**1. What is OpenFlow and SDN?**

Before you start:

The Infrastructure layer includes the routers and switches inside the network core.

The Control layer includes the PC that runs an OpenFlow controller along with the controller itself.

The Application layer includes the applications that run on top of that controller. In Ryu, these applications are written in Python.

OpenFlow is a protocol using which the Infrastructure and the Control layer interact. OpenFlow does not provide an API of itself. It is an open source protocol that is used by vendors who develop OpenFlow capable switches and by developers who write the controllers, like Ryu. The API is provided by the controller.

So why is there a need for SDN? Many factors contribute to this actually, such as the fast-growing complexity of networks, unreachable scalability, manufacturers dependency, more traffic required, big data, bandwidth and great cloud computing services.

Before SDN, the traditional planes were as follows:

A screenshot of a cell phone

Description automatically generated

For every data plane, there was a dependency with a specific control plane which then later transitioned to the next data plane that did the exact same thing with the control plane except that this was another control plane, and so on.

With SDN, there is only 1 control plane that manages every data plane, saving unnecessary traffic and speeding up the process.A close up of text on a white background

Description automatically generated

Now for the actual architecture, we have a control layer that allows us to manipulate the network via APIs such as OpenFlow.

A picture containing text

Description automatically generated

So, what is OpenFlow? OpenFlow is an open standard protocol to manage SDN networks, it is not the same as a SDN, OpenFlow is but a protocol that many people use since it has been standardized.

**2. Setting up the Ryu OpenFlow controller on Ubuntu 16.01**

**Prerequisites**

You need internet access. If you are running Ubuntu inside a Virtual Machine, issue the following command to automatically configure your Ethernet interface via NAT:

su

dhclient eth0

**Enable sudo**

Ubuntu does not come with sudo by default. Some Ryu applications you'll use later on require sudo. You can install sudo and add yourself to the sudo'ers list as follows:

su

apt-get install sudo # you might need to do apt-get update first!

nano /etc/sudoers

Find the line that says %sudo ALL=(ALL:ALL) ALL and add an entry immediately below it:

yourusername ALL=(ALL:ALL) ALL

Press CTRL+X and then press Y to save the changes to the sudoers file. Now you can logout as root to return to your own shell

exit

**Install Git**

sudo apt-get install git

**Install Mininet**

Mininet allows you to virtually emulate various network interfaces on your laptop/PC. Install it using Git:

cd ~ # if you are in some other directory

git clone git://github.com/mininet/mininet

cd mininet

git tag # this will list available versions

git checkout -b 2.2.1 2.2.1 # replace 2.2.1 with the version you wish to install

cd ..

mininet/util/install.sh -a # default installation, includes all components, recommended

I recommend you install the OpenFlow Wireshark Dissector. You can later install Wireshark to analyze packets. The OpenFlow Wireshark Dissector helps Wireshark fetch as much information from OpenFlow packets as possible.

mininet/util/install.sh -h

Run the following command to check your mininet installation:

sudo mn --test pingall

**Install Ryu OpenFlow Controller**

An OpenFlow Controller communicates between the Control Layer and the Infrastructure layer using the OpenFlow protocol. Also, it's the controller that provides an API to develop SDN applications that run in the Application Layer (on top of the Control Layer). There are numerous OpenFlow controllers. Ryu OpenFlow controller is one that uses Python scripts as its applications. Again, install it using Git:

cd ~

git clone git://github.com/osrg/ryu.git

**Install the supporting Python modules**

Ubuntu 16.01 does come with both Python 2.7 and 3.4 installed by default. However, you need to install some Python modules that the Ryu applications (Python scripts) use. You can install Python modules using pip:

cd ~/ryu

sudo apt-get install python-dev python-pip python-setuptools

sudo pip install .

the above will automatically run setup.py located in this directory and fetch the missing Python modules from the Python Package Index. The script will automatically install all relevant modules. However, do run the following to make sure you aren't missing any module later:

sudo pip install webob

sudo pip install eventlet

sudo pip install paramiko

sudo pip install routes

**Starting up**

Start mininet to emulate 3 hosts and a switch using the following command:

sudo mn --topo single,3 --mac --switch ovsk --controller remote

You will see a mininet prompt. This prompt can be used to ping hosts, send packets between them, etc.

Open up another terminal window to run Ryu. In this example, we will run an application (simple\_switch\_13.py) that will emulate a simple layer 2 switch that will forward all received packets to all ports except the one received on.

cd ~/ryu

PYTHONPATH=. ./bin/ryu-manager ryu/app/simple\_switch\_13.py

Make sure you are in your home directory when you run this.