Administrasi dan Design Jaringan

Mininet, MiniNAM, OpenFlow, dan PoxController

Oleh :

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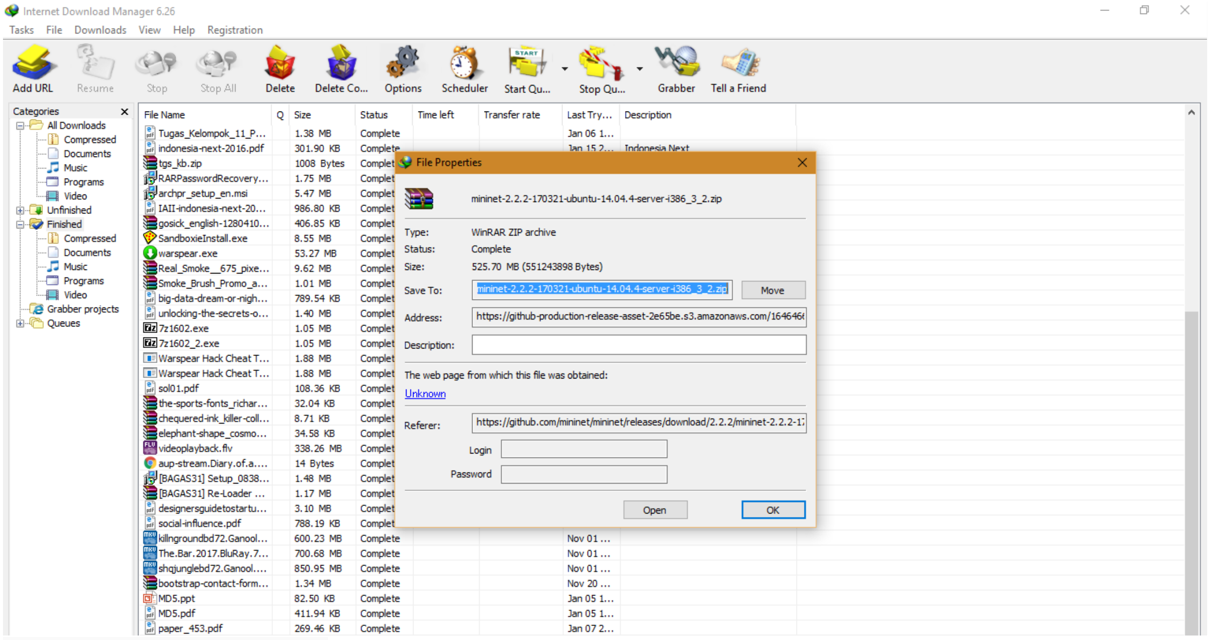
2018

Mininet

Mininet adalah emulator berbasis CLI yang digunakan pada sebuah tropologi jaringan pada software defined network dimana dapat lansung digunakan dengan menggunkan perintah command tertentu. Berikut tahapan instalasi Mininet :

1. Download Mininet



File Name	Q	Size	Status	Time left	Transfer rate	Last Try…	Description
Tugas_Kelompok_11_P…		1.38 MB	Complete			Jan 06 1…	
indonesia-next-2016.pdf		301.90 KB	Complete			Jan 15 2…	Indonesia Next
tgs_kb.zip		1008 Bytes	Complet				
RARPasswordRecovery…		1.75 MB	Complet				
archpr_setup_en.msi		5.47 MB	Complet				
IAII-indonesia-next-20…		986.80 KB	Complet				
gosick_english-1280410…		406.85 KB	Complet				
SandboxieInstall.exe		8.55 MB	Complet				
warspear.exe		53.27 MB	Complet				
Real_Smoke__675_pixe…		9.62 MB	Complet				
Smoke_Brush_Promo_a…		1.01 MB	Complet				
big-data-dream-or-nigh…		789.54 KB	Complet				
unlocking-the-secrets-o…		1.40 MB	Complet				
7z1602.exe		1.05 MB	Complet				
7z1602_2.exe		1.05 MB	Complet				
Warspear Hack Cheat T…		1.88 MB	Complet				
Warspear Hack Cheat T…		1.88 MB	Complet				
sol01.pdf		108.36 KB	Complet				
the-sports-fonts_richar…		32.04 KB	Complet				
chequered-ink_killer-coll…		8.71 KB	Complet				
elephant-shape_cosmo…		34.58 KB	Complet				
videoplayback.flv		338.26 MB	Complet				
aup-stream.Diary.of.a….		14 Bytes	Complet				
[BAGAS31] Setup_0838…		1.48 MB	Complet				
[BAGAS31] Re-Loader …		1.17 MB	Complet				
designersguidetostartu…		3.10 MB	Complet				
social-influence.pdf		788.19 KB	Complet				
killngroundbd72.Ganool…		600.23 MB	Complete			Nov 01 …	
The.Bar.2017.BluRay.7…		700.68 MB	Complete			Nov 01 …	
shqjunglebd72.Ganool….		850.95 MB	Complete			Nov 01 …	
bootstrap-contact-form…		1.34 MB	Complete			Nov 20 …	
MD5.ppt		82.50 KB	Complete			Jan 05 1…	
MD5.pdf		411.94 KB	Complete			Jan 05 1…	
paper_453.pdf		269.46 KB	Complete			Jan 07 2…	

File Properties

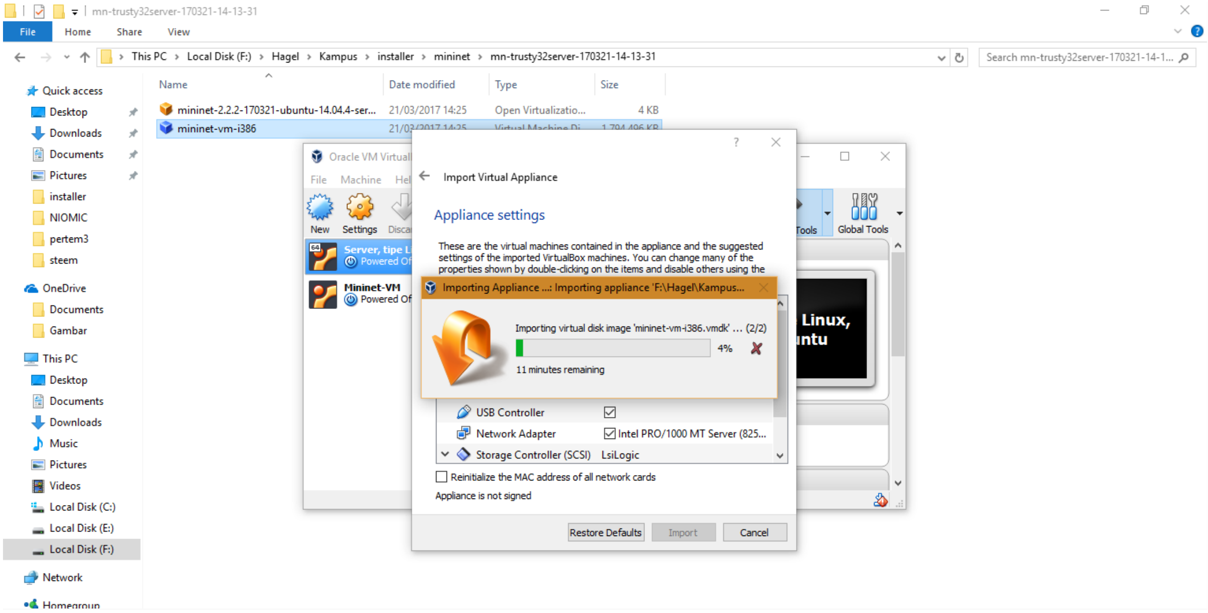
mininet-2.2.2-170321-ubuntu-14.04.4-server-i386_3_2.zip

Type: WinRAR ZIP archive
Status: Complete
Size: 525.70 MB (551243898 Bytes)
Save To: mininet-2.2.2-170321-ubuntu-14.04.4-server-i386_3_2.zip
Address: https://github-production-release-asset-2e65be.s3.amazonaws.com/164646
Description:

The web page from which this file was obtained:
Unknown

Referer: https://github.com/mininet/mininet/releases/download/2.2.2/mininet-2.2.2-17
Login
Password

2. Import Mininet pada VM



This PC › Local Disk (F:) › Hagel › Kampus › installer › mininet › mn-trusty32server-170321-14-13-31

Name	Date modified	Type	Size
mininet-2.2.2-170321-ubuntu-14.04.4-ser...	21/03/2017 14:25	Open Virtualizatio...	4 KB
mininet-vm-i386	21/03/2017 14:25	Virtual Machine Di...	1,794,496 KB

Import Virtual Appliance

Appliance settings

These are the virtual machines contained in the appliance and the suggested settings of the imported VirtualBox machines. You can change many of the properties shown by double-clicking on the items and disable others using the

Importing Appliance ...: Importing appliance 'F:\Hagel\Kampus...

Importing virtual disk image 'mininet-vm-i386.vmdk' ... (2/2)

4%

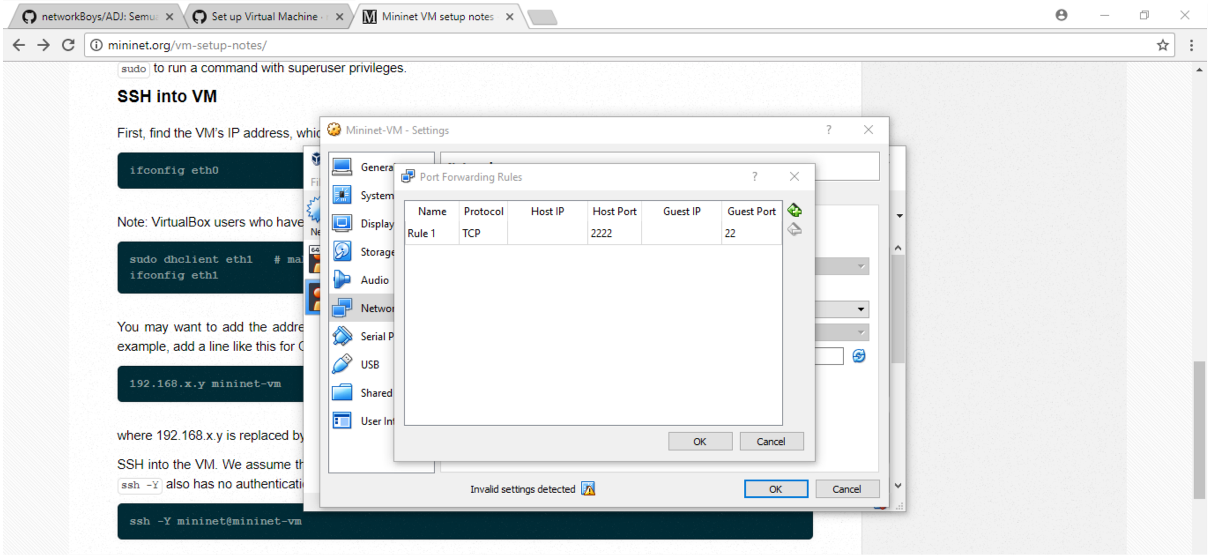
11 minutes remaining

USB Controller ☑
Network Adapter ☑ Intel PRO/1000 MT Server (825...
Storage Controller (SCSI) LsiLogic

□ Reinitialize the MAC address of all network cards

Appliance is not signed

3. Melakukan Configure Access
   Setting konfigurasi network dengan tujuan supaya berkominkasi nantiknya, lalu melakukan post forwarding



`sudo` to run a command with superuser privileges.

SSH into VM

First, find the VM's IP address, whic

```
ifconfig eth0
```

Note: VirtualBox users who have

```
sudo dhclient eth1    # ma
ifconfig eth1
```

You may want to add the addre
example, add a line like this for (

```
192.168.x.y mininet-vm
```

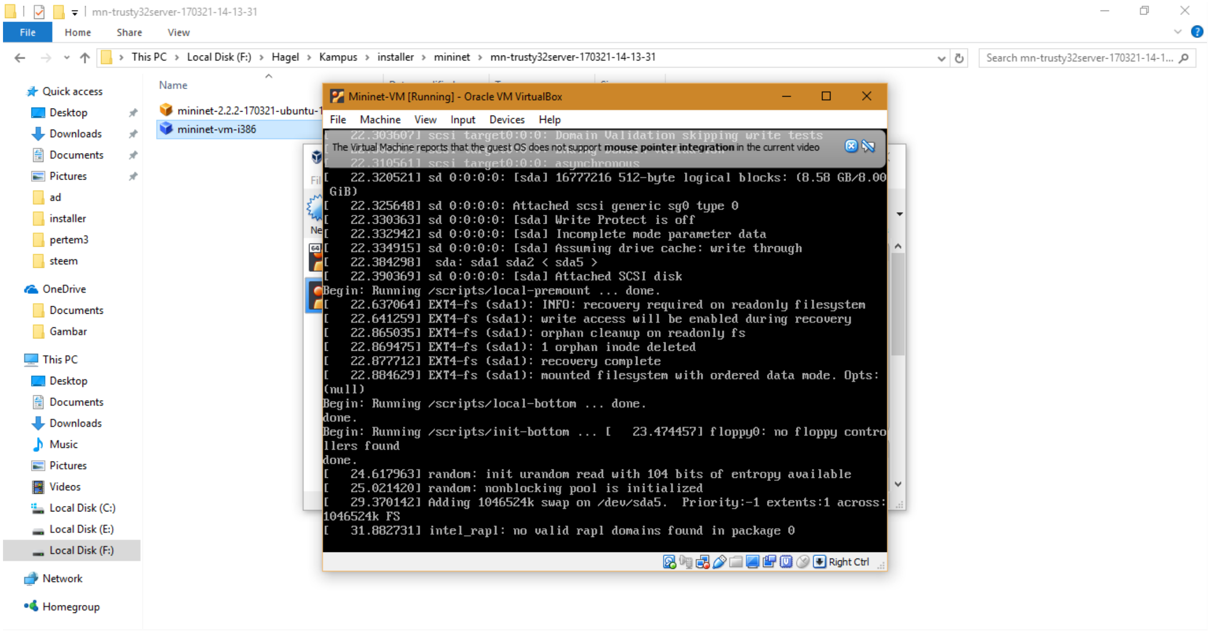
where 192.168.x.y is replaced by

SSH into the VM. We assume th
`ssh -Y` also has no authenticati

```
ssh -Y mininet@mininet-vm
```

Name	Protocol	Host IP	Host Port	Guest IP	Guest Port
Rule 1	TCP		2222		22

4. Jalankan VM
   Run mininet dengan memasukkan username “mininet” dan password “mininet”.

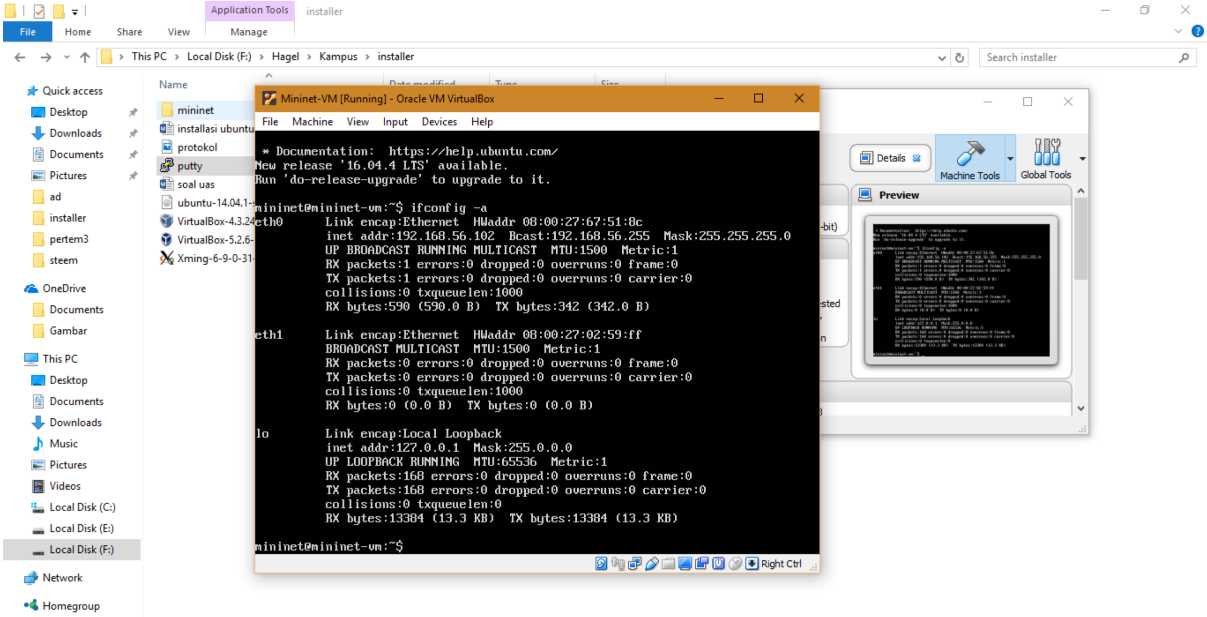


The Virtual Machine reports that the guest OS does not support **mouse pointer integration** in the current video

```
[   22.303607] scsi target0:0:0: Domain Validation skipping write tests
[   22.310561] scsi target0:0:0: asynchronous
[   22.320521] sd 0:0:0:0: [sda] 16777216 512-byte logical blocks: (8.58 GB/8.00
 GiB)
[   22.325648] sd 0:0:0:0: Attached scsi generic sg0 type 0
[   22.330363] sd 0:0:0:0: [sda] Write Protect is off
[   22.332942] sd 0:0:0:0: [sda] Incomplete mode parameter data
[   22.334915] sd 0:0:0:0: [sda] Assuming drive cache: write through
[   22.384298]  sda: sda1 sda2 < sda5 >
[   22.390369] sd 0:0:0:0: [sda] Attached SCSI disk
Begin: Running /scripts/local-premount ... done.
[   22.637064] EXT4-fs (sda1): INFO: recovery required on readonly filesystem
[   22.641259] EXT4-fs (sda1): write access will be enabled during recovery
[   22.865035] EXT4-fs (sda1): orphan cleanup on readonly fs
[   22.869475] EXT4-fs (sda1): 1 orphan inode deleted
[   22.877712] EXT4-fs (sda1): recovery complete
[   22.884629] EXT4-fs (sda1): mounted filesystem with ordered data mode. Opts:
(null)
Begin: Running /scripts/local-bottom ... done.
done.
Begin: Running /scripts/init-bottom ... [   23.474457] floppy0: no floppy contro
llers found
done.
[   24.617963] random: init urandom read with 104 bits of entropy available
[   25.021420] random: nonblocking pool is initialized
[   29.370142] Adding 1046524k swap on /dev/sda5.  Priority:-1 extents:1 across:
1046524k FS
[   31.882731] intel_rapl: no valid rapl domains found in package 0
```

5. Menlihat IP pada mininet

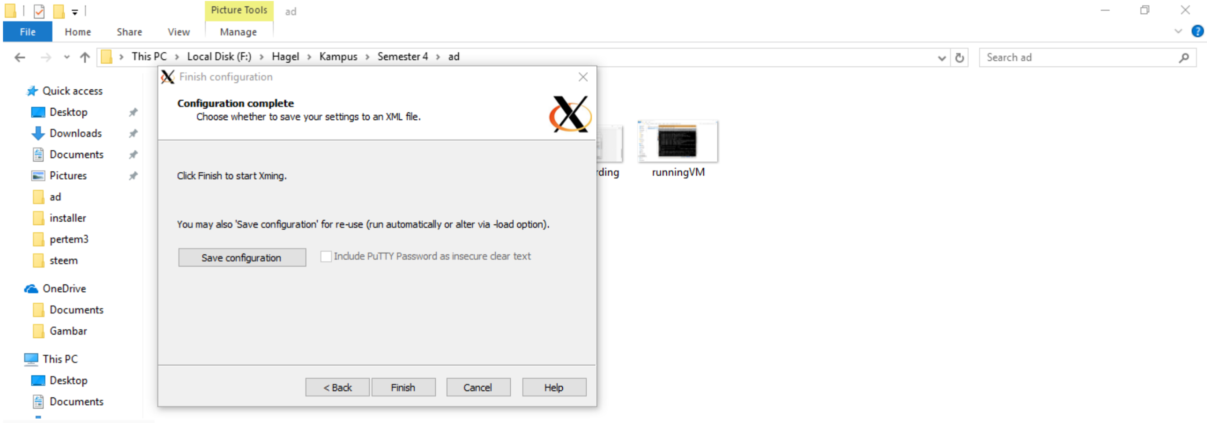
   Dengan memasukkan perintah “ifconfig -a” untuk mengetahui ip address host.



```
 * Documentation:  https://help.ubuntu.com/
New release '16.04.4 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

mininet@mininet-vm:~$ ifconfig -a
eth0      Link encap:Ethernet  HWaddr 08:00:27:67:51:8c
          inet addr:192.168.56.102  Bcast:192.168.56.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:590 (590.0 B)  TX bytes:342 (342.0 B)

eth1      Link encap:Ethernet  HWaddr 08:00:27:02:59:ff
          BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen: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:168 errors:0 dropped:0 overruns:0 frame:0
          TX packets:168 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:13384 (13.3 KB)  TX bytes:13384 (13.3 KB)

mininet@mininet-vm:~$
```

6. Mengaktifkan Xming

   xming adalah sebuah server yg kita gunakan untuk mengakses ssh x11 untuk windows os.



Configuration complete

Choose whether to save your settings to an XML file.

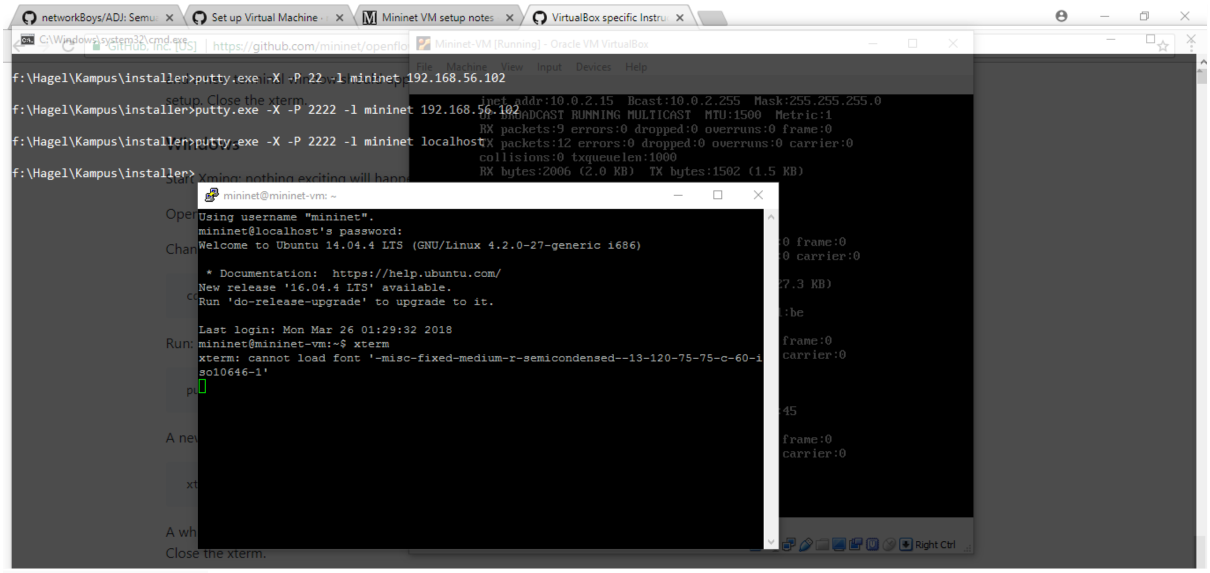
Click Finish to start Xming.

You may also 'Save configuration' for re-use (run automatically or alter via -load option).

□ Include PuTTY Password as insecure clear text

7. SSH to VM

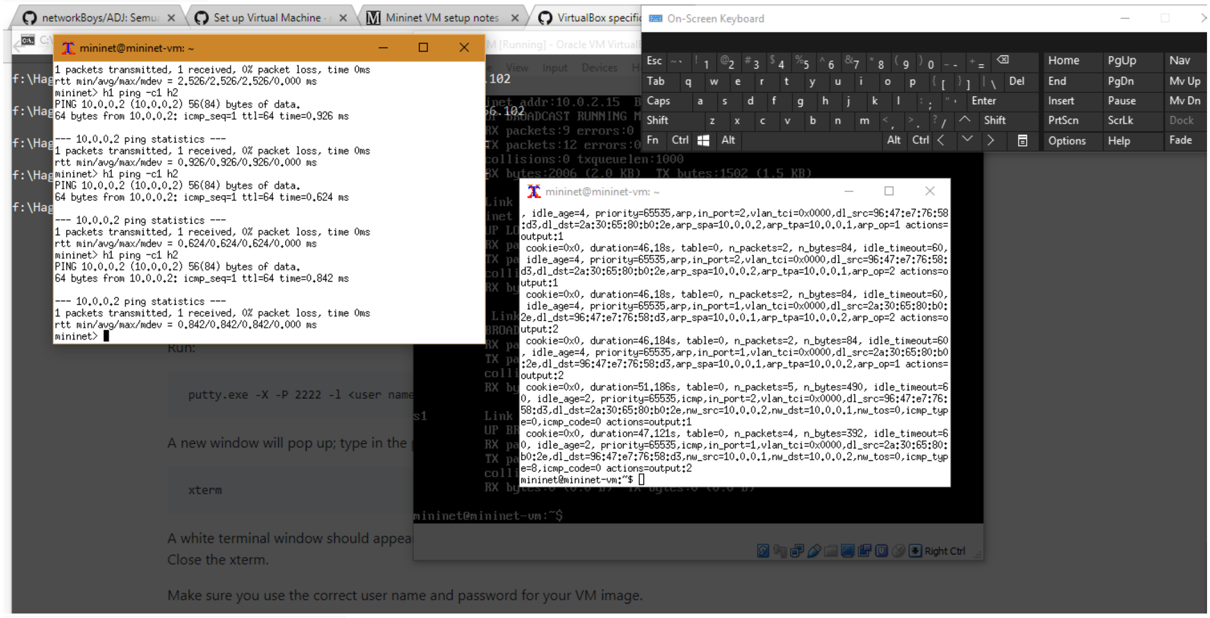
   PuTTY adalah terminal emulator, serial console dan aplikasi transfer jaringan. Aktifkan PuTTY dengan membuka cmd lalu mengisikan direktori file PuTTy.exe, lalu memasukkan perintah “putty.exe –p –l 2222 –l <username> localhost ”, dan apabila berhasil akan memunculkan terminal baru dengan backround putih (Xterminal)



```
f:\Hagel\Kampus\installer>putty.exe -X -P 22 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>
```

```
Using username "mininet".
mininet@localhost's password:
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 4.2.0-27-generic i686)

 * Documentation:  https://help.ubuntu.com/
New release '16.04.4 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Mon Mar 26 01:29:32 2018
mininet@mininet-vm:~$ xterm
xterm: cannot load font '-misc-fixed-medium-r-semicondensed--13-120-75-75-c-60-i
so10646-1'
```

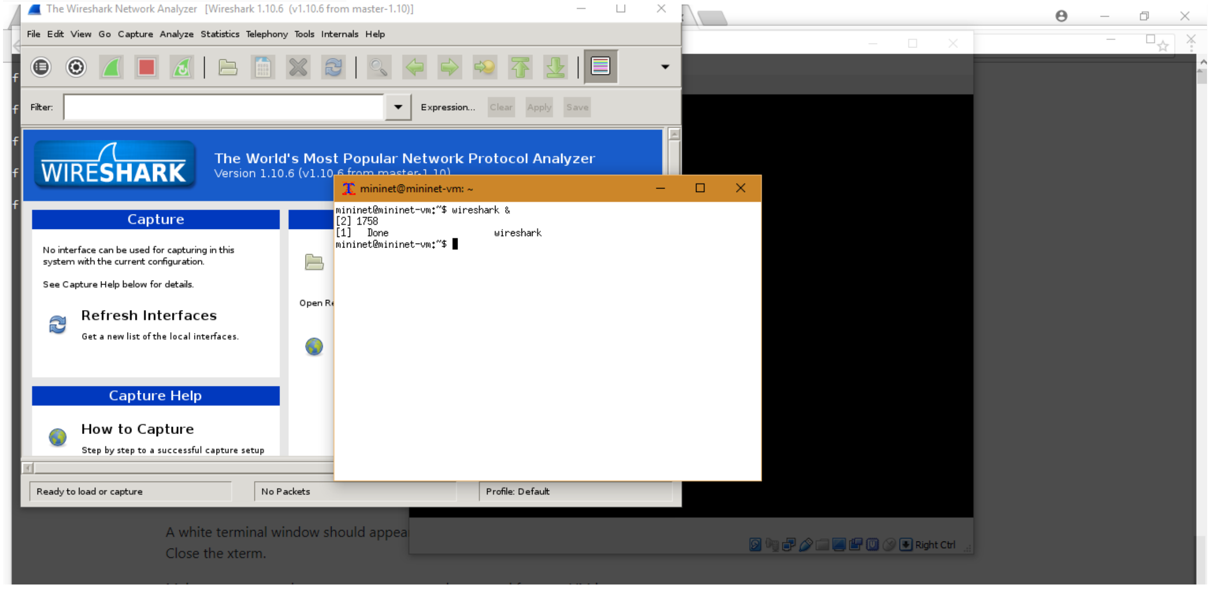
8. Access via SSH



```
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 2.526/2.526/2.526/0.000 ms
mininet> h1 ping -c1 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.926 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.926/0.926/0.926/0.000 ms
mininet> h1 ping -c1 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.624 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.624/0.624/0.624/0.000 ms
mininet> h1 ping -c1 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.842 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.842/0.842/0.842/0.000 ms
mininet>
```

```
, idle_age=4, priority=65535,arp,in_port=2,vlan_tci=0x0000,dl_src=96:47:e7:76:58
:d3,dl_dst=2a:30:65:80:b0:2e,arp_spa=10.0.0.2,arp_tpa=10.0.0.1,arp_op=1 actions=
output:1
 cookie=0x0, duration=46.18s, table=0, n_packets=2, n_bytes=84, idle_timeout=60,
 idle_age=4, priority=65535,arp,in_port=2,vlan_tci=0x0000,dl_src=96:47:e7:76:58:
d3,dl_dst=2a:30:65:80:b0:2e,arp_spa=10.0.0.2,arp_tpa=10.0.0.1,arp_op=2 actions=o
utput:1
 cookie=0x0, duration=46.18s, table=0, n_packets=2, n_bytes=84, idle_timeout=60,
 idle_age=4, priority=65535,arp,in_port=1,vlan_tci=0x0000,dl_src=2a:30:65:80:b0:
2e,dl_dst=96:47:e7:76:58:d3,arp_spa=10.0.0.1,arp_tpa=10.0.0.2,arp_op=2 actions=o
utput:2
 cookie=0x0, duration=46.184s, table=0, n_packets=2, n_bytes=84, idle_timeout=60
, idle_age=4, priority=65535,arp,in_port=1,vlan_tci=0x0000,dl_src=2a:30:65:80:b0
:2e,dl_dst=96:47:e7:76:58:d3,arp_spa=10.0.0.1,arp_tpa=10.0.0.2,arp_op=1 actions=
output:2
 cookie=0x0, duration=51.186s, table=0, n_packets=5, n_bytes=490, idle_timeout=6
0, idle_age=2, priority=65535,icmp,in_port=2,vlan_tci=0x0000,dl_src=96:47:e7:76:
58:d3,dl_dst=2a:30:65:80:b0:2e,nw_src=10.0.0.2,nw_dst=10.0.0.1,nw_tos=0,icmp_typ
e=0,icmp_code=0 actions=output:1
 cookie=0x0, duration=47.121s, table=0, n_packets=4, n_bytes=392, idle_timeout=6
0, idle_age=2, priority=65535,icmp,in_port=1,vlan_tci=0x0000,dl_src=2a:30:65:80:
b0:2e,dl_dst=96:47:e7:76:58:d3,nw_src=10.0.0.1,nw_dst=10.0.0.2,nw_tos=0,icmp_typ
e=8,icmp_code=0 actions=output:2
mininet@mininet-vm:~$
```

9. Melakukan test WireShark



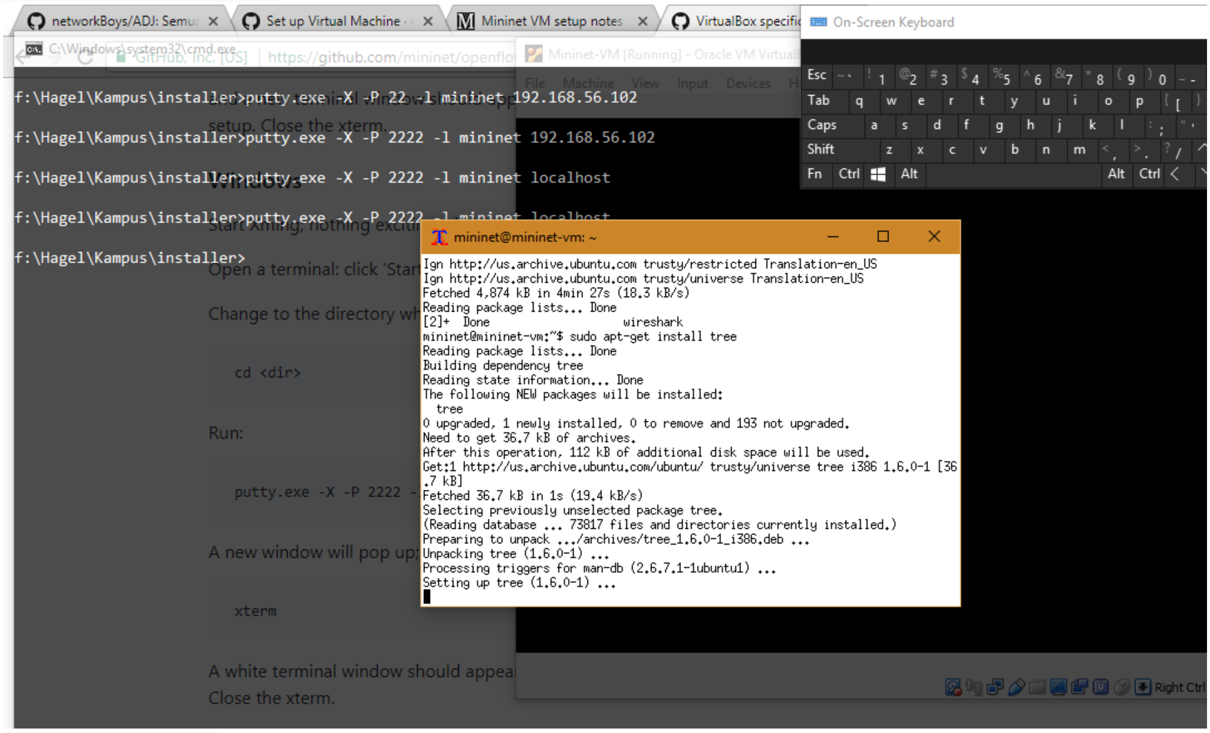
The Wireshark Network Analyzer [Wireshark 1.10.6 (v1.10.6 from master-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression... Clear Apply Save
WIRESHARK
The World's Most Popular Network Protocol Analyzer
Version 1.10.6 (v1.10.6 from master-1.10)
Capture
Refresh Interfaces
Get a new list of the local interfaces.
Capture Help
How to Capture
Step by step to a successful capture setup
Open R
Ready to load or capture
No Packets
Profile: Default

No interface can be used for capturing in this system with the current configuration.

See Capture Help below for details.

```
mininet@mininet-vm:~$ wireshark &
[2] 1758
[1]   Done                    wireshark
mininet@mininet-vm:~$
```

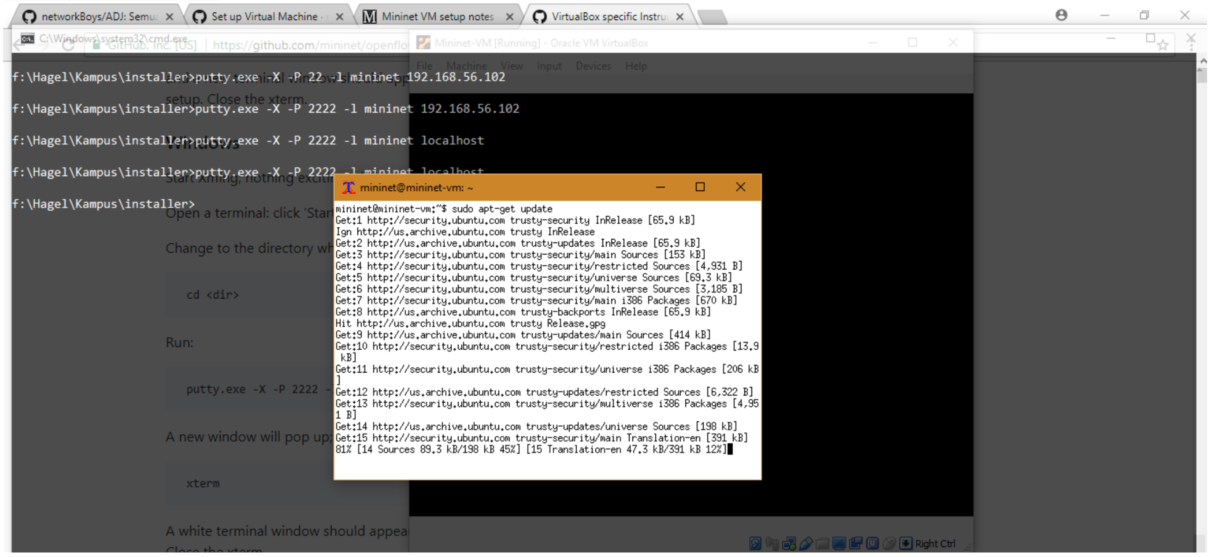
10. Melakukan instal tree



```
f:\Hagel\Kampus\installer>putty.exe -X -P 22 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>
```

```
Ign http://us.archive.ubuntu.com trusty/restricted Translation-en_US
Ign http://us.archive.ubuntu.com trusty/universe Translation-en_US
Fetched 4,874 kB in 4min 27s (18.3 kB/s)
Reading package lists... Done
[2]+  Done                    wireshark
mininet@mininet-vm:~$ sudo apt-get install tree
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  tree
0 upgraded, 1 newly installed, 0 to remove and 193 not upgraded.
Need to get 36.7 kB of archives.
After this operation, 112 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu/ trusty/universe tree i386 1.6.0-1 [36
.7 kB]
Fetched 36.7 kB in 1s (19.4 kB/s)
Selecting previously unselected package tree.
(Reading database ... 73817 files and directories currently installed.)
Preparing to unpack .../archives/tree_1.6.0-1_i386.deb ...
Unpacking tree (1.6.0-1) ...
Processing triggers for man-db (2.6.7.1-1ubuntu1) ...
Setting up tree (1.6.0-1) ...
```

11. Mengubdate tree

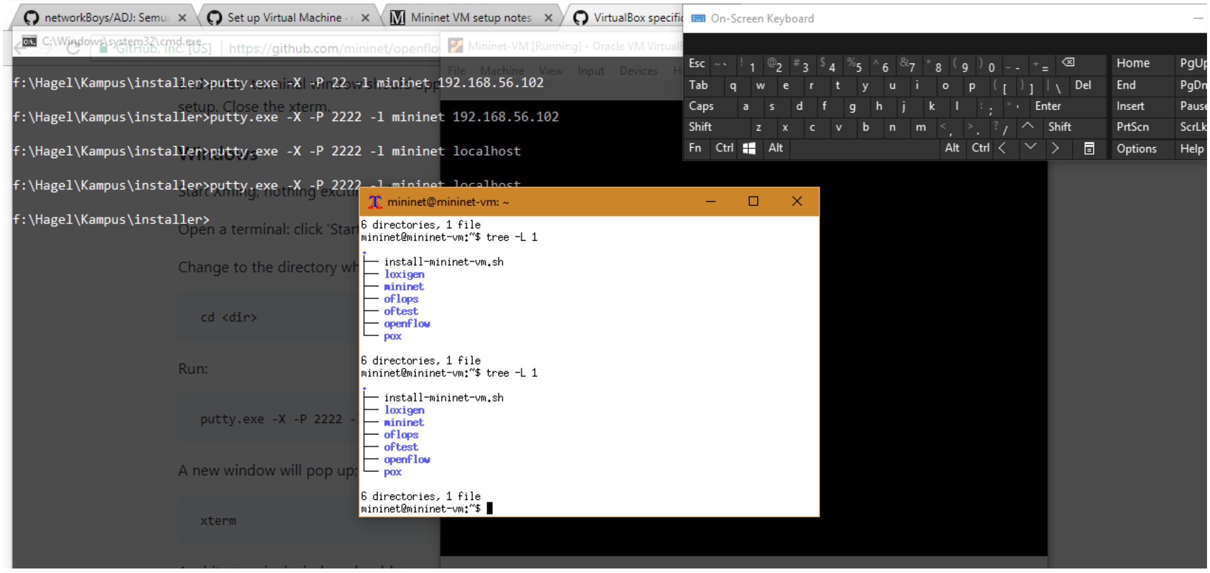


```
f:\Hagel\Kampus\installer>putty.exe -X -P 22 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>
```

```
mininet@mininet-vm:~$ sudo apt-get update
Get:1 http://security.ubuntu.com trusty-security InRelease [65.9 kB]
Ign http://us.archive.ubuntu.com trusty InRelease
Get:2 http://us.archive.ubuntu.com trusty-updates InRelease [65.9 kB]
Get:3 http://security.ubuntu.com trusty-security/main Sources [153 kB]
Get:4 http://security.ubuntu.com trusty-security/restricted Sources [4,931 B]
Get:5 http://security.ubuntu.com trusty-security/universe Sources [69.3 kB]
Get:6 http://security.ubuntu.com trusty-security/multiverse Sources [3,185 B]
Get:7 http://security.ubuntu.com trusty-security/main i386 Packages [670 kB]
Get:8 http://us.archive.ubuntu.com trusty-backports InRelease [65.9 kB]
Hit http://us.archive.ubuntu.com trusty Release.gpg
Get:9 http://us.archive.ubuntu.com trusty-updates/main Sources [414 kB]
Get:10 http://security.ubuntu.com trusty-security/restricted i386 Packages [13.9
 kB]
Get:11 http://security.ubuntu.com trusty-security/universe i386 Packages [206 kB
]
Get:12 http://us.archive.ubuntu.com trusty-updates/restricted Sources [6,322 B]
Get:13 http://security.ubuntu.com trusty-security/multiverse i386 Packages [4,95
1 B]
Get:14 http://us.archive.ubuntu.com trusty-updates/universe Sources [198 kB]
Get:15 http://security.ubuntu.com trusty-security/main Translation-en [391 kB]
81% [14 Sources 89.3 kB/198 kB 45%] [15 Translation-en 47.3 kB/391 kB 12%]
```

networkBoys/ADJ: Semu
Set up Virtual Machine
Mininet VM setup notes
VirtualBox specific Instru
C:\Windows\system32\cmd.exe
Mininet-VM [Running] - Oracle VM VirtualBox
mininet@mininet-vm: ~
Right Ctrl

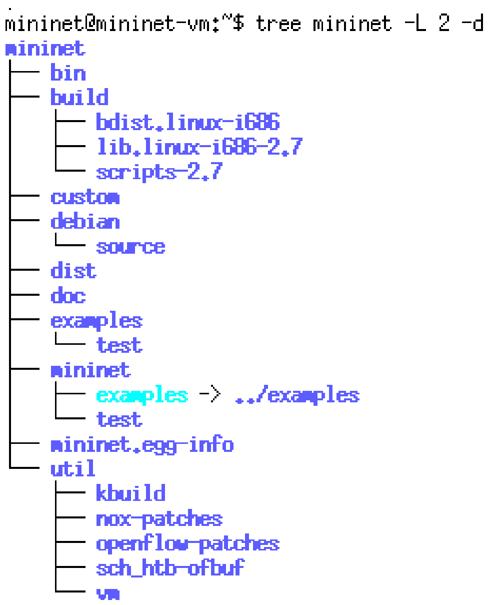
12. Melakukan cek pada tree-L1



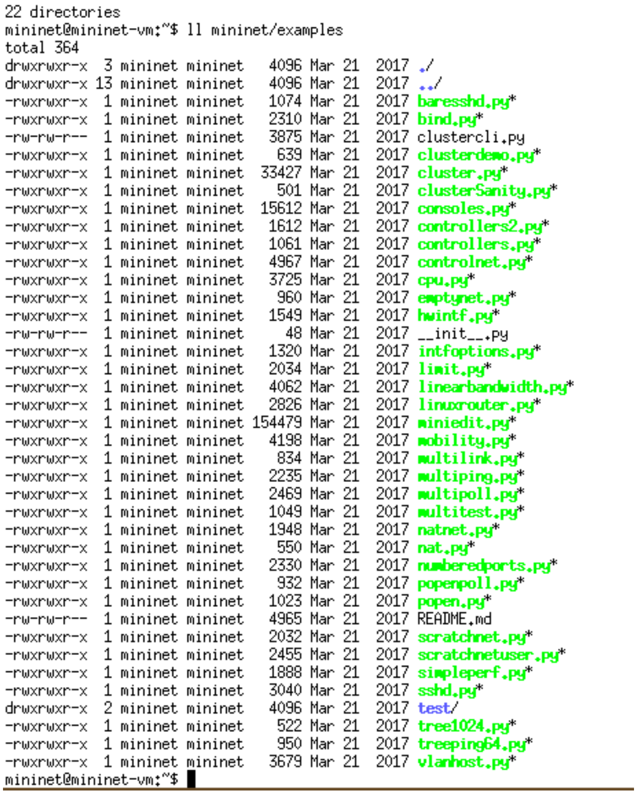
```
f:\Hagel\Kampus\installer>putty.exe -X -P 22 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet 192.168.56.102

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>putty.exe -X -P 2222 -l mininet localhost

f:\Hagel\Kampus\installer>
```

```
6 directories, 1 file
mininet@mininet-vm:~$ tree -L 1
.
├── install-mininet-vm.sh
├── loxigen
├── mininet
├── oflops
├── oftest
├── openflow
└── pox

6 directories, 1 file
mininet@mininet-vm:~$ tree -L 1
.
├── install-mininet-vm.sh
├── loxigen
├── mininet
├── oflops
├── oftest
├── openflow
└── pox

6 directories, 1 file
mininet@mininet-vm:~$
```

13. Pemeriksaan pada Mininet tree

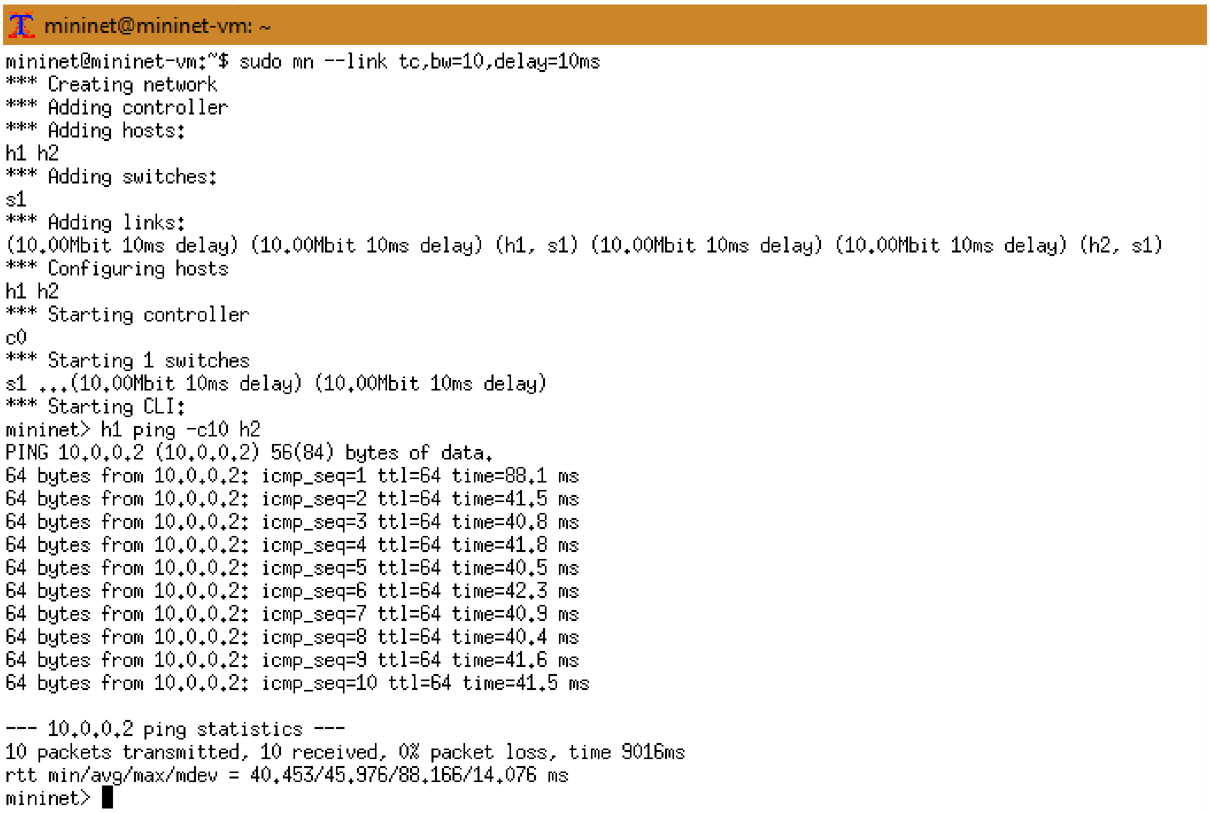


```
.
mininet@mininet-vm:~$ tree mininet -L 2 -d
mininet
├── bin
├── build
│   ├── bdist.linux-i686
│   ├── lib.linux-i686-2.7
│   └── scripts-2.7
├── custom
├── debian
│   └── source
├── dist
├── doc
├── examples
│   └── test
├── mininet
│   ├── examples -> ../examples
│   └── test
├── mininet.egg-info
└── util
    ├── kbuild
    ├── nox-patches
    ├── openflow-patches
    ├── sch_htb-ofbuf
    └── vm
```



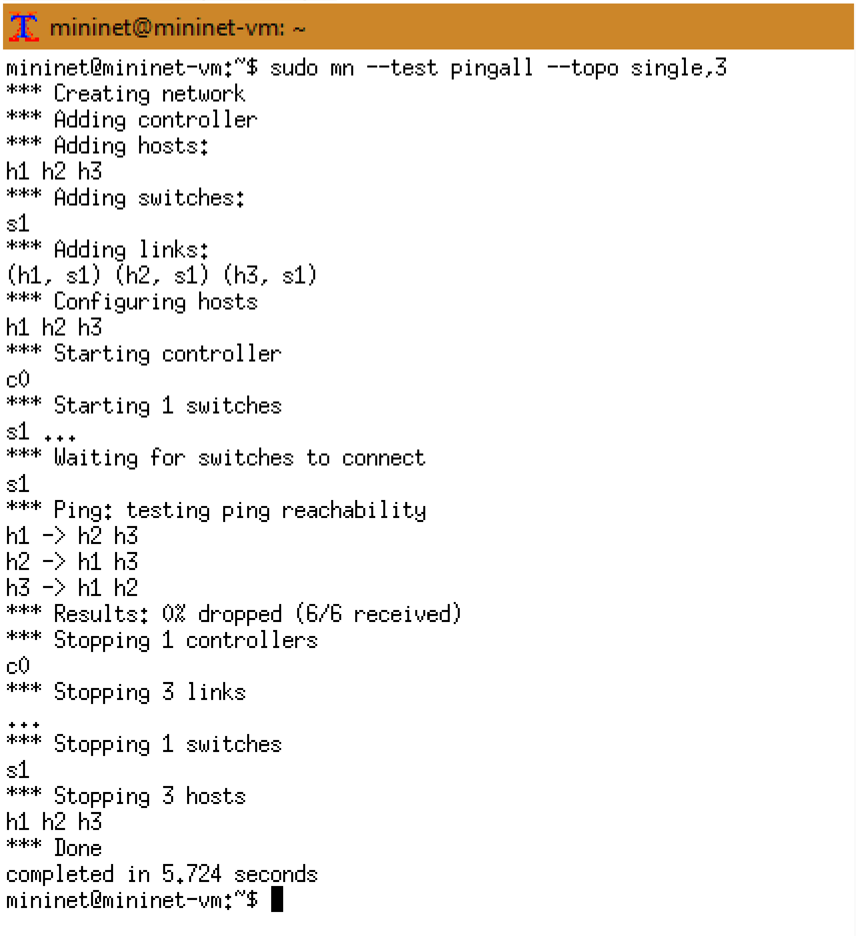
```
22 directories
mininet@mininet-vm:~$ ll mininet/examples
total 364
drwxrwxr-x  3 mininet mininet   4096 Mar 21  2017 ./
drwxrwxr-x 13 mininet mininet   4096 Mar 21  2017 ../
-rwxrwxr-x  1 mininet mininet   1074 Mar 21  2017 baresshd.py*
-rwxrwxr-x  1 mininet mininet   2310 Mar 21  2017 bind.py*
-rw-rw-r--  1 mininet mininet   3875 Mar 21  2017 clustercli.py
-rwxrwxr-x  1 mininet mininet    639 Mar 21  2017 clusterdemo.py*
-rwxrwxr-x  1 mininet mininet  33427 Mar 21  2017 cluster.py*
-rwxrwxr-x  1 mininet mininet    501 Mar 21  2017 clusterSanity.py*
-rwxrwxr-x  1 mininet mininet  15612 Mar 21  2017 consoles.py*
-rwxrwxr-x  1 mininet mininet   1612 Mar 21  2017 controllers2.py*
-rwxrwxr-x  1 mininet mininet   1061 Mar 21  2017 controllers.py*
-rwxrwxr-x  1 mininet mininet   4967 Mar 21  2017 controlnet.py*
-rwxrwxr-x  1 mininet mininet   3725 Mar 21  2017 cpu.py*
-rwxrwxr-x  1 mininet mininet    960 Mar 21  2017 emptynet.py*
-rwxrwxr-x  1 mininet mininet   1549 Mar 21  2017 hwintf.py*
-rw-rw-r--  1 mininet mininet     48 Mar 21  2017 __init__.py
-rwxrwxr-x  1 mininet mininet   1320 Mar 21  2017 intfoptions.py*
-rwxrwxr-x  1 mininet mininet   2034 Mar 21  2017 limit.py*
-rwxrwxr-x  1 mininet mininet   4062 Mar 21  2017 linearbandwidth.py*
-rwxrwxr-x  1 mininet mininet   2826 Mar 21  2017 linuxrouter.py*
-rwxrwxr-x  1 mininet mininet 154479 Mar 21  2017 miniedit.py*
-rwxrwxr-x  1 mininet mininet   4198 Mar 21  2017 mobility.py*
-rwxrwxr-x  1 mininet mininet    834 Mar 21  2017 multilink.py*
-rwxrwxr-x  1 mininet mininet   2235 Mar 21  2017 multiping.py*
-rwxrwxr-x  1 mininet mininet   2469 Mar 21  2017 multipoll.py*
-rwxrwxr-x  1 mininet mininet   1049 Mar 21  2017 multitest.py*
-rwxrwxr-x  1 mininet mininet   1948 Mar 21  2017 natnet.py*
-rwxrwxr-x  1 mininet mininet    550 Mar 21  2017 nat.py*
-rwxrwxr-x  1 mininet mininet   2330 Mar 21  2017 numberedports.py*
-rwxrwxr-x  1 mininet mininet    932 Mar 21  2017 popenpoll.py*
-rwxrwxr-x  1 mininet mininet   1023 Mar 21  2017 popen.py*
-rw-rw-r--  1 mininet mininet   4965 Mar 21  2017 README.md
-rwxrwxr-x  1 mininet mininet   2032 Mar 21  2017 scratchnet.py*
-rwxrwxr-x  1 mininet mininet   2455 Mar 21  2017 scratchnetuser.py*
-rwxrwxr-x  1 mininet mininet   1888 Mar 21  2017 simpleperf.py*
-rwxrwxr-x  1 mininet mininet   3040 Mar 21  2017 sshd.py*
drwxrwxr-x  2 mininet mininet   4096 Mar 21  2017 test/
-rwxrwxr-x  1 mininet mininet    522 Mar 21  2017 tree1024.py*
-rwxrwxr-x  1 mininet mininet    950 Mar 21  2017 treeping64.py*
-rwxrwxr-x  1 mininet mininet   3679 Mar 21  2017 vlanhost.py*
mininet@mininet-vm:~$
```

14. Melakukan link tc



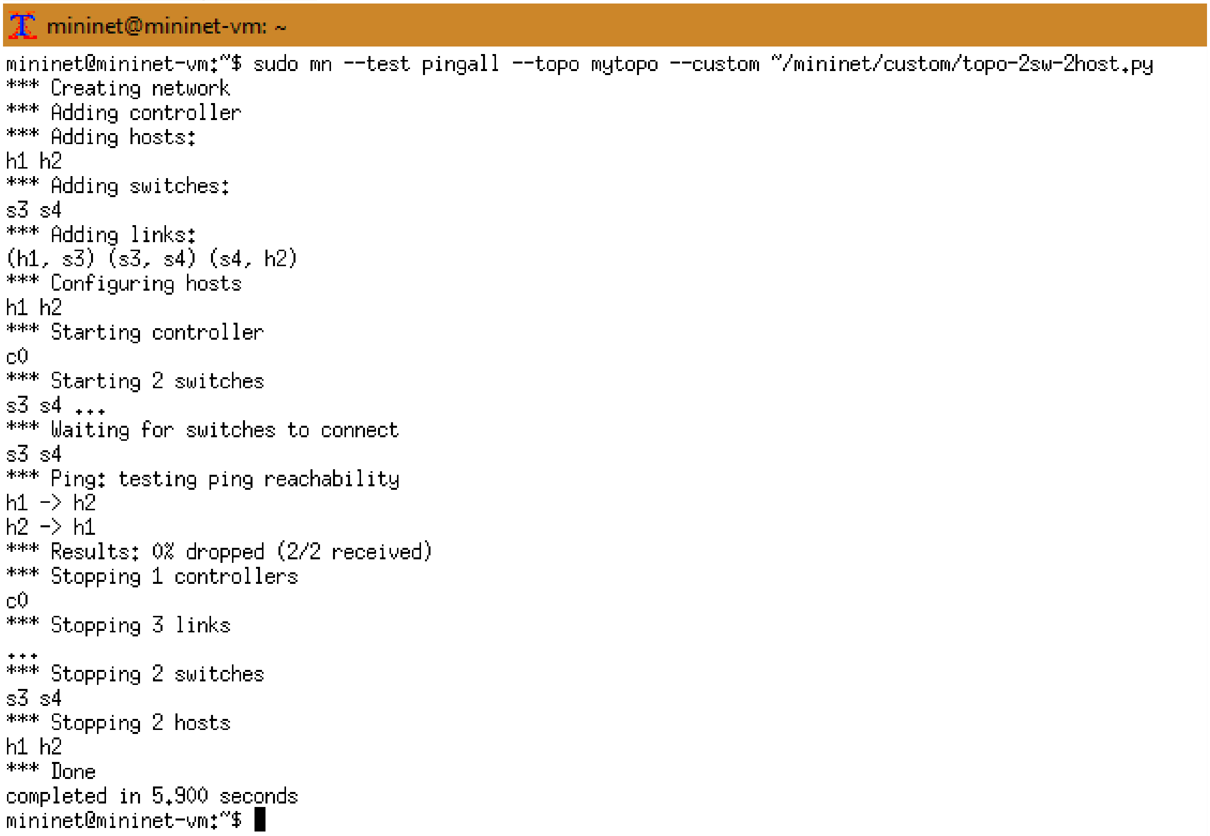
```
mininet@mininet-vm:~$ sudo mn --link tc,bw=10,delay=10ms
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(10.00Mbit 10ms delay) (10.00Mbit 10ms delay) (h1, s1) (10.00Mbit 10ms delay) (10.00Mbit 10ms delay) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...(10.00Mbit 10ms delay) (10.00Mbit 10ms delay)
*** Starting CLI:
mininet> h1 ping -c10 h2
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=88.1 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=41.5 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=40.8 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=41.8 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=40.5 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=42.3 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=40.9 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=40.4 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=41.6 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=41.5 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9016ms
rtt min/avg/max/mdev = 40.453/45.976/88.166/14.076 ms
mininet> 
```

15. Melakukan ping all single



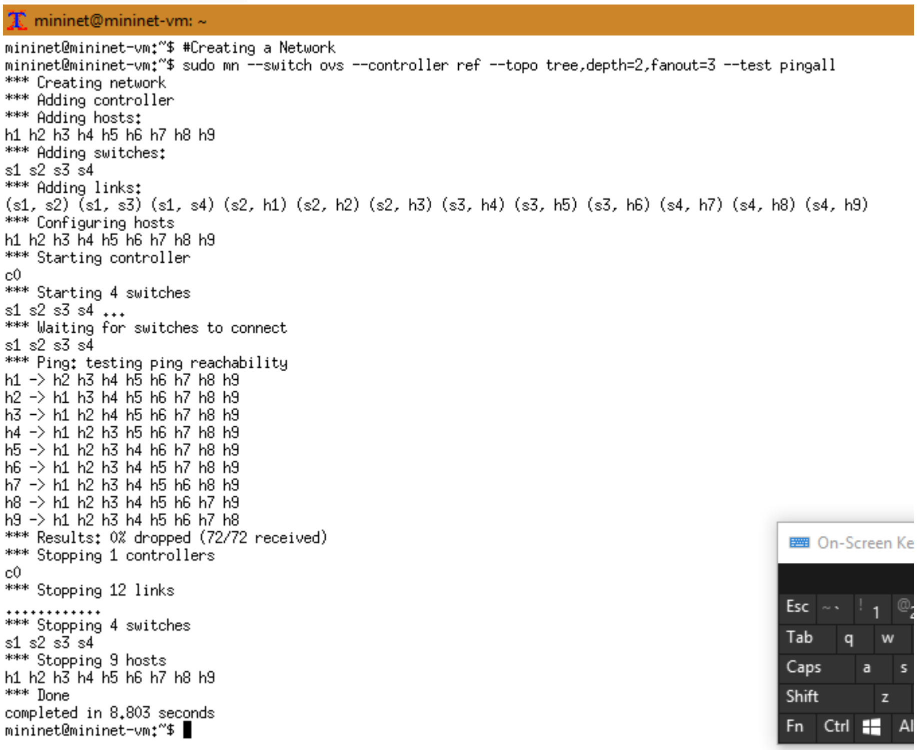
```
mininet@mininet-vm:~$ sudo mn --test pingall --topo single,3
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Waiting for switches to connect
s1
*** Ping: testing ping reachability
h1 -> h2 h3
h2 -> h1 h3
h3 -> h1 h2
*** Results: 0% dropped (6/6 received)
*** Stopping 1 controllers
c0
*** Stopping 3 links
...
*** Stopping 1 switches
s1
*** Stopping 3 hosts
h1 h2 h3
*** Done
completed in 5.724 seconds
mininet@mininet-vm:~$ 
```

16. Melakukan ping all topo



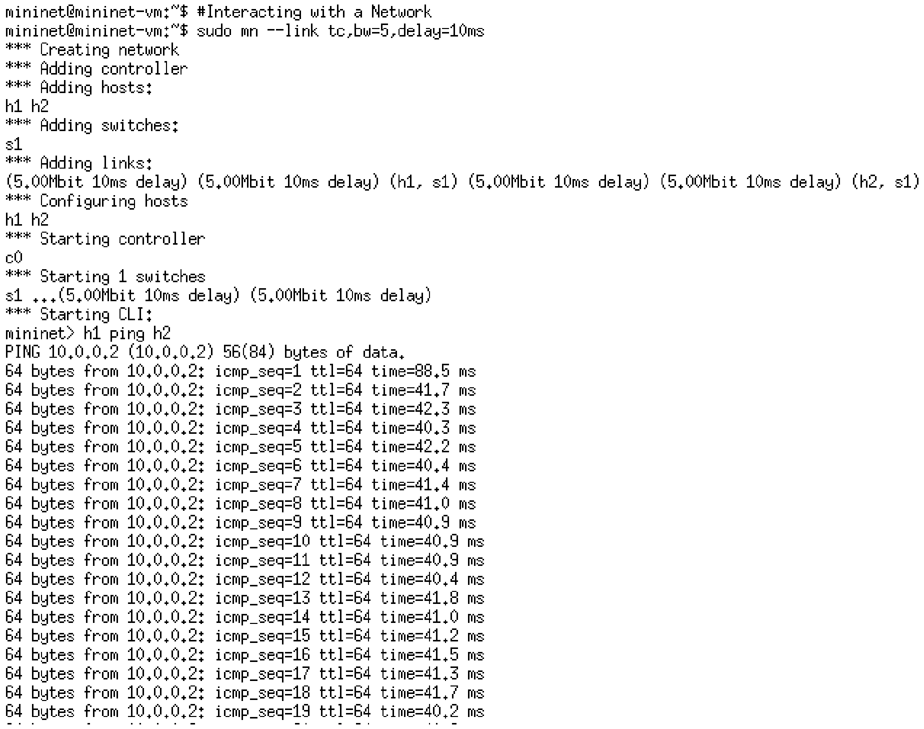
```
mininet@mininet-vm:~$ sudo mn --test pingall --topo mytopo --custom ~/mininet/custom/topo-2sw-2host.py
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s3 s4
*** Adding links:
(h1, s3) (s3, s4) (s4, h2)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 2 switches
s3 s4 ...
*** Waiting for switches to connect
s3 s4
*** Ping: testing ping reachability
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
*** Stopping 1 controllers
c0
*** Stopping 3 links
...
*** Stopping 2 switches
s3 s4
*** Stopping 2 hosts
h1 h2
*** Done
completed in 5.900 seconds
mininet@mininet-vm:~$ 
```

17. Create net network



```
mininet@mininet-vm:~$ #Creating a Network
mininet@mininet-vm:~$ sudo mn --switch ovs --controller ref --topo tree,depth=2,fanout=3 --test pingall
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Adding switches:
s1 s2 s3 s4
*** Adding links:
(s1, s2) (s1, s3) (s1, s4) (s2, h1) (s2, h2) (s2, h3) (s3, h4) (s3, h5) (s3, h6) (s4, h7) (s4, h8) (s4, h9)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Starting controller
c0
*** Starting 4 switches
s1 s2 s3 s4 ...
*** Waiting for switches to connect
s1 s2 s3 s4
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5 h6 h7 h8 h9
h2 -> h1 h3 h4 h5 h6 h7 h8 h9
h3 -> h1 h2 h4 h5 h6 h7 h8 h9
h4 -> h1 h2 h3 h5 h6 h7 h8 h9
h5 -> h1 h2 h3 h4 h6 h7 h8 h9
h6 -> h1 h2 h3 h4 h5 h7 h8 h9
h7 -> h1 h2 h3 h4 h5 h6 h8 h9
h8 -> h1 h2 h3 h4 h5 h6 h7 h9
h9 -> h1 h2 h3 h4 h5 h6 h7 h8
*** Results: 0% dropped (72/72 received)
*** Stopping 1 controllers
c0
*** Stopping 12 links
............
*** Stopping 4 switches
s1 s2 s3 s4
*** Stopping 9 hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9
*** Done
completed in 8.803 seconds
mininet@mininet-vm:~$ 
```

18. Interacting with a Network

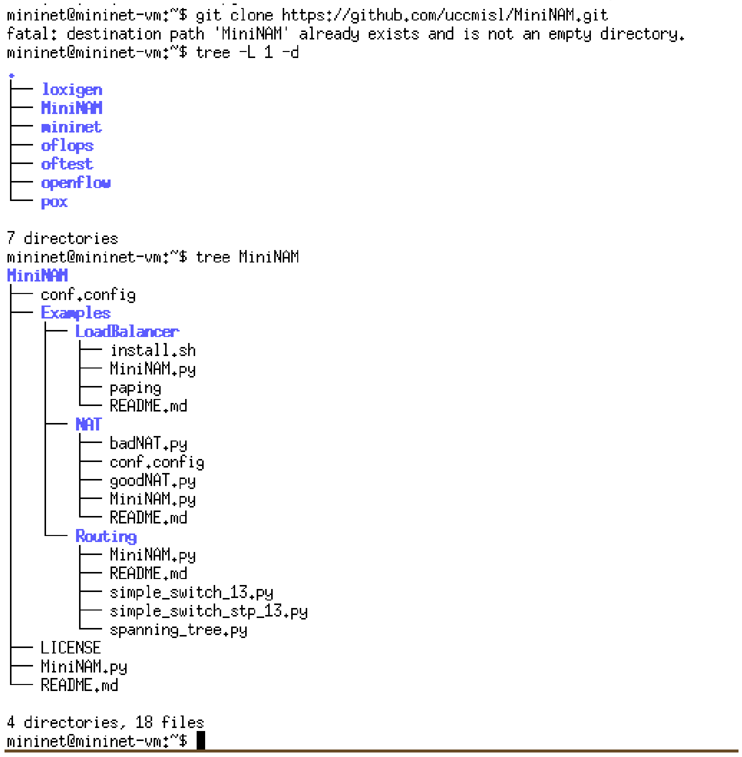


```
mininet@mininet-vm:~$ #Interacting with a Network
mininet@mininet-vm:~$ sudo mn --link tc,bw=5,delay=10ms
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(5.00Mbit 10ms delay) (5.00Mbit 10ms delay) (h1, s1) (5.00Mbit 10ms delay) (5.00Mbit 10ms delay) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...(5.00Mbit 10ms delay) (5.00Mbit 10ms delay)
*** Starting CLI:
mininet> h1 ping h2
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=88.5 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=41.7 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=42.3 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=40.3 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=42.2 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=40.4 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=41.4 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=41.0 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=40.9 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=40.9 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=40.9 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=40.4 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=41.8 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=41.0 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=41.2 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=41.5 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=41.3 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=41.7 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=40.2 ms
```

MiniNAM

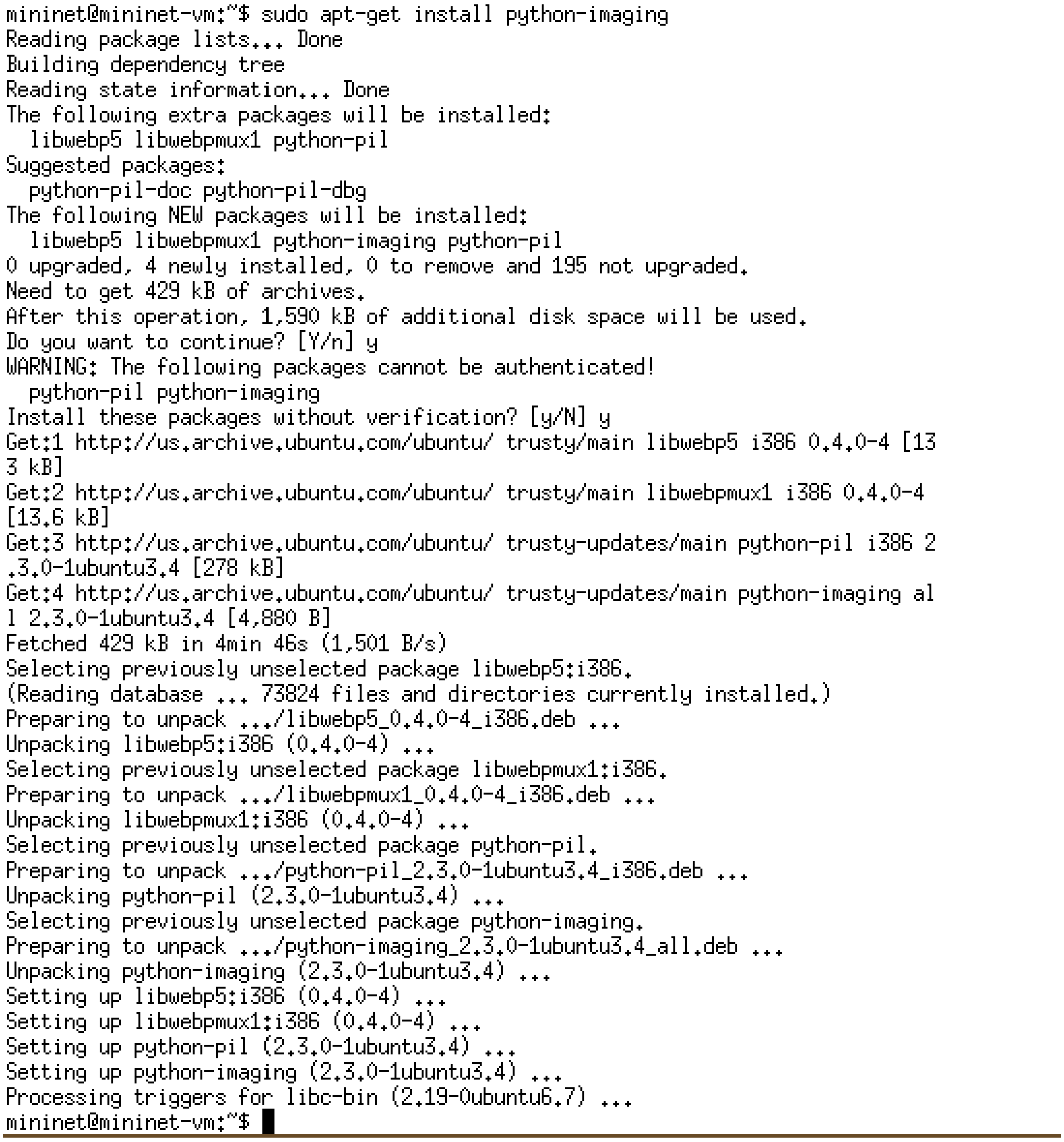
Mininam merupakan alat yang yang s angat kuat untuk debug protokol jaringan dimana ia berfungsi sebagai penyedia antarmuka pengguna grafis yang memungkinkan modifikasi dinamis preferensi dan filter paket yang sangant membantu pada prosos memahami konsep jaringan. Tahap – tahap pada MiniNAM sebagai berikut :

1. MiniNAM setup
   Instal MiniNAM dengan command “ git clone https://github.com/MiniNAM.git”, dan apabila telah terinstall akan menampilkan sebagai berikut



```
mininet@mininet-vm:~$ git clone https://github.com/uccmisl/MiniNAM.git
fatal: destination path 'MiniNAM' already exists and is not an empty directory.
mininet@mininet-vm:~$ tree -L 1 -d
.
├── loxigen
├── MiniNAM
├── mininet
├── oflops
├── oftest
├── openflow
└── pox

7 directories
mininet@mininet-vm:~$ tree MiniNAM
MiniNAM
├── conf.config
├── Examples
│   ├── LoadBalancer
│   │   ├── install.sh
│   │   ├── MiniNAM.py
│   │   ├── paping
│   │   └── README.md
│   ├── NAT
│   │   ├── badNAT.py
│   │   ├── conf.config
│   │   ├── goodNAT.py
│   │   ├── MiniNAM.py
│   │   └── README.md
│   └── Routing
│       ├── MiniNAM.py
│       ├── README.md
│       ├── simple_switch_13.py
│       ├── simple_switch_stp_13.py
│       └── spanning_tree.py
├── LICENSE
├── MiniNAM.py
└── README.md

4 directories, 18 files
mininet@mininet-vm:~$ █
```

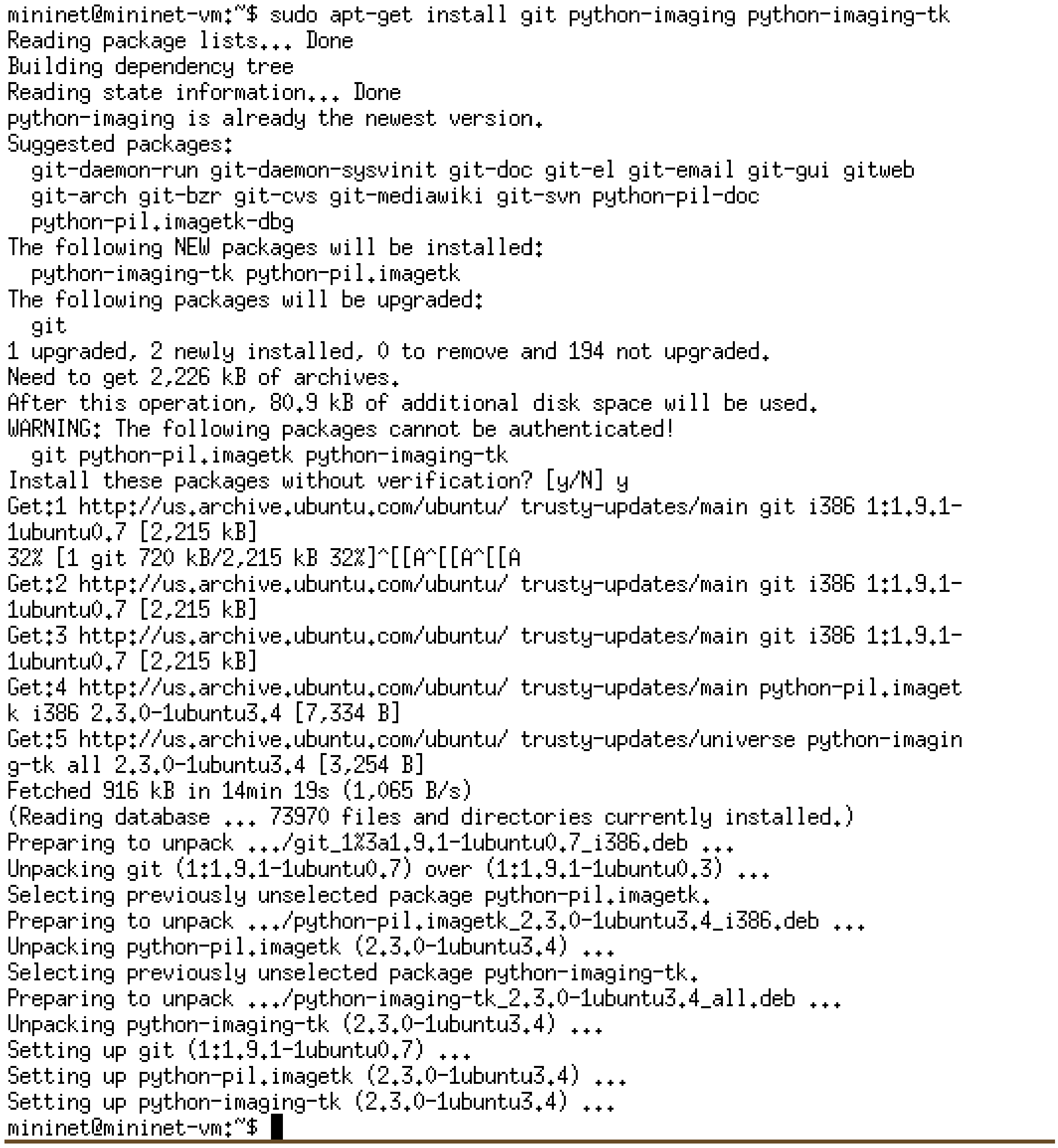
2. MiniNAM install Tkinter
   Dengan menggunakan perintah “ sudo apt-get install python-imaging ” sesuai petunjuk dari website “ https://www.ucc.ie/en/misl/research/software/mininam ”



```
mininet@mininet-vm:~$ sudo apt-get install python-imaging
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
  libwebp5 libwebpmux1 python-pil
Suggested packages:
  python-pil-doc python-pil-dbg
The following NEW packages will be installed:
  libwebp5 libwebpmux1 python-imaging python-pil
0 upgraded, 4 newly installed, 0 to remove and 195 not upgraded.
Need to get 429 kB of archives.
After this operation, 1,590 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
WARNING: The following packages cannot be authenticated!
  python-pil python-imaging
Install these packages without verification? [y/N] y
Get:1 http://us.archive.ubuntu.com/ubuntu/ trusty/main libwebp5 i386 0.4.0-4 [13
3 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu/ trusty/main libwebpmux1 i386 0.4.0-4
[13.6 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main python-pil i386 2
.3.0-1ubuntu3.4 [278 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main python-imaging al
l 2.3.0-1ubuntu3.4 [4,880 B]
Fetched 429 kB in 4min 46s (1,501 B/s)
Selecting previously unselected package libwebp5:i386.
(Reading database ... 73824 files and directories currently installed.)
Preparing to unpack .../libwebp5_0.4.0-4_i386.deb ...
Unpacking libwebp5:i386 (0.4.0-4) ...
Selecting previously unselected package libwebpmux1:i386.
Preparing to unpack .../libwebpmux1_0.4.0-4_i386.deb ...
Unpacking libwebpmux1:i386 (0.4.0-4) ...
Selecting previously unselected package python-pil.
Preparing to unpack .../python-pil_2.3.0-1ubuntu3.4_i386.deb ...
Unpacking python-pil (2.3.0-1ubuntu3.4) ...
Selecting previously unselected package python-imaging.
Preparing to unpack .../python-imaging_2.3.0-1ubuntu3.4_all.deb ...
Unpacking python-imaging (2.3.0-1ubuntu3.4) ...
Setting up libwebp5:i386 (0.4.0-4) ...
Setting up libwebpmux1:i386 (0.4.0-4) ...
Setting up python-pil (2.3.0-1ubuntu3.4) ...
Setting up python-imaging (2.3.0-1ubuntu3.4) ...
Processing triggers for libc-bin (2.19-0ubuntu6.7) ...
mininet@mininet-vm:~$ █
```

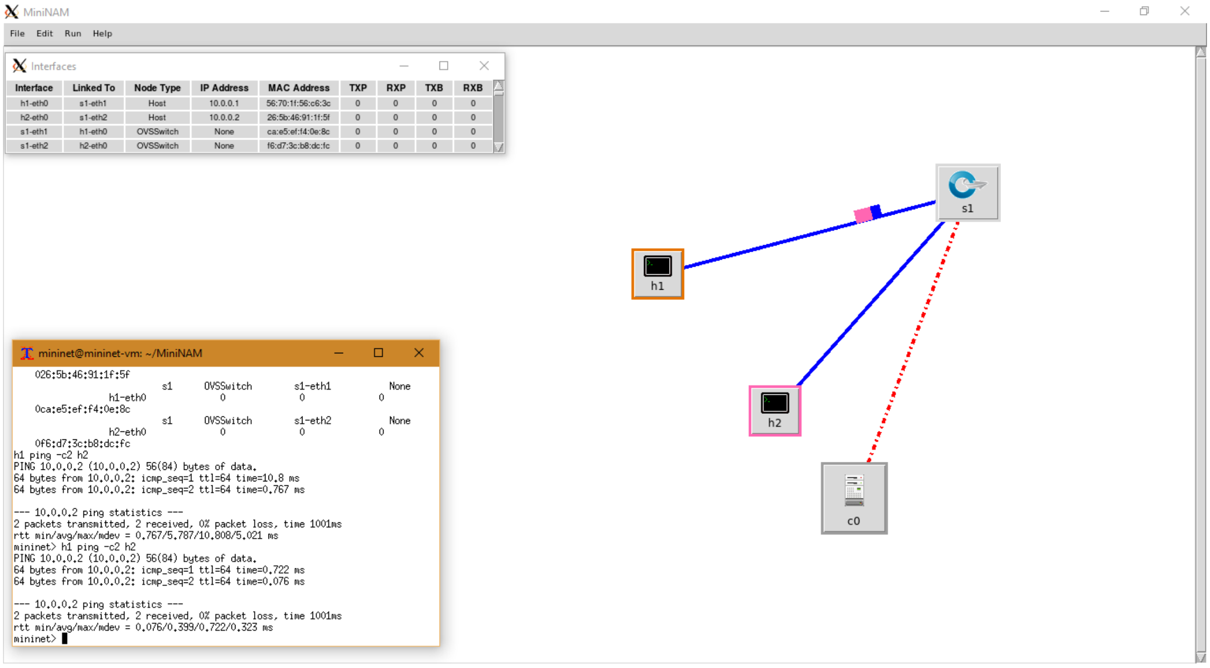
3. MiniNAM Install python imaging

   Penggunaan perintah “ sudo apt-get-install git python-imaging python-imaging-tk ”



```
mininet@mininet-vm:~$ sudo apt-get install git python-imaging python-imaging-tk
Reading package lists... Done
Building dependency tree
Reading state information... Done
python-imaging is already the newest version.
Suggested packages:
  git-daemon-run git-daemon-sysvinit git-doc git-el git-email git-gui gitweb
  git-arch git-bzr git-cvs git-mediawiki git-svn python-pil-doc
  python-pil.imagetk-dbg
The following NEW packages will be installed:
  python-imaging-tk python-pil.imagetk
The following packages will be upgraded:
  git
1 upgraded, 2 newly installed, 0 to remove and 194 not upgraded.
Need to get 2,226 kB of archives.
After this operation, 80.9 kB of additional disk space will be used.
WARNING: The following packages cannot be authenticated!
  git python-pil.imagetk python-imaging-tk
Install these packages without verification? [y/N] y
Get:1 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main git i386 1:1.9.1-
1ubuntu0.7 [2,215 kB]
32% [1 git 720 kB/2,215 kB 32%]^[[A^[[A^[[A
Get:2 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main git i386 1:1.9.1-
1ubuntu0.7 [2,215 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main git i386 1:1.9.1-
1ubuntu0.7 [2,215 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main python-pil.imaget
k i386 2.3.0-1ubuntu3.4 [7,334 B]
Get:5 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/universe python-imagin
g-tk all 2.3.0-1ubuntu3.4 [3,254 B]
Fetched 916 kB in 14min 19s (1,065 B/s)
(Reading database ... 73970 files and directories currently installed.)
Preparing to unpack .../git_1%3a1.9.1-1ubuntu0.7_i386.deb ...
Unpacking git (1:1.9.1-1ubuntu0.7) over (1:1.9.1-1ubuntu0.3) ...
Selecting previously unselected package python-pil.imagetk.
Preparing to unpack .../python-pil.imagetk_2.3.0-1ubuntu3.4_i386.deb ...
Unpacking python-pil.imagetk (2.3.0-1ubuntu3.4) ...
Selecting previously unselected package python-imaging-tk.
Preparing to unpack .../python-imaging-tk_2.3.0-1ubuntu3.4_all.deb ...
Unpacking python-imaging-tk (2.3.0-1ubuntu3.4) ...
Setting up git (1:1.9.1-1ubuntu0.7) ...
Setting up python-pil.imagetk (2.3.0-1ubuntu3.4) ...
Setting up python-imaging-tk (2.3.0-1ubuntu3.4) ...
mininet@mininet-vm:~$ █
```

4. MiniNAM ping
   run miniNAM dengan cara akses ke direktori MiniNAM lalu berikan perintah 'sudo python MiniNAM.py', maka GUI MiniNAM akan muncul dengan setting default, lalu lakukan ping dari host 1 ke host 2 dengan perintah 'h1 ping -c2 h2' pada CLI mininet.



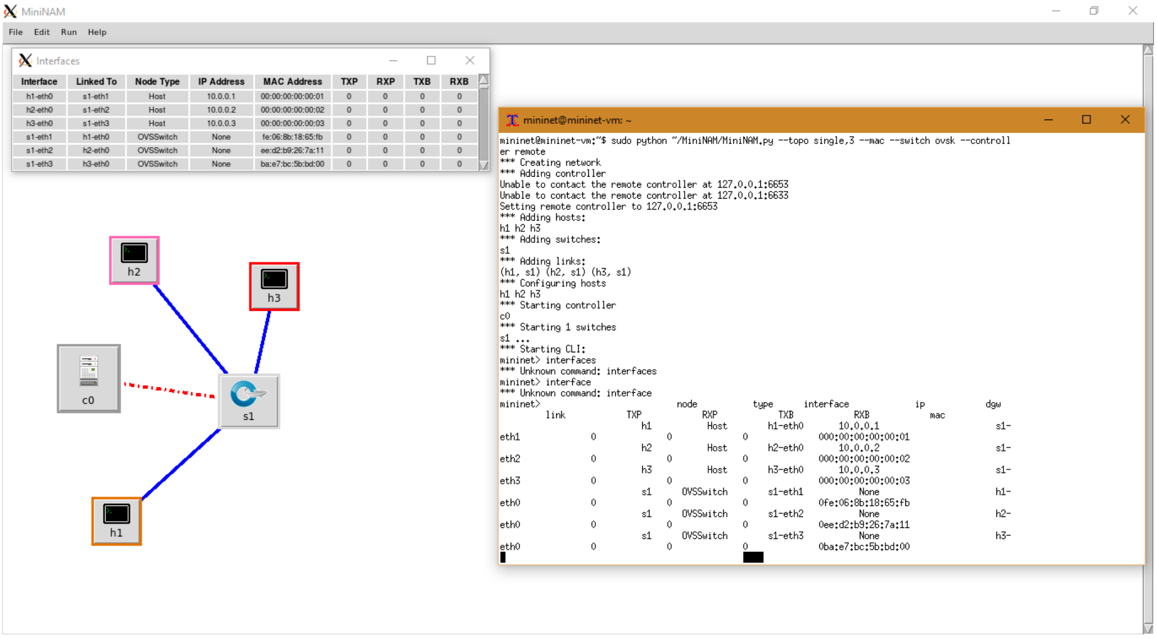
Interface	Linked To	Node Type	IP Address	MAC Address	TXP	RXP	TXB	RXB
h1-eth0	s1-eth1	Host	10.0.0.1	56:70:1f:56:c6:3c	0	0	0	0
h2-eth0	s1-eth2	Host	10.0.0.2	26:5b:46:91:1f:5f	0	0	0	0
s1-eth1	h1-eth0	OVSSwitch	None	ca:e5:ef:f4:0e:8c	0	0	0	0
s1-eth2	h2-eth0	OVSSwitch	None	f6:d7:3c:b8:dc:fc	0	0	0	0

```
    026:5b:46:91:1f:5f
                           s1      OVSSwitch        s1-eth1         None
              h1-eth0                  0                0              0
    0ca:e5:ef:f4:0e:8c
                           s1      OVSSwitch        s1-eth2         None
              h2-eth0                  0                0              0
    0f6:d7:3c:b8:dc:fc
h1 ping -c2 h2
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=10.8 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.767 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.767/5.787/10.808/5.021 ms
mininet> h1 ping -c2 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.722 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.076 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.076/0.399/0.722/0.323 ms
mininet> 
```

Open Flow

OpenFlow adalah sebuah protokol yang memungkinkan pengaturan penjaluran dan pengiriman packet ketika melalui sebuah switch dimana setiap switch hanya berfungsi meneruskan packet yang lewat ke port yang sesuai tanpa dapat membedakan type protokol data yang dikirimkan. Tahap-tahapnya sebagai berikut

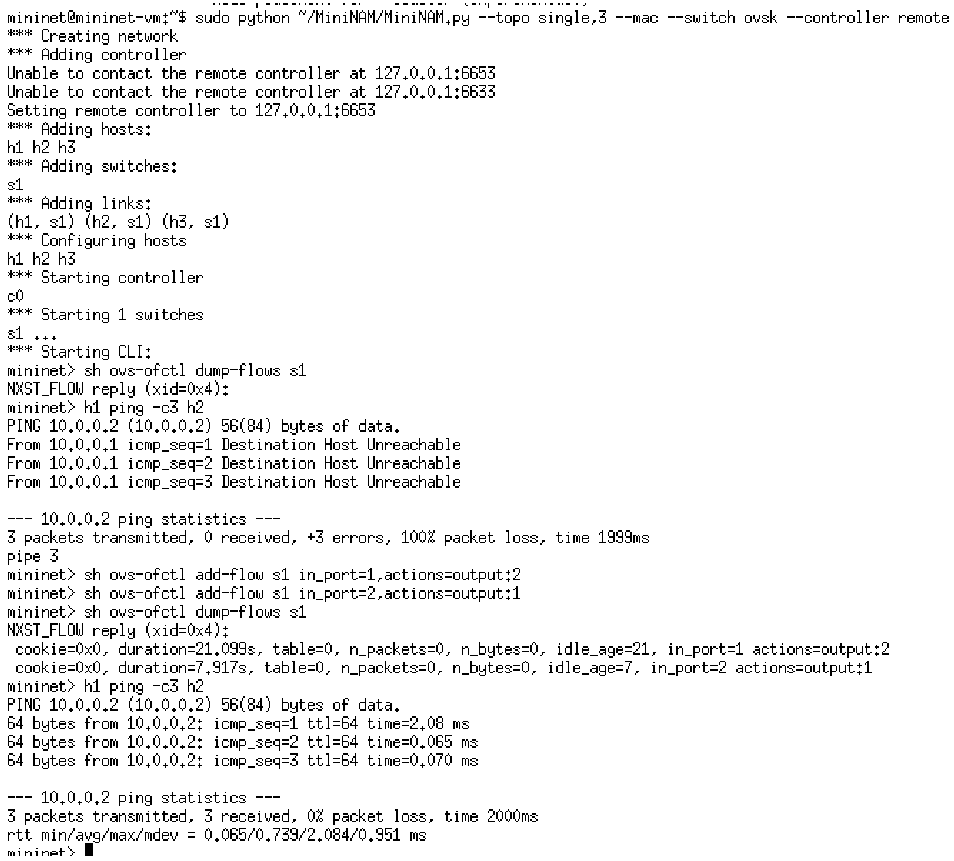
1. Membuat 3 host dan 1 switch



Interface	Linked To	Node Type	IP Address	MAC Address	TXP	RXP	TXB	RXB
h1-eth0	s1-eth1	Host	10.0.0.1	00:00:00:00:00:01	0	0	0	0
h2-eth0	s1-eth2	Host	10.0.0.2	00:00:00:00:00:02	0	0	0	0
h3-eth0	s1-eth3	Host	10.0.0.3	00:00:00:00:00:03	0	0	0	0
s1-eth1	h1-eth0	OVSSwitch	None	fe:06:8b:18:65:fb	0	0	0	0
s1-eth2	h2-eth0	OVSSwitch	None	ee:d2:b9:26:7a:11	0	0	0	0
s1-eth3	h3-eth0	OVSSwitch	None	ba:e7:bc:5b:bd:00	0	0	0	0

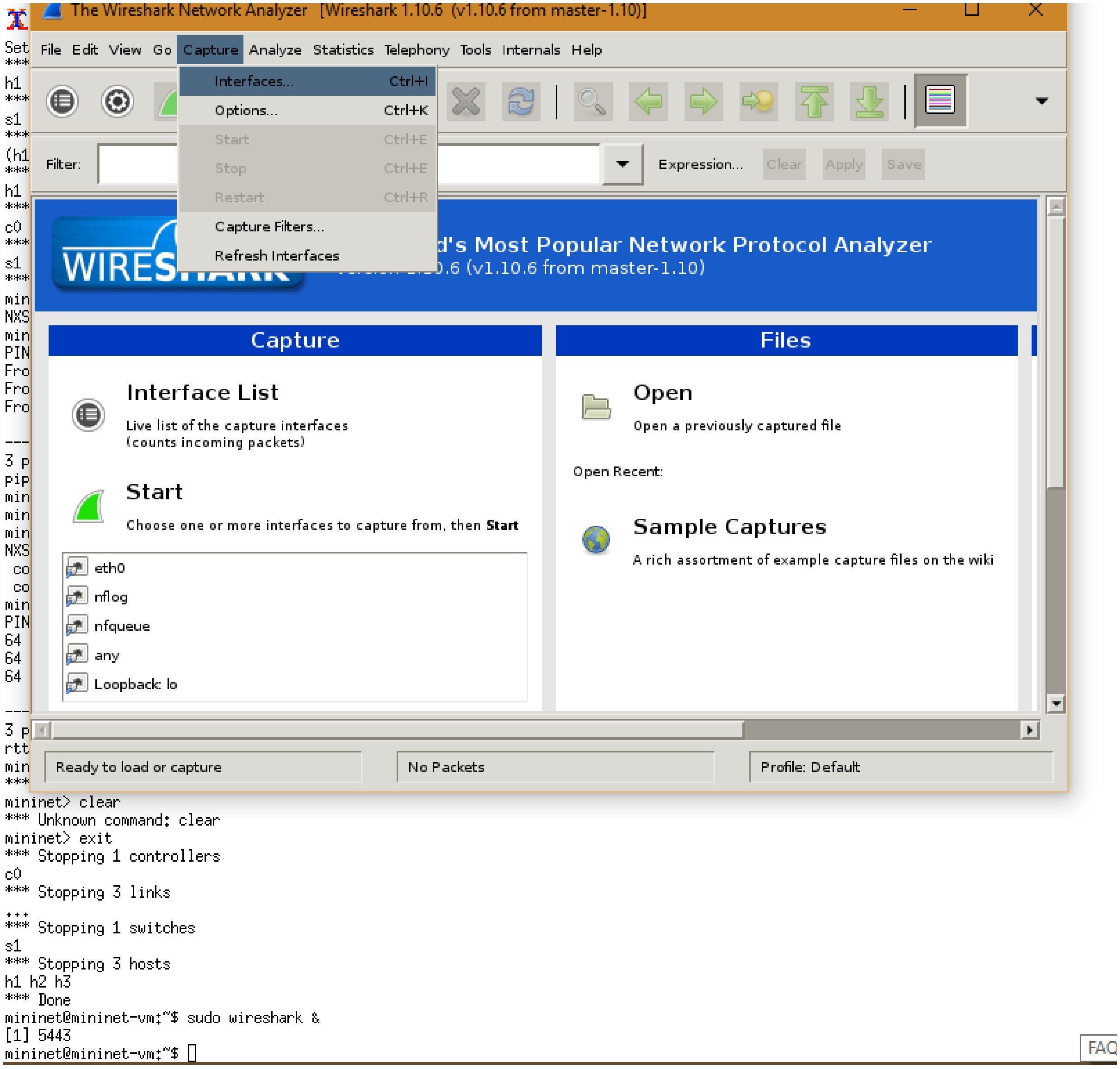
```
mininet@mininet-vm:~$ sudo python ~/MiniNAM/MiniNAM.py --topo single,3 --mac --switch ovsk --controll
er remote
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Unable to contact the remote controller at 127.0.0.1:6633
Setting remote controller to 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> interfaces
*** Unknown command: interfaces
mininet> interface
*** Unknown command: interface
mininet>                          node          type      interface          ip           dgw
        link          TXP           RXP           TXB           RXB              mac
                            h1          Host        h1-eth0      10.0.0.1                     s1-
eth1                0             0             0             000:00:00:00:00:01
                            h2          Host        h2-eth0      10.0.0.2                     s1-
eth2                0             0             0             000:00:00:00:00:02
                            h3          Host        h3-eth0      10.0.0.3                     s1-
eth3                0             0             0             000:00:00:00:00:03
                            s1      OVSSwitch       s1-eth1          None                     h1-
eth0                0             0             0             0fe:06:8b:18:65:fb
                            s1      OVSSwitch       s1-eth2          None                     h2-
eth0                0             0             0             0ee:d2:b9:26:7a:11
                            s1      OVSSwitch       s1-eth3          None                     h3-
eth0                0             0             0             0ba:e7:bc:5b:bd:00
```

2. Menambahkan openvswitch flow ke tropologi



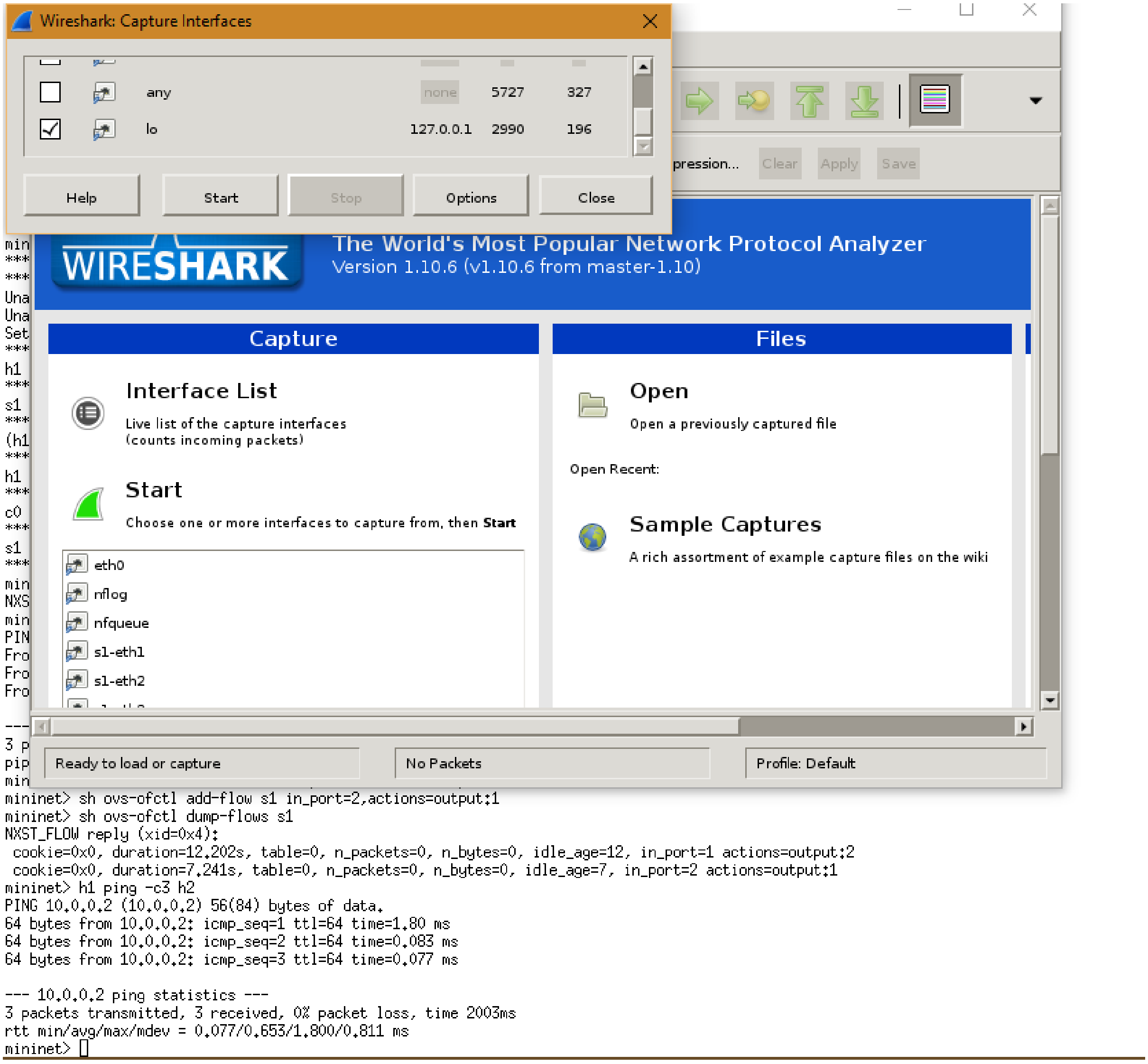
```
mininet@mininet-vm:~$ sudo python ~/MiniNAM/MiniNAM.py --topo single,3 --mac --switch ovsk --controller remote
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Unable to contact the remote controller at 127.0.0.1:6633
Setting remote controller to 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> sh ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
mininet> h1 ping -c3 h2
PING 10.0.0.2 (10.0.0.2) 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

--- 10.0.0.2 ping statistics ---
3 packets transmitted, 0 received, +3 errors, 100% packet loss, time 1999ms
pipe 3
mininet> sh ovs-ofctl add-flow s1 in_port=1,actions=output:2
mininet> sh ovs-ofctl add-flow s1 in_port=2,actions=output:1
mininet> sh ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=21.099s, table=0, n_packets=0, n_bytes=0, idle_age=21, in_port=1 actions=output:2
 cookie=0x0, duration=7.917s, table=0, n_packets=0, n_bytes=0, idle_age=7, in_port=2 actions=output:1
mininet> h1 ping -c3 h2
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=2.08 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.065 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.070 ms

--- 10.0.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2000ms
rtt min/avg/max/mdev = 0.065/0.739/2.084/0.951 ms
mininet>
```

3. Membuka WireShark dengan perintah “ sudo wireshark &”



```
Set
***
h1
***
s1
***
(h1
***
h1
***
c0
***
s1
***
min
NXS
min
PIN
Fro
Fro
Fro

---
3 p
pip
min
min
min
NXS
 co
 co
min
PIN
64
64
64

---
3 p
rtt
min
***
mininet> clear
*** Unknown command: clear
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 3 links
...
*** Stopping 1 switches
s1
*** Stopping 3 hosts
h1 h2 h3
*** Done
mininet@mininet-vm:~$ sudo wireshark &
[1] 5443
mininet@mininet-vm:~$ 
```

4. Membuka capture interface dan memilih io lalu start



Wireshark: Capture Interfaces

□		any	none	5727	327
☑		lo	127.0.0.1	2990	196

The World's Most Popular Network Protocol Analyzer
Version 1.10.6 (v1.10.6 from master-1.10)

Capture

Interface List

Live list of the capture interfaces (counts incoming packets)

Start

Choose one or more interfaces to capture from, then **Start**

- eth0
- nflog
- nfqueue
- s1-eth1
- s1-eth2

Files

Open

Open a previously captured file

Open Recent:

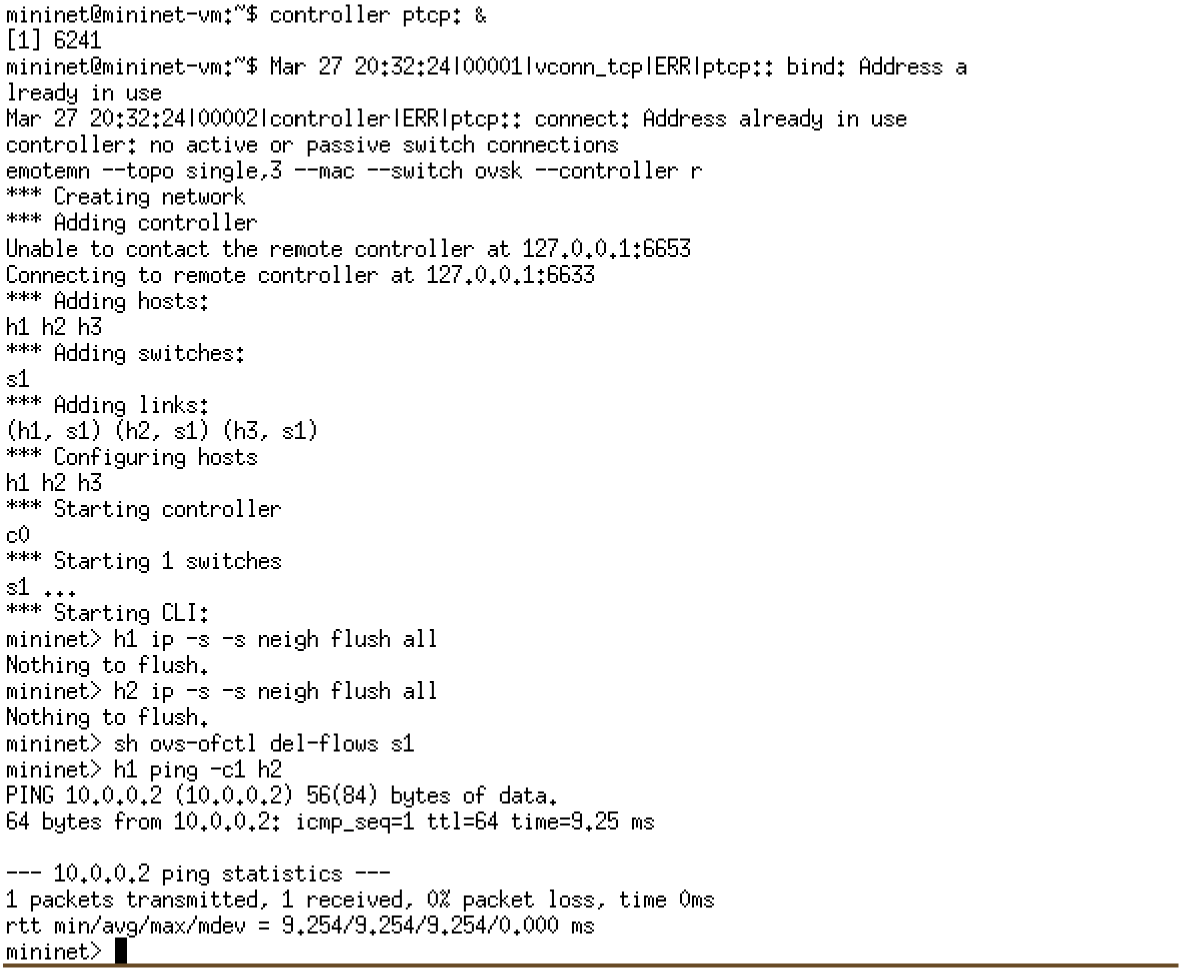
Sample Captures

A rich assortment of example capture files on the wiki

Ready to load or capture | No Packets | Profile: Default

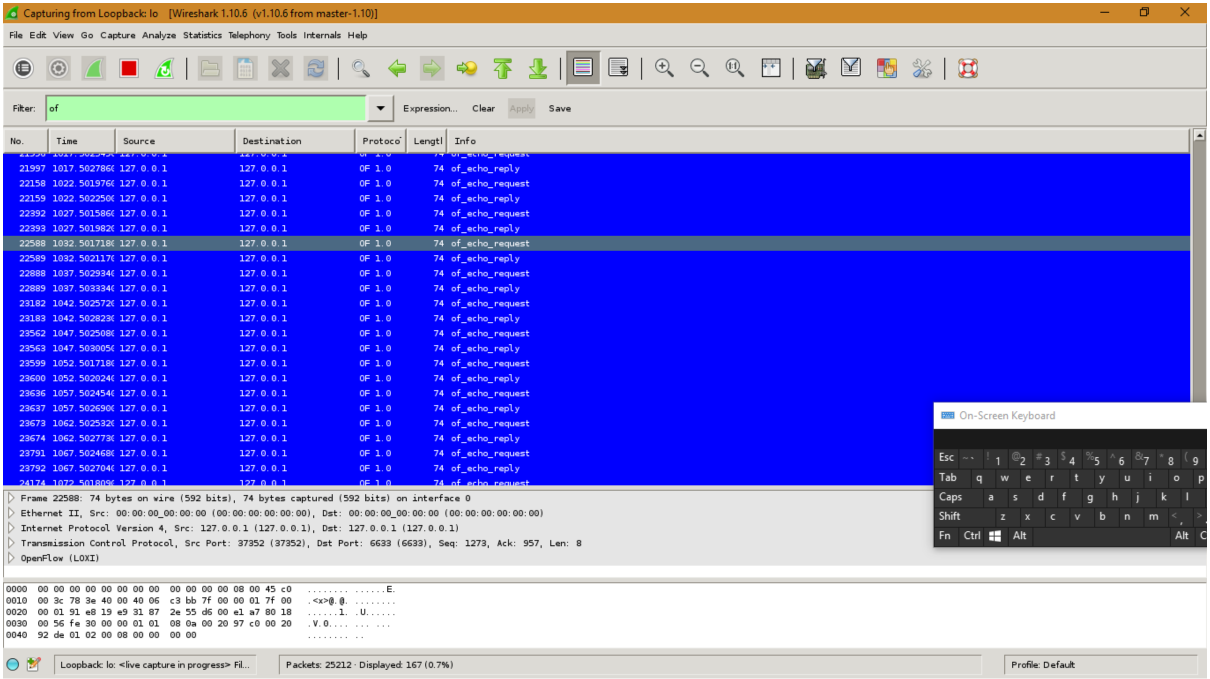
```
mininet> sh ovs-ofctl add-flow s1 in_port=2,actions=output:1
mininet> sh ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=12.202s, table=0, n_packets=0, n_bytes=0, idle_age=12, in_port=1 actions=output:2
 cookie=0x0, duration=7.241s, table=0, n_packets=0, n_bytes=0, idle_age=7, in_port=2 actions=output:1
mininet> h1 ping -c3 h2
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=1.80 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.083 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.077 ms

--- 10.0.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 0.077/0.653/1.800/0.811 ms
mininet> 
```

5. Membuat referensi OF controler



```
mininet@mininet-vm:~$ controller ptcp: &
[1] 6241
mininet@mininet-vm:~$ Mar 27 20:32:24|00001|vconn_tcp|ERR|ptcp:: bind: Address a
lready in use
Mar 27 20:32:24|00002|controller|ERR|ptcp:: connect: Address already in use
controller: no active or passive switch connections
emotemn --topo single,3 --mac --switch ovsk --controller r
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Connecting to remote controller at 127.0.0.1:6633
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> h1 ip -s -s neigh flush all
Nothing to flush.
mininet> h2 ip -s -s neigh flush all
Nothing to flush.
mininet> sh ovs-ofctl del-flows s1
mininet> h1 ping -c1 h2
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=9.25 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 9.254/9.254/9.254/0.000 ms
mininet> 
```

6. Filter OF pada WireShark dan apply



Capturing from Loopback: lo   [Wireshark 1.10.6 (v1.10.6 from master-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Expression... Clear Apply Save
On-Screen Keyboard

Filter: of

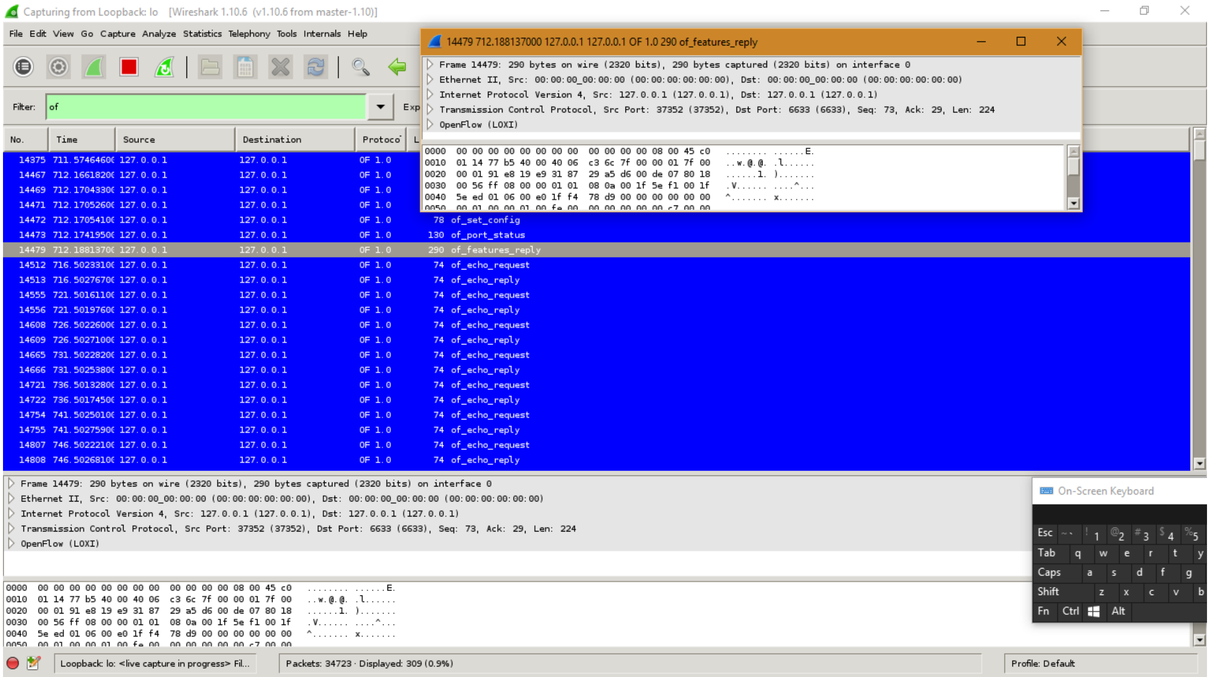
No.	Time	Source	Destination	Protoco	Lengtl	Info
21997	1017.502786(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
22158	1022.501976(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
22159	1022.502250(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
22392	1027.501586(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
22393	1027.501982(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
22588	1032.501718(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
22589	1032.502117(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
22888	1037.502934(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
22889	1037.503334(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
23182	1042.502572(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
23183	1042.502823(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
23562	1047.502508(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
23563	1047.503005(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
23599	1052.501718(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
23600	1052.502024(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
23636	1057.502454(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
23637	1057.502690(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
23673	1062.502532(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
23674	1062.502773(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
23791	1067.502468(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request
23792	1067.502704(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_reply
24174	1072.501809(	127.0.0.1	127.0.0.1	OF 1.0	74	of_echo_request

```
▷ Frame 22588: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
▷ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
▷ Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
▷ Transmission Control Protocol, Src Port: 37352 (37352), Dst Port: 6633 (6633), Seq: 1273, Ack: 957, Len: 8
▷ OpenFlow (LOXI)
```

```
0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 c0   ........ ......E.
0010  00 3c 78 3e 40 00 40 06  c3 bb 7f 00 00 01 7f 00   .<x>@.@. ........
0020  00 01 91 e8 19 e9 31 87  2e 55 d6 00 e1 a7 80 18   ......1. .U......
0030  00 56 fe 30 00 00 01 01  08 0a 00 20 97 c0 00 20   .V.0.... ... ...
0040  92 de 01 02 00 08 00 00  00 00                     ........ ..
```

Loopback: lo: <live capture in progress> Fil...   Packets: 25212 · Displayed: 167 (0.7%)   Profile: Default

7. Inspect packet


Capturing from Loopback: lo   [Wireshark 1.10.6 (v1.10.6 from master-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter: of
Exp
On-Screen Keyboard

```
No.     Time        Source        Destination    Protoco  L
 14375  711.574646( 127.0.0.1     127.0.0.1      OF 1.0
 14467  712.166182( 127.0.0.1     127.0.0.1      OF 1.0
 14469  712.170433( 127.0.0.1     127.0.0.1      OF 1.0
 14471  712.170526( 127.0.0.1     127.0.0.1      OF 1.0
 14472  712.170541( 127.0.0.1     127.0.0.1      OF 1.0     78  of_set_config
 14473  712.174195( 127.0.0.1     127.0.0.1      OF 1.0    130  of_port_status
 14479  712.188137( 127.0.0.1     127.0.0.1      OF 1.0    290  of_features_reply
 14512  716.502331( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14513  716.502767( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
 14555  721.501611( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14556  721.501976( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
 14608  726.502260( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14609  726.502710( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
 14665  731.502282( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14666  731.502538( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
 14721  736.501328( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14722  736.501745( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
 14754  741.502501( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14755  741.502759( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
 14807  746.502221( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_request
 14808  746.502681( 127.0.0.1     127.0.0.1      OF 1.0     74  of_echo_reply
```

14479 712.188137000 127.0.0.1 127.0.0.1 OF 1.0 290 of_features_reply

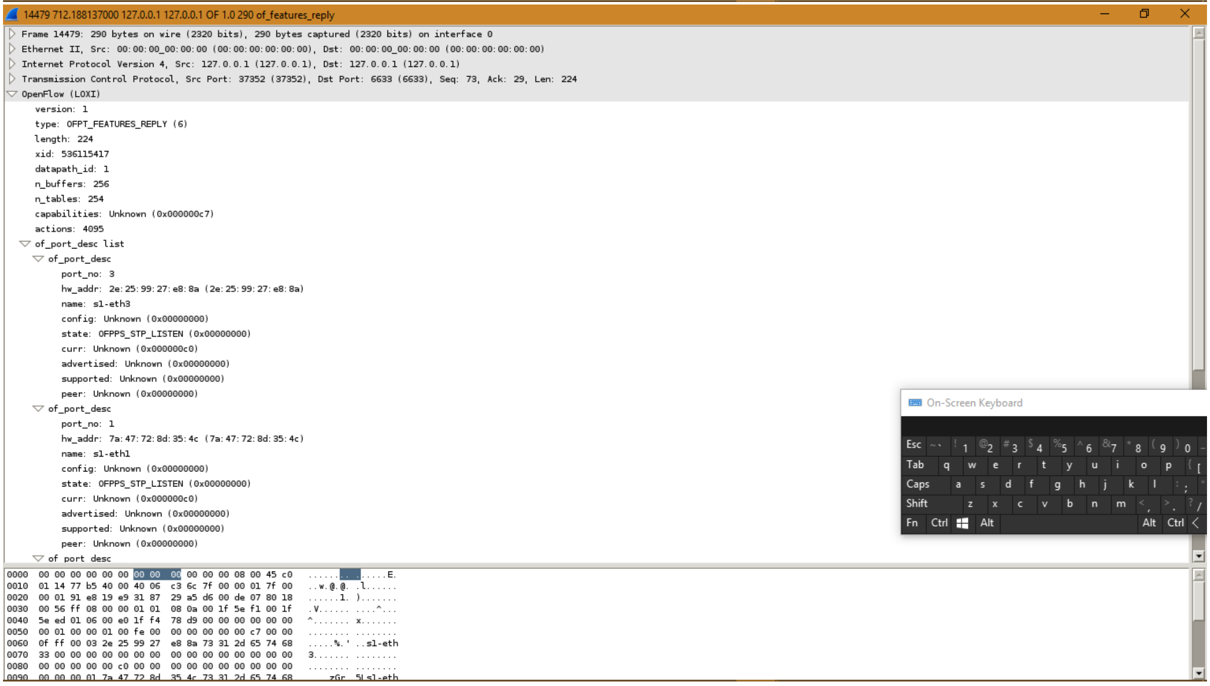
```
▷ Frame 14479: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface 0
▷ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
▷ Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
▷ Transmission Control Protocol, Src Port: 37352 (37352), Dst Port: 6633 (6633), Seq: 73, Ack: 29, Len: 224
▷ OpenFlow (LOXI)

0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 c0   ........ ......E.
0010  01 14 77 b5 40 00 40 06  c3 6c 7f 00 00 01 7f 00   ..w.@.@. .l......
0020  00 01 91 e8 19 e9 31 87  29 a5 d6 00 de 07 80 18   ......1. ).......
0030  00 56 ff 08 00 00 01 01  08 0a 00 1f 5e f1 00 1f   .V...... ....^...
0040  5e ed 01 06 00 e0 1f f4  78 d9 00 00 00 00 00 00   ^....... x.......
0050  00 01 00 00 01 00 fe 00  00 00 00 00 00 c7 00 00
```

```
▷ Frame 14479: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface 0
▷ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
▷ Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
▷ Transmission Control Protocol, Src Port: 37352 (37352), Dst Port: 6633 (6633), Seq: 73, Ack: 29, Len: 224
▷ OpenFlow (LOXI)

0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 c0   ........ ......E.
0010  01 14 77 b5 40 00 40 06  c3 6c 7f 00 00 01 7f 00   ..w.@.@. .l......
0020  00 01 91 e8 19 e9 31 87  29 a5 d6 00 de 07 80 18   ......1. ).......
0030  00 56 ff 08 00 00 01 01  08 0a 00 1f 5e f1 00 1f   .V...... ....^...
0040  5e ed 01 06 00 e0 1f f4  78 d9 00 00 00 00 00 00   ^....... x.......
0050  00 01 00 00 01 00 fe 00  00 00 00 00 00 c7 00 00
```

Loopback: lo: <live capture in progress> Fil...

Packets: 34723 · Displayed: 309 (0.9%)

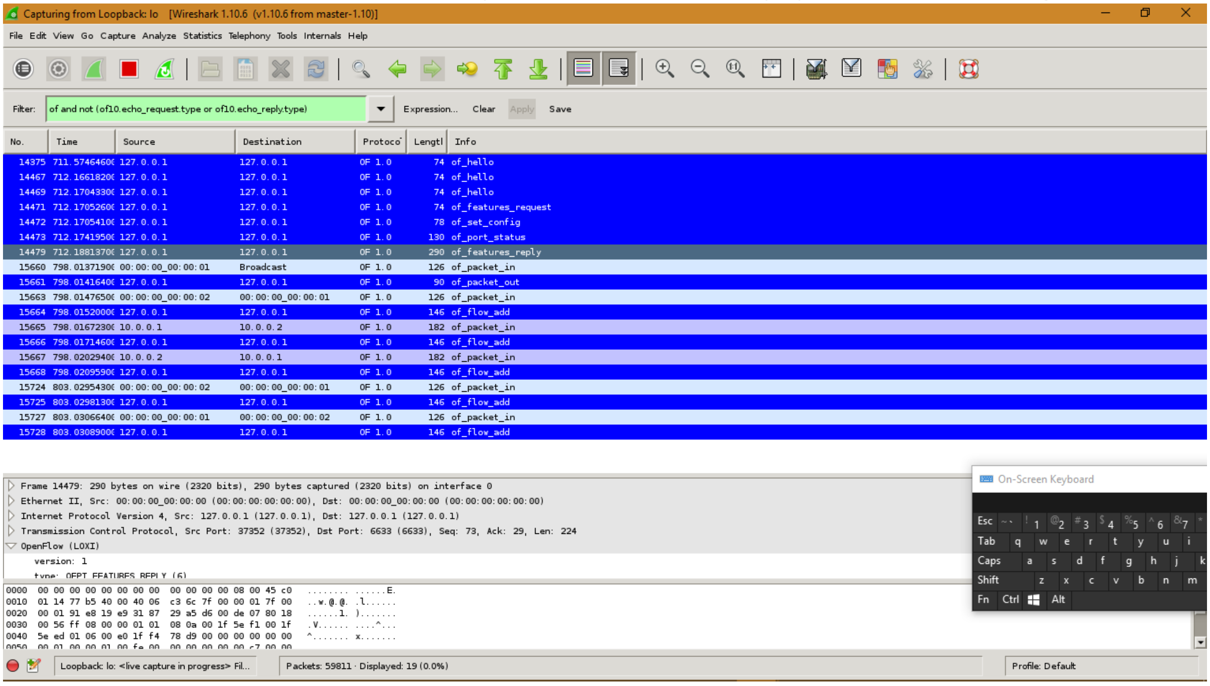
Profile: Default



14479 712.188137000 127.0.0.1 127.0.0.1 OF 1.0 290 of_features_reply

```
▷ Frame 14479: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface 0
▷ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
▷ Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
▷ Transmission Control Protocol, Src Port: 37352 (37352), Dst Port: 6633 (6633), Seq: 73, Ack: 29, Len: 224
▽ OpenFlow (LOXI)
    version: 1
    type: OFPT_FEATURES_REPLY (6)
    length: 224
    xid: 536115417
    datapath_id: 1
    n_buffers: 256
    n_tables: 254
    capabilities: Unknown (0x000000c7)
    actions: 4095
  ▽ of_port_desc list
    ▽ of_port_desc
        port_no: 3
        hw_addr: 2e:25:99:27:e8:8a (2e:25:99:27:e8:8a)
        name: s1-eth3
        config: Unknown (0x00000000)
        state: OFPPS_STP_LISTEN (0x00000000)
        curr: Unknown (0x000000c0)
        advertised: Unknown (0x00000000)
        supported: Unknown (0x00000000)
        peer: Unknown (0x00000000)
    ▽ of_port_desc
        port_no: 1
        hw_addr: 7a:47:72:8d:35:4c (7a:47:72:8d:35:4c)
        name: s1-eth1
        config: Unknown (0x00000000)
        state: OFPPS_STP_LISTEN (0x00000000)
        curr: Unknown (0x000000c0)
        advertised: Unknown (0x00000000)
        supported: Unknown (0x00000000)
        peer: Unknown (0x00000000)
    ▽ of_port_desc

0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 c0   ........ ......E.
0010  01 14 77 b5 40 00 40 06  c3 6c 7f 00 00 01 7f 00   ..w.@.@. .l......
0020  00 01 91 e8 19 e9 31 87  29 a5 d6 00 de 07 80 18   ......1. ).......
0030  00 56 ff 08 00 00 01 01  08 0a 00 1f 5e f1 00 1f   .V...... ....^...
0040  5e ed 01 06 00 e0 1f f4  78 d9 00 00 00 00 00 00   ^....... x.......
0050  00 01 00 00 01 00 fe 00  00 00 00 00 00 c7 00 00   ........ ........
0060  0f ff 00 03 2e 25 99 27  e8 8a 73 31 2d 65 74 68   .....%.' ..s1-eth
0070  33 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   3....... ........
0080  00 00 00 00 00 c0 00 00  00 00 00 00 00 00 00 00   ........ ........
0090  00 00 00 01 7a 47 72 8d  35 4c 73 31 2d 65 74 68   ....zGr. 5Ls1-eth
```

8. Filter of dan not (of10.echo_request.type or of10.echo_reply.type) setelah h1 ping h2


Capturing from Loopback: lo   [Wireshark 1.10.6 (v1.10.6 from master-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Expression... Clear Apply Save
Profile: Default

Filter: of and not (of10.echo_request.type or of10.echo_reply.type)

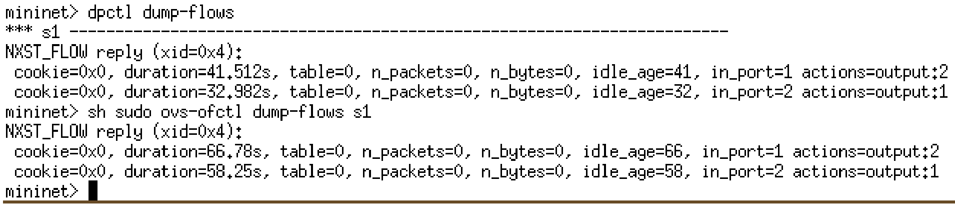
```
No.    Time         Source              Destination         Protoco Lengtl Info
14375  711.5746460( 127.0.0.1           127.0.0.1           OF 1.0     74  of_hello
14467  712.1661820( 127.0.0.1           127.0.0.1           OF 1.0     74  of_hello
14469  712.1704330( 127.0.0.1           127.0.0.1           OF 1.0     74  of_hello
14471  712.1705260( 127.0.0.1           127.0.0.1           OF 1.0     74  of_features_request
14472  712.1705410( 127.0.0.1           127.0.0.1           OF 1.0     78  of_set_config
14473  712.1741950( 127.0.0.1           127.0.0.1           OF 1.0    130  of_port_status
14479  712.1881370( 127.0.0.1           127.0.0.1           OF 1.0    290  of_features_reply
15660  798.0137190( 00:00:00_00:00:01   Broadcast           OF 1.0    126  of_packet_in
15661  798.0141640( 127.0.0.1           127.0.0.1           OF 1.0     90  of_packet_out
15663  798.0147650( 00:00:00_00:00:02   00:00:00_00:00:01   OF 1.0    126  of_packet_in
15664  798.0152000( 127.0.0.1           127.0.0.1           OF 1.0    146  of_flow_add
15665  798.0167230( 10.0.0.1            10.0.0.2            OF 1.0    182  of_packet_in
15666  798.0171460( 127.0.0.1           127.0.0.1           OF 1.0    146  of_flow_add
15667  798.0202940( 10.0.0.2            10.0.0.1            OF 1.0    182  of_packet_in
15668  798.0209590( 127.0.0.1           127.0.0.1           OF 1.0    146  of_flow_add
15724  803.0295430( 00:00:00_00:00:02   00:00:00_00:00:01   OF 1.0    126  of_packet_in
15725  803.0298130( 127.0.0.1           127.0.0.1           OF 1.0    146  of_flow_add
15727  803.0306640( 00:00:00_00:00:01   00:00:00_00:00:02   OF 1.0    126  of_packet_in
15728  803.0308900( 127.0.0.1           127.0.0.1           OF 1.0    146  of_flow_add
```

```
▷ Frame 14479: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface 0
▷ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
▷ Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
▷ Transmission Control Protocol, Src Port: 37352 (37352), Dst Port: 6633 (6633), Seq: 73, Ack: 29, Len: 224
▽ OpenFlow (LOXI)
    version: 1
    type: OFPT_FEATURES_REPLY (6)
```

```
0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 c0   ........ ......E.
0010  01 14 77 b5 40 00 40 06  c3 6c 7f 00 00 01 7f 00   ..w.@.@. .l......
0020  00 01 91 e8 19 e9 31 87  29 a5 d6 00 de 07 80 18   ......1. )........
0030  00 56 ff 08 00 00 01 01  08 0a 00 1f 5e f1 00 1f   .V...... ....^...
0040  5e ed 01 06 00 e0 1f f4  78 d9 00 00 00 00 00 00   ^....... x.......
0050  00 01 00 00 01 00 fe 00  00 00 00 00 00 c7 00 00
```

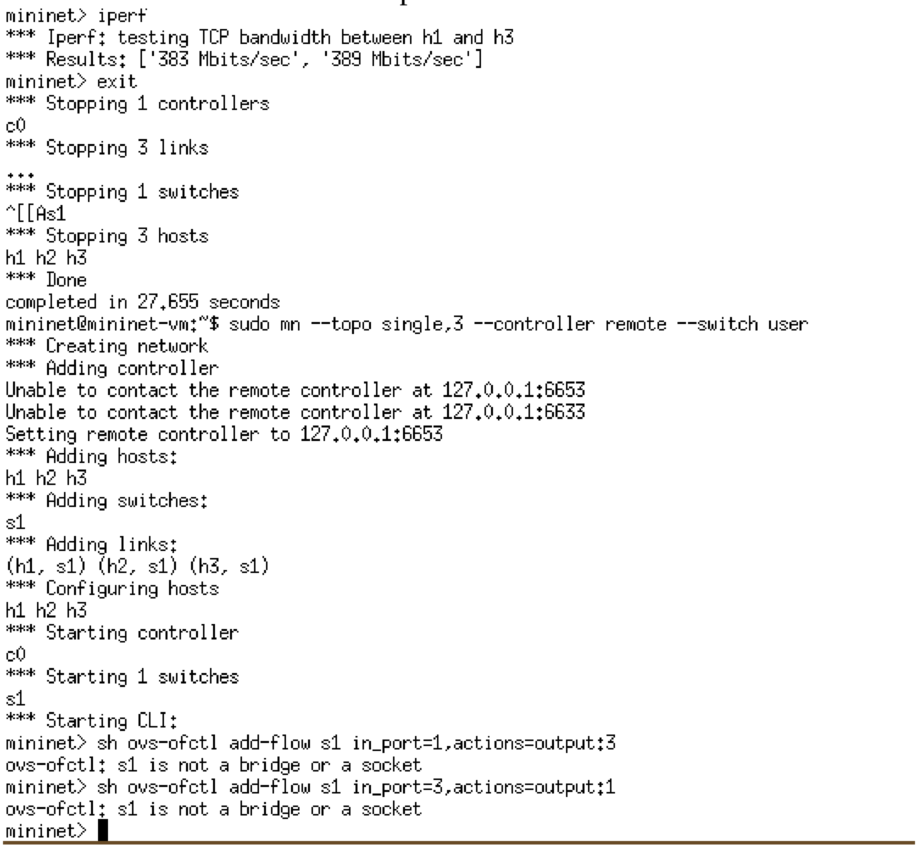
Loopback: lo: <live capture in progress> Fil...   Packets: 59811 · Displayed: 19 (0.0%)

9. Flow entries



```
mininet> dpctl dump-flows
*** s1 ------------------------------------------------------------------------
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=41.512s, table=0, n_packets=0, n_bytes=0, idle_age=41, in_port=1 actions=output:2
 cookie=0x0, duration=32.982s, table=0, n_packets=0, n_bytes=0, idle_age=32, in_port=2 actions=output:1
mininet> sh sudo ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=66.78s, table=0, n_packets=0, n_bytes=0, idle_age=66, in_port=1 actions=output:2
 cookie=0x0, duration=58.25s, table=0, n_packets=0, n_bytes=0, idle_age=58, in_port=2 actions=output:1
mininet> █
```

10. Benchmark kernel-v vs –user space

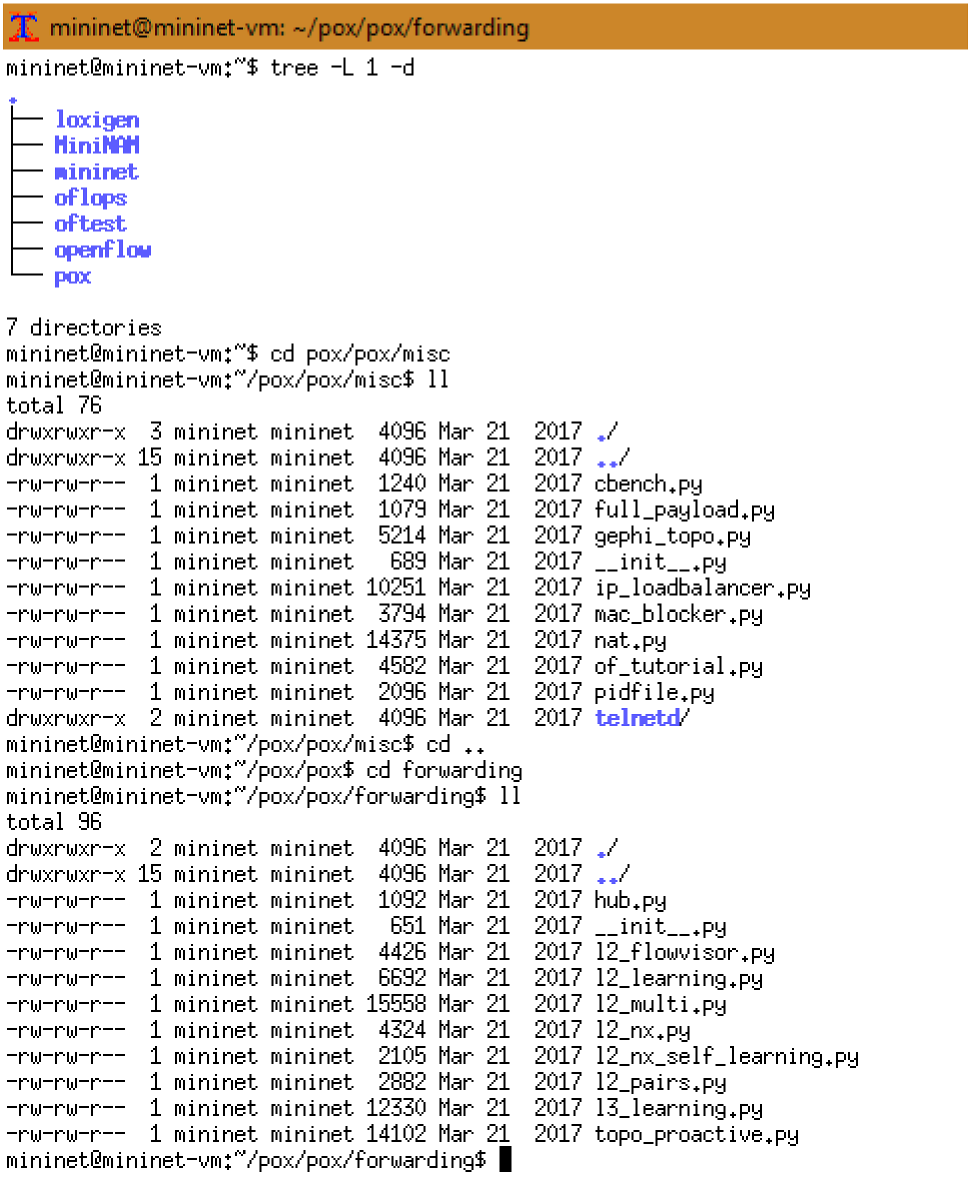


```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h3
*** Results: ['383 Mbits/sec', '389 Mbits/sec']
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 3 links
...
*** Stopping 1 switches
^[[As1
*** Stopping 3 hosts
h1 h2 h3
*** Done
completed in 27.655 seconds
mininet@mininet-vm:~$ sudo mn --topo single,3 --controller remote --switch user
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Unable to contact the remote controller at 127.0.0.1:6633
Setting remote controller to 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1
*** Starting CLI:
mininet> sh ovs-ofctl add-flow s1 in_port=1,actions=output:3
ovs-ofctl: s1 is not a bridge or a socket
mininet> sh ovs-ofctl add-flow s1 in_port=3,actions=output:1
ovs-ofctl: s1 is not a bridge or a socket
mininet> █
```

POX Controller

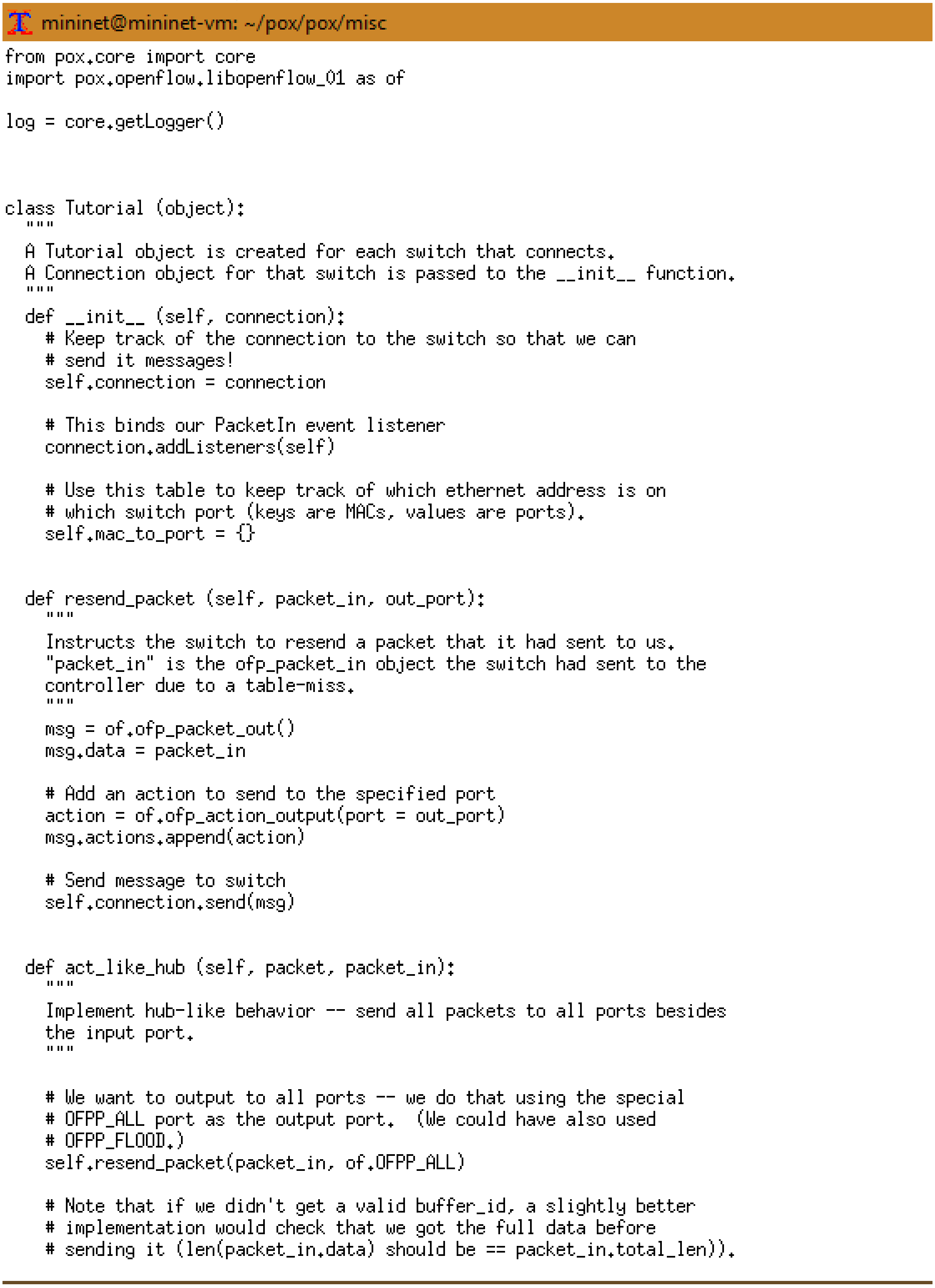
POX controller adalah salah satu controller SDN yang mendukung protokol OpenFlow. POX adalah controller yang berbasis bahasa Python. Tahapannya sebagai berikut.

1. POX Controller files pada Mininet



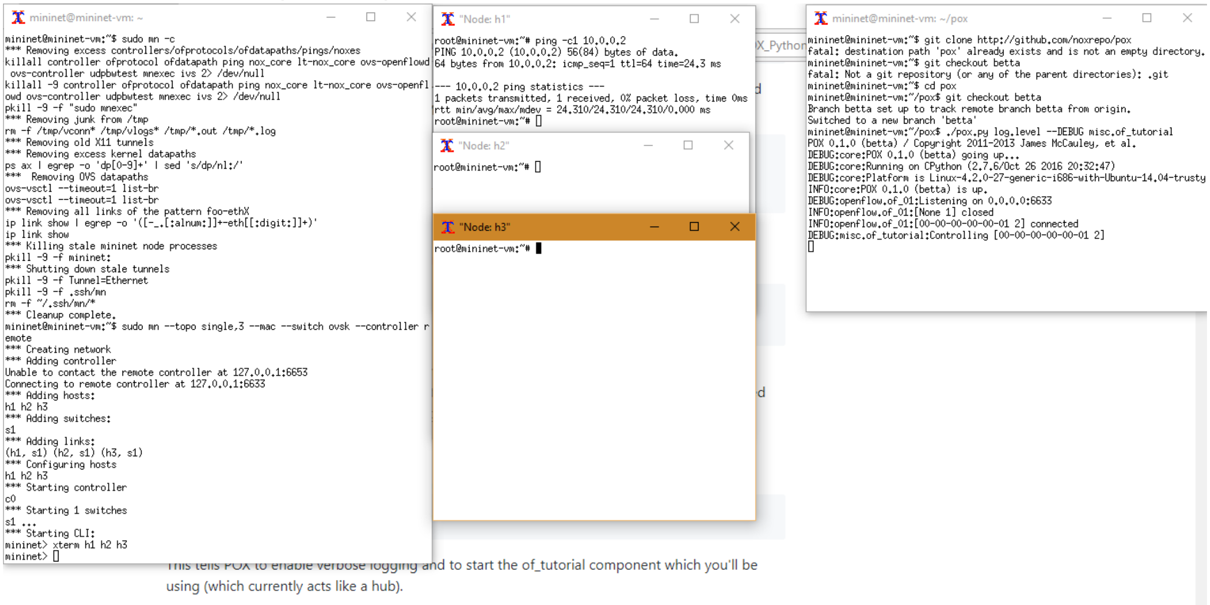
```
mininet@mininet-vm:~$ tree -L 1 -d
.
├── loxigen
├── MiniNAM
├── mininet
├── oflops
├── oftest
├── openflow
└── pox

7 directories
mininet@mininet-vm:~$ cd pox/pox/misc
mininet@mininet-vm:~/pox/pox/misc$ ll
total 76
drwxrwxr-x  3 mininet mininet  4096 Mar 21  2017 ./
drwxrwxr-x 15 mininet mininet  4096 Mar 21  2017 ../
-rw-rw-r--  1 mininet mininet  1240 Mar 21  2017 cbench.py
-rw-rw-r--  1 mininet mininet  1079 Mar 21  2017 full_payload.py
-rw-rw-r--  1 mininet mininet  5214 Mar 21  2017 gephi_topo.py
-rw-rw-r--  1 mininet mininet   689 Mar 21  2017 __init__.py
-rw-rw-r--  1 mininet mininet 10251 Mar 21  2017 ip_loadbalancer.py
-rw-rw-r--  1 mininet mininet  3794 Mar 21  2017 mac_blocker.py
-rw-rw-r--  1 mininet mininet 14375 Mar 21  2017 nat.py
-rw-rw-r--  1 mininet mininet  4582 Mar 21  2017 of_tutorial.py
-rw-rw-r--  1 mininet mininet  2096 Mar 21  2017 pidfile.py
drwxrwxr-x  2 mininet mininet  4096 Mar 21  2017 telnetd/
mininet@mininet-vm:~/pox/pox/misc$ cd ..
mininet@mininet-vm:~/pox/pox$ cd forwarding
mininet@mininet-vm:~/pox/pox/forwarding$ ll
total 96
drwxrwxr-x  2 mininet mininet  4096 Mar 21  2017 ./
drwxrwxr-x 15 mininet mininet  4096 Mar 21  2017 ../
-rw-rw-r--  1 mininet mininet  1092 Mar 21  2017 hub.py
-rw-rw-r--  1 mininet mininet   651 Mar 21  2017 __init__.py
-rw-rw-r--  1 mininet mininet  4426 Mar 21  2017 l2_flowvisor.py
-rw-rw-r--  1 mininet mininet  6692 Mar 21  2017 l2_learning.py
-rw-rw-r--  1 mininet mininet 15558 Mar 21  2017 l2_multi.py
-rw-rw-r--  1 mininet mininet  4324 Mar 21  2017 l2_nx.py
-rw-rw-r--  1 mininet mininet  2105 Mar 21  2017 l2_nx_self_learning.py
-rw-rw-r--  1 mininet mininet  2882 Mar 21  2017 l2_pairs.py
-rw-rw-r--  1 mininet mininet 12330 Mar 21  2017 l3_learning.py
-rw-rw-r--  1 mininet mininet 14102 Mar 21  2017 topo_proactive.py
mininet@mininet-vm:~/pox/pox/forwarding$ █
```

2. Memilih of_tutorial.py pada pox/pox/misc



```
from pox.core import core
import pox.openflow.libopenflow_01 as of

log = core.getLogger()



class Tutorial (object):
  """
  A Tutorial object is created for each switch that connects.
  A Connection object for that switch is passed to the __init__ function.
  """
  def __init__ (self, connection):
    # Keep track of the connection to the switch so that we can
    # send it messages!
    self.connection = connection

    # This binds our PacketIn event listener
    connection.addListeners(self)

    # Use this table to keep track of which ethernet address is on
    # which switch port (keys are MACs, values are ports).
    self.mac_to_port = {}


  def resend_packet (self, packet_in, out_port):
    """
    Instructs the switch to resend a packet that it had sent to us.
    "packet_in" is the ofp_packet_in object the switch had sent to the
    controller due to a table-miss.
    """
    msg = of.ofp_packet_out()
    msg.data = packet_in

    # Add an action to send to the specified port
    action = of.ofp_action_output(port = out_port)
    msg.actions.append(action)

    # Send message to switch
    self.connection.send(msg)


  def act_like_hub (self, packet, packet_in):
    """
    Implement hub-like behavior -- send all packets to all ports besides
    the input port.
    """

    # We want to output to all ports -- we do that using the special
    # OFPP_ALL port as the output port.  (We could have also used
    # OFPP_FLOOD.)
    self.resend_packet(packet_in, of.OFPP_ALL)

    # Note that if we didn't get a valid buffer_id, a slightly better
    # implementation would check that we got the full data before
    # sending it (len(packet_in.data) should be == packet_in.total_len)).
```

3. memulai pox controller dengan './pox.py log.level --DEBUG misc.of_tutorial pada directory pox'. lalu mulai membuat network pada terminal lain dengan perintah 'sudo mn --topo single,3 --mac --witch ovsk --controller remote'. jika pox controller terhubung, akan muncul 'INFO:openflow.of_01:[00-00-00-00-00-01 2] connected' pada terminal poxcontroller. lalu mulailah membuka terminal untuk node 1,2, dan 3 dengan perintah 'xterm h1 h2 h3' pada console jaringan yang akan memuncul 3 terminal untuk masing-masing node.



```
mininet@mininet-vm:~$ sudo mn -c
*** Removing excess controllers/ofprotocols/ofdatapaths/pings/noxes
killall controller ofprotocol ofdatapath ping nox_core lt-nox_core ovs-openflowd
 ovs-controller udpbwtest mnexec ivs 2> /dev/null
killall -9 controller ofprotocol ofdatapath ping nox_core lt-nox_core ovs-openfl
owd ovs-controller udpbwtest mnexec ivs 2> /dev/null
pkill -9 -f "sudo mnexec"
*** Removing junk from /tmp
rm -f /tmp/vconn* /tmp/vlogs* /tmp/*.out /tmp/*.log
*** Removing old X11 tunnels
*** Removing excess kernel datapaths
ps ax | egrep -o 'dp[0-9]+' | sed 's/dp/nl:/'
***  Removing OVS datapaths
ovs-vsctl --timeout=1 list-br
ovs-vsctl --timeout=1 list-br
*** Removing all links of the pattern foo-ethX
ip link show | egrep -o '([-_.[:alnum:]]+-eth[[:digit:]]+)'
ip link show
*** Killing stale mininet node processes
pkill -9 -f mininet:
*** Shutting down stale tunnels
pkill -9 -f Tunnel=Ethernet
pkill -9 -f .ssh/mn
rm -f ~/.ssh/mn/*
*** Cleanup complete.
mininet@mininet-vm:~$ sudo mn --topo single,3 --mac --switch ovsk --controller r
emote
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Connecting to remote controller at 127.0.0.1:6633
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> xterm h1 h2 h3
mininet> 
```

```
root@mininet-vm:~# ping -c1 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=24.3 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 24.310/24.310/24.310/0.000 ms
root@mininet-vm:~# 
```

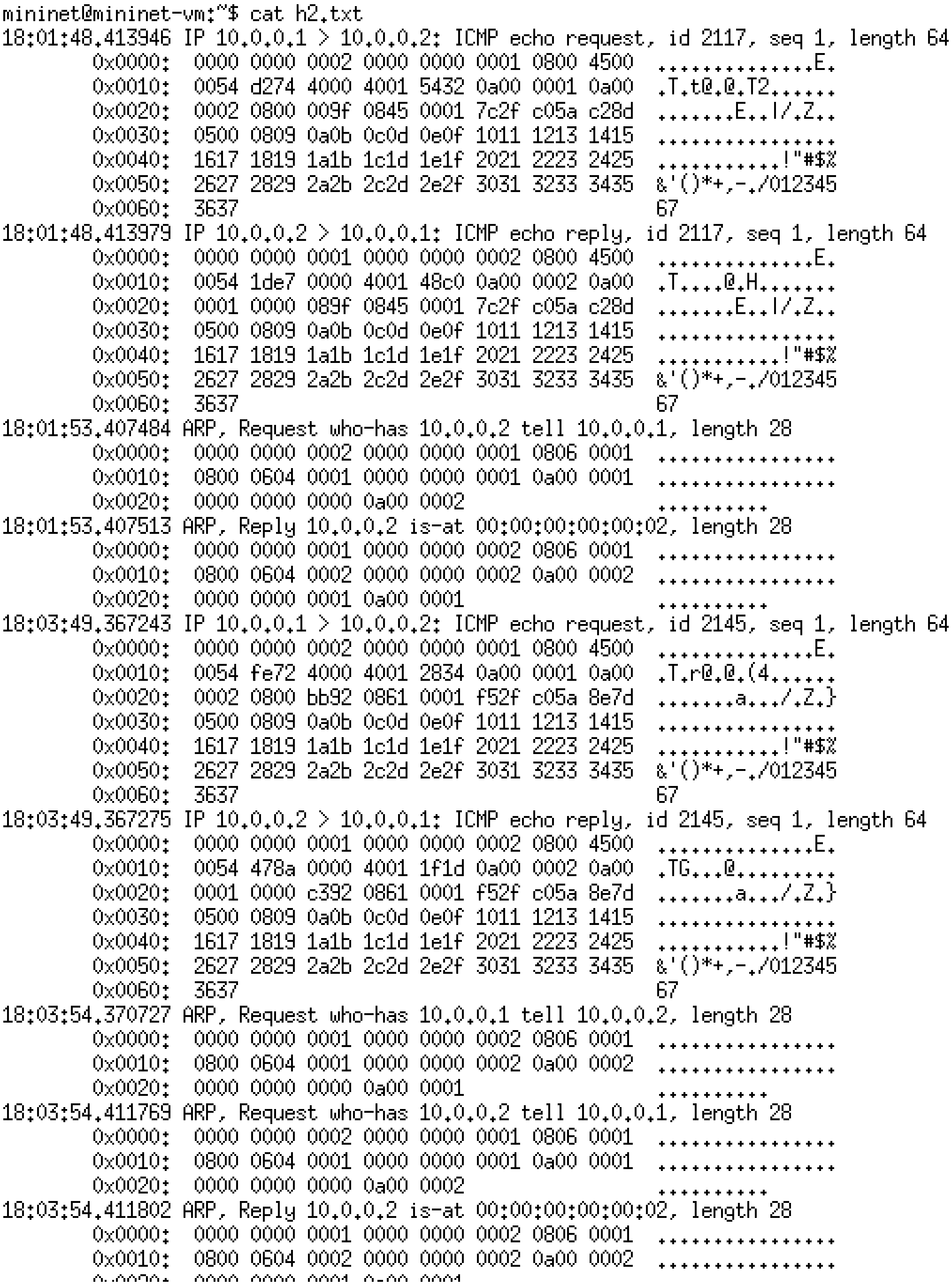
```
root@mininet-vm:~# 
```

```
root@mininet-vm:~# 
```

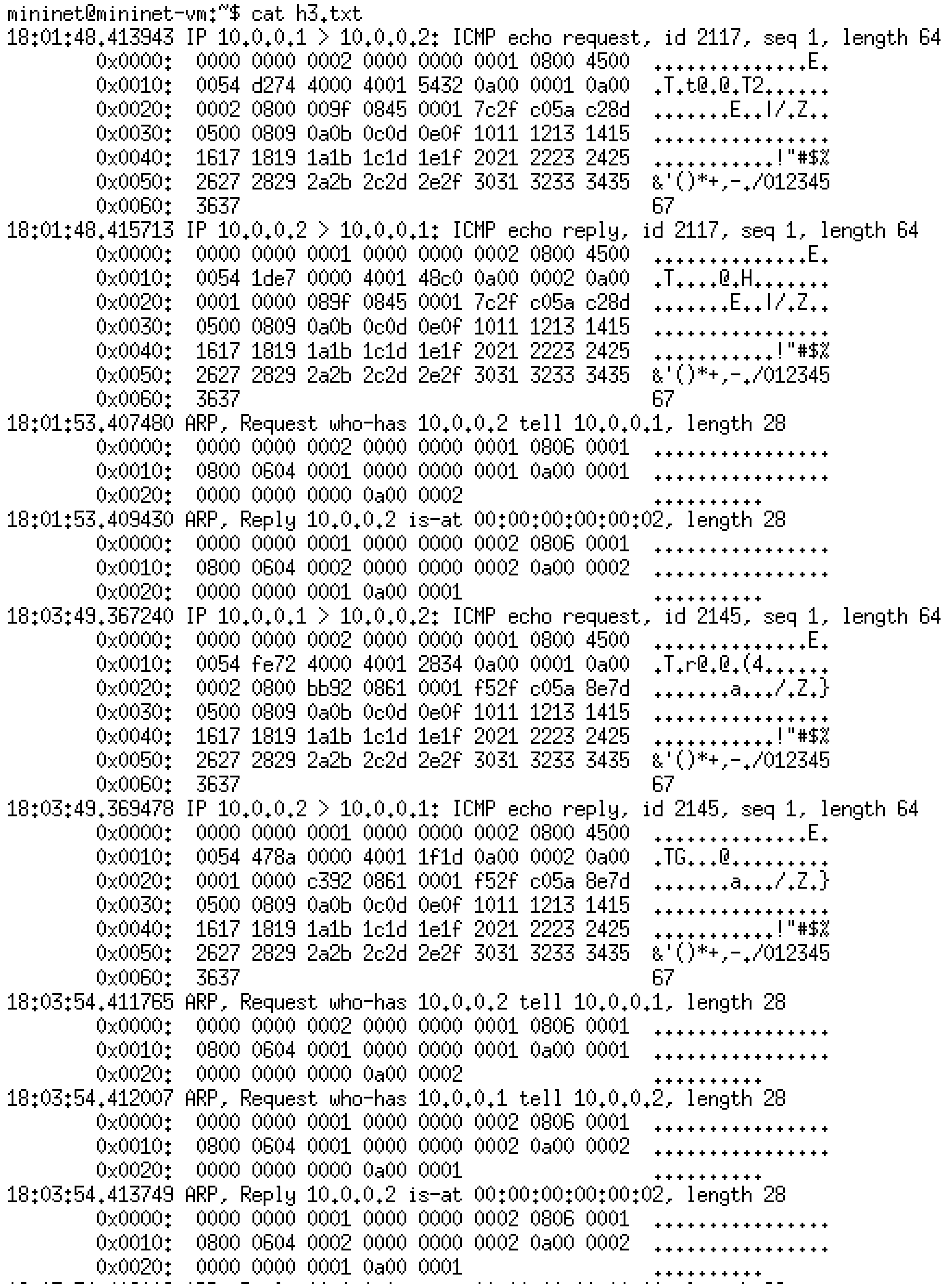
```
mininet@mininet-vm:~$ git clone http://github.com/noxrepo/pox
fatal: destination path 'pox' already exists and is not an empty directory.
mininet@mininet-vm:~$ git checkout betta
fatal: Not a git repository (or any of the parent directories): .git
mininet@mininet-vm:~$ cd pox
mininet@mininet-vm:~/pox$ git checkout betta
Branch betta set up to track remote branch betta from origin.
Switched to a new branch 'betta'
mininet@mininet-vm:~/pox$ ./pox.py log.level --DEBUG misc.of_tutorial
POX 0.1.0 (betta) / Copyright 2011-2013 James McCauley, et al.
DEBUG:core:POX 0.1.0 (betta) going up...
DEBUG:core:Running on CPython (2.7.6/Oct 26 2016 20:32:47)
DEBUG:core:Platform is Linux-4.2.0-27-generic-i686-with-Ubuntu-14.04-trusty
INFO:core:POX 0.1.0 (betta) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633
INFO:openflow.of_01:[None 1] closed
INFO:openflow.of_01:[00-00-00-00-00-01 2] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-01 2]
```

This tells POX to enable verbose logging and to start the of_tutorial component which you'll be using (which currently acts like a hub).

4. berikan perintah 'tcpdump -XX -n -i h2-eth0 > h2.txt' pada terminal node 2, dan 'tcpdump -XX -n -i h3-eth0 > h3.txt' pada terminal node 3, perintah tersebut memerintahkan terminal node untuk merekam aktivitas node dan menyimpannya pada file h2.txt dan h3.txt. Lalu lakukan ping pada terminal node 1 dengan perintah 'ping -c1 10.0.0.2'. lalu hentikan perintah merekam aktivitas node 2 dan 3 dengan menekan tombol ctrl+c. lalu buka file h2.txt dan h3.txt untuk melihat hasil dari perintah 'ping -c1 10.0.0.2' tadi.

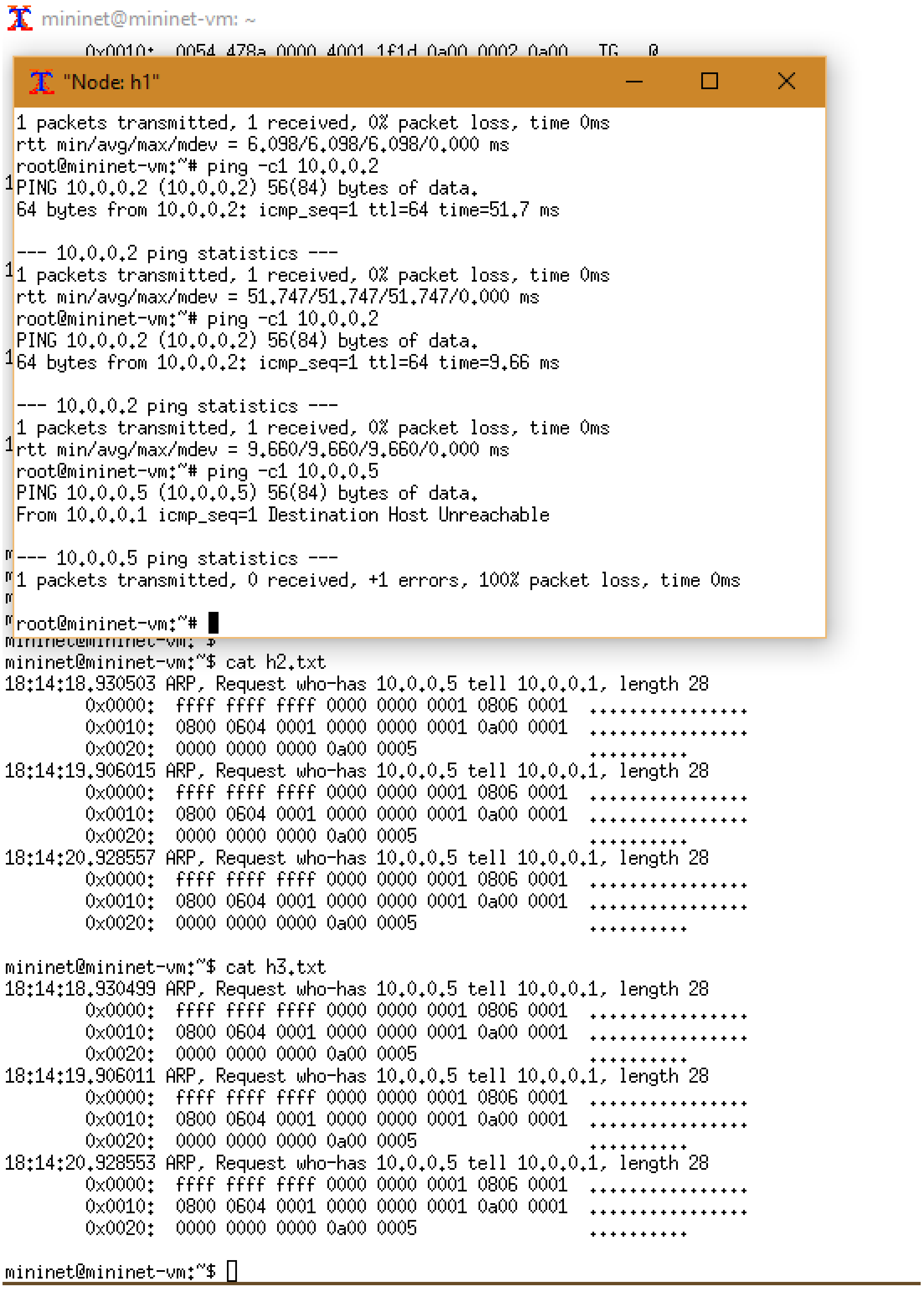


```
mininet@mininet-vm:~$ cat h2.txt
18:01:48.413946 IP 10.0.0.1 > 10.0.0.2: ICMP echo request, id 2117, seq 1, length 64
        0x0000:  0000 0000 0002 0000 0000 0001 0800 4500  ..............E.
        0x0010:  0054 d274 4000 4001 5432 0a00 0001 0a00  .T.t@.@.T2......
        0x0020:  0002 0800 009f 0845 0001 7c2f c05a c28d  .......E..|/.Z..
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ............!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:01:48.413979 IP 10.0.0.2 > 10.0.0.1: ICMP echo reply, id 2117, seq 1, length 64
        0x0000:  0000 0000 0001 0000 0000 0002 0800 4500  ..............E.
        0x0010:  0054 1de7 0000 4001 48c0 0a00 0002 0a00  .T....@.H.......
        0x0020:  0001 0000 089f 0845 0001 7c2f c05a c28d  .......E..|/.Z..
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ............!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:01:53.407484 ARP, Request who-has 10.0.0.2 tell 10.0.0.1, length 28
        0x0000:  0000 0000 0002 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0002                 ..........
18:01:53.407513 ARP, Reply 10.0.0.2 is-at 00:00:00:00:00:02, length 28
        0x0000:  0000 0000 0001 0000 0000 0002 0806 0001  ................
        0x0010:  0800 0604 0002 0000 0000 0002 0a00 0002  ................
        0x0020:  0000 0000 0001 0a00 0001                 ..........
18:03:49.367243 IP 10.0.0.1 > 10.0.0.2: ICMP echo request, id 2145, seq 1, length 64
        0x0000:  0000 0000 0002 0000 0000 0001 0800 4500  ..............E.
        0x0010:  0054 fe72 4000 4001 2834 0a00 0001 0a00  .T.r@.@.(4......
        0x0020:  0002 0800 bb92 0861 0001 f52f c05a 8e7d  .......a.../.Z.}
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ............!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:03:49.367275 IP 10.0.0.2 > 10.0.0.1: ICMP echo reply, id 2145, seq 1, length 64
        0x0000:  0000 0000 0001 0000 0000 0002 0800 4500  ..............E.
        0x0010:  0054 478a 0000 4001 1f1d 0a00 0002 0a00  .TG...@.........
        0x0020:  0001 0000 c392 0861 0001 f52f c05a 8e7d  .......a.../.Z.}
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ............!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:03:54.370727 ARP, Request who-has 10.0.0.1 tell 10.0.0.2, length 28
        0x0000:  0000 0000 0001 0000 0000 0002 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0002 0a00 0002  ................
        0x0020:  0000 0000 0000 0a00 0001                 ..........
18:03:54.411769 ARP, Request who-has 10.0.0.2 tell 10.0.0.1, length 28
        0x0000:  0000 0000 0002 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0002                 ..........
18:03:54.411802 ARP, Reply 10.0.0.2 is-at 00:00:00:00:00:02, length 28
        0x0000:  0000 0000 0001 0000 0000 0002 0806 0001  ................
        0x0010:  0800 0604 0002 0000 0000 0002 0a00 0002  ................
        0x0020:  0000 0000 0001 0a00 0001
```



```
mininet@mininet-vm:~$ cat h3.txt
18:01:48.413943 IP 10.0.0.1 > 10.0.0.2: ICMP echo request, id 2117, seq 1, length 64
        0x0000:  0000 0000 0002 0000 0000 0001 0800 4500  ..............E.
        0x0010:  0054 d274 4000 4001 5432 0a00 0001 0a00  .T.t@.@.T2......
        0x0020:  0002 0800 009f 0845 0001 7c2f c05a c28d  .......E..|/.Z..
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ...........!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:01:48.415713 IP 10.0.0.2 > 10.0.0.1: ICMP echo reply, id 2117, seq 1, length 64
        0x0000:  0000 0000 0001 0000 0000 0002 0800 4500  ..............E.
        0x0010:  0054 1de7 0000 4001 48c0 0a00 0002 0a00  .T....@.H.......
        0x0020:  0001 0000 089f 0845 0001 7c2f c05a c28d  .......E..|/.Z..
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ...........!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:01:53.407480 ARP, Request who-has 10.0.0.2 tell 10.0.0.1, length 28
        0x0000:  0000 0000 0002 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0002                 ..........
18:01:53.409430 ARP, Reply 10.0.0.2 is-at 00:00:00:00:00:02, length 28
        0x0000:  0000 0000 0001 0000 0000 0002 0806 0001  ................
        0x0010:  0800 0604 0002 0000 0000 0002 0a00 0002  ................
        0x0020:  0000 0000 0001 0a00 0001                 ..........
18:03:49.367240 IP 10.0.0.1 > 10.0.0.2: ICMP echo request, id 2145, seq 1, length 64
        0x0000:  0000 0000 0002 0000 0000 0001 0800 4500  ..............E.
        0x0010:  0054 fe72 4000 4001 2834 0a00 0001 0a00  .T.r@.@.(4......
        0x0020:  0002 0800 bb92 0861 0001 f52f c05a 8e7d  .......a.../.Z.}
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ...........!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:03:49.369478 IP 10.0.0.2 > 10.0.0.1: ICMP echo reply, id 2145, seq 1, length 64
        0x0000:  0000 0000 0001 0000 0000 0002 0800 4500  ..............E.
        0x0010:  0054 478a 0000 4001 1f1d 0a00 0002 0a00  .TG...@.........
        0x0020:  0001 0000 c392 0861 0001 f52f c05a 8e7d  .......a.../.Z.}
        0x0030:  0500 0809 0a0b 0c0d 0e0f 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ...........!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
18:03:54.411765 ARP, Request who-has 10.0.0.2 tell 10.0.0.1, length 28
        0x0000:  0000 0000 0002 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0002                 ..........
18:03:54.412007 ARP, Request who-has 10.0.0.1 tell 10.0.0.2, length 28
        0x0000:  0000 0000 0001 0000 0000 0002 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0002 0a00 0002  ................
        0x0020:  0000 0000 0000 0a00 0001                 ..........
18:03:54.413749 ARP, Reply 10.0.0.2 is-at 00:00:00:00:00:02, length 28
        0x0000:  0000 0000 0001 0000 0000 0002 0806 0001  ................
        0x0010:  0800 0604 0002 0000 0000 0002 0a00 0002  ................
        0x0020:  0000 0000 0001 0a00 0001                 ..........
```

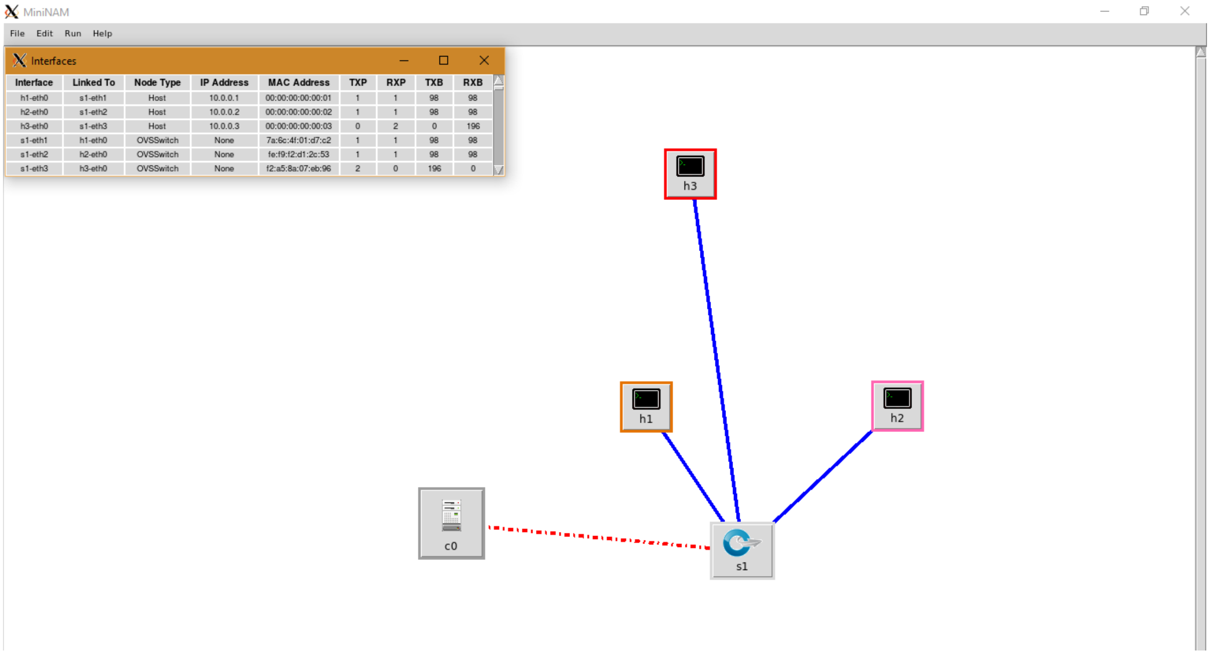
5. berikan perintah merekam aktivitas node lagi pada node 2 dan 3. lalu kali ini kita mencoba melakukan ping ke ip yg tidak ada, disini contohnya 10.0.0.5. lalu buka h2.txt dan h3.txt maka hasilnya akan seperti gambar, ip 10.0.0.1 merequest “who has 10.0.05 ? ”sampai 3 kali dan tidak menemukannya.



```
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 6.098/6.098/6.098/0.000 ms
root@mininet-vm:~# ping -c1 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=51.7 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 51.747/51.747/51.747/0.000 ms
root@mininet-vm:~# ping -c1 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=9.66 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 9.660/9.660/9.660/0.000 ms
root@mininet-vm:~# ping -c1 10.0.0.5
PING 10.0.0.5 (10.0.0.5) 56(84) bytes of data.
From 10.0.0.1 icmp_seq=1 Destination Host Unreachable

--- 10.0.0.5 ping statistics ---
1 packets transmitted, 0 received, +1 errors, 100% packet loss, time 0ms

root@mininet-vm:~# 
```

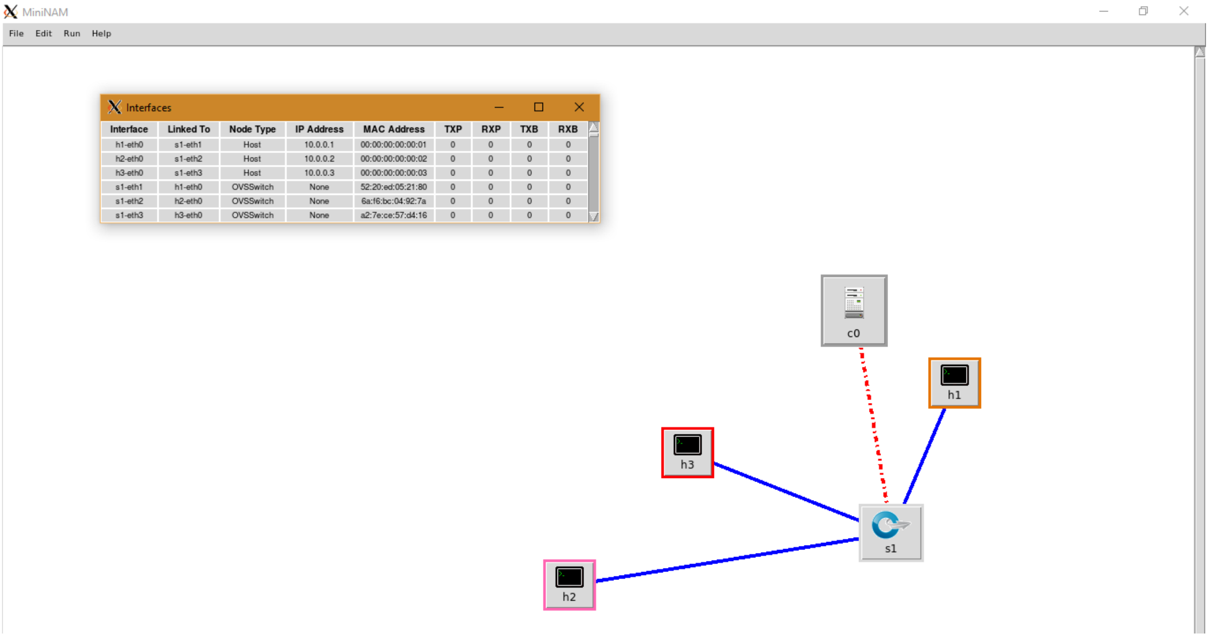
```
        0x0010:  0054 478a 0000 4001 1f1d 0a00 0002 0a00  .TG....@
mininet@mininet-vm:~$
mininet@mininet-vm:~$ cat h2.txt
18:14:18.930503 ARP, Request who-has 10.0.0.5 tell 10.0.0.1, length 28
        0x0000:  ffff ffff ffff 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0005                 ..........
18:14:19.906015 ARP, Request who-has 10.0.0.5 tell 10.0.0.1, length 28
        0x0000:  ffff ffff ffff 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0005                 ..........
18:14:20.928557 ARP, Request who-has 10.0.0.5 tell 10.0.0.1, length 28
        0x0000:  ffff ffff ffff 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0005                 ..........

mininet@mininet-vm:~$ cat h3.txt
18:14:18.930499 ARP, Request who-has 10.0.0.5 tell 10.0.0.1, length 28
        0x0000:  ffff ffff ffff 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0005                 ..........
18:14:19.906011 ARP, Request who-has 10.0.0.5 tell 10.0.0.1, length 28
        0x0000:  ffff ffff ffff 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0005                 ..........
18:14:20.928553 ARP, Request who-has 10.0.0.5 tell 10.0.0.1, length 28
        0x0000:  ffff ffff ffff 0000 0000 0001 0806 0001  ................
        0x0010:  0800 0604 0001 0000 0000 0001 0a00 0001  ................
        0x0020:  0000 0000 0000 0a00 0005                 ..........

mininet@mininet-vm:~$ 
```

6. Tampilan jaringan yg kita buat tadi pada MiniNAM ketika ping dari 10.0.0.1 ke 10.0.0.2. terlihat ada komunikasi antara host 1 dan 2.



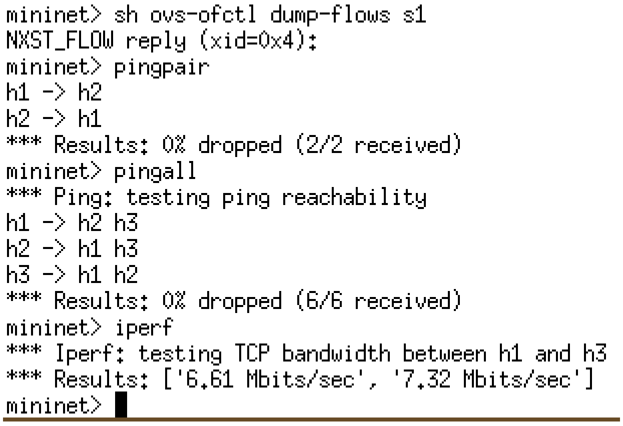
Interface	Linked To	Node Type	IP Address	MAC Address	TXP	RXP	TXB	RXB
h1-eth0	s1-eth1	Host	10.0.0.1	00:00:00:00:00:01	1	1	98	98
h2-eth0	s1-eth2	Host	10.0.0.2	00:00:00:00:00:02	1	1	98	98
h3-eth0	s1-eth3	Host	10.0.0.3	00:00:00:00:00:03	0	2	0	196
s1-eth1	h1-eth0	OVSSwitch	None	7a:6c:4f:01:d7:c2	1	1	98	98
s1-eth2	h2-eth0	OVSSwitch	None	fe:f9:f2:d1:2c:53	1	1	98	98
s1-eth3	h3-eth0	OVSSwitch	None	f2:a5:8a:07:eb:96	2	0	196	0

7. Tampilan jaringan yg kita buat tadi pada MiniNAM ketika ping dari 10.0.0.1 ke 10.0.0.5. terlihat tidak ada komunikasi antar host.



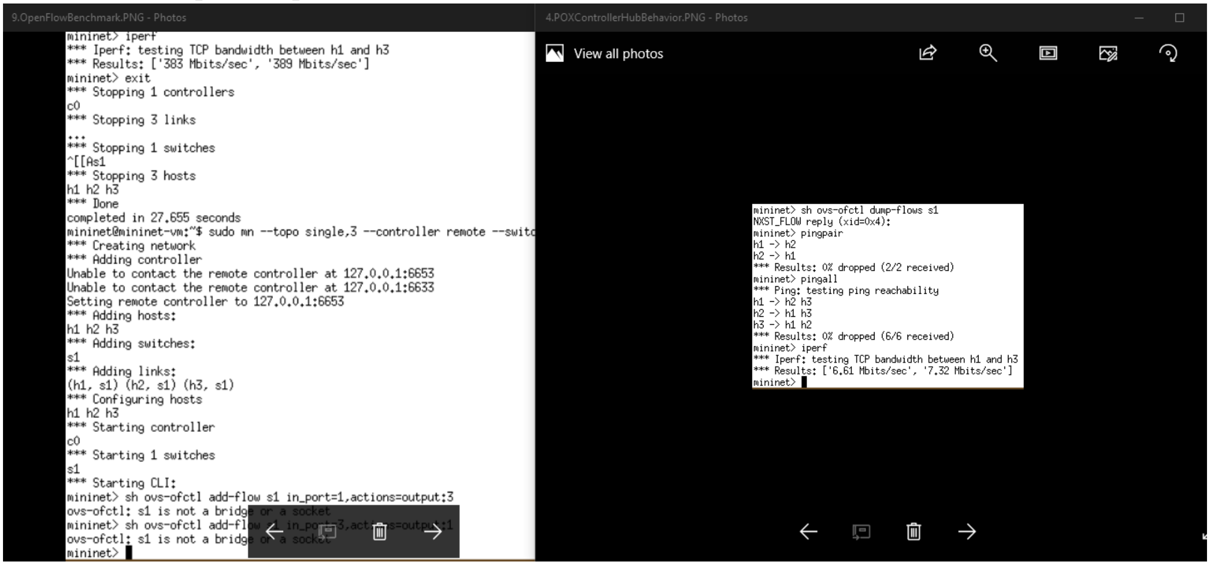
Interface	Linked To	Node Type	IP Address	MAC Address	TXP	RXP	TXB	RXB
h1-eth0	s1-eth1	Host	10.0.0.1	00:00:00:00:00:01	0	0	0	0
h2-eth0	s1-eth2	Host	10.0.0.2	00:00:00:00:00:02	0	0	0	0
h3-eth0	s1-eth3	Host	10.0.0.3	00:00:00:00:00:03	0	0	0	0
s1-eth1	h1-eth0	OVSSwitch	None	52:20:ed:05:21:80	0	0	0	0
s1-eth2	h2-eth0	OVSSwitch	None	6a:f6:bc:04:92:7a	0	0	0	0
s1-eth3	h3-eth0	OVSSwitch	None	a2:7e:ce:57:d4:16	0	0	0	0

8. disini kita akan melakukan perbandingan antara kecepatan menggunakan hub dan switch. berikan perintah iperf pada console.



```
mininet> sh ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
mininet> pingpair
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3
h2 -> h1 h3
h3 -> h1 h2
*** Results: 0% dropped (6/6 received)
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h3
*** Results: ['6.61 Mbits/sec', '7.32 Mbits/sec']
mininet> 
```

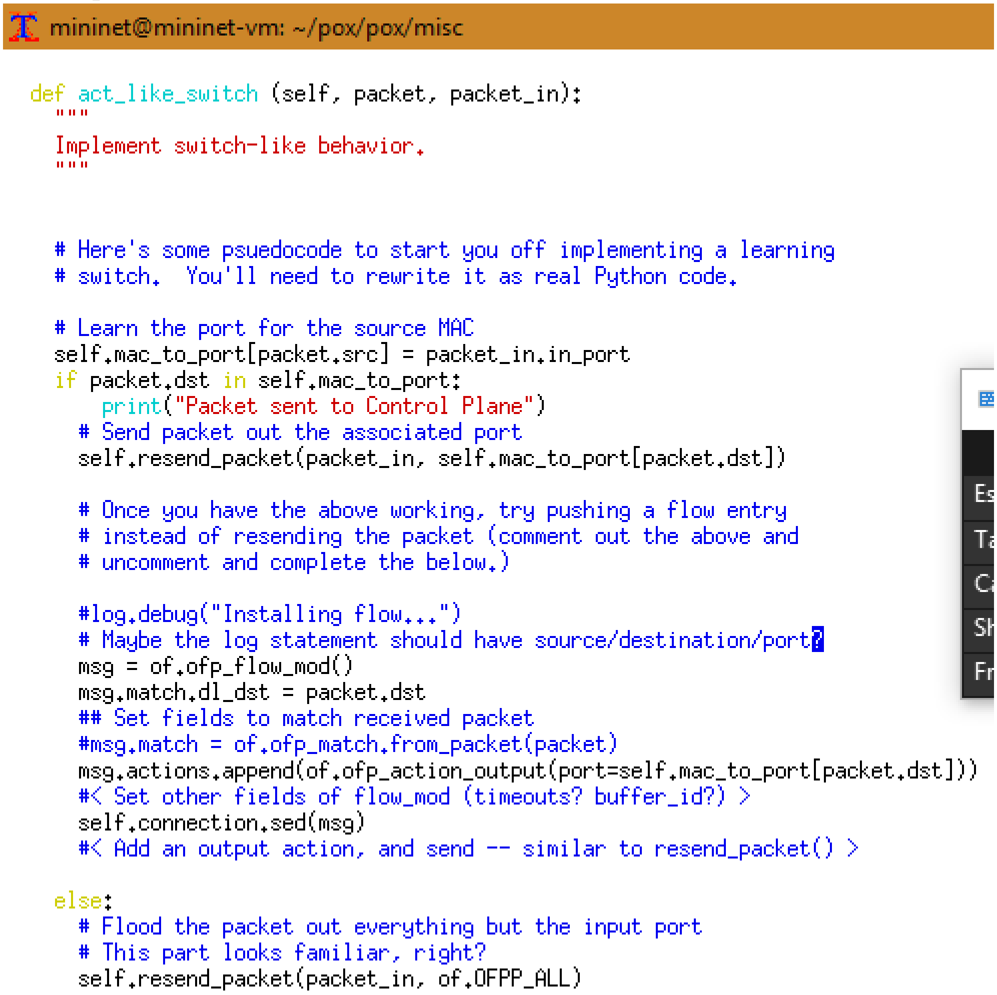
9. switch lebih cepat daripada hub


9.OpenFlowBenchmark.PNG - Photos
4.POXControllerHubBehavior.PNG - Photos
View all photos

```
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h3
*** Results: ['383 Mbits/sec', '389 Mbits/sec']
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 3 links
...
*** Stopping 1 switches
^[[As1
*** Stopping 3 hosts
h1 h2 h3
*** Done
completed in 27.655 seconds
mininet@mininet-vm:~$ sudo mn --topo single,3 --controller remote --switc
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Unable to contact the remote controller at 127.0.0.1:6633
Setting remote controller to 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1
*** Starting CLI:
mininet> sh ovs-ofctl add-flow s1 in_port=1,actions=output:3
ovs-ofctl: s1 is not a bridge or a socket
mininet> sh ovs-ofctl add-flow s1 in_port=3,actions=output:1
ovs-ofctl: s1 is not a bridge or a socket
mininet> 
```

```
mininet> sh ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
mininet> pingpair
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3
h2 -> h1 h3
h3 -> h1 h2
*** Results: 0% dropped (6/6 received)
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h3
*** Results: ['6.61 Mbits/sec', '7.32 Mbits/sec']
mininet> 
```

10. Menambah fungsi act_like_switch ke of_tutorial.py, dengan menggunakna vim editor, vim sudah ada pada mininet jadi kita tinggal memasukkan command “ vi f_tutorial.py” pada directory pox/pox/misc. Cara menggunakan vim editor bisa dilihat di “ https://vim.rtorr.com/”



```
def act_like_switch (self, packet, packet_in):
  """
  Implement switch-like behavior.
  """


  # Here's some psuedocode to start you off implementing a learning
  # switch.  You'll need to rewrite it as real Python code.

  # Learn the port for the source MAC
  self.mac_to_port[packet.src] = packet_in.in_port
  if packet.dst in self.mac_to_port:
      print("Packet sent to Control Plane")
    # Send packet out the associated port
    self.resend_packet(packet_in, self.mac_to_port[packet.dst])

    # Once you have the above working, try pushing a flow entry
    # instead of resending the packet (comment out the above and
    # uncomment and complete the below.)

    #log.debug("Installing flow...")
    # Maybe the log statement should have source/destination/port?
    msg = of.ofp_flow_mod()
    msg.match.dl_dst = packet.dst
    ## Set fields to match received packet
    #msg.match = of.ofp_match.from_packet(packet)
    msg.actions.append(of.ofp_action_output(port=self.mac_to_port[packet.dst]))
    #< Set other fields of flow_mod (timeouts? buffer_id?) >
    self.connection.sed(msg)
    #< Add an output action, and send -- similar to resend_packet() >

  else:
    # Flood the packet out everything but the input port
    # This part looks familiar, right?
    self.resend_packet(packet_in, of.OFPP_ALL)
```