>
<Host h95: h95-eth0:10.0.0.95 pid=2044>
<Host h96: h96-eth0:10.0.0.96 pid=2046>
<Host h97: h97-eth0:10.0.0.97 pid=2048>
<Host h98: h98-eth0:10.0.0.98 pid=2050>
<Host h99: h99-eth0:10.0.0.99 pid=2052>
<Host h100: h100-eth0:10.0.0.100 pid=2054>
<Host h101: h101-eth0:10.0.0.101 pid=2056>
<Host h102: h102-eth0:10.0.0.102 pid=2058>
<Host h103: h103-eth0:10.0.0.103 pid=2060>
<Host h104: h104-eth0:10.0.0.104 pid=2062>
<Host h105: h105-eth0:10.0.0.105 pid=2064>
<Host h106: h106-eth0:10.0.0.106 pid=2066>
<Host h107: h107-eth0:10.0.0.107 pid=2068>
<Host h108: h108-eth0:10.0.0.108 pid=2070>
<Host h109: h109-eth0:10.0.0.109 pid=2072>
<Host h110: h110-eth0:10.0.0.110 pid=2074>
<Host h111: h111-eth0:10.0.0.111 pid=2076>
<Host h112: h112-eth0:10.0.0.112 pid=2078>
<Host h113: h113-eth0:10.0.0.113 pid=2080>
<Host h114: h114-eth0:10.0.0.114 pid=2082>
<Host h115: h115-eth0:10.0.0.115 pid=2084>
<Host h116: h116-eth0:10.0.0.116 pid=2086>
<Host h117: h117-eth0:10.0.0.117 pid=2088>
<Host h118: h118-eth0:10.0.0.118 pid=2090>
<Host h119: h119-eth0:10.0.0.119 pid=2092>
<Host h120: h120-eth0:10.0.0.120 pid=2094>
<Host h121: h121-eth0:10.0.0.121 pid=2096>
<Host h122: h122-eth0:10.0.0.122 pid=2098>
<Host h123: h123-eth0:10.0.0.123 pid=2100>
<Host h124: h124-eth0:10.0.0.124 pid=2102>
<Host h125: h125-eth0:10.0.0.125 pid=2104>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None,s1-eth4:None,s1-eth5:None pid=2109>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None,s2-eth4:None,s2-eth5:None,s2-eth6:None pid=2112>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None,s3-eth4:None,s3-eth5:None,s3-eth6:None pid=2115>
<OVSSwitch s4: lo:127.0.0.1,s4-eth1:None,s4-eth2:None,s4-eth3:None,s4-eth4:None,s4-eth5:None,s4-eth6:None pid=2118>
<OVSSwitch s5: lo:127.0.0.1,s5-eth1:None,s5-eth2:None,s5-eth3:None,s5-eth4:None,s5-eth5:None,s5-eth6:None pid=2121>
<OVSSwitch s6: lo:127.0.0.1,s6-eth1:None,s6-eth2:None,s6-eth3:None,s6-eth4:None,s6-eth5:None,s6-eth6:None pid=2124>
<OVSSwitch s7: lo:127.0.0.1,s7-eth1:None,s7-eth2:None,s7-eth3:None,s7-eth4:None,s7-eth5:None,s7-eth6:None pid=2127>
<OVSSwitch s8: lo:127.0.0.1,s8-eth1:None,s8-eth2:None,s8-eth3:None,s8-eth4:None,s8-eth5:None,s8-eth6:None pid=2131>
<OVSSwitch s9: lo:127.0.0.1,s9-eth1:None,s9-eth2:None,s9-eth3:None,s9-eth4:None,s9-eth5:None,s9-eth6:None pid=2134>
<OVSSwitch s10: lo:127.0.0.1,s10-eth1:None,s10-eth2:None,s10-eth3:None,s10-eth4:None,s10-eth5:None,s10-eth6:None pid=2137>
<OVSSwitch s11: lo:127.0.0.1,s11-eth1:None,s11-eth2:None,s11-eth3:None,s11-eth4:None,s11-eth5:None,s11-eth6:None pid=2140>
<OVSSwitch s12: lo:127.0.0.1,s12-eth1:None,s12-eth2:None,s12-eth3:None,s12-eth4:None,s12-eth5:None,s12-eth6:None pid=2143>
<OVSSwitch s13: lo:127.0.0.1,s13-eth1:None,s13-eth2:None,s13-eth3:None,s13-eth4:None,s13-eth5:None,s13-eth6:None pid=2146>
<OVSSwitch s14: lo:127.0.0.1,s14-eth1:None,s14-eth2:None,s14-eth3:None,s14-eth4:None,s14-eth5:None,s14-eth6:None pid=2149>
<OVSSwitch s15: lo:127.0.0.1,s15-eth1:None,s15-eth2:None,s15-eth3:None,s15-eth4:None,s15-eth5:None,s15-eth6:None pid=2152>
<OVSSwitch s16: lo:127.0.0.1,s16-eth1:None,s16-eth2:None,s16-eth3:None,s16-eth4:None,s16-eth5:None,s16-eth6:None pid=2155>
<OVSSwitch s17: lo:127.0.0.1,s17-eth1:None,s17-eth2:None,s17-eth3:None,s17-eth4:None,s17-eth5:None,s17-eth6:None pid=2158>
<OVSSwitch s18: lo:127.0.0.1,s18-eth1:None,s18-eth2:None,s18-eth3:None,s18-eth4:None,s18-eth5:None,s18-eth6:None pid=2161>
<OVSSwitch s19: lo:127.0.0.1,s19-eth1:None,s19-eth2:None,s19-eth3:None,s19-eth4:None,s19-eth5:None,s19-eth6:None pid=2164>
<OVSSwitch s20: lo:127.0.0.1,s20-eth1:None,s20-eth2:None,s20-eth3:None,s20-eth4:None,s20-eth5:None,s20-eth6:None pid=2167>
<OVSSwitch s21: lo:127.0.0.1,s21-eth1:None,s21-eth2:None,s21-eth3:None,s21-eth4:None,s21-eth5:None,s21-eth6:None pid=2170>
<OVSSwitch s22: lo:127.0.0.1,s22-eth1:None,s22-eth2:None,s22-eth3:None,s22-eth4:None,s22-eth5:None,s22-eth6:None pid=2173>
<OVSSwitch s23: lo:127.0.0.1,s23-eth1:None,s23-eth2:None,s23-eth3:None,s23-eth4:None,s23-eth5:None,s23-eth6:None pid=2176>
<OVSSwitch s24: lo:127.0.0.1,s24-eth1:None,s24-eth2:None,s24-eth3:None,s24-eth4:None,s24-eth5:None,s24-eth6:None pid=2179>
<OVSSwitch s25: lo:127.0.0.1,s25-eth1:None,s25-eth2:None,s25-eth3:None,s25-eth4:None,s25-eth5:None,s25-eth6:None pid=2182>
<OVSSwitch s26: lo:127.0.0.1,s26-eth1:None,s26-eth2:None,s26-eth3:None,s26-eth4:None,s26-eth5:None,s26-eth6:None pid=2185>
<OVSSwitch s27: lo:127.0.0.1,s27-eth1:None,s27-eth2:None,s27-eth3:None,s27-eth4:None,s27-eth5:None,s27-eth6:None pid=2188>
<OVSSwitch s28: lo:127.0.0.1,s28-eth1:None,s28-eth2:None,s28-eth3:None,s28-eth4:None,s28-eth5:None,s28-eth6:None pid=2191>
<OVSSwitch s29: lo:127.0.0.1,s29-eth1:None,s29-eth2:None,s29-eth3:None,s29-eth4:None,s29-eth5:None,s29-eth6:None pid=2194>
<OVSSwitch s30: lo:127.0.0.1,s30-eth1:None,s30-eth2:None,s30-eth3:None,s30-eth4:None,s30-eth5:None,s30-eth6:None pid=2197>
<OVSSwitch s31: lo:127.0.0.1,s31-eth1:None,s31-eth2:None,s31-eth3:None,s31-eth4:None,s31-eth5:None,s31-eth6:None pid=2200>
<Controller c0: 127.0.0.1:6653 pid=1849>
mininet>

```

2 – h1 config -a

```

mininet> h1 ifconfig -a
h1-eth0  Link encap:Ethernet  HWaddr 00:00:00:00:00:01
         inet addr:10.0.0.1  Bcast:10.0.255.255  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>

```

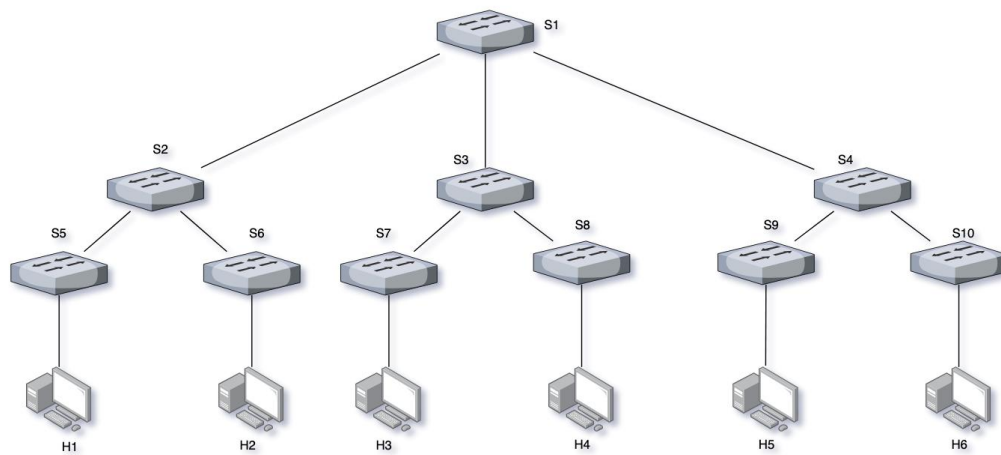
3 – sh ovs-ofctl show s1

```

mininet> sh ovs-ofctl show s1
OFPST_FEATURES_REPLY (xid=0x2): dpid:0000000000000001
n_tables:254, n_buffers:256
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS ARP_MATCH_IP
actions: OUTPUT SET_VLAN_VID SET_VLAN_PCP STRIP_VLAN SET_DL_SRC SET_DL_DST SET_NW_SRC SET_NW_DST SET_NW_TOS SET_TP_SRC SET_TP_DST ENQUEUE
1(s1-eth1): addr:5a:d6:cca1:ab:47
  config:
    state: 0
    current: 10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
2(s1-eth2): addr:62:fa:c1:71:f5:38
  config:
    state: 0
    current: 10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
3(s1-eth3): addr:9a:8c:fe:a5:d1:68
  config:
    state: 0
    current: 10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
4(s1-eth4): addr:d2:69:3a:32:23:bb
  config:
    state: 0
    current: 10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
5(s1-eth5): addr:9e:16:c7:53:ce:6e
  config:
    state: 0
    current: 10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
LOCAL(s1): addr:96:3e:de:02:0a:4c
  config:
    state: 0
    speed: 0 Mbps now, 0 Mbps max
OFPST_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
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.

```
mininet> xterm h2 mininet> xterm h3
```

```
"Node: h2"
root@mininet-vm:~# tcpdump -XX -n -i h2-eth0
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on h2-eth0, link-type EN10MB (Ethernet), capture size 262144 bytes
[]

"Node: h3"
root@mininet-vm:~# tcpdump -XX -n -i h3-eth0
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on h3-eth0, link-type EN10MB (Ethernet), capture size 262144 bytes
[]
```



```

mininet> h2 ping h3
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=23.0 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=11.5 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.138 ms
64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.127 ms
64 bytes from 10.0.0.3: icmp_seq=5 ttl=64 time=0.137 ms
64 bytes from 10.0.0.3: icmp_seq=6 ttl=64 time=0.084 ms
64 bytes from 10.0.0.3: icmp_seq=7 ttl=64 time=3.77 ms
64 bytes from 10.0.0.3: icmp_seq=8 ttl=64 time=0.097 ms
64 bytes from 10.0.0.3: icmp_seq=9 ttl=64 time=0.070 ms
64 bytes from 10.0.0.3: icmp_seq=10 ttl=64 time=0.144 ms
64 bytes from 10.0.0.3: icmp_seq=11 ttl=64 time=0.153 ms
64 bytes from 10.0.0.3: icmp_seq=12 ttl=64 time=0.167 ms
64 bytes from 10.0.0.3: icmp_seq=13 ttl=64 time=0.105 ms
64 bytes from 10.0.0.3: icmp_seq=14 ttl=64 time=0.091 ms
64 bytes from 10.0.0.3: icmp_seq=15 ttl=64 time=0.073 ms
64 bytes from 10.0.0.3: icmp_seq=16 ttl=64 time=0.072 ms
64 bytes from 10.0.0.3: icmp_seq=17 ttl=64 time=0.094 ms
64 bytes from 10.0.0.3: icmp_seq=18 ttl=64 time=0.073 ms
64 bytes from 10.0.0.3: icmp_seq=19 ttl=64 time=0.135 ms
64 bytes from 10.0.0.3: icmp_seq=20 ttl=64 time=0.098 ms
64 bytes from 10.0.0.3: icmp_seq=21 ttl=64 time=0.070 ms
64 bytes from 10.0.0.3: icmp_seq=22 ttl=64 time=0.077 ms
64 bytes from 10.0.0.3: icmp_seq=23 ttl=64 time=0.095 ms
64 bytes from 10.0.0.3: icmp_seq=24 ttl=64 time=0.101 ms
64 bytes from 10.0.0.3: icmp_seq=25 ttl=64 time=0.085 ms
64 bytes from 10.0.0.3: icmp_seq=26 ttl=64 time=0.052 ms
64 bytes from 10.0.0.3: icmp_seq=27 ttl=64 time=0.094 ms
64 bytes from 10.0.0.3: icmp_seq=28 ttl=64 time=0.141 ms
64 bytes from 10.0.0.3: icmp_seq=29 ttl=64 time=0.046 ms
64 bytes from 10.0.0.3: icmp_seq=30 ttl=64 time=0.048 ms
64 bytes from 10.0.0.3: icmp_seq=31 ttl=64 time=0.066 ms
64 bytes from 10.0.0.3: icmp_seq=32 ttl=64 time=0.298 ms
64 bytes from 10.0.0.3: icmp_seq=33 ttl=64 time=0.056 ms
64 bytes from 10.0.0.3: icmp_seq=34 ttl=64 time=0.070 ms
64 bytes from 10.0.0.3: icmp_seq=35 ttl=64 time=0.095 ms
64 bytes from 10.0.0.3: icmp_seq=36 ttl=64 time=0.062 ms
64 bytes from 10.0.0.3: icmp_seq=37 ttl=64 time=0.151 ms
64 bytes from 10.0.0.3: icmp_seq=38 ttl=64 time=0.098 ms
^C
--- 10.0.0.3 ping statistics ---
38 packets transmitted, 38 received, 0% packet loss, time 37012ms
rtt min/avg/max/mdev = 0.046/1.104/23.073/4.084 ms

```

The image shows two side-by-side packet capture windows. The left window is titled "Node: h2" and the right window is titled "Node: h3". Both windows display a list of captured packets. The packets are ICMP echo requests and replies between 10.0.0.2 and 10.0.0.3. The packets are numbered 1 through 38. The left window shows the first 38 packets, and the right window shows the same 38 packets. The packets are captured on the interface eth0. The left window shows the first 38 packets, and the right window shows the same 38 packets. The packets are captured on the interface eth0. The left window shows the first 38 packets, and the right window shows the same 38 packets. The packets are captured on the interface eth0.

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 30 e 40 Mbps (Necessário reconstruir a topologia para os outros valores).

```
mininet> xterm h1
mininet> xterm h2
mininet>
```

```

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

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

[320] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 4422
[320]  Interval:           Transfer           Bandwidth
[320]  0.0- 1.0 sec      3.30 MBytes      30.4 Mbits/sec
[320]  1.0- 2.0 sec      3.28 MBytes      27.5 Mbits/sec
[320]  2.0- 3.0 sec      3.24 MBytes      27.2 Mbits/sec
[320]  3.0- 4.0 sec      3.24 MBytes      27.2 Mbits/sec
[320]  4.0- 5.0 sec      3.14 MBytes      26.3 Mbits/sec
[320]  5.0- 6.0 sec      3.26 MBytes      27.4 Mbits/sec
[320]  6.0- 7.0 sec      3.27 MBytes      27.4 Mbits/sec
[320]  7.0- 8.0 sec      3.26 MBytes      27.3 Mbits/sec
[320]  8.0- 9.0 sec      3.23 MBytes      27.1 Mbits/sec
[320]  9.0-10.0 sec      3.25 MBytes      27.2 Mbits/sec
[320] 10.0-11.0 sec      3.23 MBytes      27.6 Mbits/sec
[320] 11.0-12.0 sec      3.25 MBytes      27.2 Mbits/sec
[320] 12.0-13.0 sec      3.28 MBytes      27.5 Mbits/sec
[320] 13.0-14.0 sec      3.25 MBytes      27.2 Mbits/sec
[320] 14.0-15.0 sec      3.28 MBytes      27.5 Mbits/sec
[320] 0.0-15.3 sec      49.9 MBytes      27.3 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: 85.3 KByte (default)

[319] local 10.0.0.2 port 4422 connected with 10.0.0.1 port 5555
[319]  Interval:           Transfer           Bandwidth
[319]  0.0- 1.0 sec      3.62 MBytes      30.4 Mbits/sec
[319]  1.0- 2.0 sec      3.38 MBytes      28.3 Mbits/sec
[319]  2.0- 3.0 sec      3.25 MBytes      27.3 Mbits/sec
[319]  3.0- 4.0 sec      3.38 MBytes      28.3 Mbits/sec
[319]  4.0- 5.0 sec      3.12 MBytes      26.2 Mbits/sec
[319]  5.0- 6.0 sec      3.12 MBytes      26.2 Mbits/sec
[319]  6.0- 7.0 sec      3.38 MBytes      28.3 Mbits/sec
[319]  7.0- 8.0 sec      3.12 MBytes      26.2 Mbits/sec
[319]  8.0- 9.0 sec      3.38 MBytes      28.3 Mbits/sec
[319]  9.0-10.0 sec      3.25 MBytes      27.3 Mbits/sec
[319] 10.0-11.0 sec      3.25 MBytes      27.3 Mbits/sec
[319] 11.0-12.0 sec      3.25 MBytes      27.3 Mbits/sec
[319] 12.0-13.0 sec      3.38 MBytes      28.3 Mbits/sec
[319] 13.0-14.0 sec      3.12 MBytes      26.2 Mbits/sec
[319] 14.0-15.0 sec      3.38 MBytes      28.3 Mbits/sec
[319] 0.0-15.2 sec      49.9 MBytes      27.5 Mbits/sec
root@mininet-vm:~#

```

```

mininet@mininet-vm:~$ sudo mn --topo tree,depth=3,fanout=5 --mac --link tc,bw=40
*** Creating network
*** Adding controller
*** Adding hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16 h17 h18 h19 h20 h21 h22 h23 h24 h25 h26 h27 h28 h29 h30 h31 h32 h33 h34 h35 h36 h37 h38 h39 h40 h41 h42
h43 h44 h45 h46 h47 h48 h49 h50 h51 h52 h53 h54 h55 h56 h57 h58 h59 h60 h61 h62 h63 h64 h65 h66 h67 h68 h69 h70 h71 h72 h73 h74 h75 h76 h77 h78 h79 h80 h81
h82 h83 h84 h85 h86 h87 h88 h89 h90 h91 h92 h93 h94 h95 h96 h97 h98 h99 h100 h101 h102 h103 h104 h105 h106 h107 h108 h109 h110 h111 h112 h113 h114 h115 h116
h117 h118 h119 h120 h121 h122 h123 h124 h125
*** Adding links
s1 s2 s3 s4 s5 s6 s7 s8 s9 s10 s11 s12 s13 s14 s15 s16 s17 s18 s19 s20 s21 s22 s23 s24 s25 s26 s27 s28 s29 s30 s31
*** Adding links
(40.0Gbit) (40.0Gbit) (s1, s2) (40.0Gbit) (40.0Gbit) (s1, s8) (40.0Gbit) (40.0Gbit) (s1, s14) (40.0Gbit) (40.0Gbit) (s1, s20) (40.0Gbit) (40.0Gbit) (s1, s26) (40.0Gbit) (s1, s32) (40.0Gbit) (s2, s3) (40.0Gbit) (s2, s4) (40.0Gbit) (40.0Gbit) (s2, s9) (40.0Gbit) (s2, s15) (40.0Gbit) (s2, s21) (40.0Gbit) (s2, s27) (40.0Gbit) (s2, s33) (40.0Gbit) (s3, s4) (40.0Gbit) (s3, s5) (40.0Gbit) (40.0Gbit) (s3, s10) (40.0Gbit) (40.0Gbit) (s3, s16) (40.0Gbit) (40.0Gbit) (s3, s22) (40.0Gbit) (40.0Gbit) (s3, s28) (40.0Gbit) (40.0Gbit) (s3, s34) (40.0Gbit) (s4, s5) (40.0Gbit) (40.0Gbit) (s4, s6) (40.0Gbit) (40.0Gbit) (40.0Gbit) (s4, s11) (40.0Gbit) (40.0Gbit) (40.0Gbit) (s4, s17) (40.0Gbit) (40.0Gbit) (s4, s23) (40.0Gbit) (40.0Gbit) (s4, s29) (40.0Gbit) (40.0Gbit) (s4, s35) (40.0Gbit) (s5, s6) (40.0Gbit) (40.0Gbit) (s5, s12) (40.0Gbit) (40.0Gbit) (s5, s18) (40.0Gbit) (40.0Gbit) (s5, s24) (40.0Gbit) (40.0Gbit) (s5, s30) (40.0Gbit) (40.0Gbit) (s5, s36) (40.0Gbit) (s6, s7) (40.0Gbit) (40.0Gbit) (s6, s13) (40.0Gbit) (40.0Gbit) (s6, s19) (40.0Gbit) (40.0Gbit) (s6, s25) (40.0Gbit) (40.0Gbit) (s6, s31) (40.0Gbit) (s7, s8) (40.0Gbit) (40.0Gbit) (s7, s14) (40.0Gbit) (40.0Gbit) (s7, s20) (40.0Gbit) (40.0Gbit) (s7, s26) (40.0Gbit) (40.0Gbit) (s7, s32) (40.0Gbit) (s8, s9) (40.0Gbit) (40.0Gbit) (s8, s15) (40.0Gbit) (40.0Gbit) (s8, s21) (40.0Gbit) (40.0Gbit) (s8, s27) (40.0Gbit) (40.0Gbit) (s8, s33) (40.0Gbit) (s9, s10) (40.0Gbit) (40.0Gbit) (s9, s16) (40.0Gbit) (40.0Gbit) (s9, s22) (40.0Gbit) (40.0Gbit) (s9, s28) (40.0Gbit) (40.0Gbit) (s9, s34) (40.0Gbit) (s10, s11) (40.0Gbit) (40.0Gbit) (s10, s17) (40.0Gbit) (40.0Gbit) (s10, s23) (40.0Gbit) (40.0Gbit) (s10, s29) (40.0Gbit) (40.0Gbit) (s10, s35) (40.0Gbit) (s11, s12) (40.0Gbit) (40.0Gbit) (s11, s18) (40.0Gbit) (40.0Gbit) (s11, s24) (40.0Gbit) (40.0Gbit) (s11, s30) (40.0Gbit) (s12, s13) (40.0Gbit) (40.0Gbit) (s12, h2) (40.0Gbit) (40.0Gbit) (s12, h8) (40.0Gbit) (40.0Gbit) (s12, h14) (40.0Gbit) (40.0Gbit) (s12, h20) (40.0Gbit) (40.0Gbit) (s12, h26) (40.0Gbit) (40.0Gbit) (s12, h32) (40.0Gbit) (40.0Gbit) (s12, h38) (40.0Gbit) (40.0Gbit) (s12, h44) (40.0Gbit) (40.0Gbit) (s12, h50) (40.0Gbit) (40.0Gbit) (s12, h56) (40.0Gbit) (40.0Gbit) (s12, h62) (40.0Gbit) (40.0Gbit) (s12, h68) (40.0Gbit) (40.0Gbit) (s12, h74) (40.0Gbit) (40.0Gbit) (s12, h80) (40.0Gbit) (40.0Gbit) (s12, h86) (40.0Gbit) (40.0Gbit) (s12, h92) (40.0Gbit) (40.0Gbit) (s12, h98) (40.0Gbit) (40.0Gbit) (s12, h104) (40.0Gbit) (40.0Gbit) (s12, h110) (40.0Gbit) (40.0Gbit) (s12, h116) (40.0Gbit) (40.0Gbit) (s12, h122) (40.0Gbit) (40.0Gbit) (s12, h128) (40.0Gbit) (40.0Gbit) (s12, h134) (40.0Gbit) (40.0Gbit) (s12, h140) (40.0Gbit) (40.0Gbit) (s12, h146) (40.0Gbit) (40.0Gbit) (s12, h152) (40.0Gbit) (40.0Gbit) (s12, h158) (40.0Gbit) (40.0Gbit) (s12, h164) (40.0Gbit) (40.0Gbit) (s12, h170) (40.0Gbit) (40.0Gbit) (s12, h176) (40.0Gbit) (40.0Gbit) (s12, h182) (40.0Gbit) (40.0Gbit) (s12, h188) (40.0Gbit) (40.0Gbit) (s12, h194) (40.0Gbit) (40.0Gbit) (s12, h200) (40.0Gbit) (40.0Gbit) (s12, h206) (40.0Gbit) (40.0Gbit) (s12, h212) (40.0Gbit) (40.0Gbit) (s12, h218) (40.0Gbit) (40.0Gbit) (s12, h224) (40.0Gbit) (40.0Gbit) (s12, h230) (40.0Gbit) (40.0Gbit) (s12, h236) (40.0Gbit) (40.0Gbit) (s12, h242) (40.0Gbit) (40.0Gbit) (s12, h248) (40.0Gbit) (40.0Gbit) (s12, h254) (40.0Gbit) (40.0Gbit) (s12, h260) (40.0Gbit) (40.0Gbit) (s12, h266) (40.0Gbit) (40.0Gbit) (s12, h272) (40.0Gbit) (40.0Gbit) (s12, h278) (40.0Gbit) (40.0Gbit) (s12, h284) (40.0Gbit) (40.0Gbit) (s12, h290) (40.0Gbit) (40.0Gbit) (s12, h296) (40.0Gbit) (40.0Gbit) (s12, h302) (40.0Gbit) (40.0Gbit) (s12, h308) (40.0Gbit) (40.0Gbit) (s12, h314) (40.0Gbit) (40.0Gbit) (s12, h320) (40.0Gbit) (40.0Gbit) (s12, h326) (40.0Gbit) (40.0Gbit) (s12, h332) (40.0Gbit) (40.0Gbit) (s12, h338) (40.0Gbit) (40.0Gbit) (s12, h344) (40.0Gbit) (40.0Gbit) (s12, h350) (40.0Gbit) (40.0Gbit) (s12, h356) (40.0Gbit) (40.0Gbit) (s12, h362) (40.0Gbit) (40.0Gbit) (s12, h368) (40.0Gbit) (40.0Gbit) (s12, h374) (40.0Gbit) (40.0Gbit) (s12, h380) (40.0Gbit) (40.0Gbit) (s12, h386) (40.0Gbit) (40.0Gbit) (s12, h392) (40.0Gbit) (40.0Gbit) (s12, h398) (40.0Gbit) (40.0Gbit) (s12, h404) (40.0Gbit) (40.0Gbit) (s12, h410) (40.0Gbit) (40.0Gbit) (s12, h416) (40.0Gbit) (40.0Gbit) (s12, h422) (40.0Gbit) (40.0Gbit) (s12, h428) (40.0Gbit) (40.0Gbit) (s12, h434) (40.0Gbit) (40.0Gbit) (s12, h440) (40.0Gbit) (40.0Gbit) (s12, h446) (40.0Gbit) (40.0Gbit) (s12, h452) (40.0Gbit) (40.0Gbit) (s12, h458) (40.0Gbit) (40.0Gbit) (s12, h464) (40.0Gbit) (40.0Gbit) (s12, h470) (40.0Gbit) (40.0Gbit) (s12, h476) (40.0Gbit) (40.0Gbit) (s12, h482) (40.0Gbit) (40.0Gbit) (s12, h488) (40.0Gbit) (40.0Gbit) (s12, h494) (40.0Gbit) (40.0Gbit) (s12, h500) (40.0Gbit) (4
```

[illegible]

```

"Node: h1"
root@mininet-vm:~# iperf -s -p 5555 -i 1
-----
Server listening on TCP port 5555
TCP window size: 85,3 KByte (default)
-----
[320] local 10.0.0.1 port 5555 connected with 10.0.0.2 port 44468
[ ID] Interval      Transfer    Bandwidth
[320] 0.0- 1.0 sec  4.30 MBytes 36.1 Mbits/sec
[320] 1.0- 2.0 sec  4.32 MBytes 36.2 Mbits/sec
[320] 2.0- 3.0 sec  4.30 MBytes 36.1 Mbits/sec
[320] 3.0- 4.0 sec  4.32 MBytes 36.3 Mbits/sec
[320] 4.0- 5.0 sec  4.13 MBytes 35.2 Mbits/sec
[320] 5.0- 6.0 sec  4.40 MBytes 36.9 Mbits/sec
[320] 6.0- 7.0 sec  4.33 MBytes 36.4 Mbits/sec
[320] 7.0- 8.0 sec  4.31 MBytes 36.2 Mbits/sec
[320] 8.0- 9.0 sec  4.29 MBytes 36.0 Mbits/sec
[320] 9.0-10.0 sec  4.33 MBytes 36.3 Mbits/sec
[320] 10.0-11.0 sec 4.33 MBytes 36.4 Mbits/sec
[320] 11.0-12.0 sec 4.30 MBytes 36.1 Mbits/sec
[320] 12.0-13.0 sec 4.31 MBytes 36.2 Mbits/sec
[320] 13.0-14.0 sec 4.31 MBytes 36.2 Mbits/sec
[320] 14.0-15.0 sec 4.24 MBytes 35.6 Mbits/sec
[320] 0.0-15.5 sec 66.9 MBytes 36.1 Mbits/sec

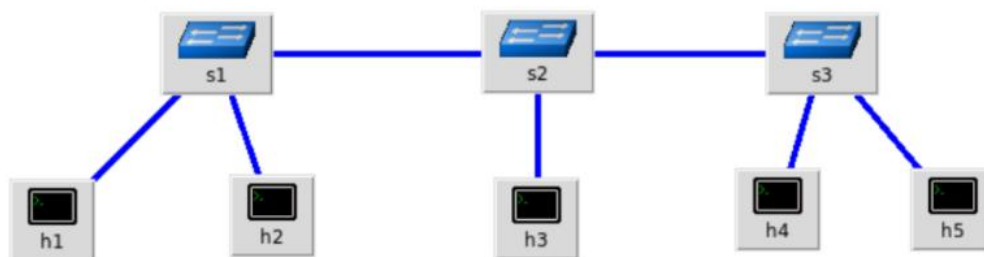
```

```

"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: 85,3 KByte (default)
-----
[319] local 10.0.0.2 port 44468 connected with 10.0.0.1 port 5555
[ ID] Interval      Transfer    Bandwidth
[319] 0.0- 1.0 sec  4.88 MBytes 40.9 Mbits/sec
[319] 1.0- 2.0 sec  4.25 MBytes 35.7 Mbits/sec
[319] 2.0- 3.0 sec  4.50 MBytes 37.7 Mbits/sec
[319] 3.0- 4.0 sec  4.12 MBytes 34.6 Mbits/sec
[319] 4.0- 5.0 sec  4.25 MBytes 35.7 Mbits/sec
[319] 5.0- 6.0 sec  4.50 MBytes 37.7 Mbits/sec
[319] 6.0- 7.0 sec  4.25 MBytes 35.7 Mbits/sec
[319] 7.0- 8.0 sec  4.38 MBytes 36.7 Mbits/sec
[319] 8.0- 9.0 sec  4.38 MBytes 36.7 Mbits/sec
[319] 9.0-10.0 sec 4.38 MBytes 36.7 Mbits/sec
[319] 10.0-11.0 sec 4.38 MBytes 36.7 Mbits/sec
[319] 11.0-12.0 sec 4.25 MBytes 35.7 Mbits/sec
[319] 12.0-13.0 sec 4.38 MBytes 36.7 Mbits/sec
[319] 13.0-14.0 sec 4.38 MBytes 36.7 Mbits/sec
[319] 14.0-15.0 sec 4.00 MBytes 33.6 Mbits/sec
^C[319] 0.0-15.4 sec 66.9 MBytes 36.5 Mbits/sec

```

2) Crie um código Python para a topologia customizada abaixo:



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:~/trabalho$ sudo python TrabalhoMininet-final.py
*** Creating network
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3
*** Adding links:
(h1, s1) (h2, s1) (h3, s2) (h4, s3) (h5, s3) (s1, s2) (s2, s3)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller

*** Starting 3 switches
s1 s2 s3 ...

```

b - Inspeccione informações das interfaces, endereços MAC, IP e portas através de linhas de comando;

```

mininet> nodes
available nodes are:
h1 h2 h3 h4 h5 s1 s2 s3

```

```

mininet> net
h1 h1-eth0:s1-eth1
h2 h2-eth0:s1-eth2
h3 h3-eth0:s2-eth1
h4 h4-eth0:s3-eth1
h5 h5-eth0:s3-eth2
s1 lo: s1-eth1:h1-eth0 s1-eth2:h2-eth0 s1-eth3:s2-eth2
s2 lo: s2-eth1:h3-eth0 s2-eth2:s1-eth3 s2-eth3:s3-eth3
s3 lo: s3-eth1:h4-eth0 s3-eth2:h5-eth0 s3-eth3:s2-eth3

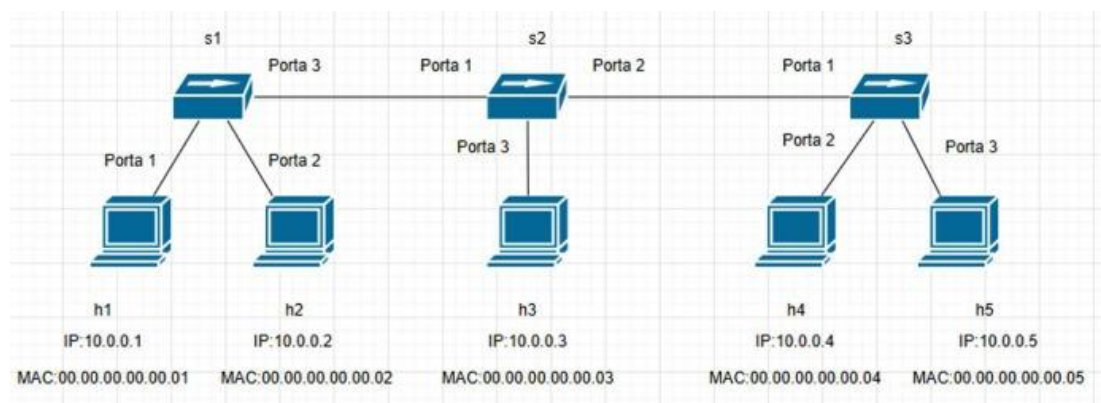
```

```

mininet> dump
<Host h1: h1-eth0:10.0.0.1 pid=3511>
<Host h2: h2-eth0:10.0.0.2 pid=3513>
<Host h3: h3-eth0:10.0.0.3 pid=3515>
<Host h4: h4-eth0:10.0.0.4 pid=3517>
<Host h5: h5-eth0:10.0.0.5 pid=3519>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None pid=3524>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None pid=3527>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None pid=3530>

```

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



d - Faça testes de ping considerando os switches normais;

```

=== Testando conectividade (ping all) ===
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)

```


e - Apague as regras anteriores e crie regras baseadas em endereços MAC para alguns nós.

```
mininet> sh ovs-ofctl del-flows s1
mininet> sh ovs-ofctl del-flows s2
mininet> sh ovs-ofctl del-flows s3

mininet> sh ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:03,actions=output:3
mininet> sh ovs-ofctl add-flow s2 dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:03,actions=output:1
mininet> sh ovs-ofctl add-flow s2 dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:01,actions=output:2
mininet> sh ovs-ofctl add-flow s1 dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:01,actions=output:1
```

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

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> X h3 X X
h2 -> X X X X
h3 -> h1 X X X
h4 -> X X X X
h5 -> X X X X
*** Results: 90% dropped (2/20 received)
```