ARIZONA STATE UNIVERSITY

CSE 434, SLN 70569 — **Computer Networks** — Fall 2021

Lab #4

Due: Tuesday, 11/30/2021

The objective of this lab is to showcase some simple SDN OpenFlow capabilities. This lab has two parts: The first is an introduction to OpenFlow on GENI and uses a OpenFlow Software Switch, Open vSwitch (OVS). The second (optional, for a bonus) part uses a hardware OpenFlow switch in BYENG 217.

1 An Introduction to OpenFlow on GENI

IMPORTANT: Instructions for Step 1, and Step 2 onwards, are from different links. Please follow instructions carefully! We want to use the POX framework not Floodlight.

This introduction to OpenFlow (OVS) tutorial guides you through some simple OpenFlow controllers. After configuring the switch, and seeing the operation of a learning switch, you will experiment with three different POX (`python` based) controllers:

1. A *traffic duplicator controller* duplicates all the traffic of the OpenFlow switch out a specific port.
2. A *TCP port forwarding controller* diverts all traffic destined to host A on TCP port X, to the same host A on TCP port Y.
3. A *proxy controller* diverts all traffic destined to host A on TCP port X, to host B on TCP port Y.

In this tutorial we use an OpenFlow Software Switch, Open vSwitch (OVS). Figure 1 shows the topology. In general, the controller needs to have a public IP address, so that it can exchange messages with the OpenFlow switch. The controller for the switch can run anywhere in the Internet. In this tutorial we are going to use a POX controller, which is just one example of many controller frameworks.

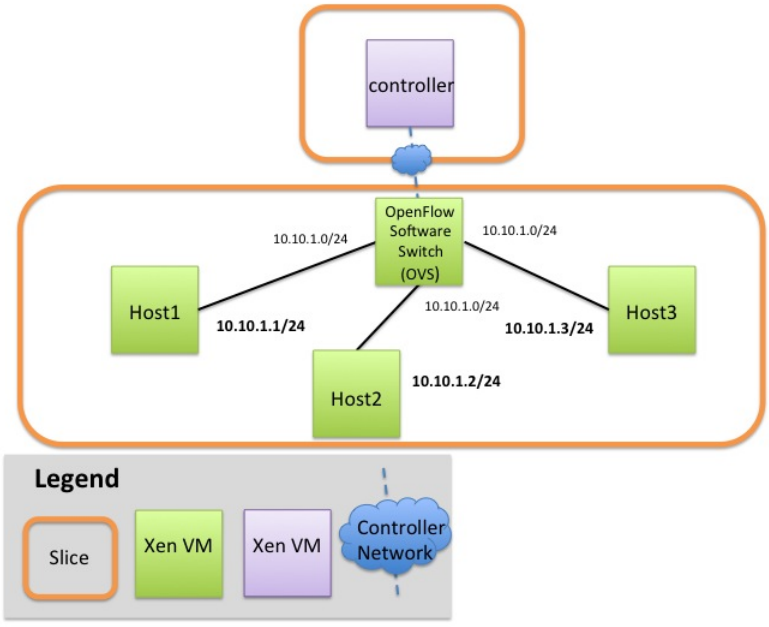

Figure 1: The GENI topology used.

1.1 Experiment Set-up

As Figure 1 shows, we use OVS connected to three hosts. OVS is a software switch running on a compute resource. The other three hosts can only communicate through the OVS switch. The experiment needs:

- One Xen VM with a public IP to run an OpenFlow controller.
- One Xen VM to be the OpenFlow switch.
- Three Xen VMs as hosts.

IMPORTANT: Instructions for Step 1, and Step 2 and onwards, are from different links. Follow instructions carefully!

To complete the tutorial successfully, follow the instructions in Step 1 to obtain the needed resources. Note that the IP addresses assigned may be different from those in Figure 1. If so, you will need to adapt the instructions that follow accordingly.

Once the resources have been obtained, continue with instructions starting at Step 2 to configure the Open vSwitch.

Exercise 1.1: For your lab report: In Step 2a (Configure the Software Switch (OVS Window)) part v, take a screen shot for your report that shows that your software switch is configured. Explain by referencing your screen shot.

Exercise 1.2: In Step 2b (Point your switch to a controller) part v, take a screen shot for your lab report that shows that your switch is pointed at a controller. Explain by referencing your screen shot.

Follow this by Step 3, logging in to your hosts and using the learning switch controller.

Exercise 1.3: For your lab report:

1. In Step 3b (Use a Learning Switch Controller) step 3, take a screen shot that illustrates the operation of the learning switch controller, *i.e.*, shows that the `ping` between `host1` and `host2` works.
2. In Step 3b step 4, take a screen shot of the flows installed on the switch by the controller.

For both screen shots, provide a brief explanation of what you observe in your screen shot.

In Step 3f, a traffic duplication controller is run.

Exercise 1.4: In Step 3f (Run a Traffic Duplication Controller), take a screen shot for your lab report that illustrates the operation of the traffic duplication controller, *i.e.*, the `tcpdump` in step 4 that shows duplication is happening. Provide a brief explanation of what is observed in your screen shot.

In Step 3g, a port forwarding controller is run.

Exercise 1.5: In Step 3g (Run a Port Forward Controller), take screen shots for your lab report that illustrate the operation of the port forwarding controller, *i.e.*, in step 5 showing the functionality before the port forwarding controller is inserted, and in step 8, afterwards. Provide a brief explanation of what is observed in the screen shots.

Finally, in Step 3h, a server proxy controller is run.

Exercise 1.6: In Step 3h (Run a Server Proxy Controller), take screen shots for your lab report that illustrate the operation of the proxy controller, *i.e.*, in step 2 before the traffic is diverted, and in step 6, showing the diverted traffic. Provide a brief explanation of what is observed in the screen shots.

Before tearing down your experiment, delete your bridge (see Step 3h).

2 Bonus: Introduction to OpenFlow on a Hardware SDN Switch

In this part of the lab, you will use either the **HP PoE** or the **HP Procurve** OpenFlow switch, depending upon the rack in BYENG 217 that you have reserved, instead of an OVS (software) switch.

Connect Ethernet cables between the `p2p1` interfaces of the computers and the HP OpenFlow switch. Connect Computer A to port 1, Computer B to port 2, Computer C to port 3, and Computer D to port 4. Use this specific mapping because of the switch configuration described later.

The HP OpenFlow switch is configured through serial communication using `minicom` from one of the computers. Connect the serial cable (with female DB9 connectors at both the ends) from the console port of the OpenFlow switch to the serial port (male DB9 connector) of Computer A. See Figure 2.

Warning: Do not connect a serial cable (the flat blue cables) to an Ethernet port or an Ethernet cable to a serial port (labelled "console" on the switch and routers). This could damage the devices at either or both endpoints because RS-232 uses a different voltage level from Ethernet.

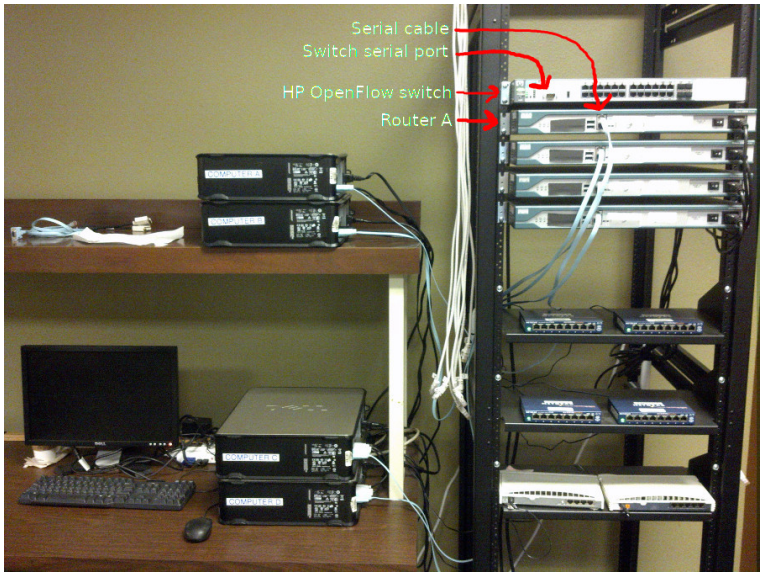

Figure 2: Lab equipment with OpenFlow switch labelled.

2.1 Configuring the Hosts

We will use the same configuration for the hosts as in §1 of this lab. However, we will configure 10.10.0.1 for `p2p1` of Computer A to serve as the controller and 10.10.0.2 for port 1 of the HP OpenFlow switch (which will be connected to Computer A, and use a POX controller).

Assign IP addresses and netmasks to the `p2p1` interfaces on the computers as given in Table 1. Computer A will run the controller, while Computers B through D will correspond to host1 through host3 according to the GENI tutorial labelling (see Figure 1).

Table 1: IP addresses.

Linux PC	IP Address of `p2p1` interface
Computer A	`10.10.0.1/24`
Computer B	`10.10.1.11/24`
Computer C	`10.10.1.12/24`
Computer D	`10.10.1.13/24`

2.2 Configuring the Hardware SDN Switch

Configuring the switch requires using a serial connection. In Linux, the program `minicom` can be used to make a serial connection. Start `minicom` and follow the steps listed:

```
minicom -s
go down to Serial port setup  <enter>
select A to change serial device setting
change /dev/modem    to    /dev/ttyS1
<enter>
<enter>
then select  exit   <enter>
press   <ctrl>a   p    then type   C <enter>  to select 9600  8N1
<enter>   again to start the dialog with the HP ProCurve/PoE
```

When you have started a dialog with the HP ProCurve/PoE, if you get a response from the switch asking you to press enter to continue, do so. You should now have a prompt.

At the prompt, type `delete config` and answer "Y" when it asks if you want to erase the configuration and reboot. Wait for the switch to reboot.

At the prompt, type `configure` to configure the switch, then enter the following commands. You do not need to indent the commands; this just indicates that the prompt changes.

```
hostname "HP-3500yl-24G"
openflow
   controller-id 1 ip 10.10.0.1 controller-interface vlan 2
   instance "pox"
      listen-port
      member vlan 3
      controller-id 1
      enable
      exit
   enable
   exit
vlan 2
   name "controller"
   untagged 1
   ip address 10.10.0.2 255.255.255.0
   exit
vlan 3
   name "openflow"
   untagged 2-24
   no ip address
   exit
exit
```

Once you have configured the switch, exit `minicom` by pressing `<ctrl>a x`, then selecting Yes.

2.3 Running a Controller

You may need to install POX and the POX apps under the `root` (/) folder of Computer A. Here is a POX repo on github, and instructions for installing POX.

For this part of lab, select at one of the four controllers from the GENI part of the lab to get working with the hardware switch. After configuring the HP OpenFlow switch as described in §2.2, follow the instructions

from Step 3, Execute Experiment, in the GENI tutorial to run one of the controller applications. However, there are a few differences from the steps GENI documentation:

- Instead of `ssh` to the controller, just switch the KVM to Computer A. Similarly, when asked to run a command on another host, switch the KVM to the corresponding computer. Remember that the lab machines name their Ethernet interface `p2p1` instead of `eth0`.
- You do not need to type `sudo` before any commands, because the lab machines are already running as root.
- If you run the **traffic duplication controller**, run `tcpdump` on Computers C and D using `tcpdump -i p2p1`.

2.4 Lab Report

Exercise 2.1 (optional/bonus): For the lab report, capture the operation of the controller you have selected working with the hardware switch. Compare the output of the hardware switch with that of the software switch.

2.5 Teardown

Unplug the Ethernet cables you used and hang them over the rack. Also please log out from all of the computers.