

Project/Lab 2

Submitted by : Nandini Krupa Krishnamurthy

Task:

To launch a DoS attack on the SDN data plane and explain the attack consequences.

Experiment:

All the steps are explained along with the screenshots.

Step1 : Starting the experiment by creating a profile.

Figures starting from Fig1 to Fig6 show the steps needed to start this experiment. It is essential to choose DosServer to demonstrate DoS attack as shown in the figures below.

Note: As the topology used is default to DosServer, no changes to topology have been made in this experiment.

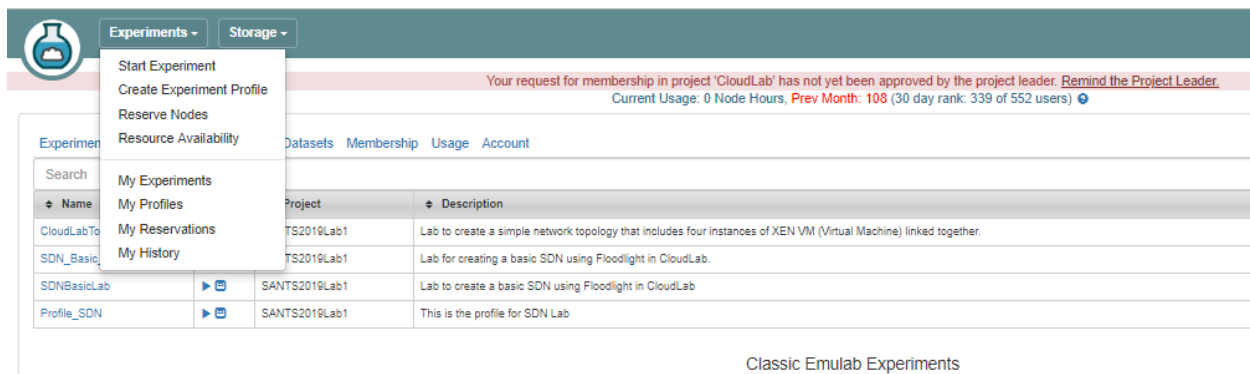


Fig 1 – Starting an Experiment.

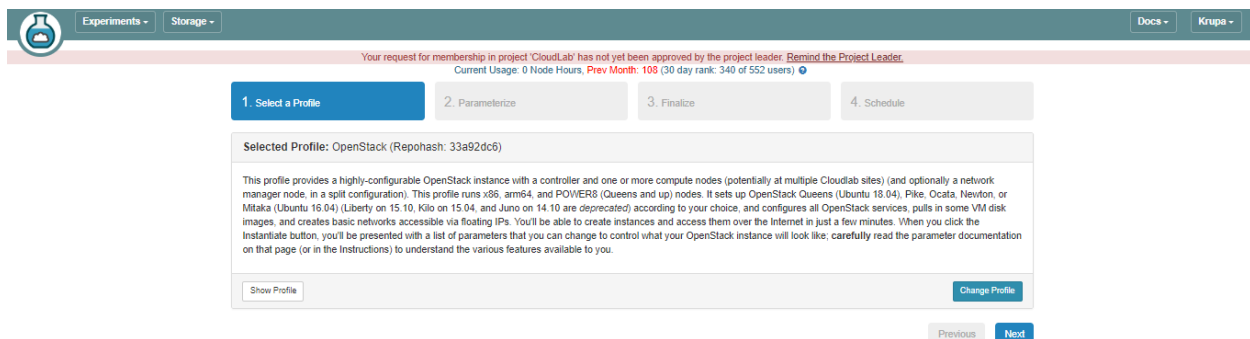


Fig 2 – Changing a profile.

Select a Profile✕

dos

My Profiles -

SANTS2019Lab1 -

DoSServer

Default Profiles -

Other Profiles -

Lab3DoSAttackSDN

CloudLab

Lab_3_DDOS

CloudLab

Cloudlab3_dos

CloudLab

ddos_attack

CloudLab

Lab_DDOS

CloudLab

LAB-5DDoSattack

CloudLab

AartiDdos29

CloudLab

shyamddos

CloudLab

DOSAttack_sunil

CloudLab

RtDoslab

CloudLab

dos_trial

CloudLab

DoSServer

★ Add to Favorites

Created By:

hongdal

Project:

SANTS2019Lab1

Latest Version:

0

Last Updated:

2019-02-25 21:27:48

Description:

Dos Attack Server

node-0

Select Profile

Cancel

Fig 3 – Selecting a DOS Server.

Your request for membership in project 'CloudLab' has not yet been approved by the project leader. [Remind the Project Leader.](#)

Current Usage: 0 Node Hours, **Prev Month: 108** (30 day rank: 340 of 552 users) ⓘ

1. Select a Profile

2. Parameterize

3. Finalize

4. Schedule

Selected Profile: DoSServer

Dos Attack Server

Copy Profile

Show Profile

Change Profile

Previous

Next

Fig 4 – Selecting and changing a profile.

Your request for membership in project 'CloudLab' has not yet been approved by the project leader. [Remind the Project Leader.](#)
 Current Usage: 0 Node Hours, **Prev Month: 108** (30 day rank: 340 of 552 users) ⓘ

1. Select a Profile 2. Parameterize **3. Finalize** 4. Schedule

Profile: DoSServer Version: 0 [Source](#)


Please review the selections below and then click Next.

Name:

Cluster: ⓘ

[+ Advanced Options](#)

[Check Resource Availability](#)



[Previous](#) [Next](#)

Fig 5 – Selecting a Cluster (the one chosen here is Emulab).

Your request for membership in project 'CloudLab' has not yet been approved by the project leader. [Remind the Project Leader.](#)
 Current Usage: 0 Node Hours, **Prev Month: 108** (30 day rank: 339 of 552 users) ⓘ

1. Select a Profile 2. Parameterize **3. Finalize** **4. Schedule**

Please select when you would like to start this experiment and then click Finish.

Start immediately ☒

or

Start on date/time

 ⓘ

Experiment Duration

hours ⓘ

[Previous](#) [Finish](#)

Fig 6 – Final Step – to select the duration of the experiment.

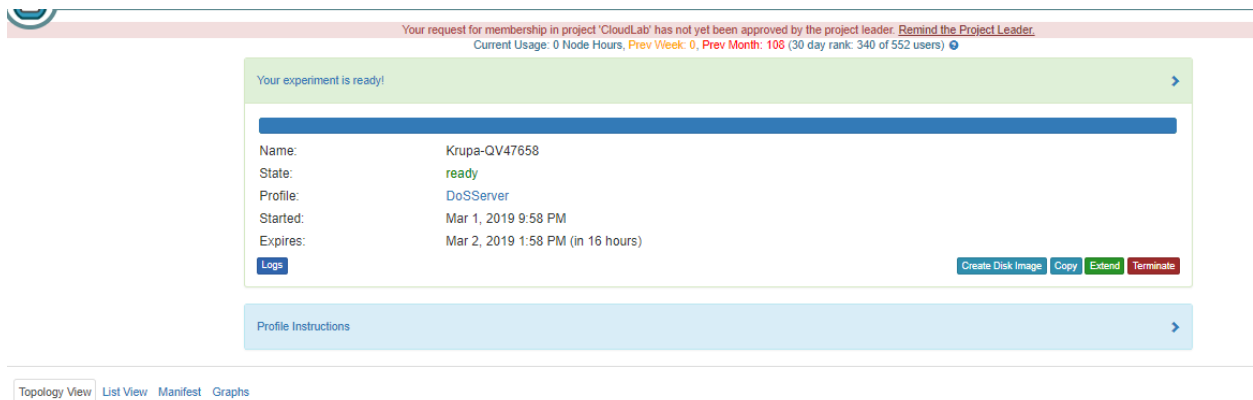


Fig 7 – The console when instantiated.

Step2: Conducting the Experiment.

Section 2.1 : Installing Dependencies

The figures from Fig 8 to Fig 37 demonstrate the installation of dependencies for carrying out the experiment. Further, there are three dependencies created. They are:

1. Floodlight – Fig 8 to Fig 27
2. Mininet – Fig 28 to Fig 35
3. Hping - Fig 36 and Fig 37

Installing Floodlight

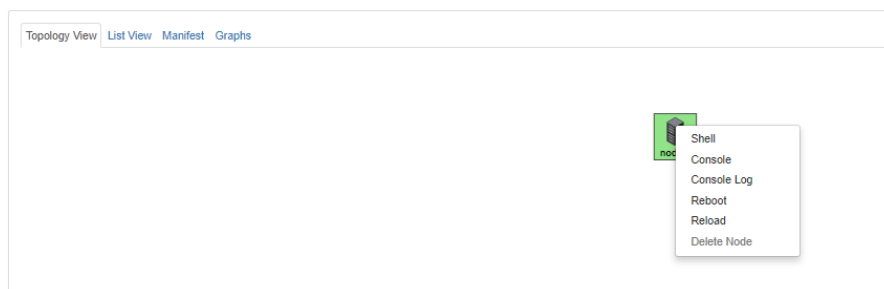


Fig 8 – Opening a Shell.

```
Topology View List View Manifest Graphs node-0 x
Welcome to Ubuntu 14.04.1 LTS (GNU/Linux 3.13.0-165-generic x86_64)

* Documentation:  https://help.ubuntu.com/

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

node-0:~> █
```

Fig 9 - Shell

```
Topology View List View Manifest Graphs node-0 x
node-0:~> sudo apt-get update
```

Fig 10 – Update apt using “apt-get update”.

```
Topology View List View Manifest Graphs node-0 x
Get:21 http://us.archive.ubuntu.com trusty Release [58.5 kB]
Get:22 http://us.archive.ubuntu.com trusty/main Sources [1,064 kB]
Get:23 http://security.ubuntu.com trusty-security/restricted Translation-en [3,556 B]
Get:25 http://us.archive.ubuntu.com trusty/universe Sources [6,399 kB]
Get:26 http://us.archive.ubuntu.com trusty/main amd64 Packages [1,350 kB]
Get:27 http://us.archive.ubuntu.com trusty/restricted amd64 Packages [13.0 kB]
Get:29 http://us.archive.ubuntu.com trusty/main i386 Packages [1,348 kB]
Get:30 http://us.archive.ubuntu.com trusty/restricted i386 Packages [13.4 kB]
Get:31 http://us.archive.ubuntu.com trusty/universe i386 Packages [5,866 kB]
Get:33 http://us.archive.ubuntu.com trusty/restricted Translation-en [3,457 B]
Get:34 http://us.archive.ubuntu.com trusty/universe Translation-en [4,089 kB]
Ign http://us.archive.ubuntu.com trusty/main Translation-en_US
Ign http://us.archive.ubuntu.com trusty/universe Translation-en_US
Fetched 33.8 MB in 15s (2,216 kB/s)
Reading package lists... Done
node-0:~> █
```

Fig 11 – Apt updating done.

```
Topology View List View Manifest Graphs node-0 x
node-0:~> sudo apt-get install default-jdk -y
```

Fig 12 – install jdk using “sudo apt-get install default-jdk -y”

```
Topology View List View Manifest Graphs node-0 x
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/jsadebugd to provide /usr/bin/jsadebugd (jsadebugd) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/jstack to provide /usr/bin/jstack (jstack) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/jstatd to provide /usr/bin/jstatd (jstatd) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/native2ascii to provide /usr/bin/native2ascii (native2ascii) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/rmic to provide /usr/bin/rmic (rmic) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/serialver to provide /usr/bin/serialver (serialver) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/wsgen to provide /usr/bin/wsgen (wsgen) in auto mode
update-alternatives: using /usr/lib/jvm/java-7-openjdk-amd64/bin/wsimport to provide /usr/bin/wsimport (wsimport) in auto mode
Setting up default-jdk (2:1.7-51) ...
Processing triggers for libc-bin (2.19-0ubuntu6.14) ...
Processing triggers for ca-certificates (20170717~14.04.1) ...
Running hooks in /etc/ca-certificates/update.d..., 0 removed; done.
done.
done.
node-0:~>
```

Fig 13 – jdk is installed.

```
Topology View List View Manifest Graphs node-0 x
node-0:~> sudo apt-get install default-jre -y
```

Fig 14 – Install jre using “sudo apt-get install default-jre -y”

```
Topology View List View Manifest Graphs node-0 x
node-0:~> sudo apt-get install default-jre -y
Reading package lists... Done
Building dependency tree
Reading state information... Done
default-jre is already the newest version.
default-jre set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 136 not upgraded.
node-0:~> apt-get install default-jre -y
E: Could not open lock file /var/lib/dpkg/lock - open (13: Permission denied)
E: Unable to lock the administration directory (/var/lib/dpkg/), are you root?
node-0:~> sudo su
```

Fig 15 – get SU.

```
Topology View List View Manifest Graphs node-0 X
root@node-0:/users/Krupa# apt-get install build-essential maven ant python- dev
```

Fig 16 – build essential using “apt-get install build-essential maven ant python- dev”

```
Topology View List View Manifest Graphs node-0 X
root@node-0:/users/Krupa# apt-get install build-essential maven ant python- dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package dev
root@node-0:/users/Krupa#
```

Fig 17 – Error occurred in building.

```
Topology View List View Manifest Graphs node-0 X
root@node-0:/users/Krupa# apt-get install build-essential maven ant python- dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package dev
root@node-0:/users/Krupa# sudo apt-get install build-essential maven ant python- dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package dev
root@node-0:/users/Krupa# apt-get update
```

Fig 18 – To overcome error, update apt using “apt-get update”.

```
Topology View List View Manifest Graphs node-0 X
Hit http://us.archive.ubuntu.com trusty Release
Hit http://security.ubuntu.com trusty-security/main Translation-en
Hit http://us.archive.ubuntu.com trusty/main Sources
Hit http://security.ubuntu.com trusty-security/restricted Translation-en

Hit http://us.archive.ubuntu.com trusty/universe Sources
Hit http://us.archive.ubuntu.com trusty/main amd64 Packages
Hit http://us.archive.ubuntu.com trusty/universe amd64 Packageses

Hit http://us.archive.ubuntu.com trusty/main i386 Packages
Hit http://us.archive.ubuntu.com trusty/restricted i386 Packages
Hit http://us.archive.ubuntu.com trusty/main Translation-enges

Hit http://us.archive.ubuntu.com trusty/restricted Translation-en
Hit http://us.archive.ubuntu.com trusty/universe Translation-en
Ign http://us.archive.ubuntu.com trusty/restricted Translation-en_US

Ign http://us.archive.ubuntu.com trusty/universe Translation-en_US
Reading package lists... Done
root@node-0:/users/Krupa#
```

Fig 19 – apt update done.

Topology View List View Manifest Graphs node-0 ^x

```
root@node-0:/users/Krupa# sudo apt-get install build-essential maven ant python- dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package dev
root@node-0:/users/Krupa# apt-get install build-essential maven ant python- dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package dev
root@node-0:/users/Krupa# apt-get install build-essential ant maven python-dev
```

Fig 20 – Now build essential using same command.

Topology View List View Manifest Graphs node-0 ^x

```
Setting up libxom-java (1.2.10-1) ...
Setting up python-dev (2.7.5-5ubuntu3) ...

Setting up rhino (1.7R4-2) ...
update-alternatives: using /usr/bin/rhino to provide /usr/bin/js (js) in auto mode
Setting up libmaven-scm-java (1.3-5) ...

Setting up libwagon-java (1.0.0-2ubuntu2) ...
Setting up libosgi-compendium-java (4.3.0-1) ...
Setting up libwagon2-java (2.5-1) ...ava (1.0-2) ...

Setting up libmaven2-core-java (2.2.1-14) ...
Setting up libplexus-containers1.5-java (1.5.5-6) ...
Setting up libaether-java (1.13.1-2) ....

Setting up libgeronimo-jpa-2.0-spec-java (1.1-2) ...
Setting up maven (3.0.5-1) ...
root@node-0:/users/Krupa# /usr/share/maven/bin/mvn to provide /usr/bin/mvn (mvn) in auto mode

root@node-0:/users/Krupa#
```

Fig 21 – Maven is set up.

Topology View List View Manifest Graphs node-0 ^x

```
root@node-0:/users/Krupa# git clone git://github.com/floodlight/floodlight.git -b v1.2
```

Fig 22 – Clone GitHub for floodlight.


```
Topology View List View Manifest Graphs node-0 X
root@node-0:/users/Krupa# git clone git://github.com/floodlight/floodlight.git -b v1.2
Cloning into 'floodlight'...
remote: Enumerating objects: 11, done.
remote: Counting objects: 100% (11/11), done.
remote: Total 52768 (delta 10), reused 10 (delta 10), pack-reused 52757
Receiving objects: 100% (52768/52768), 383.91 MiB | 7.50 MiB/s, done.
Resolving deltas: 100% (34214/34214), done.
Checking connectivity... done.
root@node-0:/users/Krupa#
```

Fig 23 – Cloning done right.

```
Topology View List View Manifest Graphs node-0 X
root@node-0:/users/Krupa# cd floodlight
root@node-0:/users/Krupa/floodlight# git submodule update
root@node-0:/users/Krupa/floodlight#
```

Fig 24 – getting into floodlight directory.

```
Topology View List View Manifest Graphs node-0 X
root@node-0:/users/Krupa# cd floodlight
root@node-0:/users/Krupa/floodlight# git submodule update
root@node-0:/users/Krupa/floodlight# ant
```

Fig 25 – install ant.

```
Topology View List View Manifest Graphs node-0 X
Total time: 14 seconds
root@node-0:/users/Krupa/floodlight# ant
Buildfile: /users/Krupa/floodlight/build.xml
init:

compile:
[javac] Compiling 1 source file to /users/Krupa/floodlight/target/bin

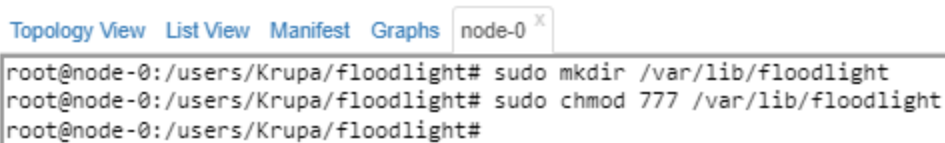
compile-test:

[echo] Setting Floodlight version: 1.2

[echo] Setting Floodlight name: floodlight
[jar] Building jar: /users/Krupa/floodlight/target/floodlight.jar
[jar] Building jar: /users/Krupa/floodlight/target/floodlight-test.jar

BUILD SUCCESSFUL
Total time: 14 seconds
root@node-0:/users/Krupa/floodlight#
```

Fig 26 –build is successful.

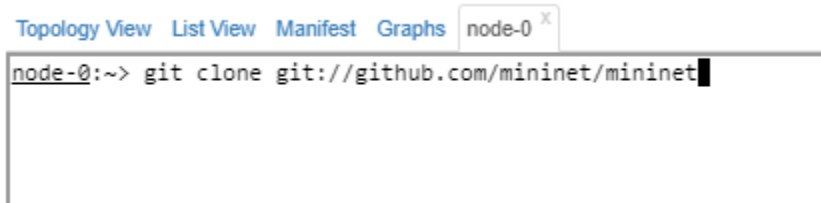


The screenshot shows a terminal window with tabs for 'Topology View', 'List View', 'Manifest', and 'Graphs'. The active tab is 'node-0'. The terminal output shows the following commands and their results:

```
root@node-0:/users/Krupa/floodlight# sudo mkdir /var/lib/floodlight
root@node-0:/users/Krupa/floodlight# sudo chmod 777 /var/lib/floodlight
root@node-0:/users/Krupa/floodlight#
```

Fig 27 – Create a directory and change permissions.

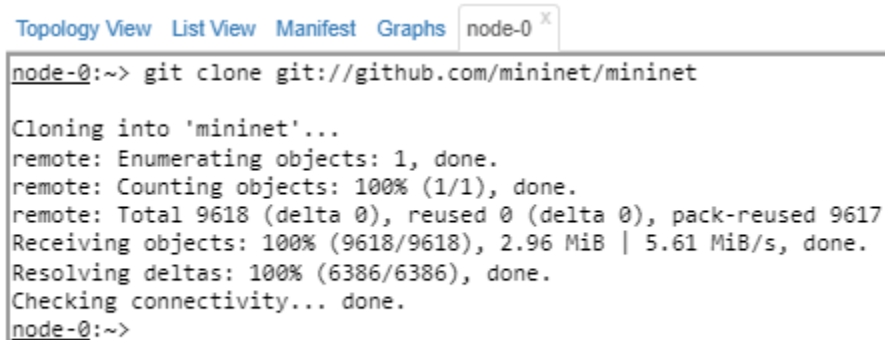
Installing Mininet



The screenshot shows a terminal window with tabs for 'Topology View', 'List View', 'Manifest', and 'Graphs'. The active tab is 'node-0'. The terminal output shows the following command and its result:

```
node-0:~> git clone git://github.com/mininet/mininet
```

Fig 28 – Clone Github for mininet.

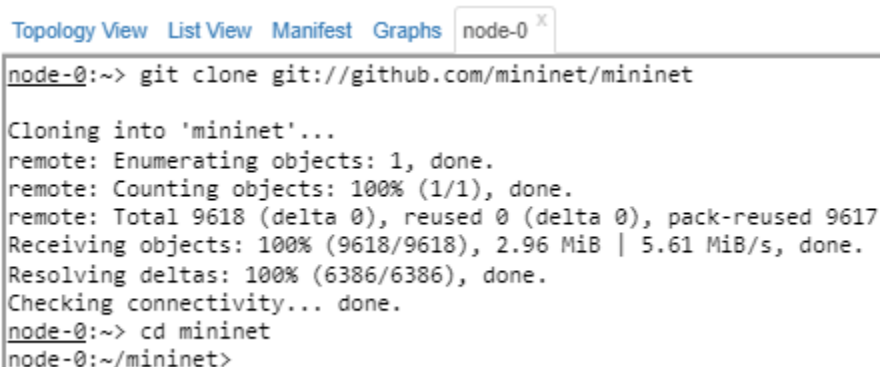


The screenshot shows a terminal window with tabs for 'Topology View', 'List View', 'Manifest', and 'Graphs'. The active tab is 'node-0'. The terminal output shows the following command and its result:

```
node-0:~> git clone git://github.com/mininet/mininet

Cloning into 'mininet'...
remote: Enumerating objects: 1, done.
remote: Counting objects: 100% (1/1), done.
remote: Total 9618 (delta 0), reused 0 (delta 0), pack-reused 9617
Receiving objects: 100% (9618/9618), 2.96 MiB | 5.61 MiB/s, done.
Resolving deltas: 100% (6386/6386), done.
Checking connectivity... done.
node-0:~>
```

Fig 29 – Cloning done



The screenshot shows a terminal window with tabs for 'Topology View', 'List View', 'Manifest', and 'Graphs'. The active tab is 'node-0'. The terminal output shows the following commands and their results:

```
node-0:~> git clone git://github.com/mininet/mininet

Cloning into 'mininet'...
remote: Enumerating objects: 1, done.
remote: Counting objects: 100% (1/1), done.
remote: Total 9618 (delta 0), reused 0 (delta 0), pack-reused 9617
Receiving objects: 100% (9618/9618), 2.96 MiB | 5.61 MiB/s, done.
Resolving deltas: 100% (6386/6386), done.
Checking connectivity... done.
node-0:~> cd mininet
node-0:~/mininet>
```

Fig 30 – Moving into mininet.

```
Topology View List View Manifest Graphs node-0 x
remote: Counting objects: 100% (1/1), done.
remote: Total 9618 (delta 0), reused 0 (delta 0), pack-reused 9617
Receiving objects: 100% (9618/9618), 2.96 MiB | 5.61 MiB/s, done.
Resolving deltas: 100% (6386/6386), done.
Checking connectivity... done.
node-0:~> cd mininet
node-0:~/mininet> git tag

1.0.0
2.0.0
2.1.0
2.1.0p1
2.1.0p2
2.2.0
2.2.1
2.2.2
2.3.0d4

cs244-spring-2012-final
node-0:~/mininet>
```

Fig 31 – To see available branches use “git tag”.

```
Topology View List View Manifest Graphs node-0 x
node-0:~/mininet> git checkout -b 2.2.1 2.2.1

Switched to a new branch '2.2.1'
node-0:~/mininet> █
```

Fig 32 – Install mininet version 2.2.1 using “git checkout -b 2.2.1 2.2.1”.

```
Topology View List View Manifest Graphs node-0 x
node-0:~/mininet> git checkout -b 2.2.1 2.2.1

Switched to a new branch '2.2.1'
node-0:~/mininet> cd ..
node-0:~>
```

Fig 33 – coming out of mininet directory.

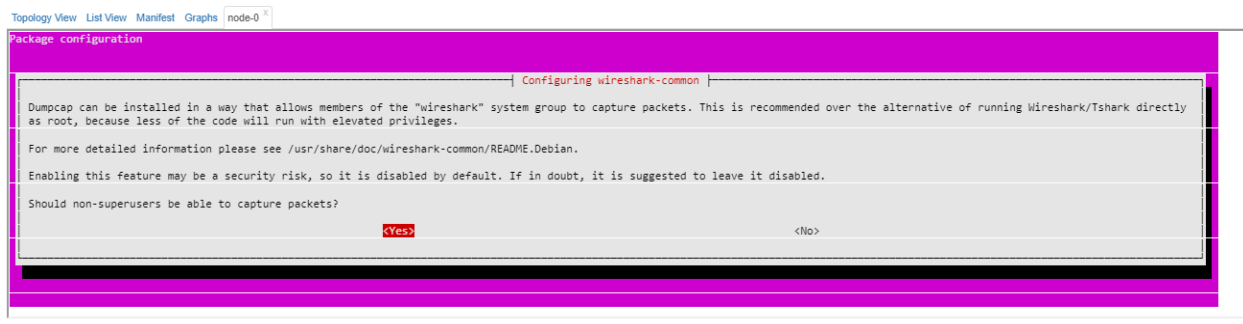


Fig 34 – Installing mininet using “mininet/util/install.sh -a” and Choosing “yes” to continue installation.

```
Topology View List View Manifest Graphs node-0 X
make[3]: Nothing to be done for `install-exec-am'.
make[3]: Nothing to be done for `install-data-am'.
make[3]: Leaving directory `/users/Krupa/oflops/example_modules'
make[2]: Leaving directory `/users/Krupa/oflops/example_modules'
make[1]: Leaving directory `/users/Krupa/oflops/example_modules'
Making install in cbench
make[1]: Entering directory `/users/Krupa/oflops/cbench'
make[2]: Entering directory `/users/Krupa/oflops/cbench'
/bin/mkdir -p '/usr/local/bin'
/bin/bash ../libtool --mode=install /usr/bin/install -c cbench '/usr/local/bin'
libtool: install: /usr/bin/install -c cbench /usr/local/bin/cbench
make[2]: Nothing to be done for `install-data-am'.
make[2]: Leaving directory `/users/Krupa/oflops/cbench'
make[1]: Leaving directory `/users/Krupa/oflops/cbench'
Making install in doc
make[1]: Entering directory `/users/Krupa/oflops/doc'
make[1]: Nothing to be done for `install'.
make[1]: Leaving directory `/users/Krupa/oflops/doc'
Enjoy Mininet!
node-0:~> █
```

Fig 35 – Mininet installed.

Installing Hping3

```
Topology View List View Manifest Graphs node-0 X
root@node-0:~# sudo apt-get install hping3
```

Fig 36 – to install Hping3 use “sudo apt-get install hping3”.

```
Topology View List View Manifest Graphs node-0 x
root@node-0:~# sudo apt-get install hping3
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  hping3
0 upgraded, 1 newly installed, 0 to remove and 130 not upgraded.
Need to get 113 kB of archives.
After this operation, 260 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu/ trusty/universe hping3 amd64 3.a2.ds2-6.1 [113 kB]
Fetched 113 kB in 0s (187 kB/s)
Selecting previously unselected package hping3.
(Reading database ... 94626 files and directories currently installed.)
Preparing to unpack .../hping3_3.a2.ds2-6.1_amd64.deb ...
Unpacking hping3 (3.a2.ds2-6.1) ...
Processing triggers for man-db (2.6.7.1-1) ...
Setting up hping3 (3.a2.ds2-6.1) ...
root@node-0:~#
```

Fig 37 – Hping successfully installed.

Section 2.2 Running floodlight

The figures below show running of floodlight to how to start a flood of packets to demonstrate DoS attack.

```
Topology View List View Manifest Graphs node-0 x node-0 x
Welcome to Ubuntu 14.04.1 LTS (GNU/Linux 3.13.0-165-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
Last login: Fri Mar  1 21:01:36 2019 from ops.emulab.net
node-0:~> cd floodlight
node-0:~/floodlight> java -jar target/floodlight.jar
```

Fig 38 – After changing the directory to floodlight in a new shell, use “java -jar target/floodlight.jar” to run Floodlight Controller.

```

Topology View List View Manifest Graphs node-0 x node-0 x node-0 x node-0 x
--pin                pin hosts to CPU cores (requires --host cfs or --host
                    rt)
                    to the physical network. Warning: This may route anyts
                    traffic on the machine that uses Mininet's IP subnet
                    into the Mininet network. If you need to change
--version            prints the version and exits --ipbase option.

--cluster=server1,server2...
                    run on multiple servers (experimental!)
                    node placement for --cluster (experimental!)

node-0:~> sudo mn --controller=remote,ip=127.0.0.1,port=6653 --switch ovsk,protocols=OpenFlow13
usage: sudo -h | -K | -k | -V
usage: sudo -l [-AknS] [-g group] [-h host] [-p prompt] [-U user] [-u user] [command]

usage: sudo [-AbEHknPS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-u user] [VAR=value] [-i|-s] [<command>]
usage: sudo -e [-AknS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-u user] file ...
*** Creating networkcontroller=remote,ip=127.0.0.1,port=6653 --switch ovsk,protocols=OpenFlow13

```

Fig 39 – try running mininet using “sudo mn --controller=remote,ip=127.0.0.1,port=6653 --switch ovsk, protocols=OpenFlow13”

```

Topology View List View Manifest Graphs node-0 x node-0 x node-0 x node-0 x
usage: sudo -h | -K | -k | -V
usage: sudo -l [-AknS] [-g group] [-h host] [-p prompt] [-U user] [-u user] [command]

usage: sudo [-AbEHknPS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-u user] [VAR=value] [-i|-s] [<command>]
usage: sudo -e [-AknS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-u user] file ...
*** Creating networkcontroller=remote,ip=127.0.0.1,port=6653 --switch ovsk,protocols=OpenFlow13

*** Adding controller
*** Adding hosts:
*** Adding switches:

s1
*** Adding links:
*** Configuring hosts

h1 h2
*** Starting controller
*** Starting 1 switches

s1 ...
*** Starting CLI:
mininet>

```

Fig 40 – The result: 2 hosts are created by default and are connected using OVS Bridges.

```

Topology View List View Manifest Graphs node-0 x node-0 x node-0 x node-0 x
*** Adding controller
*** Adding hosts:
*** Adding switches:

s1
*** Adding links:
*** Configuring hosts

h1 h2
*** Starting controller
*** Starting 1 switches

s1 ...
*** Starting CLI:
*** Ping: testing ping reachability

h1 -> h2
h2 -> h1
mininet> ts: 0% dropped (2/2 received)

```

Fig 42 – pingall test to see connectivity.


```
Topology View List View Manifest Graphs node-0 x node-0 x node-0 x node-0 x
mininet> ts: 0% dropped (2/2 received)

mininet> pingall
*** Ping: testing ping reachability
h2 -> h1

*** Results: 0% dropped (2/2 received)
mininet> h1 hping3 h2 --c 10000 -S --flood --rand-source -V
mininet> ou must specify only one target host at a time

mininet>
mininet> h1 hping3 h2 --c 10000 -S --flood --rand-source -V
HPING 10.0.0.2 (h1-eth0 10.0.0.2): S set, 40 headers + 0 data bytes

hping in flood mode, no replies will be shown
^C
6998679 packets transmitted, 0 packets received, 100% packet loss

round-trip min/avg/max = 0.0/0.0/0.0 ms
mininet>
```

Fig 44 – Stop mininet in its terminal by using ctrl+c and ping h2 from h1.

```
Topology View List View Manifest Graphs node-0 x node-0 x node-0 x node-0 x
mininet>
mininet> h1 hping3 h2 --c 10000 -S --flood --rand-source -V
HPING 10.0.0.2 (h1-eth0 10.0.0.2): S set, 40 headers + 0 data bytes

hping in flood mode, no replies will be shown
^C
6998679 packets transmitted, 0 packets received, 100% packet loss

round-trip min/avg/max = 0.0/0.0/0.0 ms
mininet> h1 ping h2
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=4.31 ms

64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.364 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.065 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.076 ms

64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.073 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.068 ms
█
```

Fig 45 -pinging again (repetitions of previous step)

```
Topology View List View Manifest Graphs node-0 x node-0 x node-0 x node-0 x
Welcome to Ubuntu 14.04.1 LTS (GNU/Linux 3.13.0-165-generic x86_64)

* Documentation:  https://help.ubuntu.com/
New release '16.04.6 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Mon Mar  4 15:07:14 2019 from ops.emulab.net
node-0:~> sudo ovs-ofctl dump-flows s1 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x2000000000000000, duration=141.246s, table=0, n_packets=140, n_bytes=13720, idle_timeout=5, priority=1,ip,in_port=2,d1_src=32:1c:69:28:fe:35,d1_dst=de:13:ea:61:e8:a2,nw_src=10.0.0.2,nw_dst=10.0.0.1 actions=output:1
 cookie=0x2000000000000000, duration=141.248s, table=0, n_packets=140, n_bytes=13720, idle_timeout=5, priority=1,ip,in_port=1,d1_src=de:13:ea:61:e8:a2,d1_dst=32:1c:69:28:fe:35,nw_src=10.0.0.1,nw_dst=10.0.0.2 actions=output:2
 cookie=0x0, duration=1834.597s, table=0, n_packets=1553629, n_bytes=83893818, priority=0 actions=CONTROLLER:65535
node-0:~>
```

Fig 46 – Checking flow rules in an empty terminal

Observations and Conclusions:

We come to know how a DoS attack works. A DoS attack doesn't necessarily sniff out data, but makes the system unreliable by bombarding it with a flood of packets thus making it overloaded and hence making no resources available for it. Since no resources are available, its services get disrupted.

This observation clearly demonstrates the DoS attack. We see that when flooding of packets is started, flow table of OVS switch is full and hence it cannot receive any more number of packets. This is because the space is insufficient and cannot store more packets. This leads to inefficiency as switches are refrained from obtaining data packets. Therefore there is an error here. The switch now send a OFPT_ERROR to the controller saying that the flow table is full by using OFPFMFC_TABLE_FULL. Since it now has no space to store packets, it is forced to drop the incoming packets thus losing data. Furthermore, it also has no resource to update a flowtable entry. This is the demonstration of DoS attack.