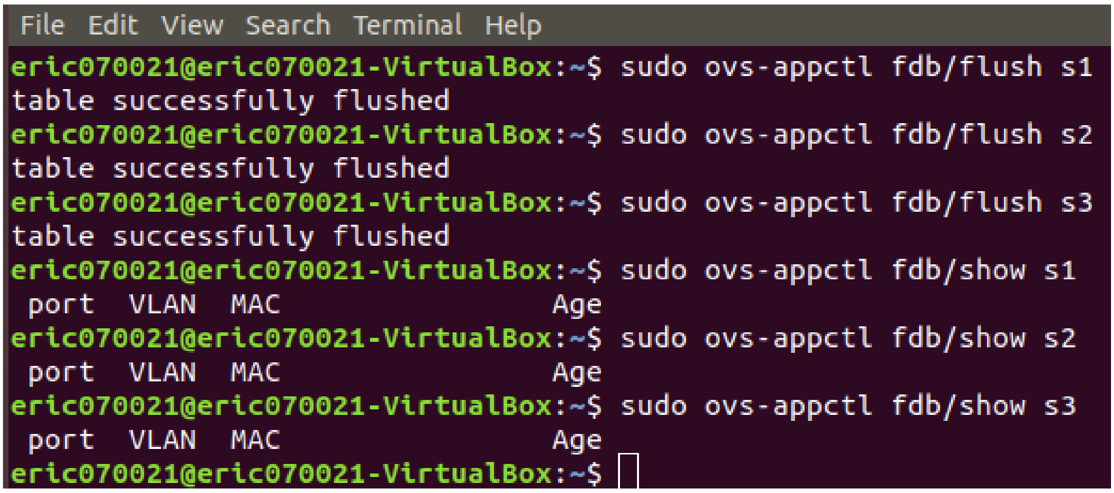
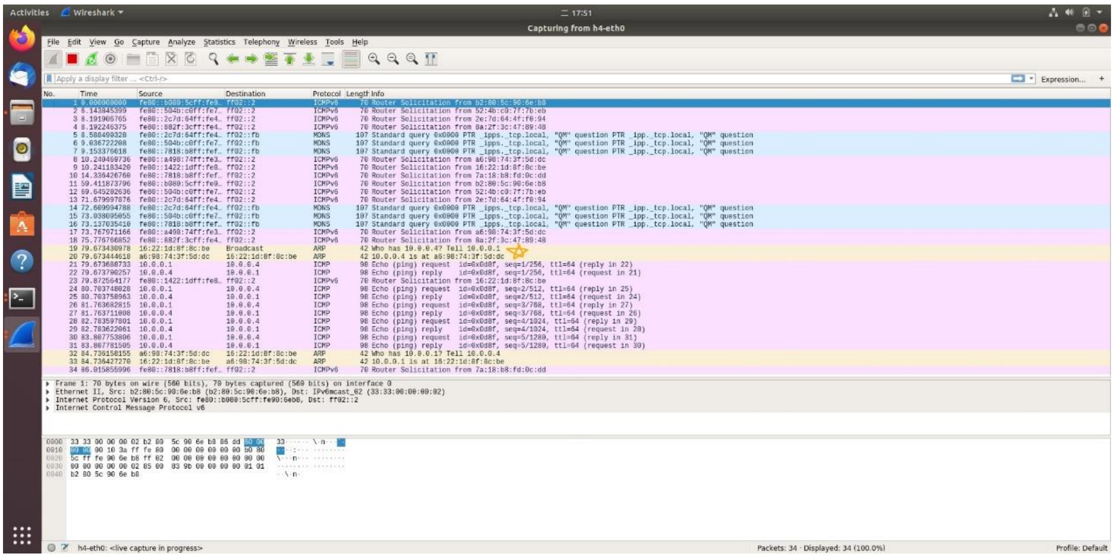
Part1: A Tree Topology

1.



```
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s1
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s2
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s3
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s1
 port  VLAN  MAC                Age
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s2
 port  VLAN  MAC                Age
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s3
 port  VLAN  MAC                Age
eric070021@eric070021-VirtualBox:~$ 
```

2.

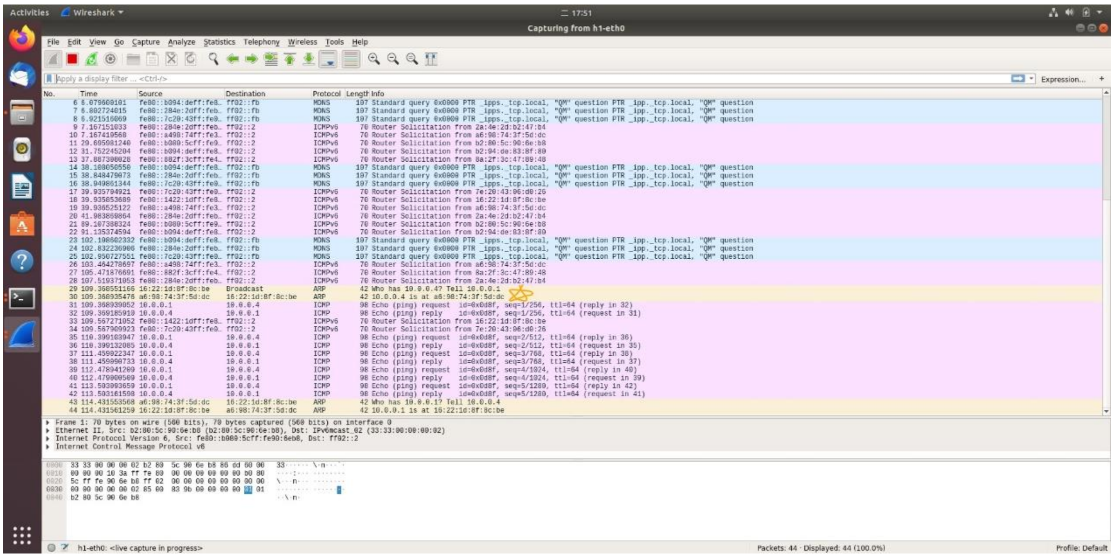


Activities
Wireshark
17:51
Capturing from h4-eth0
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...

```
No.  Time          Source                 Destination        Protocol Length Info
   1 0.000000000   fe80::b080:5cff:fe9…   ff02::2            ICMPv6    70 Router Solicitation from b2:80:5c:90:6e:b8
   2 6.143845399   fe80::504b:c0ff:fe7…   ff02::2            ICMPv6    70 Router Solicitation from 52:4b:c0:7f:7b:eb
   3 8.191906765   fe80::2c7d:64ff:fe4…   ff02::2            ICMPv6    70 Router Solicitation from 2e:7d:64:4f:f0:94
   4 8.192246375   fe80::882f:3cff:fe4…   ff02::2            ICMPv6    70 Router Solicitation from 8a:2f:3c:47:89:48
   5 8.588490328   fe80::2c7d:64ff:fe4…   ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
   6 9.036722208   fe80::504b:c0ff:fe7…   ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
   7 9.153376618   fe80::7818:b8ff:fef…   ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
   8 10.240469736  fe80::a498:74ff:fe3…   ff02::2            ICMPv6    70 Router Solicitation from a6:98:74:3f:5d:dc
   9 10.241183420  fe80::1422:1dff:fe8…   ff02::2            ICMPv6    70 Router Solicitation from 16:22:1d:8f:8c:be
  10 14.336426760  fe80::7818:b8ff:fef…   ff02::2            ICMPv6    70 Router Solicitation from 7a:18:b8:fd:0c:dd
  11 59.411873796  fe80::b080:5cff:fe9…   ff02::2            ICMPv6    70 Router Solicitation from b2:80:5c:90:6e:b8
  12 69.645202636  fe80::504b:c0ff:fe7…   ff02::2            ICMPv6    70 Router Solicitation from 52:4b:c0:7f:7b:eb
  13 71.679997876  fe80::2c7d:64ff:fe4…   ff02::2            ICMPv6    70 Router Solicitation from 2e:7d:64:4f:f0:94
  14 72.809994788  fe80::2c7d:64ff:fe4…   ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
  15 73.038095055  fe80::504b:c0ff:fe7…   ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
  16 73.137035410  fe80::7818:b8ff:fef…   ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
  17 73.767971166  fe80::a498:74ff:fe3…   ff02::2            ICMPv6    70 Router Solicitation from a6:98:74:3f:5d:dc
  18 75.776766852  fe80::882f:3cff:fe4…   ff02::2            ICMPv6    70 Router Solicitation from 8a:2f:3c:47:89:48
  19 79.673430978  16:22:1d:8f:8c:be      Broadcast          ARP       42 Who has 10.0.0.4? Tell 10.0.0.1
  20 79.673444618  a6:98:74:3f:5d:dc      16:22:1d:8f:8c:be  ARP       42 10.0.0.4 is at a6:98:74:3f:5d:dc
  21 79.673688733  10.0.0.1               10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=1/256, ttl=64 (reply in 22)
  22 79.673700257  10.0.0.4               10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=1/256, ttl=64 (request in 21)
  23 79.872564177  fe80::1422:1dff:fe8…   ff02::2            ICMPv6    70 Router Solicitation from 16:22:1d:8f:8c:be
  24 80.703748028  10.0.0.1               10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=2/512, ttl=64 (reply in 25)
  25 80.703758963  10.0.0.4               10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=2/512, ttl=64 (request in 24)
  26 81.763682815  10.0.0.1               10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=3/768, ttl=64 (reply in 27)
  27 81.763711008  10.0.0.4               10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=3/768, ttl=64 (request in 26)
  28 82.783597801  10.0.0.1               10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=4/1024, ttl=64 (reply in 29)
  29 82.783622061  10.0.0.4               10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=4/1024, ttl=64 (request in 28)
  30 83.807753806  10.0.0.1               10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=5/1280, ttl=64 (reply in 31)
  31 83.807781505  10.0.0.4               10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=5/1280, ttl=64 (request in 30)
  32 84.736158155  a6:98:74:3f:5d:dc      16:22:1d:8f:8c:be  ARP       42 Who has 10.0.0.1? Tell 10.0.0.4
  33 84.736427270  16:22:1d:8f:8c:be      a6:98:74:3f:5d:dc  ARP       42 10.0.0.1 is at 16:22:1d:8f:8c:be
  34 86.015855996  fe80::7818:b8ff:fef…   ff02::2            ICMPv6    70 Router Solicitation from 7a:18:b8:fd:0c:dd

▸ Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
▸ Ethernet II, Src: b2:80:5c:90:6e:b8 (b2:80:5c:90:6e:b8), Dst: IPv6mcast_02 (33:33:00:00:00:02)
▸ Internet Protocol Version 6, Src: fe80::b080:5cff:fe90:6eb8, Dst: ff02::2
▸ Internet Control Message Protocol v6

0000  33 33 00 00 00 02 b2 80  5c 90 6e b8 86 dd 60 00   33······\·n···`·
0010  00 00 00 10 3a ff fe 80  00 00 00 00 00 00 b0 80   ····:···········
0020  5c ff fe 90 6e b8 ff 02  00 00 00 00 00 00 00 00   \···n···········
0030  00 00 00 00 00 02 85 00  83 9b 00 00 00 00 01 01   ················
0040  b2 80 5c 90 6e b8                                  ··\·n·

h4-eth0: <live capture in progress>        Packets: 34 · Displayed: 34 (100.0%)        Profile: Default
```

The screenshot is h4's wireshark. h1 ping h4, but h1 don't know the mac address of h4. Thus, h1 send an arp request packet to all the other hosts in the LAN. h4 get the arp request and record the source ip/ mac pair in its arp table.

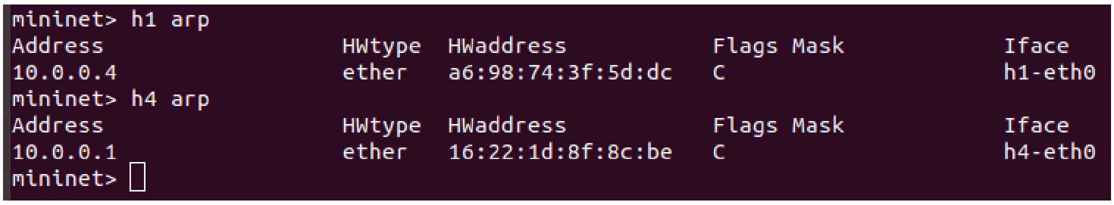
3.



Activities
Wireshark
17:51
Capturing from h1-eth0
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter … <Ctrl-/>
Expression…

```
No. Time          Source                 Destination        Protocol Length Info
 6 6.079600101   fe80::b094:deff:fe8…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
 7 6.802724015   fe80::284e:2dff:feb…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
 8 6.921516069   fe80::7c20:43ff:fe0…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
 9 7.167151033   fe80::284e:2dff:feb…  ff02::2            ICMPv6    70 Router Solicitation from 2a:4e:2d:b2:47:b4
10 7.167410568   fe80::a498:74ff:fe3…  ff02::2            ICMPv6    70 Router Solicitation from a6:98:74:3f:5d:dc
11 29.695981240  fe80::b080:5cff:fe9…  ff02::2            ICMPv6    70 Router Solicitation from b2:80:5c:90:6e:b8
12 31.752245204  fe80::b094:deff:fe8…  ff02::2            ICMPv6    70 Router Solicitation from b2:94:de:83:8f:80
13 37.887308028  fe80::882f:3cff:fe4…  ff02::2            ICMPv6    70 Router Solicitation from 8a:2f:3c:47:89:48
14 38.100050550  fe80::b094:deff:fe8…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
15 38.848479073  fe80::284e:2dff:feb…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
16 38.949861344  fe80::7c20:43ff:fe0…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
17 39.935704921  fe80::7c20:43ff:fe0…  ff02::2            ICMPv6    70 Router Solicitation from 7e:20:43:06:d0:26
18 39.935853689  fe80::1422:1dff:fe8…  ff02::2            ICMPv6    70 Router Solicitation from 16:22:1d:8f:8c:be
19 39.936525122  fe80::a498:74ff:fe3…  ff02::2            ICMPv6    70 Router Solicitation from a6:98:74:3f:5d:dc
20 41.983869864  fe80::284e:2dff:feb…  ff02::2            ICMPv6    70 Router Solicitation from 2a:4e:2d:b2:47:b4
21 89.107388324  fe80::b080:5cff:fe9…  ff02::2            ICMPv6    70 Router Solicitation from b2:80:5c:90:6e:b8
22 91.135374594  fe80::b094:deff:fe8…  ff02::2            ICMPv6    70 Router Solicitation from b2:94:de:83:8f:80
23 102.108602332 fe80::b094:deff:fe8…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
24 102.832236906 fe80::284e:2dff:feb…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
25 102.950727551 fe80::7c20:43ff:fe0…  ff02::fb           MDNS     107 Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" question
26 103.464278697 fe80::a498:74ff:fe3…  ff02::2            ICMPv6    70 Router Solicitation from a6:98:74:3f:5d:dc
27 105.471876691 fe80::882f:3cff:fe4…  ff02::2            ICMPv6    70 Router Solicitation from 8a:2f:3c:47:89:48
28 107.519371053 fe80::284e:2dff:feb…  ff02::2            ICMPv6    70 Router Solicitation from 2a:4e:2d:b2:47:b4
29 109.368551166 16:22:1d:8f:8c:be     Broadcast          ARP       42 Who has 10.0.0.4? Tell 10.0.0.1
30 109.368935476 a6:98:74:3f:5d:dc     16:22:1d:8f:8c:be  ARP       42 10.0.0.4 is at a6:98:74:3f:5d:dc
31 109.368939052 10.0.0.1              10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=1/256, ttl=64 (reply in 32)
32 109.369185910 10.0.0.4              10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=1/256, ttl=64 (request in 31)
33 109.567271052 fe80::1422:1dff:fe8…  ff02::2            ICMPv6    70 Router Solicitation from 16:22:1d:8f:8c:be
34 109.567909923 fe80::7c20:43ff:fe0…  ff02::2            ICMPv6    70 Router Solicitation from 7e:20:43:06:d0:26
35 110.399103947 10.0.0.1              10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=2/512, ttl=64 (reply in 36)
36 110.399132085 10.0.0.4              10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=2/512, ttl=64 (request in 35)
37 111.459022347 10.0.0.1              10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=3/768, ttl=64 (reply in 38)
38 111.459090733 10.0.0.4              10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=3/768, ttl=64 (request in 37)
39 112.478941209 10.0.0.1              10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=4/1024, ttl=64 (reply in 40)
40 112.479000509 10.0.0.4              10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=4/1024, ttl=64 (request in 39)
41 113.503093659 10.0.0.1              10.0.0.4           ICMP      98 Echo (ping) request  id=0x0d8f, seq=5/1280, ttl=64 (reply in 42)
42 113.503161598 10.0.0.4              10.0.0.1           ICMP      98 Echo (ping) reply    id=0x0d8f, seq=5/1280, ttl=64 (request in 41)
43 114.431553568 a6:98:74:3f:5d:dc     16:22:1d:8f:8c:be  ARP       42 Who has 10.0.0.1? Tell 10.0.0.4
44 114.431561259 16:22:1d:8f:8c:be     a6:98:74:3f:5d:dc  ARP       42 10.0.0.1 is at 16:22:1d:8f:8c:be

▸ Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
▸ Ethernet II, Src: b2:80:5c:90:6e:b8 (b2:80:5c:90:6e:b8), Dst: IPv6mcast_02 (33:33:00:00:00:02)
▸ Internet Protocol Version 6, Src: fe80::b080:5cff:fe90:6eb8, Dst: ff02::2
▸ Internet Control Message Protocol v6

0000  33 33 00 00 00 02 b2 80  5c 90 6e b8 86 dd 60 00   33······\·n···`·
0010  00 00 00 10 3a ff fe 80  00 00 00 00 00 00 b0 80   ····:···········
0020  5c ff fe 90 6e b8 ff 02  00 00 00 00 00 00 00 00   \···n···········
0030  00 00 00 00 00 02 85 00  83 9b 00 00 00 00 01 01   ················
0040  b2 80 5c 90 6e b8                                  ··\·n·

h1-eth0: <live capture in progress>          Packets: 44 · Displayed: 44 (100.0%)          Profile: Default
```

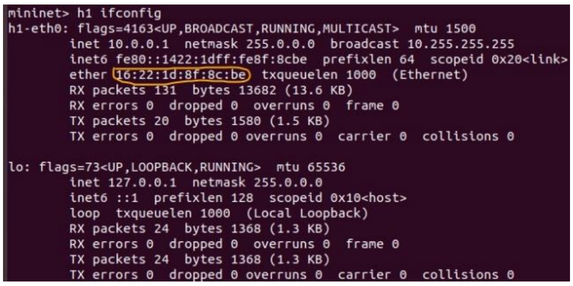
The screenshot is h1's wireshark. h1 ping h4, but h1 don't know the mac address of h4. Thus, h1 send an arp request packet to all the other hosts in the LAN. h4 get the request and response its mac address to h1. H1 then record them on its arp table. Below are the arp tables of h1 and h4 after ping.



```
mininet> h1 arp
Address                  HWtype  HWaddress           Flags Mask            Iface
10.0.0.4                 ether   a6:98:74:3f:5d:dc   C                     h1-eth0
mininet> h4 arp
Address                  HWtype  HWaddress           Flags Mask            Iface
10.0.0.1                 ether   16:22:1d:8f:8c:be   C                     h4-eth0
mininet> 
```

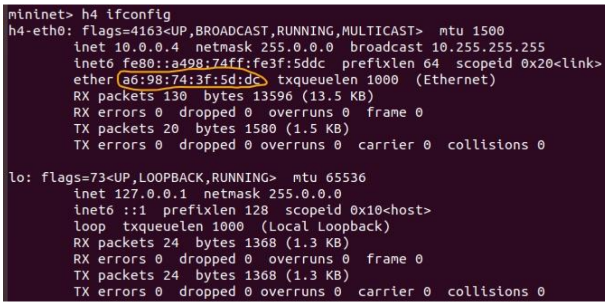
4. Since h1 need to send arp request and wait for h4 response, it will take longer time for first ping.

5.



```
mininet> h1 ifconfig
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.0.1  netmask 255.0.0.0  broadcast 10.255.255.255
        inet6 fe80::1422:1dff:fe8f:8cbe  prefixlen 64  scopeid 0x20<link>
        ether 16:22:1d:8f:8c:be  txqueuelen 1000  (Ethernet)
        RX packets 131  bytes 13682 (13.6 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 20  bytes 1580 (1.5 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 24  bytes 1368 (1.3 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 24  bytes 1368 (1.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

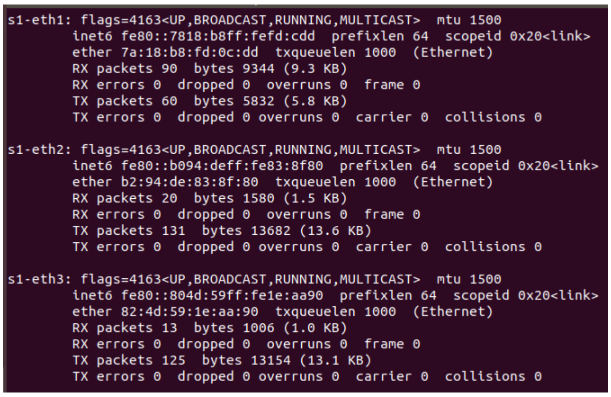
H1's ifconfig
Mac address: 16:22:1d:8f:8c:be



```
mininet> h4 ifconfig
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
        inet6 fe80::a498:74ff:fe3f:5ddc  prefixlen 64  scopeid 0x20<link>
        ether a6:98:74:3f:5d:dc  txqueuelen 1000  (Ethernet)
        RX packets 130  bytes 13596 (13.5 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 20  bytes 1580 (1.5 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 24  bytes 1368 (1.3 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 24  bytes 1368 (1.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

h4's ifconfig

Mac address: a6:98:74:3f:5d:dc



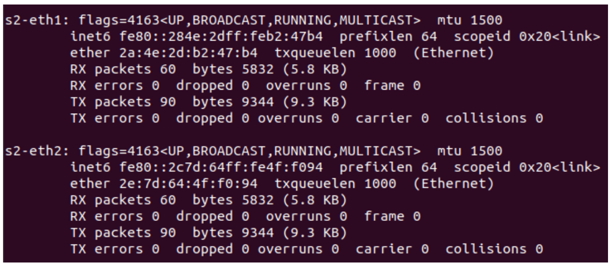
```
s1-eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::7818:b8ff:fefd:cdd  prefixlen 64  scopeid 0x20<link>
        ether 7a:18:b8:fd:0c:dd  txqueuelen 1000  (Ethernet)
        RX packets 90  bytes 9344 (9.3 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 60  bytes 5832 (5.8 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

s1-eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::b094:deff:fe83:8f80  prefixlen 64  scopeid 0x20<link>
        ether b2:94:de:83:8f:80  txqueuelen 1000  (Ethernet)
        RX packets 20  bytes 1580 (1.5 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 131  bytes 13682 (13.6 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

s1-eth3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::804d:59ff:fe1e:aa90  prefixlen 64  scopeid 0x20<link>
        ether 82:4d:59:1e:aa:90  txqueuelen 1000  (Ethernet)
        RX packets 13  bytes 1006 (1.0 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 125  bytes 13154 (13.1 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

s1's ifconfig

1st port: 7a:18:b8:fd:0c:dd

2nd port: b2:94:de:83:8f:80

3rd port: 82:4d:59:1e:aa:90

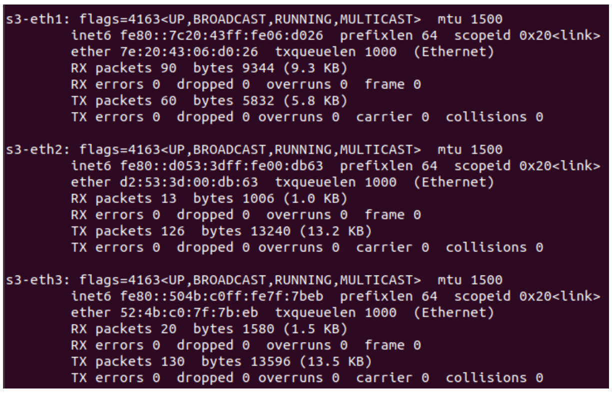


```
s2-eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::284e:2dff:feb2:47b4  prefixlen 64  scopeid 0x20<link>
        ether 2a:4e:2d:b2:47:b4  txqueuelen 1000  (Ethernet)
        RX packets 60  bytes 5832 (5.8 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 90  bytes 9344 (9.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

s2-eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::2c7d:64ff:fe4f:f094  prefixlen 64  scopeid 0x20<link>
        ether 2e:7d:64:4f:f0:94  txqueuelen 1000  (Ethernet)
        RX packets 60  bytes 5832 (5.8 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 90  bytes 9344 (9.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

s2's ifconfig

1st port: 2a:4e:2d:b2:47:b4

2nd port: 2e:7d:64:4f:f0:94



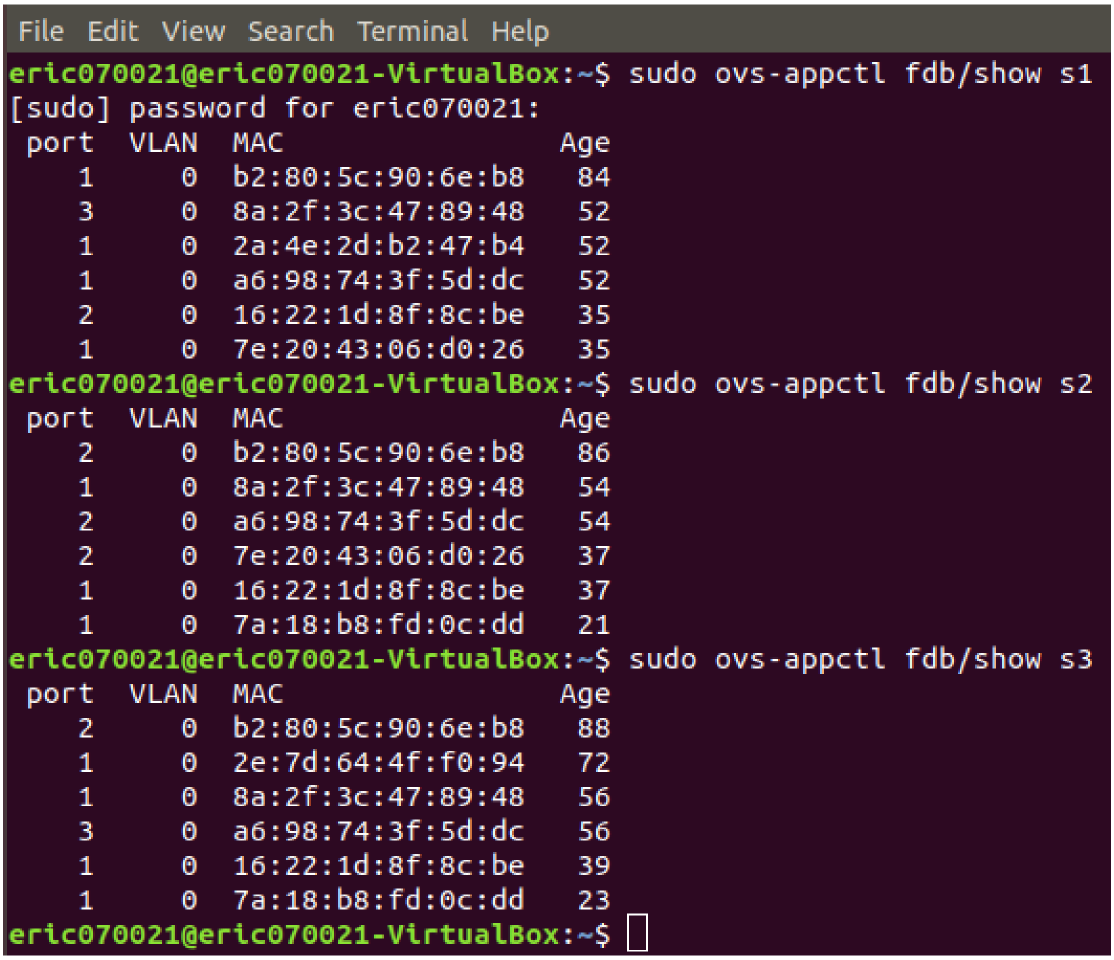
```
s3-eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::7c20:43ff:fe06:d026  prefixlen 64  scopeid 0x20<link>
        ether 7e:20:43:06:d0:26  txqueuelen 1000  (Ethernet)
        RX packets 90  bytes 9344 (9.3 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 60  bytes 5832 (5.8 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

s3-eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::d053:3dff:fe00:db63  prefixlen 64  scopeid 0x20<link>
        ether d2:53:3d:00:db:63  txqueuelen 1000  (Ethernet)
        RX packets 13  bytes 1006 (1.0 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 126  bytes 13240 (13.2 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

s3-eth3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::504b:c0ff:fe7f:7beb  prefixlen 64  scopeid 0x20<link>
        ether 52:4b:c0:7f:7b:eb  txqueuelen 1000  (Ethernet)
        RX packets 20  bytes 1580 (1.5 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 130  bytes 13596 (13.5 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

s3's ifconfig

1st port: 7e:20:43:06:d0:26

2nd port: d2:53:3d:00:db:63

3rd port: 52:4b:c0:7f:7b:eb

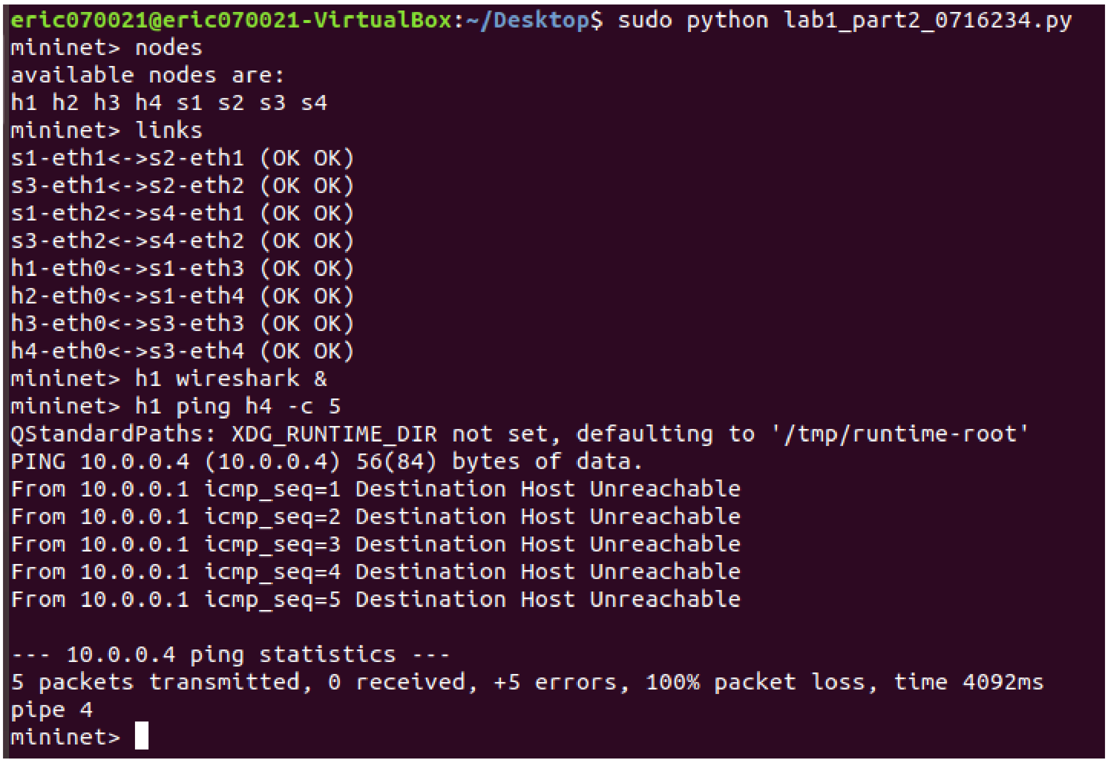


```
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s1
[sudo] password for eric070021:
 port  VLAN  MAC                Age
    1     0  b2:80:5c:90:6e:b8   84
    3     0  8a:2f:3c:47:89:48   52
    1     0  2a:4e:2d:b2:47:b4   52
    1     0  a6:98:74:3f:5d:dc   52
    2     0  16:22:1d:8f:8c:be   35
    1     0  7e:20:43:06:d0:26   35
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s2
 port  VLAN  MAC                Age
    2     0  b2:80:5c:90:6e:b8   86
    1     0  8a:2f:3c:47:89:48   54
    2     0  a6:98:74:3f:5d:dc   54
    2     0  7e:20:43:06:d0:26   37
    1     0  16:22:1d:8f:8c:be   37
    1     0  7a:18:b8:fd:0c:dd   21
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s3
 port  VLAN  MAC                Age
    2     0  b2:80:5c:90:6e:b8   88
    1     0  2e:7d:64:4f:f0:94   72
    1     0  8a:2f:3c:47:89:48   56
    3     0  a6:98:74:3f:5d:dc   56
    1     0  16:22:1d:8f:8c:be   39
    1     0  7a:18:b8:fd:0c:dd   23
eric070021@eric070021-VirtualBox:~$ 
```

By the above information, we can constitute the path of ping.
h1 -> s1’s port 2 -> s2’s port 1 -> s3’s port 1(by s2’s port 2) -> h4(by s3’s port 3)

Part2: A Leaf-Spine Topology

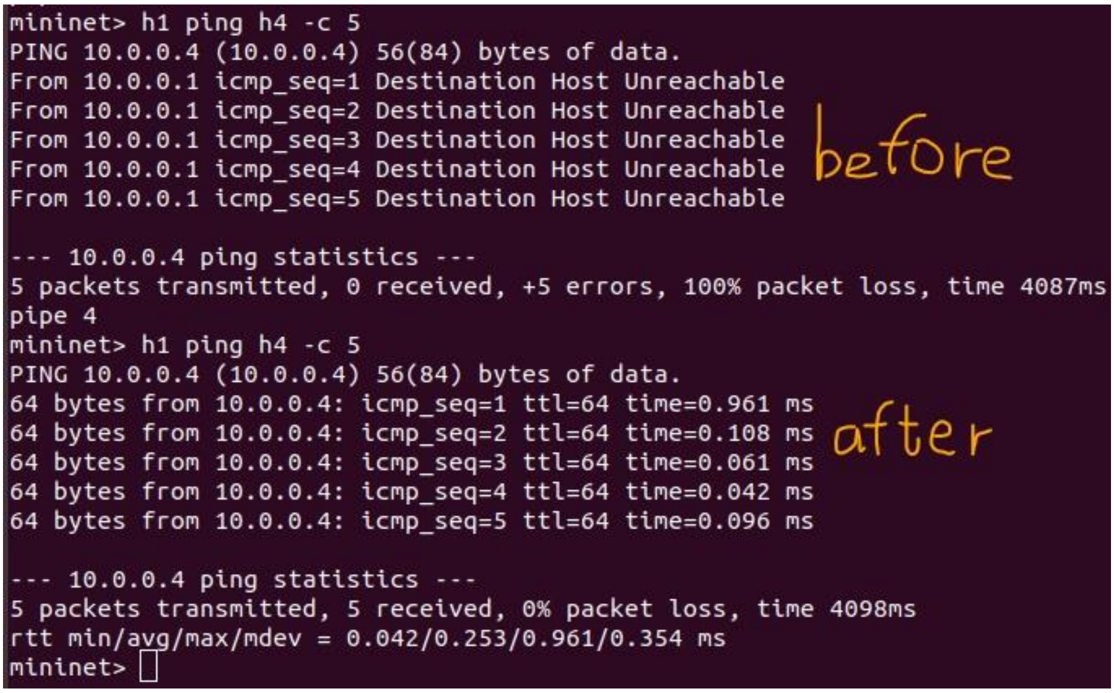
1.



```
eric070021@eric070021-VirtualBox:~/Desktop$ sudo python lab1_part2_0716234.py
mininet> nodes
available nodes are:
h1 h2 h3 h4 s1 s2 s3 s4
mininet> links
s1-eth1<->s2-eth1 (OK OK)
s3-eth1<->s2-eth2 (OK OK)
s1-eth2<->s4-eth1 (OK OK)
s3-eth2<->s4-eth2 (OK OK)
h1-eth0<->s1-eth3 (OK OK)
h2-eth0<->s1-eth4 (OK OK)
h3-eth0<->s3-eth3 (OK OK)
h4-eth0<->s3-eth4 (OK OK)
mininet> h1 wireshark &
mininet> h1 ping h4 -c 5
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
From 10.0.0.1 icmp_seq=1 Destination Host Unreachable
From 10.0.0.1 icmp_seq=2 Destination Host Unreachable
From 10.0.0.1 icmp_seq=3 Destination Host Unreachable
From 10.0.0.1 icmp_seq=4 Destination Host Unreachable
From 10.0.0.1 icmp_seq=5 Destination Host Unreachable

--- 10.0.0.4 ping statistics ---
5 packets transmitted, 0 received, +5 errors, 100% packet loss, time 4092ms
pipe 4
mininet>
```

No, h1 can’t successfully ping h4 before enable STP.

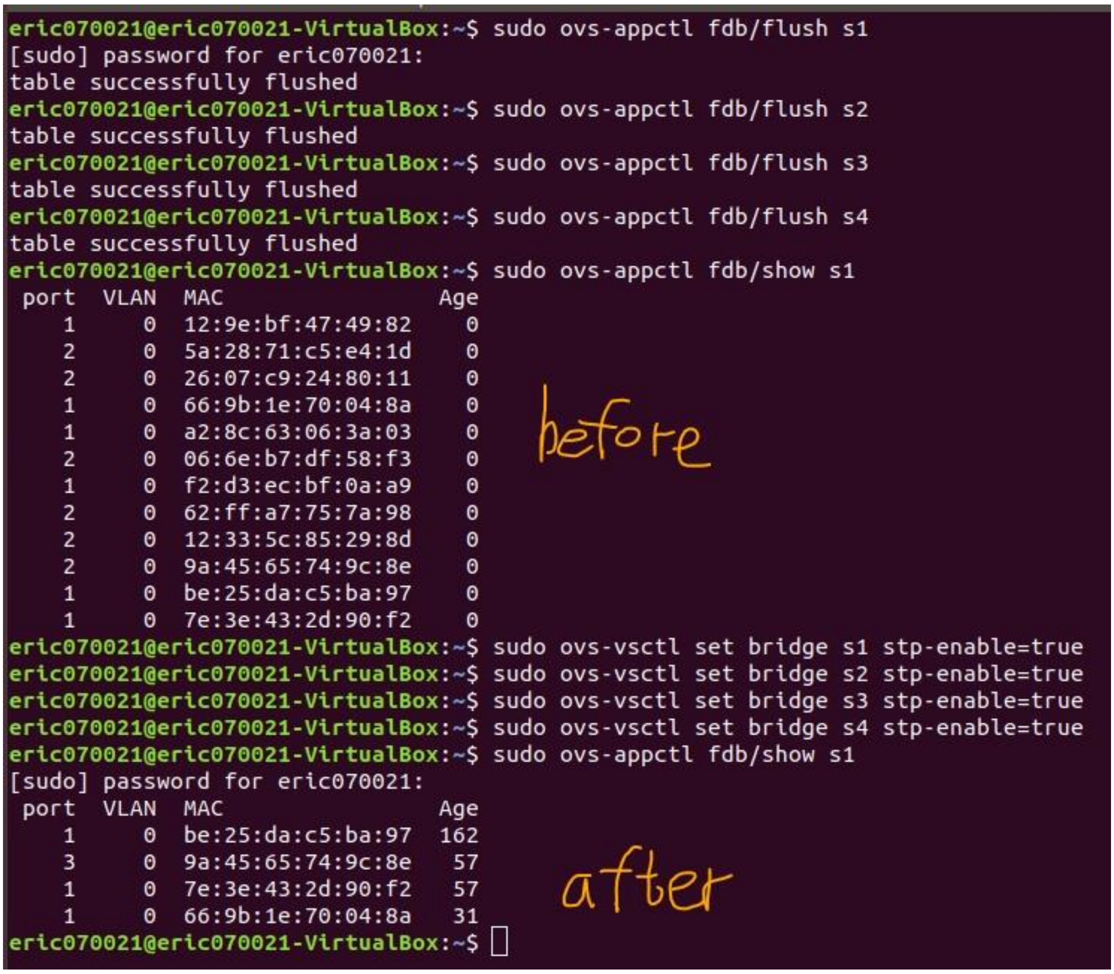
2.



```
mininet> h1 ping h4 -c 5
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
From 10.0.0.1 icmp_seq=1 Destination Host Unreachable
From 10.0.0.1 icmp_seq=2 Destination Host Unreachable
From 10.0.0.1 icmp_seq=3 Destination Host Unreachable
From 10.0.0.1 icmp_seq=4 Destination Host Unreachable
From 10.0.0.1 icmp_seq=5 Destination Host Unreachable

--- 10.0.0.4 ping statistics ---
5 packets transmitted, 0 received, +5 errors, 100% packet loss, time 4087ms
pipe 4
mininet> h1 ping h4 -c 5
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
64 bytes from 10.0.0.4: icmp_seq=1 ttl=64 time=0.961 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=0.108 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=0.061 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=0.042 ms
64 bytes from 10.0.0.4: icmp_seq=5 ttl=64 time=0.096 ms

--- 10.0.0.4 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4098ms
rtt min/avg/max/mdev = 0.042/0.253/0.961/0.354 ms
mininet>
```

Yes, h1 can successfully ping h4 after enable STP.

3



```
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s1
[sudo] password for eric070021:
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s2
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s3
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/flush s4
table successfully flushed
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s1
 port  VLAN  MAC                Age
    1     0  12:9e:bf:47:49:82    0
    2     0  5a:28:71:c5:e4:1d    0
    2     0  26:07:c9:24:80:11    0
    1     0  66:9b:1e:70:04:8a    0
    1     0  a2:8c:63:06:3a:03    0
    2     0  06:6e:b7:df:58:f3    0
    1     0  f2:d3:ec:bf:0a:a9    0
    2     0  62:ff:a7:75:7a:98    0
    2     0  12:33:5c:85:29:8d    0
    2     0  9a:45:65:74:9c:8e    0
    1     0  be:25:da:c5:ba:97    0
    1     0  7e:3e:43:2d:90:f2    0
eric070021@eric070021-VirtualBox:~$ sudo ovs-vsctl set bridge s1 stp-enable=true
eric070021@eric070021-VirtualBox:~$ sudo ovs-vsctl set bridge s2 stp-enable=true
eric070021@eric070021-VirtualBox:~$ sudo ovs-vsctl set bridge s3 stp-enable=true
eric070021@eric070021-VirtualBox:~$ sudo ovs-vsctl set bridge s4 stp-enable=true
eric070021@eric070021-VirtualBox:~$ sudo ovs-appctl fdb/show s1
[sudo] password for eric070021:
 port  VLAN  MAC                Age
    1     0  be:25:da:c5:ba:97  162
    3     0  9a:45:65:74:9c:8e   57
    1     0  7e:3e:43:2d:90:f2   57
    1     0  66:9b:1e:70:04:8a   31
eric070021@eric070021-VirtualBox:~$
```

Since there are loop in the switches, s1's mac table will contain every mac address in the LAN(12) before enable STP.
After enable STP, only root and designated port will be able to transmit data, so the mac table of s1 will contain less mac address.

4.
This lab let me quickly review the main concept of the network. Including arp protocol, how the packet is process on the internet. I also know more about switch. Before this class, I can't even distinguish between switch and hub. I also observe that internet is really complicated. It has a lot of rule and protocol. To learn all the protocols is impractical. So, we need to learn the main concept like what is the problem, how this internet protocol solves it. This may be the key point in learning internet.