CYBER DEFENSE USING PRETENSE FOR SDX-DRIVEN CLOUD PLATFORMS

Complete Experiment Instructions

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Cloud Computing 1

Outline

The purpose of this document is to provide simple instructions, anyone can follow, which will allow them to perform our experiment Moving Target Defence with Pretense.

GENI Slice Creation

1. Take the attached rspec in the Appendix and load it into your GENI Slice.

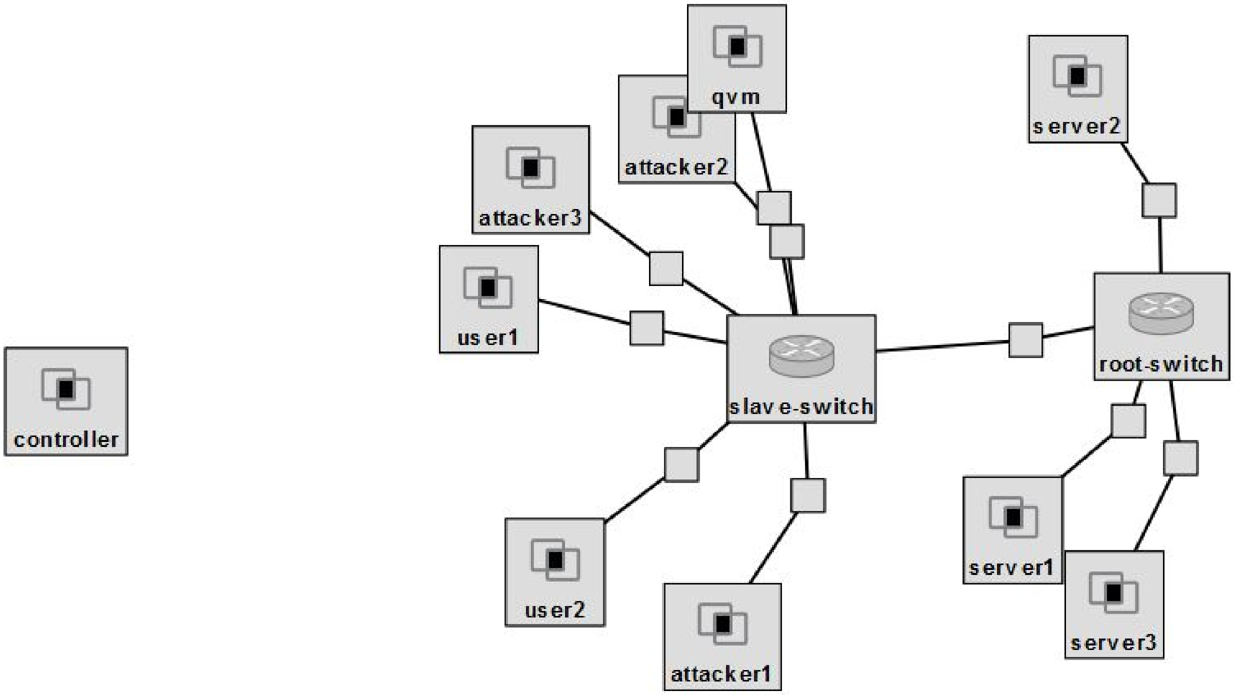


Figure 1: The GENI Slice

2. Select an Aggregate for the Site. For our experiment we used Cornell InstaGENI.
3. Reserve the Resources and wait for all resources to become available on the Slice

Installation of all Required Software

1. Controller installation

a. Locate the details to ssh into the controller (i.e. ssh neelyt@pcvm1-12.geni.it.cornell.edu -i ~/.ssh/id_geni_ssh_rsa.ppk) and login to the controller
b. Run the following commands in order
    i. sudo apt-get update
    ii. sudo apt-get -y install git
    iii. git clone https://github.com/frenetic-lang/frenetic-vm
    iv. cd frenetic-vm
    v. chmod u+x ./root-bootstrap.sh
    vi. sudo ./root-bootstrap.sh

vii. sudo adduser frenetic

    1. Give the user a password and remember it!
    2. Use the default values for the user settings by just pressing enter when prompted
    3. Enter y when prompted

viii. sudo adduser frenetic sudo

ix. sftp frenetic@localhost

    1. yes
    2. put user-bootstrap.sh
    3. quit

x. sudo -i -u frenetic

xi. mkdir src

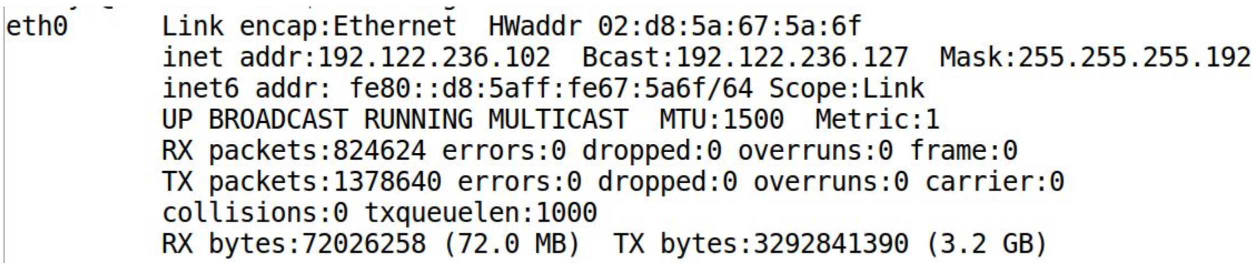
xii. chmod u+x ./user-bootstrap.sh

xiii. ./user-bootstrap.sh

    1. Sometimes it seems like this installation will fail on the ./user-bootstrap.sh due to being out of memory. If this happens run ‘sudo reboot now’ on the Controller to reboot the machine and then start over from step x (sudo -i -u frenetic) and try running the ./user-bootstrap.sh again

xiv. Ifconfig

    1. Get the details about the public ip address for the Controller. It should be under eth0, the inet addr. Ours was 192.122.236.102. Save this information for use later.



```
eth0      Link encap:Ethernet  HWaddr 02:d8:5a:67:5a:6f
          inet addr:192.122.236.102  Bcast:192.122.236.127  Mask:255.255.255.192
          inet6 addr: fe80::d8:5aff:fe67:5a6f/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:824624 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1378640 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:72026258 (72.0 MB)  TX bytes:3292841390 (3.2 GB)
```

Figure 2: Controller ifconfig info

2. root-switch Installation

a. Locate the details to ssh into the root-switch (i.e. ssh neelyt@pcvm1-12.geni.it.cornell.edu -i ~/.ssh/id_geni_ssh_rsa.ppk) and login to the root-switch

b. Run the following commands

    i. sudo apt-get update
    ii. sudo apt-get install -y openvswitch-switch

   iii. sudo ovs-vsctl add-br br0
   iv. ifconfig
      1. For these steps, you only want to run these on ethx which are on the local network (10.0.0.x). It will most likely be what is displayed here but you should check the output of your ifconfig to make sure. Be CERTAIN to NOT disable the main adapter (it should have an address other than 10.0.0.x and will probably be eth0, otherwise you will disable your switch and be unable to reach it)
      2. sudo ifconfig eth1 0
      3. sudo ifconfig eth2 0
      4. sudo ifconfig eth3 0
      5. sudo ifconfig eth4 0
      6. sudo ovs-vsctl add-port br0 eth1
      7. sudo ovs-vsctl add-port br0 eth2
      8. sudo ovs-vsctl add-port br0 eth3
      9. sudo ovs-vsctl add-port br0 eth4
      10. sudo ovs-vsctl set-controller br0 tcp:<controller IP Address from step 1.b.xiv.1 above>:6633 (i. e. sudo ovs-vsctl set-controller br0 tcp:192.122.236.102:6633)
      11. sudo ovs-vsctl set-fail-mode br0 secure

3. slave-switch Installation

a. Locate the details to ssh into the root-switch (i.e. ssh neelyt@pcvm1-12.geni.it.cornell.edu -i ~/.ssh/id_geni_ssh_rsa.ppk) and login to the root-switch
b. Run the following commands
   i. sudo apt-get update
   ii. sudo apt-get install -y openvswitch-switch
   iii. sudo ovs-vsctl add-br br0
   iv. ifconfig
      1. For these steps, you only want to run these on ethx which are on the local network (10.0.0.x). It will most likely be what is displayed here but you should check the output of your ifconfig to make sure. Be CERTAIN to NOT disable the main adapter (it should have an address other than 10.0.0.x and will probably be eth0, otherwise you will disable your switch and be unable to reach it)
      2. sudo ifconfig eth1 0
      3. sudo ifconfig eth2 0
      4. sudo ifconfig eth3 0
      5. sudo ifconfig eth4 0
      6. sudo ifconfig eth5 0

7. sudo ifconfig eth6 0
8. sudo ifconfig eth7 0
9. sudo ovs-vsctl add-port br0 eth1
10. sudo ovs-vsctl add-port br0 eth2
11. sudo ovs-vsctl add-port br0 eth3
12. sudo ovs-vsctl add-port br0 eth4
13. sudo ovs-vsctl add-port br0 eth5
14. sudo ovs-vsctl add-port br0 eth6
15. sudo ovs-vsctl add-port br0 eth7
16. sudo ovs-vsctl set-controller br0 tcp:<controller IP Address from step 1.b.xiv.1 above>:6633 (i. e. sudo ovs-vsctl set-controller br0 tcp:192.122.236.102:6633)
17. sudo ovs-vsctl set-fail-mode br0 secure

4. Install LAMP (Apache, MySQL, PHP) on the Controller

a. ssh into the Controller and run the following commands
    i. sudo apt-get -y install mysql-server apache2 php libapache2-mod-php php-mysql php-curl
        1. Enter a password for the root account for mysql. This is only for administering the database but it will be needed later.

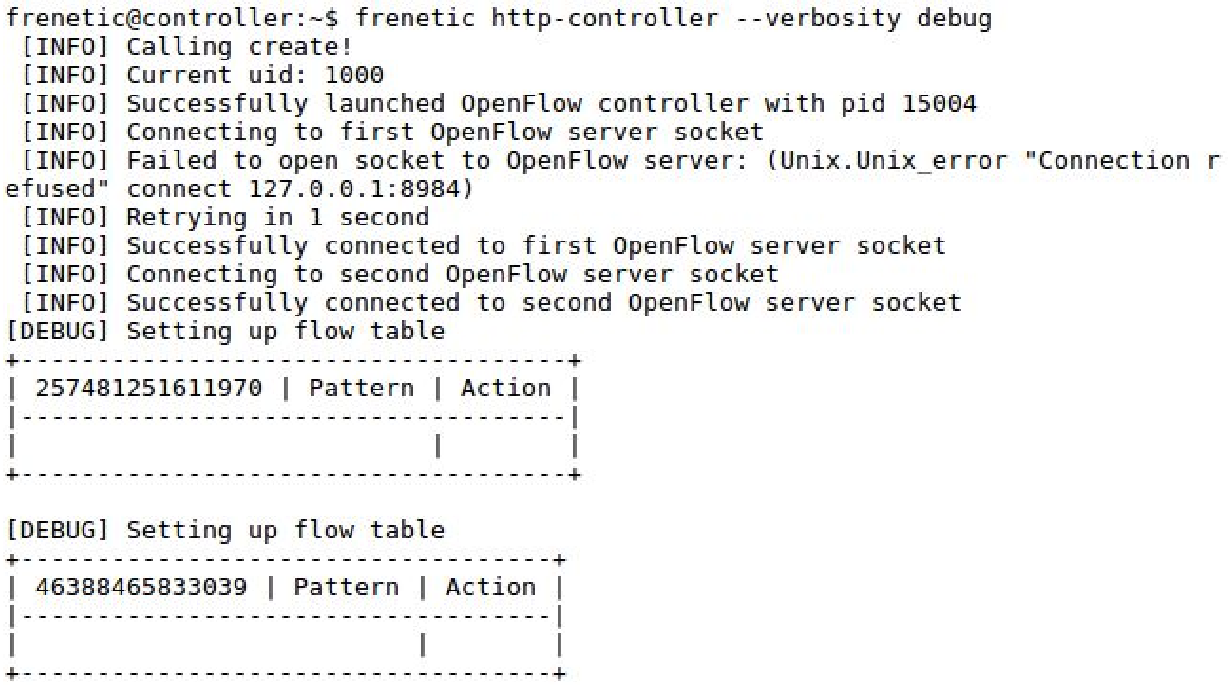
5. Install Scapy and Python on both attacker1 and qvm

a. ssh into both attacker1 and qvm
b. Run the following commands on each of the machines
    i. sudo apt-get update
    ii. sudo apt-get -y install python-pip python-scapy
    iii. sudo pip install scapy
c. On the qvm run the following command
    i. pip install pymysql

6. Test Frenetic and get Switch IDs

a. ssh into the controller
b. Login as the frenetic user
    i. sudo -i -u frenetic
c. Start frenetic
    i. frenetic http-controller --verbosity debug

d. Take note of the switch IDs displayed in the window (about 20 digits long), as they will be used later. What you are currently seeing are the OpenFlow tables for each switch.



```
frenetic@controller:~$ frenetic http-controller --verbosity debug
 [INFO] Calling create!
 [INFO] Current uid: 1000
 [INFO] Successfully launched OpenFlow controller with pid 15004
 [INFO] Connecting to first OpenFlow server socket
 [INFO] Failed to open socket to OpenFlow server: (Unix.Unix_error "Connection r
efused" connect 127.0.0.1:8984)
 [INFO] Retrying in 1 second
 [INFO] Successfully connected to first OpenFlow server socket
 [INFO] Connecting to second OpenFlow server socket
 [INFO] Successfully connected to second OpenFlow server socket
[DEBUG] Setting up flow table
+------------------------------------+
| 257481251611970 | Pattern | Action |
|------------------------------------|
|                           |        |
+------------------------------------+

[DEBUG] Setting up flow table
+-----------------------------------+
| 46388465833039 | Pattern | Action |
|-----------------------------------|
|                          |        |
+-----------------------------------+
```

e. ssh into either the root switch or the slave switch and reboot it
   i. sudo reboot now
   ii. Now quickly close frenetic (Control+C) and restart it. Take note of which switch ID is missing, that is the switch you just rebooted, you will need to know which ID is which later. The switch ID should pop up in a moment once the switch starts up.

f. Go ahead and close Frenetic by pressing Control+C

Installation of Experiment Files

1. Create experiment files

a. From your local machine copy the Admin UI files into /var/www/html (instructions for linux shell)

i. scp -vr -i /your/local/path/to/the/AdminUI/mtdFolder username@controller:/var/www/html/

1. /home/travis/project/files/mini-controller/www/html neelyt@pcvm5-31.instageni.northwestern.edu:/var/www/)

ii. (i.e. scp -vr -i ~/.ssh/id_geni_ssh_rsa.ppk

b. ssh into the controller and login as the frenetic user

i. sudo -i -u frenetic

c. On the controller, modify your /var/www/html/mtd/pages/settings.php file

i. Modify line 21 ($url = "http://pcvm1-12.geni.it.cornell.edu:9000/rest_policy/update_json";) to point to your controller.

d. On the controller, modify the following json

e. On the controller, create the following files

i. network_information_base.py - Code in the Appendix

ii. stats-switch-root.py - Code in the Appendix

iii. stats-switch-slave.py - Code in the Appendix

f. On the controller, modify these json files to update them to use your switch ids

i. sed -i 's/200298535524941/switch-root-id/g' /var/www/html/mtd/js/json/*.json

1. (i.e. sed -i 's/200298535524941/46388465833039/g' /var/www/html/mtd/js/json/*.json)

ii. sed -i 's/33035025751368/switch-slave-id/g' /var/www/html/mtd/js/json/*.json

1. (i.e. sed -i 's/33035025751368/257481251611970/g' /var/www/html/mtd/js/json/*.json)

g. On the controller, create the mysql mtd7000 user by running these commands

i. mysql -u root -p

1. Enter the root mysql password
2. create user 'mtd7000'@'localhost' identified by 'mtd';
3. grant all on mtd.* to 'mtd7000'@'localhost';

ii. mysql -u root -p

1. Enter the root mysql password
2. Restore the database from the sqldump in the Appendix
3. Run sqldump file

h. Test the website by opening your browser and going to: yourControllerPublicName/mtd/pages/dashboard.php

i. (i.e. http://pcvm5-31.instageni.northwestern.edu/mtd/pages/dashboard.php)

i. You should get the Admin UI with blank graphs.

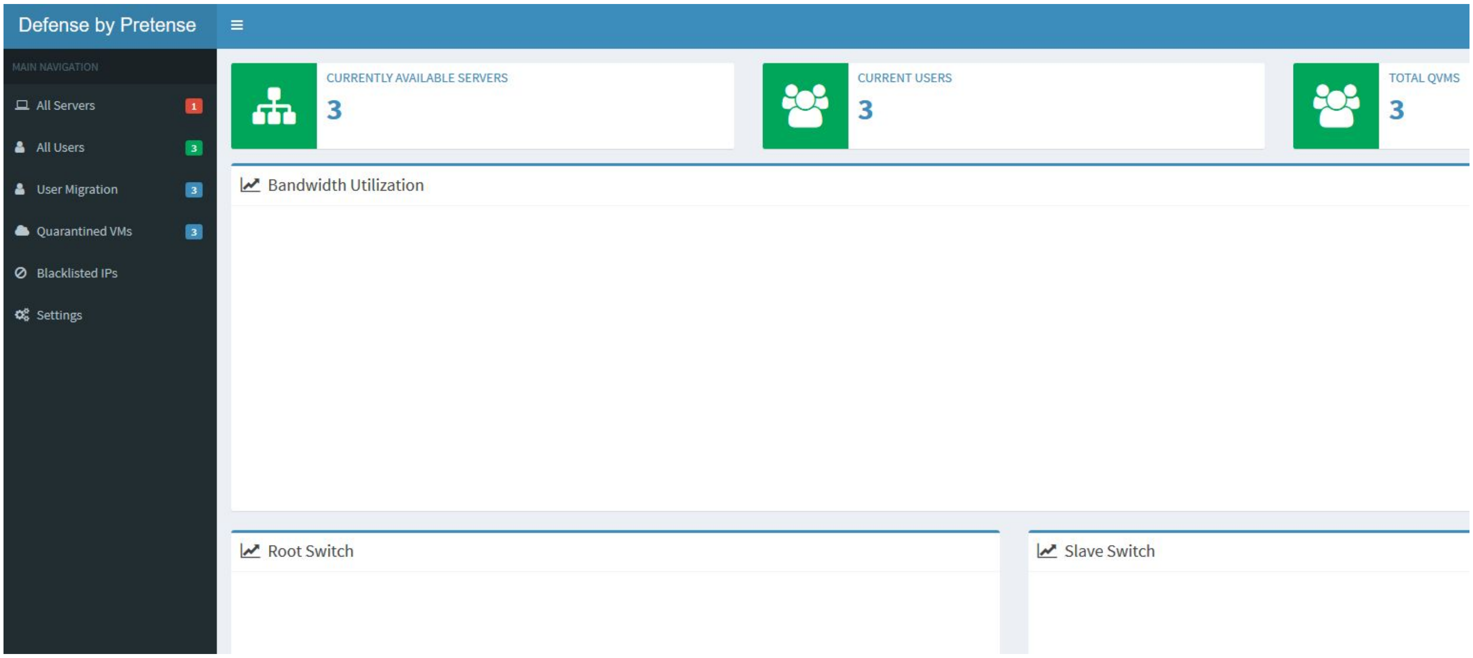


Figure 3: The fresh Admin UI installation

j. ssh into attacker1 and create the following files as specified
   i. attack.sh - See attack.sh in the Appendix for code
      1. chmod u+x ./attack.sh #make the file executable
   ii. attacker_script.py - See attacker_script.py in the Appendix for code

k. ssh into qvm and create the following files as specified
   i. defend.py - See defend.py in the Appendix for code

Running the Experiment

1. ssh into the controller
2. Login as frenetic
   a. sudo -i -u frenetic
3. Start frenetic
   a. frenetic http-controller --verbosity debug
4. Open another shell on the controller with the frenetic user and run the stats-switch-root.py script
   a. python stats-swtich-root.py
5. Do the same thing for the stats-switch-slave.py
   a. python stats-switch-slave.py

6. You will now begin to notice the bandwidth statistics updating on the Admin UI
7. ssh into attacker1
    a. Start the attack.sh script
        i. sudo ./attack.sh
8. ssh into qvm
    a. Start the defend script
        i. sudo python defend.py

Appendix

Rpec for the GENI Slice:

```
<rspec xmlns="http://www.geni.net/resources/rspec/3"
xmlns:emulab="http://www.protogeni.net/resources/rspec/ext/emulab/1"
xmlns:tour="http://www.protogeni.net/resources/rspec/ext/apt-tour/1"
xmlns:jacks="http://www.protogeni.net/resources/rspec/ext/jacks/1"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.geni.net/resources/rspec/3
http://www.geni.net/resources/rspec/3/request.xsd" type="request">
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="controller">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<routable_control_ip xmlns="http://www.protogeni.net/resources/rspec/ext/emulab/1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="root-switch">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/router.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="emulab-xen">
<disk_image xmlns="http://www.geni.net/resources/rspec/3"
name="urn:publicid:IDN+emulab.net+image+emulab-ops:UBUNTU16-64-STD"/>
</sliver_type>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-1">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.102" type="ipv4"
netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-3">
```

```
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.101" type="ipv4"
netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-5">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.103" type="ipv4"
netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-7">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.50" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="server1">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-2">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.1" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="server2">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-0">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.2" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="server3">
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url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-4">
```

```
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.3" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="slave-switch">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/router.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<routable_control_ip xmlns="http://www.protogeni.net/resources/rspec/ext/emulab/1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="emulab-xen">
<disk_image xmlns="http://www.geni.net/resources/rspec/3"
name="urn:publicid:IDN+emulab.net+image+emulab-ops:UBUNTU16-64-STD"/>
</sliver_type>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-6">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.51" type="ipv4"
netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-9">
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netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-11">
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netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-13">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.109" type="ipv4"
netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-15">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.105" type="ipv4"
netmask="255.255.255.0"/>
</interface>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-17">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.106" type="ipv4"
netmask="255.255.255.0"/>
</interface>

<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-21">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.104" type="ipv4"
netmask="255.255.255.0"/>
```

```
</interface>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="attacker1">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<routable_control_ip xmlns="http://www.protogeni.net/resources/rspec/ext/emulab/1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-8">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.7" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
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url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<routable_control_ip xmlns="http://www.protogeni.net/resources/rspec/ext/emulab/1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
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netmask="255.255.255.0"/>
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url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-12">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.9" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
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url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<routable_control_ip xmlns="http://www.protogeni.net/resources/rspec/ext/emulab/1"/>
```

```
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-14">
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netmask="255.255.255.0"/>
</interface>
</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="user2">
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url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-16">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.6" type="ipv4"
netmask="255.255.255.0"/>
</interface>

</node>
<node xmlns="http://www.geni.net/resources/rspec/3" client_id="qvm">
<icon xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1"
url="https://portal.geni.net/images/VM-noTxt-centered.svg"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="Site 1"/>
<sliver_type xmlns="http://www.geni.net/resources/rspec/3" name="default-vm"/>
<services xmlns="http://www.geni.net/resources/rspec/3"/>
<interface xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-20">
<ip xmlns="http://www.geni.net/resources/rspec/3" address="10.0.0.4" type="ipv4"
netmask="255.255.255.0"/>
</interface>
</node>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-0">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-0"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-1"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-1">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-2"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-3"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-2">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-4"/>
```

```
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-5"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-3">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-6"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-7"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-4">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-8"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-9"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-5">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-10"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-11"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-6">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-12"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-13"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-7">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-14"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-15"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-8">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-16"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-17"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
<link xmlns="http://www.geni.net/resources/rspec/3" client_id="link-10">
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-20"/>
<interface_ref xmlns="http://www.geni.net/resources/rspec/3" client_id="interface-21"/>
<site xmlns="http://www.protogeni.net/resources/rspec/ext/jacks/1" id="undefined"/>
</link>
</rspec>
```

attack.sh:

```
python -W ignore attacker_script.py
```

attacker_script.py:

```
import logging
logging.getLogger("scapy.runtime").setLevel(logging.ERROR)
from scapy.all import *

print(srloop(IP(dst="10.0.0.1")/ICMP()/"Blah", inter = 1, timeout = .01, prnfail=lambda x:x.summary()))
```

defend.py:

```
from datetime import datetime
from scapy.all import *
from random import randint
from time import time, strftime,tzset
import csv
import os
import pymysql
import pickle

os.environ['TZ'] = 'America/Chicago'


server_down = randint(20,40)
count = 0
start = 0

blacklist = list()
def check_ip(ip):
  for atkr_ip in blacklist:
      if atkr_ip == ip:
            return True
  return False
```

```
def save_blacklist():
    try:
            thefile = open("blacklist.txt", "w")
            for item in blacklist:
                    thefile.write("%s\n" % item)
            thefile.close()
            print "Blacklist saved"
    except:
                    print("The blacklisted IPs couldn't be saved")

def load_blacklist():
    try:
            blacklist_file = open("blacklist.txt", "r")
                    for item in blacklist_file:
                    blacklist.append(item)
                    blacklist_file.close()
            print "Blacklist accessed"
    except:
                    print "No previous blacklisted IPs"

def update_database(IP, HWADR):
    hostname = 'pcvm3-28.instageni.illinois.edu'
    username = 'mtd7000'
    password = 'mtd'
    database = 'mtd'
    myConnection = pymysql.connect( host=hostname, user=username, passwd=password,
db=database )
    cur = myConnection.cursor()
    insert = [IP,HWADR,str(datetime.now())]
    cur.execute("INSERT INTO mtd.blacklist VALUES (%s,%s,%s)" , insert )
    cur.close()
    myConnection.commit()

def get_age(start):
            current_time = time()
            difference = current_time - start
            hours = difference // 3600
            difference = difference % 3600
            mins = difference // 60
            seconds = difference % 60
            return int(seconds), int(mins), int(hours)
```

```
def my_response(incomming_packet):
        print "Attacker MAC: ", incomming_packet[Ether].src
   print "Attacker IP: ", incomming_packet[IP].src


   if (check_ip(incomming_packet[IP].src) == False):
         blacklist.append(incomming_packet[IP].src)
         update_database(str(incomming_packet[IP].src),str(incomming_packet[Ether].src))
         save_blacklist()

        global start
        if start == 0:
                start = time()
        current_seconds, current_minutes, current_hours = get_age(start)
        print "time since attack started: ",current_hours ,"h", current_minutes, "m",
current_seconds,"s"
        if current_seconds < server_down and current_minutes < 1 and current_hours < 1:
                print "No more packets should be sent after: ", server_down - current_seconds,
"s"
                response_packet_ip = IP(dst = "10.0.0.7", src = "10.0.0.1",  id = 1, ttl = 64, proto
= "icmp")
         response_packet_icmp = ICMP(type = 0, code = 0, seq = 0x0, id = 0x0, chksum =
0x542b)
                load = "Blah"
                packet = response_packet_ip / response_packet_icmp / load
                packet.summary()
                send(packet)
        else:
                print "Tricking the attacker into thinking their attack was successful"

def main():
   global blacklist
   load_blacklist()
        sniff(filter = "icmp and src 10.0.0.7", iface = "eth1", prn = my_response)
main()
```

sqldump

```
CREATE DATABASE  IF NOT EXISTS `mtd` /*!40100 DEFAULT CHARACTER SET latin1 */;
USE `mtd`;
-- MySQL dump 10.13  Distrib 5.7.17, for Win64 (x86_64)
--
-- Host: pcvm3-28.instageni.illinois.edu         Database: mtd
-- ------------------------------------------------------
-- Server version    5.7.17-0ubuntu0.16.04.2

/*!40101 SET @OLD_CHARACTER_SET_CLIENT=@@CHARACTER_SET_CLIENT */;
/*!40101 SET @OLD_CHARACTER_SET_RESULTS=@@CHARACTER_SET_RESULTS */;
/*!40101 SET @OLD_COLLATION_CONNECTION=@@COLLATION_CONNECTION */;
/*!40101 SET NAMES utf8 */;
/*!40103 SET @OLD_TIME_ZONE=@@TIME_ZONE */;
/*!40103 SET TIME_ZONE='+00:00' */;
/*!40014 SET @OLD_UNIQUE_CHECKS=@@UNIQUE_CHECKS, UNIQUE_CHECKS=0 */;
/*!40014 SET @OLD_FOREIGN_KEY_CHECKS=@@FOREIGN_KEY_CHECKS,
FOREIGN_KEY_CHECKS=0 */;
/*!40101 SET @OLD_SQL_MODE=@@SQL_MODE,
SQL_MODE='NO_AUTO_VALUE_ON_ZERO' */;
/*!40111 SET @OLD_SQL_NOTES=@@SQL_NOTES, SQL_NOTES=0 */;

--
-- Table structure for table `attackhistory`
--

DROP TABLE IF EXISTS `attackhistory`;
/*!40101 SET @saved_cs_client       = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `attackhistory` (
  `attacker_id` varchar(100) NOT NULL,
  `source_IP` varchar(20) DEFAULT NULL,
  `destination_IP` varchar(20) DEFAULT NULL,
  `attackStartTime` datetime DEFAULT NULL,
  `attackStopTime` datetime DEFAULT NULL,
  `numberOfPackets` int(11) DEFAULT NULL,
  PRIMARY KEY (`attacker_id`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Dumping data for table `attackhistory`
--
```

```
LOCK TABLES `attackhistory` WRITE;
/*!40000 ALTER TABLE `attackhistory` DISABLE KEYS */;
INSERT INTO `attackhistory` VALUES ('1','192.168.10.13','192.168.10.14','2017-01-01 00:00:00','2017-01-01 00:05:00',40);
/*!40000 ALTER TABLE `attackhistory` ENABLE KEYS */;
UNLOCK TABLES;

--
-- Table structure for table `blacklist`
--

DROP TABLE IF EXISTS `blacklist`;
/*!40101 SET @saved_cs_client     = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `blacklist` (
  `ipAddress` varchar(20) DEFAULT NULL,
  `macAddress` varchar(20) DEFAULT NULL,
  `blacklistedOn` datetime DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Dumping data for table `blacklist`
--

LOCK TABLES `blacklist` WRITE;
/*!40000 ALTER TABLE `blacklist` DISABLE KEYS */;
/*!40000 ALTER TABLE `blacklist` ENABLE KEYS */;
UNLOCK TABLES;

--
-- Table structure for table `logs`
--

DROP TABLE IF EXISTS `logs`;
/*!40101 SET @saved_cs_client     = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `logs` (
  `switch_id` bigint(20) unsigned NOT NULL,
  `port_id` int(10) unsigned NOT NULL,
  `timestamp` datetime NOT NULL,
  `rx_packets` bigint(20) unsigned NOT NULL DEFAULT '0',
  `delta_rx_packets` int(10) unsigned DEFAULT '0',
  `tx_packets` bigint(20) unsigned NOT NULL DEFAULT '0',
  `delta_tx_packets` int(10) unsigned DEFAULT '0',
  `rx_bytes` bigint(20) unsigned NOT NULL DEFAULT '0',
  `delta_rx_bytes` int(10) unsigned DEFAULT '0',
  `tx_bytes` bigint(20) unsigned NOT NULL DEFAULT '0',
  `delta_tx_bytes` int(10) unsigned DEFAULT '0',
  `rx_dropped` bigint(20) unsigned NOT NULL DEFAULT '0',
  `tx_dropped` bigint(20) unsigned NOT NULL DEFAULT '0',
  `rx_errors` bigint(20) unsigned NOT NULL DEFAULT '0',
  `tx_errors` bigint(20) unsigned NOT NULL DEFAULT '0',
  `rx_fram_err` bigint(20) unsigned NOT NULL DEFAULT '0',
  `rx_over_err` bigint(20) unsigned NOT NULL DEFAULT '0',
  `rx_crc_err` bigint(20) unsigned NOT NULL DEFAULT '0',
  `collisions` bigint(20) unsigned NOT NULL,
  PRIMARY KEY (`switch_id`,`port_id`,`timestamp`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Table structure for table `packet_logs`
--

DROP TABLE IF EXISTS `packet_logs`;
/*!40101 SET @saved_cs_client     = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `packet_logs` (
  `switch_id` bigint(20) unsigned NOT NULL,
  `port_id` int(10) unsigned NOT NULL,
  `timestamp` datetime NOT NULL,
  `ethType` smallint(5) unsigned DEFAULT NULL,
  `vlan` varchar(45) DEFAULT NULL,
  `vlanPcp` varchar(45) DEFAULT NULL,
  `hw_src` varchar(17) DEFAULT NULL,
  `hw_dst` varchar(17) DEFAULT NULL,
  `ip4Src` varchar(15) DEFAULT NULL,
  `ip4Dst` varchar(15) DEFAULT NULL,
  `ipProto` tinyint(3) unsigned DEFAULT NULL,
  `tcpSrcPort` smallint(5) unsigned DEFAULT NULL,
  `tcpDstPort` smallint(5) unsigned DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

```
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Table structure for table `qvm`
--

DROP TABLE IF EXISTS `qvm`;
/*!40101 SET @saved_cs_client     = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `qvm` (
  `qvmUID` varchar(100) NOT NULL,
  `qvmName` varchar(255) DEFAULT NULL,
  `qvmIP` varchar(20) DEFAULT NULL,
  `qvmStartTime` datetime DEFAULT NULL,
  `numberOfAttackers` int(11) DEFAULT NULL,
  `currentlyActive` tinyint(4) DEFAULT NULL,
  PRIMARY KEY (`qvmUID`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Dumping data for table `qvm`
--

LOCK TABLES `qvm` WRITE;
/*!40000 ALTER TABLE `qvm` DISABLE KEYS */;
INSERT INTO `qvm` VALUES ('1','abc.com','192.168.1.1','2017-04-24
00:00:00',2,1),('2','xyz.com','192.168.1.2','2017-05-25
00:00:00',1,1),('3','cde.com','192.168.1.3','2017-04-26 00:00:00',1,0);
/*!40000 ALTER TABLE `qvm` ENABLE KEYS */;
UNLOCK TABLES;

--
-- Table structure for table `servers`
--

DROP TABLE IF EXISTS `servers`;
/*!40101 SET @saved_cs_client     = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `servers` (
  `serverUID` varchar(100) NOT NULL,
  `serverName` varchar(255) NOT NULL,
  `serverIP` varchar(20) NOT NULL,
  `serverCreatedOn` datetime DEFAULT NULL,
  `reputationValue` double DEFAULT NULL,
  `bidValue` double DEFAULT NULL,
  PRIMARY KEY (`serverUID`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Dumping data for table `servers`
--

LOCK TABLES `servers` WRITE;
/*!40000 ALTER TABLE `servers` DISABLE KEYS */;
INSERT INTO `servers` VALUES ('1','abc.com','192.168.1.1','2017-01-01
00:00:00',0.1,0.11),('2','xyz.com','192.168.1.2','2017-04-02
00:00:00',0.5,0.99),('3','cde.com','192.168.1.3','2017-04-03 00:00:00',0.9,0.57);
/*!40000 ALTER TABLE `servers` ENABLE KEYS */;
UNLOCK TABLES;

--
-- Table structure for table `usermigration`
--

DROP TABLE IF EXISTS `usermigration`;
/*!40101 SET @saved_cs_client     = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `usermigration` (
  `userMigrationUID` varchar(100) NOT NULL,
  `userIP` varchar(20) DEFAULT NULL,
  `originalServerIP` varchar(20) DEFAULT NULL,
  `migratedServerIP` varchar(20) DEFAULT NULL,
  `migrationStartTime` datetime DEFAULT NULL,
  `migrationStopTime` datetime DEFAULT NULL,
  PRIMARY KEY (`userMigrationUID`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Dumping data for table `usermigration`
--
```

```
LOCK TABLES `usermigration` WRITE;
/*!40000 ALTER TABLE `usermigration` DISABLE KEYS */;
INSERT INTO `usermigration` VALUES
('1','192.123.24.12','123.431.42.35','123.432.35.56','2017-04-29 10:25:00','2017-04-29
10:25:05'),('2','192.123.24.12','123.431.42.35','123.432.35.56','2017-03-29
10:25:00','2017-03-29
10:25:05'),('3','192.123.24.12','123.431.42.35','123.432.35.56','2017-03-29
10:25:00','2017-03-29 10:25:05');
/*!40000 ALTER TABLE `usermigration` ENABLE KEYS */;
UNLOCK TABLES;

--
-- Table structure for table `users`
--

DROP TABLE IF EXISTS `users`;
/*!40101 SET @saved_cs_client       = @@character_set_client */;
/*!40101 SET character_set_client = utf8 */;
CREATE TABLE `users` (
  `userUID` varchar(100) NOT NULL,
  `username` varchar(100) DEFAULT NULL,
  `ipAddress` varchar(20) DEFAULT NULL,
  `connectionStartTime` datetime DEFAULT NULL,
  `connectionStopTime` datetime DEFAULT NULL,
  PRIMARY KEY (`userUID`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
/*!40101 SET character_set_client = @saved_cs_client */;

--
-- Dumping data for table `users`
--

LOCK TABLES `users` WRITE;
/*!40000 ALTER TABLE `users` DISABLE KEYS */;
INSERT INTO `users` VALUES ('1','abc.com','192.168.1.1','2017-01-01 00:00:00','2017-01-01
00:00:00'),('2','xyz.com','192.168.1.2','2017-03-01 00:00:00','2017-01-01
00:00:00'),('3','cde.com','192.168.1.3','2017-03-01 00:00:00','2017-01-01 00:00:00');
/*!40000 ALTER TABLE `users` ENABLE KEYS */;
UNLOCK TABLES;
/*!40103 SET TIME_ZONE=@OLD_TIME_ZONE */;

/*!40101 SET SQL_MODE=@OLD_SQL_MODE */;
```

```
/*!40014 SET FOREIGN_KEY_CHECKS=@OLD_FOREIGN_KEY_CHECKS */;
/*!40014 SET UNIQUE_CHECKS=@OLD_UNIQUE_CHECKS */;
/*!40101 SET CHARACTER_SET_CLIENT=@OLD_CHARACTER_SET_CLIENT */;
/*!40101 SET CHARACTER_SET_RESULTS=@OLD_CHARACTER_SET_RESULTS */;
/*!40101 SET COLLATION_CONNECTION=@OLD_COLLATION_CONNECTION */;
/*!40111 SET SQL_NOTES=@OLD_SQL_NOTES */;

-- Dump completed on 2017-05-04 18:48:06
```

network_information_base.py

```
class NetworkInformationBase(object):

  # ports on switch
  ports = []

  def __init__(self, logger):
          self.logger = logger

  def set_dpid(self, dpid):
          self.dpid = dpid

  def get_dpid(self):
          return self.dpid

  def switch_not_yet_connected(self):
          return self.ports == []

  def set_ports(self, list_p):
          self.ports = list_p

  def add_port(self, port_id):
          if port_id not in ports:
          self.ports.append(port_id)

  def delete_port(self, port_id):
          if port_id in ports:
          self.ports.remove(port_id)

  def all_ports(self):
    return self.ports
```

stats-switch-root.py

```
import sys, logging
import frenetic
import pymysql
from frenetic.syntax import *
from network_information_base import *
from tornado.ioloop import PeriodicCallback, IOLoop
from functools import partial

hostname = 'localhost'
username = 'mtd7000'
password = 'mtd'
database = 'mtd'
myConnection = pymysql.connect( host=hostname, user=username, passwd=password, db=database )

def doUpdate( conn, switch, data ) :
    cur = conn.cursor()
    insert = (switch, data['port_no'], data['rx_packets'], data['tx_packets'], data['rx_bytes'], data['tx_bytes'], data['rx_dropped'], data['tx_dropped'], data['rx_errors'], data['tx_errors'], data['rx_fram_err'], data['rx_over_err'], data['rx_crc_err'], data['collisions'], data['rx_packets'], switch, data['port_no'], data['tx_packets'], switch, data['port_no'], data['rx_bytes'], switch, data['port_no'], data['tx_bytes'], switch, data['port_no'])
    cur.execute("INSERT INTO mtd.logs "
        "(switch_id, port_id, timestamp, rx_packets, tx_packets, rx_bytes, tx_bytes, rx_dropped, tx_dropped, rx_errors, tx_errors, rx_fram_err, rx_over_err, rx_crc_err, collisions, delta_rx_packets, delta_tx_packets, delta_rx_bytes, delta_tx_bytes) "
        "VALUES(%s, %s, NOW(), %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, "
        "%s-(select rx_packets from mtd.logs a2 where a2.switch_id = %s and a2.port_id = %s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
        "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and a22.timestamp < NOW())),"
        "%s-(select tx_packets from mtd.logs a2 where a2.switch_id = %s and a2.port_id = %s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
        "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and a22.timestamp < NOW())),"
```

```
                "%s-(select rx_bytes from mtd.logs a2 where a2.switch_id = %s and a2.port_id =
%s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
                "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and
a22.timestamp < NOW())),"
                "%s-(select tx_bytes from mtd.logs a2 where a2.switch_id = %s and a2.port_id =
%s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
                "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and
a22.timestamp < NOW()))"
                ");", insert)
        cur.close()
        conn.commit()

class StatsApp1(frenetic.App):

  client_id = "stats"

  def __init__(self):
        frenetic.App.__init__(self)
        self.nib = NetworkInformationBase(logging)

  def connected(self):
        def handle_current_switches(switches):
        logging.info("Connected to Frenetic - Stats for switch: " + str(switches.keys()[1]))
        dpid = switches.keys()[1]
        self.nib.set_dpid(dpid)
        self.nib.set_ports( switches[dpid] )
        PeriodicCallback(self.count_ports, 1000).start()
        self.current_switches(callback=handle_current_switches)

  def print_count(self, future, switch):
        data = future.result()
        doUpdate(myConnection, switch, data)
#       myConnection.close()

  def count_ports(self):
        switch_id = self.nib.get_dpid()
#       print self.nib.all_ports()
        for port in self.nib.all_ports():
        ftr = self.port_stats(switch_id, str(port))
        f = partial(self.print_count, switch = switch_id)
        IOLoop.instance().add_future(ftr, f)
```

```
if __name__ == '__main__':
#  logging.basicConfig(\
#         stream = sys.stderr, \
#         format='%(asctime)s [%(levelname)s] %(message)s', level=logging.INFO \
#  )
  app = StatsApp1()
  app.start_event_loop()
```

stats-switch-slave.py

```
import sys, logging
import frenetic
import pymysql
from frenetic.syntax import *
from network_information_base import *
from tornado.ioloop import PeriodicCallback, IOLoop
from functools import partial

hostname = 'localhost'
username = 'mtd7000'
password = 'mtd'
database = 'mtd'
myConnection = pymysql.connect( host=hostname, user=username, passwd=password,
db=database )

def doUpdate( conn, switch, data ) :
        cur = conn.cursor()
        insert = (switch, data['port_no'], data['rx_packets'], data['tx_packets'], data['rx_bytes'],
data['tx_bytes'], data['rx_dropped'], data['tx_dropped'], data['rx_errors'], data['tx_errors'],
data['rx_fram_err'], data['rx_over_err'], data['rx_crc_err'], data['collisions'], data['rx_packets'],
switch, data['port_no'], data['tx_packets'], switch, data['port_no'], data['rx_bytes'], switch,
data['port_no'], data['tx_bytes'], switch, data['port_no'])
        cur.execute("INSERT INTO mtd.logs "
                "(switch_id, port_id, timestamp, rx_packets, tx_packets, rx_bytes, tx_bytes,
rx_dropped, tx_dropped, rx_errors, tx_errors, rx_fram_err, rx_over_err, rx_crc_err, collisions,
delta_rx_packets, delta_tx_packets, delta_rx_bytes, delta_tx_bytes) "
                "VALUES(%s, %s, NOW(), %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, "
                "%s-(select rx_packets from mtd.logs a2 where a2.switch_id = %s and a2.port_id
= %s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
                "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and
a22.timestamp < NOW())),"
                "%s-(select tx_packets from mtd.logs a2 where a2.switch_id = %s and a2.port_id
= %s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
                "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and
a22.timestamp < NOW())),"
                "%s-(select rx_bytes from mtd.logs a2 where a2.switch_id = %s and a2.port_id =
%s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
                "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and
a22.timestamp < NOW())),"
                "%s-(select tx_bytes from mtd.logs a2 where a2.switch_id = %s and a2.port_id =
%s and a2.timestamp = (select max(timestamp) from mtd.logs a22 "
                "where a22.switch_id = a2.switch_id and a22.port_id = a2.port_id and
a22.timestamp < NOW()))"
                ");", insert)
        cur.close()
        conn.commit()
        oldData = data

class StatsApp1(frenetic.App):

  client_id = "stats"

  def __init__(self):
        frenetic.App.__init__(self)
        self.nib = NetworkInformationBase(logging)

  def connected(self):
        def handle_current_switches(switches):
        logging.info("Connected to Frenetic - Stats for switch: " + str(switches.keys()[0]))
        dpid = switches.keys()[0]
        self.nib.set_dpid(dpid)
        self.nib.set_ports( switches[dpid] )
        PeriodicCallback(self.count_ports, 5000).start()
        self.current_switches(callback=handle_current_switches)

  def print_count(self, future, switch):
        data = future.result()
#       myConnection = pymysql.connect( host=hostname, user=username, passwd=password,
db=database )
        doUpdate(myConnection, switch, data)
#       myConnection.close()
```

```
  def count_ports(self):
          switch_id = self.nib.get_dpid()
#         print self.nib.all_ports()
          for port in self.nib.all_ports():
          ftr = self.port_stats(switch_id, str(port))
          f = partial(self.print_count, switch = switch_id)
          IOLoop.instance().add_future(ftr, f)

if __name__ == '__main__':
#  logging.basicConfig(\
#         stream = sys.stderr, \
#         format='%(asctime)s [%(levelname)s] %(message)s', level=logging.INFO \
#  )
  app = StatsApp1()
  app.start_event_loop()
```