



# **RAMNIRANJAN JHUNJHUNWALA COLLEGE GHATKOPAR (W), MUMBAI - 400 086**

**DEPARTMENT OF INFORMATION TECHNOLOGY  
2020 - 2021**

**M.Sc.( I.T.) SEM IV  
Software Defined Networking**

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## CERTIFICATE

This is to certify that **Mr. Rajesh Bholanath Tiwari** with Seat No. **19** has successfully completed the necessary course of experiments in the subject of **Software Defined Networking** during the academic year **2020 – 2021** complying with the requirements of **RAMNIRANJAN JHUNJHUNWALA COLLEGE OF ARTS, SCIENCE AND COMMERCE**, for the course of **M.Sc. (IT)** semester -IV.

Internal Examiner Date:

Head of Department College Seal External Examiner

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## PRACTICAL NO: 01

### **Aim: Wireshark and bash Script**

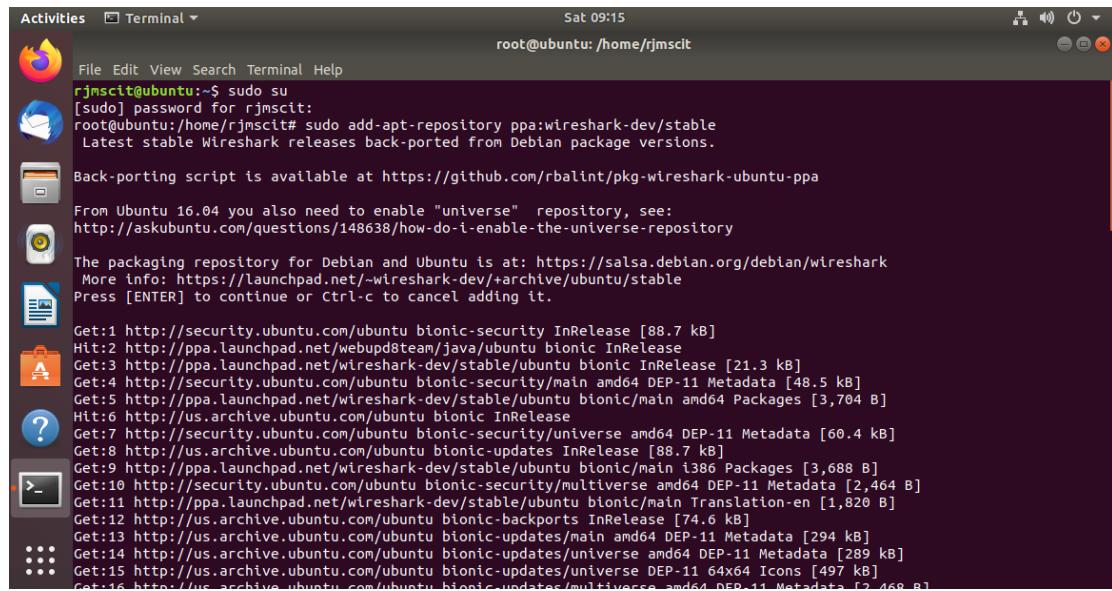
Wireshark is the world's foremost and widely-used network protocol analyzer. It lets you see what's happening on your network at a microscopic level and is the de facto (and often de jure) standard across many commercial and non-profit enterprises, government agencies, and educational institutions. Wireshark development thrives thanks to the volunteer contributions of networking experts around the globe and is the continuation of a project started by Gerald Combs in 1998.

Wireshark has a rich feature set which includes the following:

- Deep inspection of hundreds of protocols, with more being added all the time
- Live capture and offline analysis
- Standard three-pane packet browser
- Multi-platform: Runs on Windows, Linux, macOS, Solaris, FreeBSD, NetBSD, and many others
- Captured network data can be browsed via a GUI, or via the TTY-mode TShark utility
- The most powerful display filters in the industry
- Rich VoIP analysis
- Read/write many different capture file formats: tcpdump (libpcap), Pcap NG, Catapult DCT2000, Cisco Secure IDS iplog, Microsoft Network Monitor, Network General Sniffer® (compressed and uncompressed), Sniffer® Pro, and NetXray®, Network Instruments Observer, NetScreen snoop, Novell LANalyzer, RADCOM WAN/LAN Analyzer, Shomiti/Finisar Surveyor, Tektronix K12xx, Visual Networks Visual UpTime, WildPackets EtherPeek/TokenPeek/AiroPeek, and many others
- Capture files compressed with gzip can be decompressed on the fly
- Live data can be read from Ethernet, IEEE 802.11, PPP/HDLC, ATM, Bluetooth, USB, Token Ring, Frame Relay, FDDI, and others (depending on your platform)
- Decryption support for many protocols, including IPsec, ISAKMP, Kerberos, SNMPv3, SSL/TLS, WEP, and WPA/WPA2
- Coloring rules can be applied to the packet list for quick, intuitive analysis
- Output can be exported to XML, PostScript®, CSV, or plain text

## **Step 1 -> Install Wireshark**

**>> sudo add-apt-repository ppa:wireshark-dev/stable**



```
Activities Terminal Sat 09:15
root@ubuntu:/home/rjmsc1t
File Edit View Search Terminal Help
rjmsc1t@ubuntu:~$ sudo su
[sudo] password for rjmsc1t:
root@ubuntu:/home/rjmsc1t# sudo add-apt-repository ppa:wireshark-dev/stable
Latest stable Wireshark releases back-ported from Debian package versions.

Back-porting script is available at https://github.com/rbalint/pkg-wireshark-ubuntu-ppa

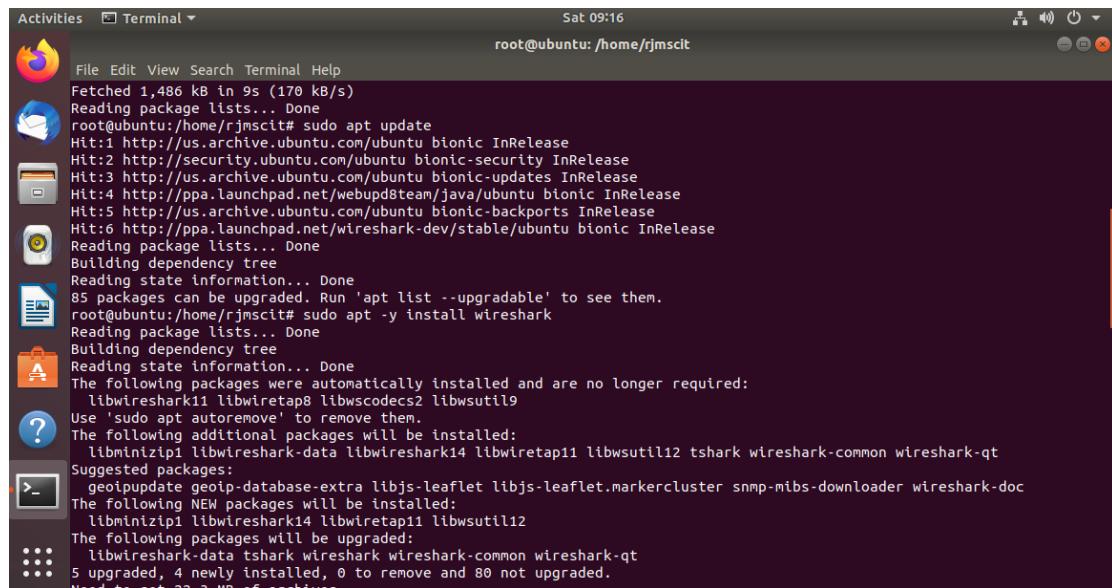
From Ubuntu 16.04 you also need to enable "universe" repository, see:
http://askubuntu.com/questions/148638/how-do-i-enable-the-universe-repository

The packaging repository for Debian and Ubuntu is at: https://salsa.debian.org/debian/wireshark
More info: https://launchpad.net/~wireshark-dev/+archive/ubuntu/stable
Press [ENTER] to continue or Ctrl-c to cancel adding it.

Get:1 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Hit:2 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Get:3 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic InRelease [21.3 kB]
Get:4 http://security.ubuntu.com/ubuntu bionic-security/main amd64 DEP-11 Metadata [48.5 kB]
Get:5 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic/main amd64 Packages [3,704 B]
Hit:6 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Get:7 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 DEP-11 Metadata [60.4 kB]
Get:8 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:9 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic/main i386 Packages [3,688 B]
Get:10 http://security.ubuntu.com/ubuntu bionic-security/multiverse amd64 DEP-11 Metadata [2,404 B]
Get:11 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic/main Translation-en [1,820 B]
Get:12 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:13 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 DEP-11 Metadata [294 kB]
Get:14 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 DEP-11 Metadata [289 kB]
Get:15 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe DEP-11 64x64 Icons [497 kB]
Get:16 http://us.archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 DEP-11 Metadata [2,468 B]
```

**>> sudo apt update**

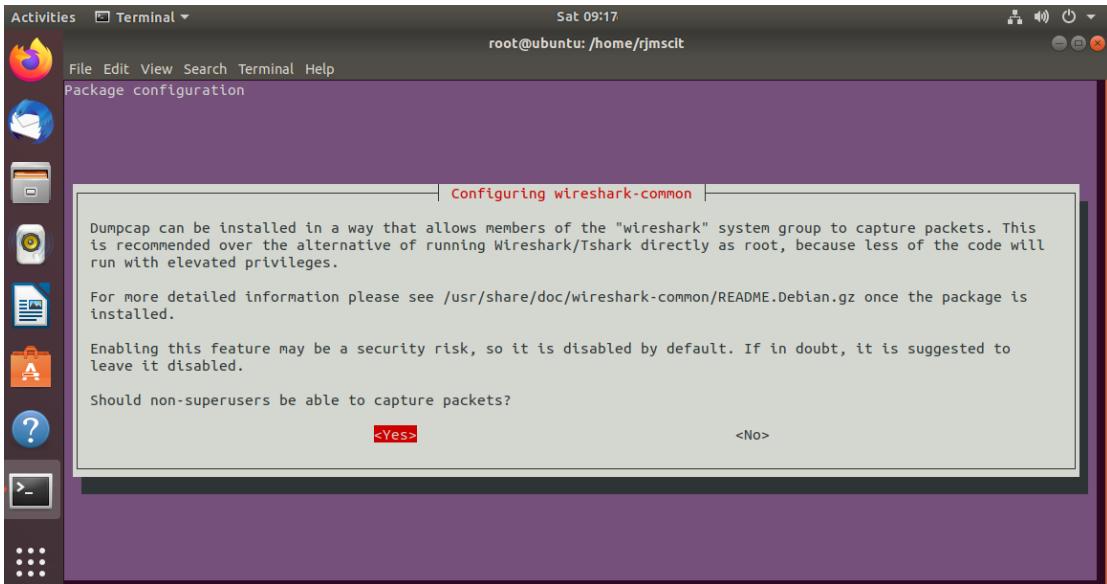
**>> sudo apt -y install wireshark**



```
Activities Terminal Sat 09:16
root@ubuntu:/home/rjmsc1t
File Edit View Search Terminal Help
Fetched 1,486 kB in 9s (170 kB/s)
Reading package lists... Done
root@ubuntu:/home/rjmsc1t# sudo apt update
Hit:1 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Hit:2 http://security.ubuntu.com/ubuntu bionic-security InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:4 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Hit:5 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease
Hit:6 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic InRelease
Reading package lists... Done
Building dependency tree
Reading state information... Done
85 packages can be upgraded. Run 'apt list --upgradable' to see them.
root@ubuntu:/home/rjmsc1t# sudo apt -y install wireshark
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libwireshark11 libwiretap8 libwscodecs2 libwsutil9
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  libminizip1 libwireshark-data libwireshark14 libwiretap11 libwsutil12 tshark wireshark-common wireshark-qt
Suggested packages:
  geoipupdate geoip-database-extra libjs-leaflet libjs-leaflet.markercluster snmp-mibs-downloader wireshark-doc
The following NEW packages will be installed:
  libminizip1 libwireshark14 libwiretap11 libwsutil12
The following packages will be upgraded:
  libwireshark-data tshark wireshark wireshark-common wireshark-qt
5 upgraded, 4 newly installed, 0 to remove and 80 not upgraded.
Need to get 32.2 MB of archives.
```

```
>> sudo dpkg-reconfigure wireshark-common
```

then press yes

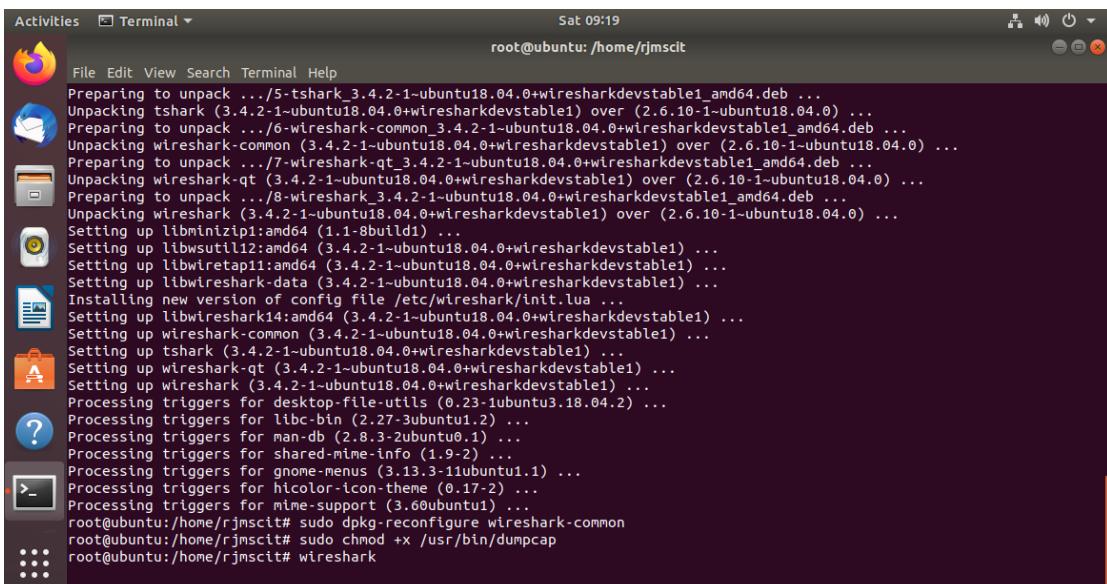


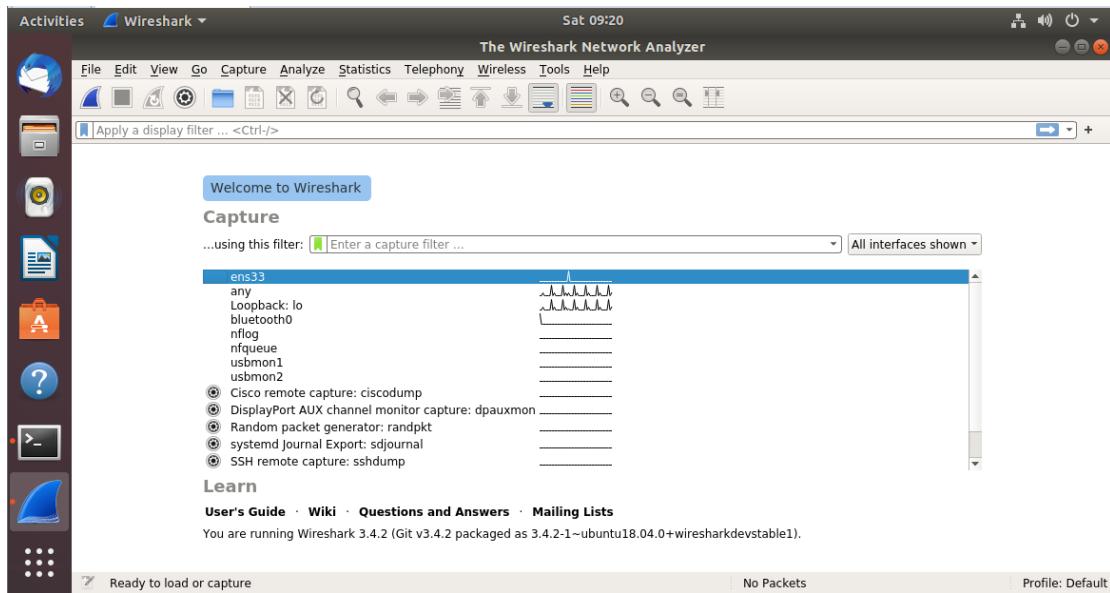
```
>> sudo chmod +x /usr/bin/dumpcap
```

## Step 2 -> Starting Wireshark

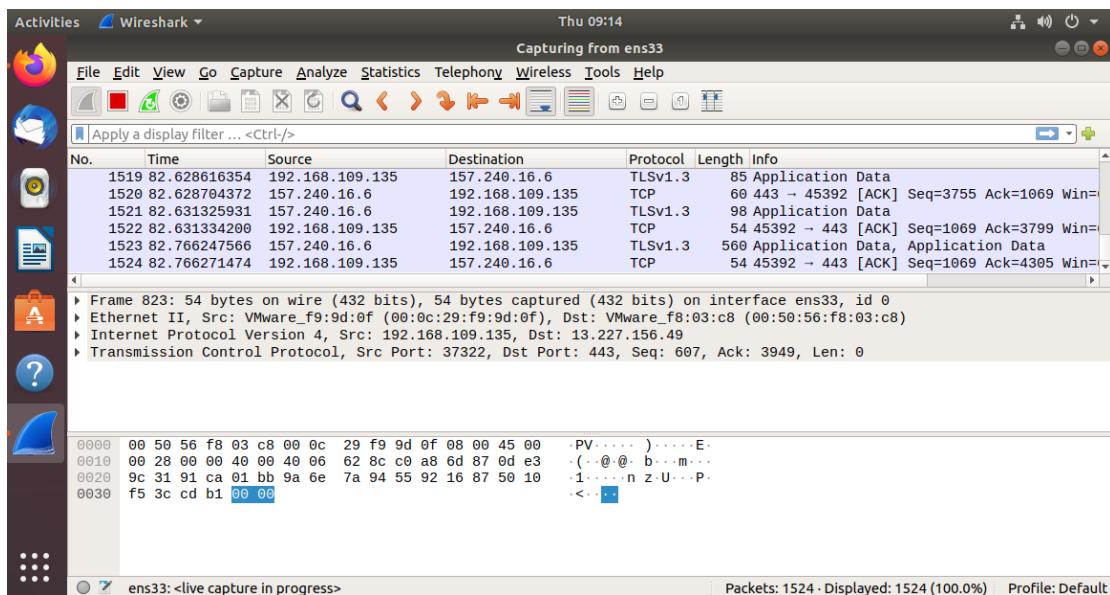
Launching a Wireshark application using CLI

Type wireshark in CLI and press enter

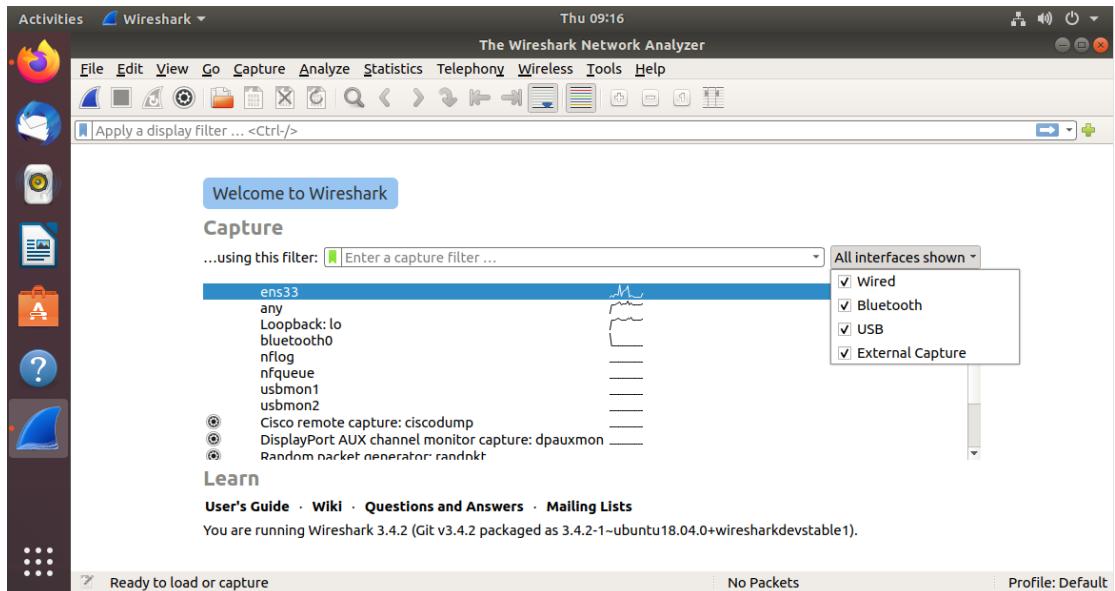




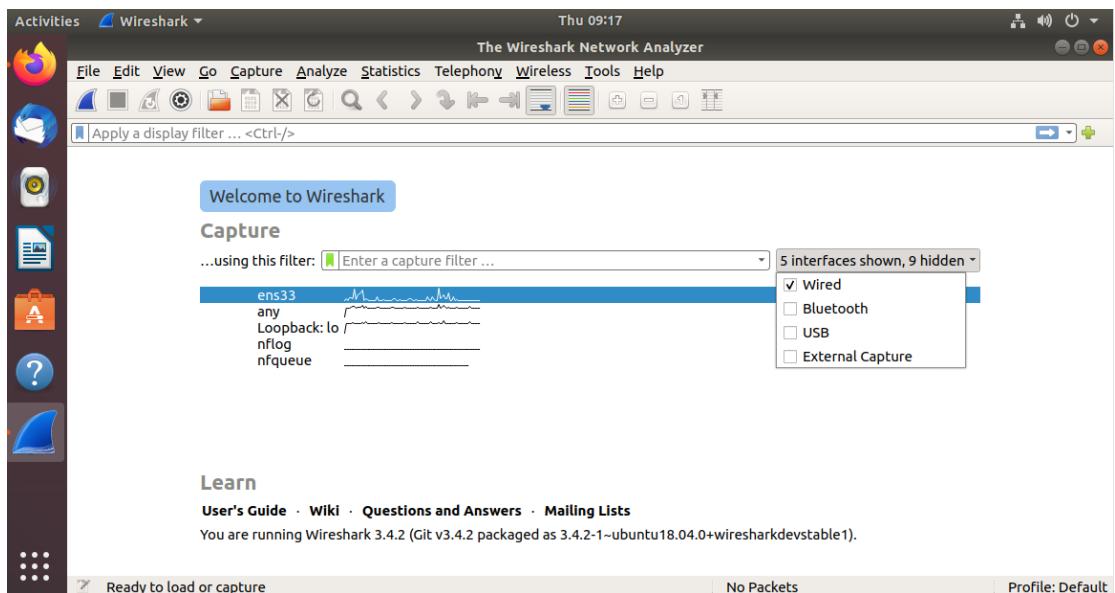
To test packets capturing, select interface to use and click “**Start capturing packets**” button.



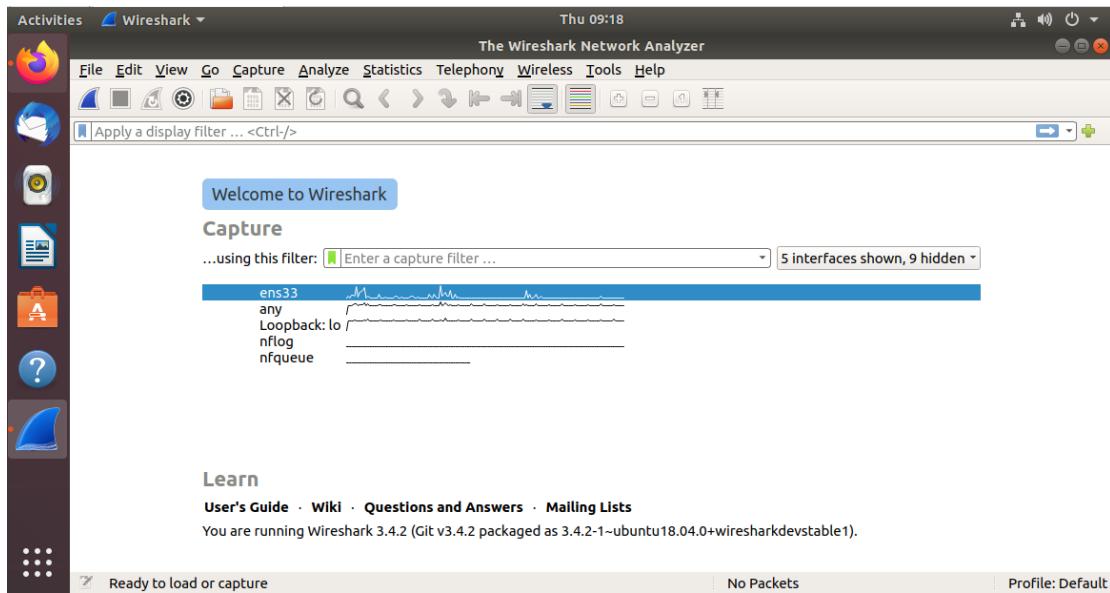
There are many types of interfaces you can monitor using Wireshark, for example, **Wired**, **Wireless**, **USB** and many external devices. You can choose to show specific types of interfaces in the welcome screen from the marked section of the screenshot below.



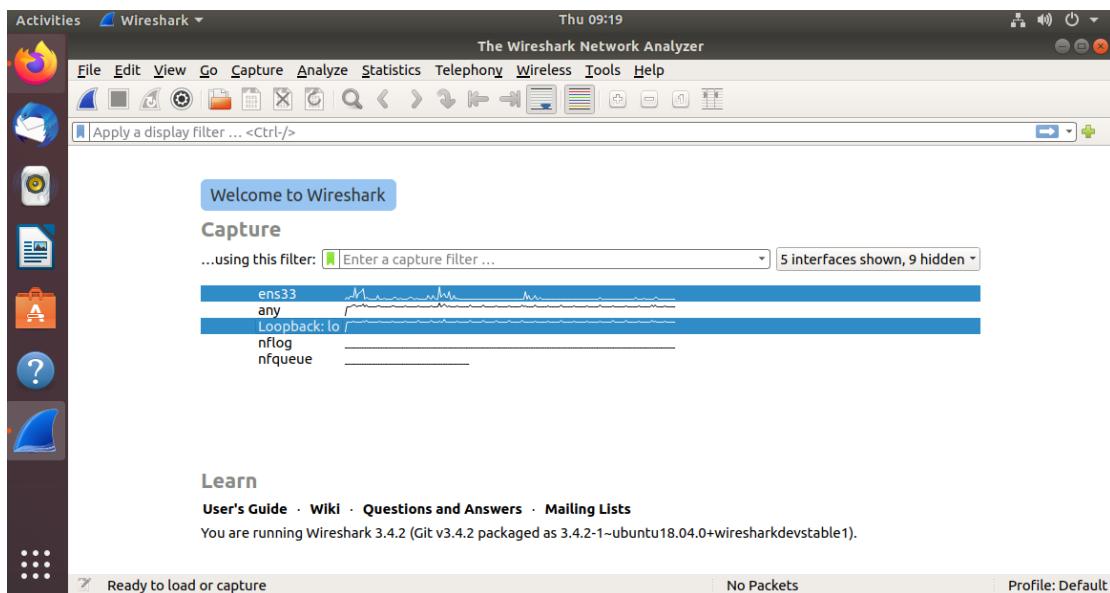
Here, I listed only the **Wired** network interfaces.



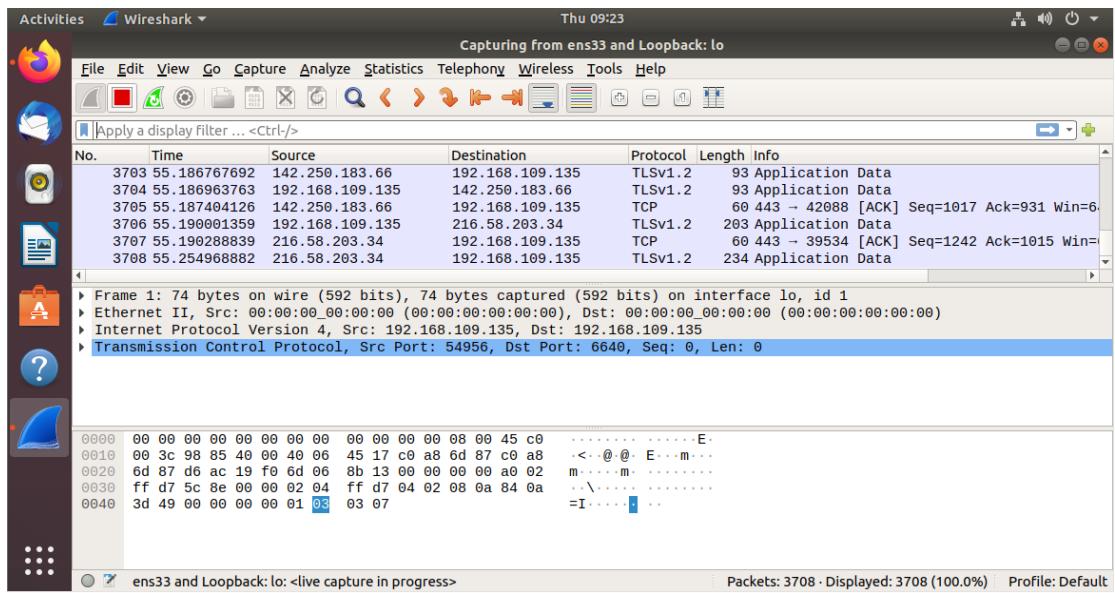
Now to start capturing packets, just select the interface (in my case interface **ens33**) and click on the **Start capturing packets icon** as marked in the screenshot below. You can also double click on the interface that you want to capture packets to and from to start capturing packets on that particular interface.



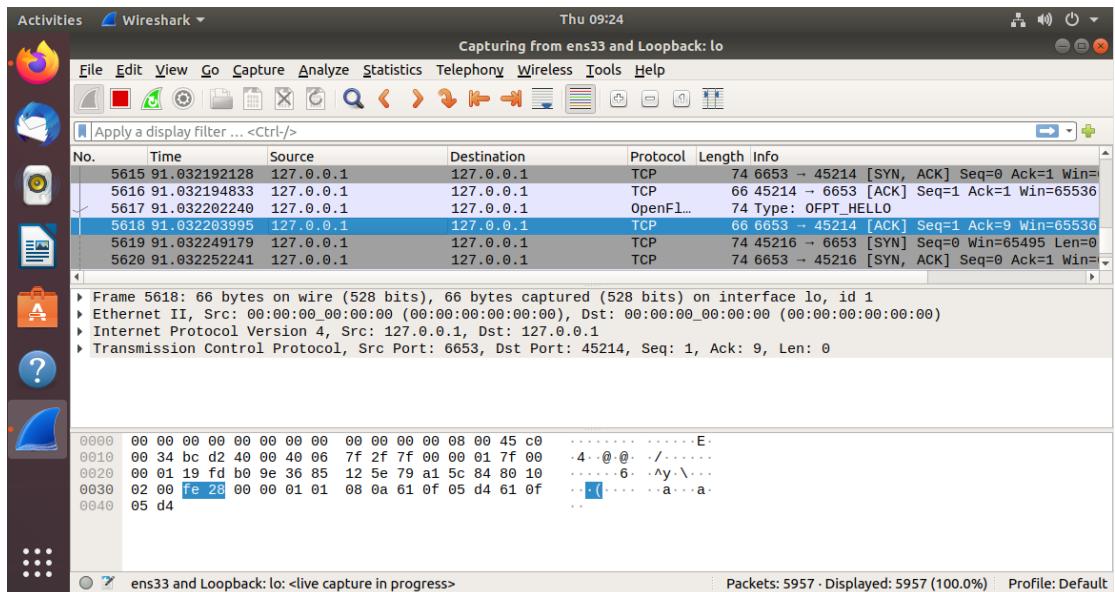
You can also capture packets to and from multiple interfaces at the same time. Just press and hold **<Ctrl>** and click on the interfaces that you want to capture packets to and from and then click on the **Start capturing packets** icon as marked in the screenshot below.



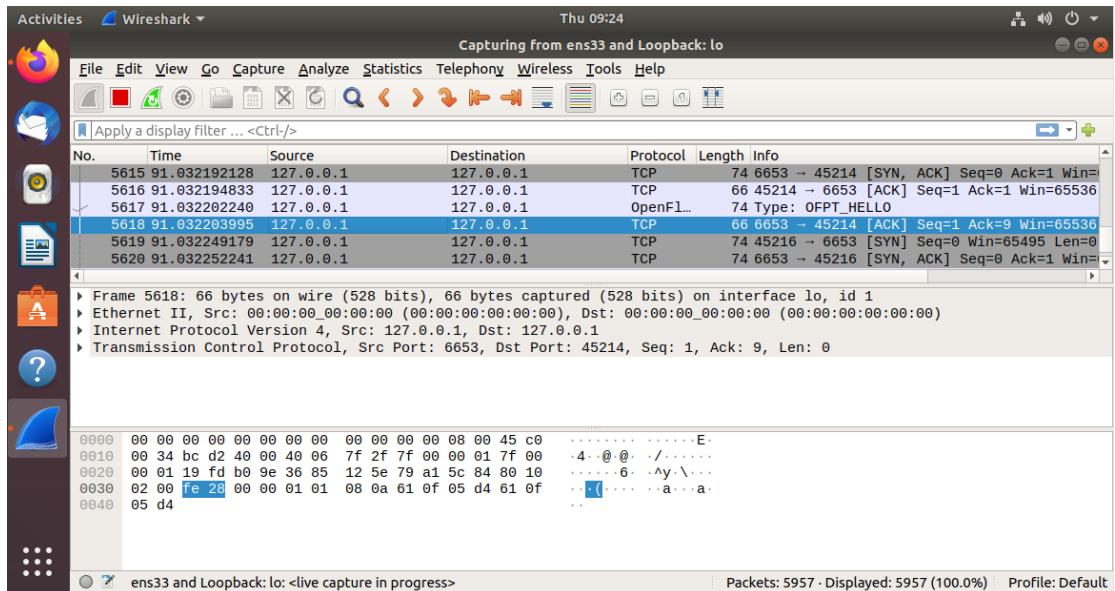
I pinged google.com from the terminal and as you can see, many packets were captured.



Now you can click on a packet to select it. Selecting a packet would show many information about that packet. As you can see, information about different layers of TCP/IP Protocol is listed.

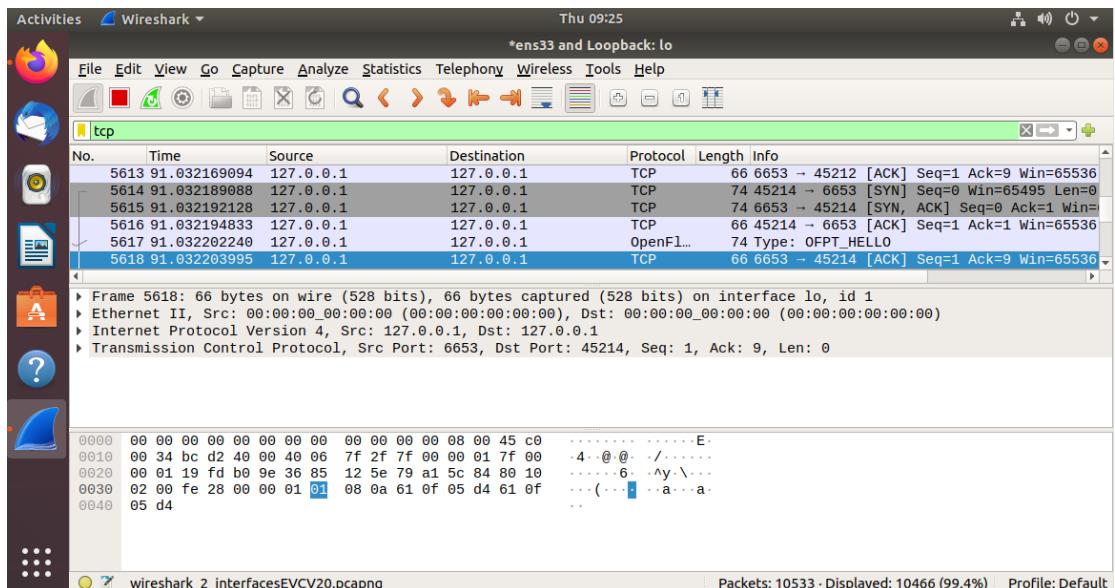


You can also see the RAW data of that particular packet.



### Filtering Packets Using Wireshark:

On a busy network thousands or millions of packets will be captured each second. So the list will be so long that it will be nearly impossible to scroll through the list and search for certain type of packet. The good thing is, in Wireshark, you can filter the packets and see only the packets that you need. To filter packets, you can directly type in the filter expression in the textbox as marked in the screenshot below.



## Bash Scripts

open text editor and save file with .sh; run in terminal

### Bash script to print current date and time and Hostname.

```
#!/bin/bash

var="Hello World"

# Run date and hostname command and store output to shell variables
now="$(date)"

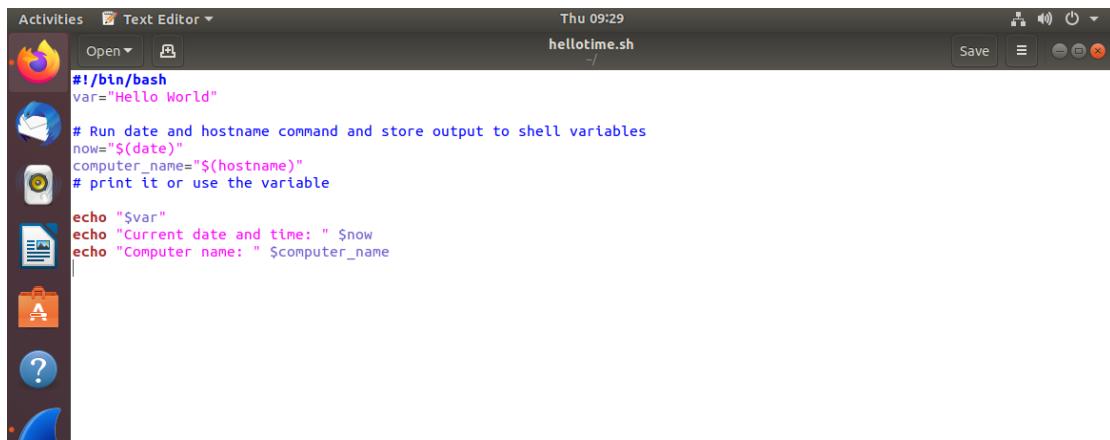
computer_name=""
$(hostname)

# print it or use the variable

echo "$var"

echo "Current date and time: " $now

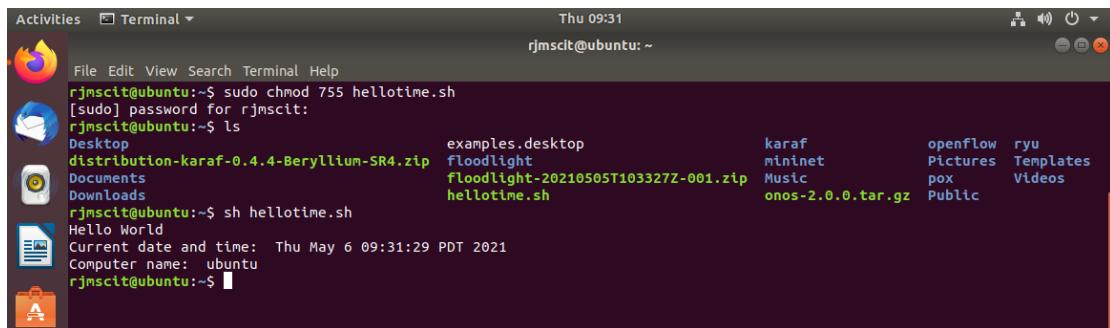
echo "Computer name: " $computer_name
```



After creating the script give execute permission to the file/script.

**>> chmod 755 hellotime.sh**

**>> sh hellotime.sh**



A screenshot of a terminal window on an Ubuntu desktop environment. The window title is "Terminal". The terminal shows the following command sequence:

```
File Edit View Search Terminal Help
rjmscjt@ubuntu:~$ sudo chmod 755 hellotime.sh
[sudo] password for rjmscjt:
rjmscjt@ubuntu:~$ ls
Desktop examples.desktop karaf openFlow ryu
distribution-karaf-0.4.4-Beryllium-SR4.zip floodlight mininet Pictures Templates
Documents helotime.sh Music pox Videos
Downloads onos-2.0.0.tar.gz Public
rjmscjt@ubuntu:~$ sh hellotime.sh
Hello World
Current date and time: Thu May 6 09:31:29 PDT 2021
Computer name: ubuntu
rjmscjt@ubuntu:~$
```

## PRACTICAL NO: 02

### Theory: HP controller, HP Network Protector, HP Network Visualizer, HP Network Optimizer, Cisco XNC Controller

#### Hewlett-Packard

HP is the first to offer SDN technologies for all three critical layers—infrastructure, control software and application—to simplify networks and improve agility across the enterprise. These layers create a complete, open SDN hardware and software solution that provides a single point of control for the entire network.

The **infrastructure layer** delivers open programmable access through OpenFlow, a networking protocol that automates hardware configurations.

- New SDN functionality in the infrastructure layer enables clients to simplify network configuration. HP today announced nine additional switch models providing OpenFlow-enabled support for HP Flex Network architecture, offering clients a flexible and programmable standards-based interface. The addition of the new HP 3800 switch series to the 16 existing models in the product portfolio reaffirms HP as the only major networking vendor with more than 15 million installed OpenFlow-enabled ports. (1)

The control-software layer creates a centralized view of the network.

- Within the control layer, the new HP Virtual Application Networks SDN Controller abstracts the physical hardware from the logical deployment, providing a centralized view and automating network configuration of all devices in the infrastructure. By eliminating thousands of manual CLI entries, the controller enables network administrators to easily and flexibly program and scale their network environment for single-touch automated applications. It also provides application program interfaces (APIs) to third-party developers to integrate custom enterprise applications.

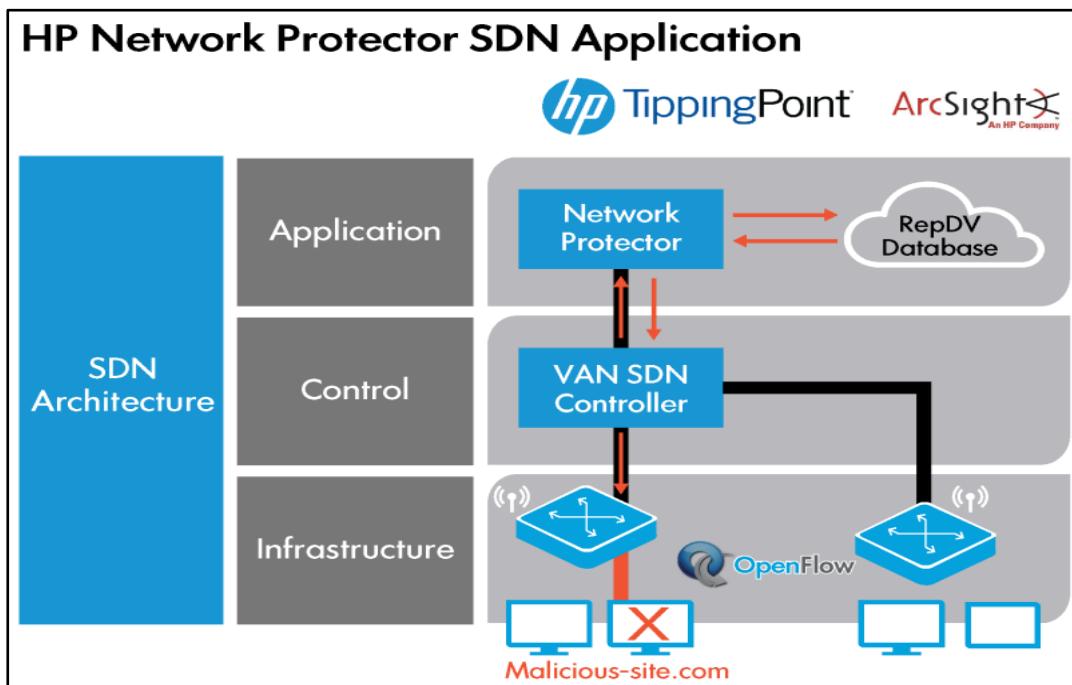
“We recognized the need to scale our perimeter firewall capacity to cope with the increase of internet traffic,” said Jean-Michel Juanito, communication systems group leader, IT Department, CERN. “In the framework of the CERN open lab R&D collaboration, we are developing with HP’s software defined network technologies a load-balancing application for the Virtual Application Networks SDN controller to distribute network traffic across multiple devices including firewalls and servers, increasing simplicity while reducing cost and bandwidth bottlenecks.”

The **application layer** delivers open programmable interfaces to automate applications across the network.

- New HP Virtual Cloud Networks software enables cloud providers to deliver automated and scalable public cloud services to enterprises. Using this software, enterprises can create an isolated virtual cloud network environment through a self-

service public cloud infrastructure, providing them complete control for introducing new services and applications to their users.

Also at the application layer, the new HP Sentinel Security software application automates network access control and intrusion prevention security for enterprise campus networks with existing OpenFlow-enabled switch hardware through HP's controller. As a result, clients can eliminate the complexity and expense of dedicated networking hardware appliances, while achieving scalable security needed for bring-your-own-device (BYOD) initiatives.



### HP Network Protector

The HP Network Protector SDN Application leverages HP Networking, Tipping Point, and ArcSight products to deliver a converged solution that addresses security threats in a completely new way by leveraging the network itself. The HP Network Protector enables network intelligence on network infrastructure devices. The application uses the HP VAN SDN (Virtual Application Network Software-Defined Networking) Controller and OpenFlow to program the network infrastructure with security intelligence from the HP Tipping Point Reputation Digital Vaccine (RepDV). This turns the entire network infrastructure into security-enforcement devices, providing visibility and threat protection against more than one million malicious botnets, malware, and spyware sites.

Some of the key features of the solution include:

- Runs on HP VAN SDN Controller
- Complimentary to Tipping Point IPS solutions
- Delivers real-time threat characterization with HP Tipping Point DVlabs Database

- Protects from over 1,000,000+ botnet, malware, spyware, and malicious sites
- OpenFlow enabled switches gain ability to detect malware, botnets, and other threats
- Ability to create custom whitelist and blacklist
- Improves visibility and accuracy with ArcSight Integration
- Dynamic switch learning with HPN OpenFlow enabled switches distributes detection into switch infrastructure

### **HP Network Visualizer**

The HP Network Visualizer SDN Application by utilizing HP VAN SDN Controller provides dynamic traffic capture with real-time detailed network monitoring allowing for fast network diagnosis and verification, rapid transition from incident to fix.

#### **Features**

##### **1. Real-time Visibility and Diagnosis**

Network Visualizer provides dynamic traffic capture to diagnose the root cause of the network. It proactively monitors the network to reduce the number of help desk issues.

##### **2. Low Cost, Simple and Automated Troubleshooting**

Network Visualizer allows for simple troubleshooting that requires high level network detail. The application eliminates the need for any expensive manual network tapping tools for troubleshooting.

##### **3. Fast Transition from Incident to Fix**

Network Visualizer solves network issues in a matter of seconds versus minutes.

### **Network Optimizer**

HP Network Optimizer SDN Application for Microsoft Lync enables automated provisioning of network policy and quality of service to provide an enhanced user experience. The Network Optimizer Application dynamically provisions the end-to-end network path and Quality of Service (QoS) policy via the HP Virtual Application Networks (VAN)SDN Controller, reducing the need for manual, device-by-device configuration via the CLI, which greatly simplifies policy deployment and reduces the likelihood of human errors.

Network Optimizer provides:

- Traffic classification – Identify application traffic requiring preferential treatment
- Policy enforcement – Prioritize time sensitive traffic based QoS profiles, supports up to 10K users within a single SDN domain
- Visibility into per call SDN operation in terms of DSCP marking applied
- Granular sorting and display filtering – by IP address, media type, call quality and jitter
- History records management
- Configurable global template and phone trust

### **Cisco XNC Controller**

Cisco created the Cisco XNC Controller, in order to keep up with the changing software-defined networking (SDN) environments. Its support of OpenFlow, the most widely used SDN communications standard, helps it integrate into varied SDN deployments to enable organizations to better control and scale their networks. As of mid-2015, Cisco has retired the Cisco XNC Controller — see [What the Cisco XNC Controller Tells Us About OpenDaylight](#) to learn about XNC's demise.

As an SDN Controller, which is the “brains” of the network, Cisco XNC uses OpenFlow to communicate information “down” to the forwarding plane (switches and routers), with southbound APIs, and “up” to the applications and business logic, with northbound APIs. It enables organizations to deploy and even develop a variety of network services, using representational state transfer application program interfaces (REST APIs), as well as Java APIs.

The XNC is Cisco’s implementation of the OpenDaylight stack. Cisco is a contributor to the OpenDaylight initiative, which is focused on developing open standards for SDN that promote innovation and interoperability. Cisco XNC is designed to deliver the cutting edge OpenDaylight technologies as commercial, enterprise-ready solutions.

## Practical No: 03

### Aim: Install ODL(Open Daylight) controller

ODL is one of the most versatile and largest open-source controllers. It is helpful for automating larger area networks and it is scalable. ODL is written in Java. Compared to all other SDN Controllers, this controller is the best out of all and it is well-known for its security.

The OpenFlow protocol, considered the first SDN standard, defines the open communications protocol that allows the SDN Controller to work with the forwarding plane and make changes to the network. This gives businesses the ability to better adapt to their changing needs, and have greater control over their networks.

The OpenDaylight Controller exposes open northbound APIs, which are used by applications. These applications use the controller to collect information about the network, run algorithms to conduct analytics, and then use the OpenDaylight Controller to create new rules throughout the network.

The OpenDaylight Controller is implemented solely in software and is kept within its own Java Virtual Machine (VM) (JVM). This means it can be deployed on hardware and any operating system platforms that support Java. The controller uses these tools:

- Maven for build automation
- OSGi for dynamically loading bundles and packaging JAR files
- JAVA interfaces for event listening, specifications, and forming patterns.
- REST APIs such as topology manager, host tracker, flow programmer, and static routing.

### STEP 1: Install java and Set JAVA\_HOME

```
>>javac -version  
>>sudo apt install openjdk-8-jre-headless  
>>sudo apt install openjdk-8-jdk  
>>java -version
```

```
Activities Terminal ▾ Sat 01:05
rjmscit@ubuntu:~$ javac -version
Command 'javac' not found, but can be installed with:
sudo apt install default-jdk
sudo apt install openjdk-11-jdk-headless
sudo apt install ecj
sudo apt install openjdk-8-jdk-headless
rjmscit@ubuntu:~$ sudo apt install openjdk-8-jre-headless
[sudo] password for rjmscit:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
ca-certificates-java java-common
Suggested packages:
default-jre fonts-dejavu-extra fonts-ipafont-gothic fonts-ipafont-mincho
fonts-wqy-microhei fonts-wqy-zenhei
The following NEW packages will be installed:
ca-certificates-java java-common openjdk-8-jre-headless
0 upgraded, 3 newly installed, 0 to remove and 83 not upgraded.
Need to get 28.3 MB of archives.
After this operation, 104 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 java-common all 0.68ubuntu1~18.04.1 [14.5 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 openjdk-8-jre-headless amd64 8u292-b10-0ubuntu1~18.04 [28.2 MB]
Get:3 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 ca-certificates-java all 20180516ubuntu1~18.04.1 [12
2 kB]
```

```
Activities Terminal ▾ Sat 01:06
rjmscit@ubuntu:~$ File Edit View Search Terminal Help
Adding debian:Microsec_e-Szigno_Root_CA_2009.pem
Adding debian:QuoVadis_Root_CA_2_G3.pem
Adding debian:GTS_Root_R3.pem
Adding debian:ssl-cert-snakeoil.pem
Adding debian:Entrust_Certification_Authority_-EC1.pem
Adding debian:COMODO_RSA_Certification_Authority.pem
done.
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
Processing triggers for ca-certificates (20210119-18.04.1) ...
Updating certificates in /etc/ssl/certs...
0 added, 0 removed; done.
Running hooks in /etc/ca-certificates/update.d...

done.
done.
Setting up openjdk-8-jre-headless:amd64 (8u292-b10-0ubuntu1~18.04) ...
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/rmid to provide /usr/bin/rmid (rmid) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/java to provide /usr/bin/java (java) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/keytool to provide /usr/bin/keytool (keytool) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/jjs to provide /usr/bin/jjs (jjs) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/pack200 to provide /usr/bin/pack200 (pack200) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/rmiregistry to provide /usr/bin/rmiregistry (rmiregistry) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/unpack200 to provide /usr/bin/unpack200 (unpack200) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/orbd to provide /usr/bin/orbd (orbd) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/servertool to provide /usr/bin/servertool (servertool) in auto mode
```

```

Activities Terminal Sat 01:12 rjmscjt@ubuntu:~ 
File Edit View Search Terminal Help
sudo apt install openjdk-11-jdk-headless
sudo apt install ecj
sudo apt install openjdk-8-jdk-headless

rjmscjt@ubuntu:~$ sudo apt install openjdk-8-jdk
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  fonts-dejavu-extra libatk-wrapper-java libatk-wrapper-jni libgif7 libice-dev libpthread-stubs0-dev libsm-dev
  libxi1-dev libx11-doc libxau-dev libxcb1-dev libxdmcp-dev libxt-dev openjdk-8-jdk-headless openjdk-8-jre
  xproto-core-dev xproto-dev xorg-sgml-doctools xtrans-dev
Suggested packages:
  libice-doc libsm-doc libxcb-doc libxt-doc openjdk-8-demo openjdk-8-source visualvm icedtea-8-plugin
The following NEW packages will be installed:
  fonts-dejavu-extra libatk-wrapper-java libatk-wrapper-java-jni libgif7 libice-dev libpthread-stubs0-dev libsm-dev
  libxi1-dev libx11-doc libxau-dev libxcb1-dev libxdmcp-dev libxt-dev openjdk-8-jdk openjdk-8-jdk-headless
  openjdk-8-jre xproto-core-dev xproto-dev xorg-sgml-doctools xtrans-dev
0 upgraded, 20 newly installed, 0 to remove and 83 not upgraded.
Need to get 15.7 MB of archives.
After this operation, 66.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 fonts-dejavu-extra all 2.37-1 [1,953 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 libatk-wrapper-java all 0.33.3-20ubuntu0.1 [34.7 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 libatk-wrapper-java-jni amd64 0.33.3-20ubuntu0.1 [28.3 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgif7 amd64 5.1.4-2ubuntu0.1 [30.9 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 xorg-sgml-doctools all 1:1.11-1 [12.9 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 xproto-dev all 2018.4-4 [251 kB]
Get:7 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 xproto-core-dev all 2018.4-4 [2,620 B]
Get:8 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 libice-dev amd64 2-1.0.9-2 [46.8 kB]

```

```

Activities Terminal Sat 01:13 rjmscjt@ubuntu:~ 
File Edit View Search Terminal Help
Setting up libsm-dev:amd64 (2:1.2.2-1) ...
Setting up x11proto-core-dev (2018.4-4) ...
Setting up libxau-dev:amd64 (1:1.0.8-1ubuntu1) ...
Setting up libatk-wrapper-java-jni:amd64 (0.33.3-20ubuntu0.1) ...
Setting up libxcb1-dev:amd64 (1.13-2-ubuntu18.04) ...
Setting up libx11-dev:amd64 (2:1.6.4-3ubuntu0.3) ...
Setting up libxt-dev:amd64 (1:1.1.5-1) ...
Setting up openjdk-8-jre:amd64 (8u292-b10-0ubuntu1-18.04) ...
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/policytool to provide /usr/bin/policytool (policytool) in auto mode
Setting up openjdk-8-jdk:amd64 (8u292-b10-0ubuntu1-18.04) ...
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/appletviewer to provide /usr/bin/appletviewer (appletviewer) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/jconsole to provide /usr/bin/jconsole (jconsole) in auto mode
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
Processing triggers for gnome-menus (3.13.3-11ubuntu1.1) ...
Processing triggers for hicolor-icon-theme (0.17-2) ...
Processing triggers for fontconfig (2.12.6-0ubuntu2) ...
Processing triggers for mime-support (3.60ubuntu1) ...
Processing triggers for desktop-file-utils (0.23-1ubuntu3.18.04.2) ...
Processing triggers for libc-bin (2.27-3ubuntu1.2) ...
rjmscjt@ubuntu:~$ javac -version
javac 1.8.0_292
rjmscjt@ubuntu:~$ java -version
openjdk version "1.8.0_292"
OpenJDK Runtime Environment (build 1.8.0_292-8u292-b10-0ubuntu1-18.04-b10)
OpenJDK 64-Bit Server VM (build 25.292-b10, mixed mode)
rjmscjt@ubuntu:~$ 

```

**>> sudo nano /etc/environment**

**>>paste at first line - JAVA\_HOME="/usr/lib/jvm/java-8-openjdk-amd64"**

**>>paste at end of Path - /usr/lib/jvm/java-8-openjdk-amd64/bin**

**>>source /etc/environment**

**>>echo \$JAVA\_HOME**

**>>echo \$PATH**

```

Activities Terminal Sat 01:32
rjmscitr@ubuntu:~$ javac -version
javac 1.8.0_292
rjmscitr@ubuntu:~$ java -version
openjdk version "1.8.0_292"
OpenJDK Runtime Environment (build 1.8.0_292-8u292-b10-0ubuntu1~18.04-b10)
OpenJDK 64-Bit Server VM (build 25.292-b10, mixed mode)
rjmscitr@ubuntu:~$ echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/usr/games:/usr/local/games:/snap/bin
rjmscitr@ubuntu:~$ echo $JAVA_HOME
A
rjmscitr@ubuntu:~$ sudo nano /etc/environment
rjmscitr@ubuntu:~$ source /etc/environment
rjmscitr@ubuntu:~$ sudo update-alternatives --config java
There is only one alternative in link group java (providing /usr/bin/java): /usr/lib/jvm/java-8-openjdk-amd64/jre/bin/java
Nothing to configure.
rjmscitr@ubuntu:~$ echo $JAVA_HOME
/usr/lib/jvm/java-8-openjdk-amd64
rjmscitr@ubuntu:~$ echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/usr/games:/usr/local/games:/usr/lib/jvm/java-8-openjdk-amd64/bin
rjmscitr@ubuntu:~$ 

```

**STEP 2:** Download **distribution-karaf-0.6.0-Carbon.zip** and unzip it Move to the directory distribution-karaf-0.6.0-Carbon and type: ./bin/karaf

```

Activities Terminal Sat 01:55
root@ubuntu: /opt/distribution-karaf-0.4.4-Beryllium-SR4/bin
File Edit View Search Terminal Help
inflating: distribution-karaf-0.4.4-Beryllium-SR4/bin/karaf.bat
inflating: distribution-karaf-0.4.4-Beryllium-SR4/bin/setenv.bat
inflating: distribution-karaf-0.4.4-Beryllium-SR4/bin/shell.bat
inflating: distribution-karaf-0.4.4-Beryllium-SR4/bin/start.bat
inflating: distribution-karaf-0.4.4-Beryllium-SR4/bin/status.bat
inflating: distribution-karaf-0.4.4-Beryllium-SR4/bin/stop.bat
rjmscitr@ubuntu:~$ sudo su
[sudo] password for rjmscitr:
root@ubuntu:/home/rjmscitr# sudo mv distribution-karaf-0.4.4-Beryllium-SR4 /opt/
root@ubuntu:/home/rjmscitr# cd /opt
root@ubuntu:/opt# ls
distribution-karaf-0.4.4-Beryllium-SR4
root@ubuntu:/opt# cd distribution-karaf-0.4.4-Beryllium-SR4/bin/
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# ./karaf
OpenJDK 64-Bit Server VM warning: ignoring option MaxPermSize=512m; support was removed in 8.0
A
?
>
Hit '<tab>' for a list of available commands
and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown OpenDaylight.
opendaylight-user@root>

```

**STEP 3:** Install features

following ARE ODL-DLUX-ALL FEATURES

```

opendaylight-user@root> feature:install odl-dlux-core
opendaylight-user@root> feature:install odl-dluxapps-nodes
opendaylight-user@root> feature:install odl-dluxapps-topology
opendaylight-user@root> feature:install odl-dluxapps-yangui
opendaylight-user@root> feature:install odl-dluxapps-yangvisualizer
opendaylight-user@root> feature:install odl-dluxapps-yangman

```

```
opendaylight-user@root>feature:install odl-dlux-all  
opendaylight-user@root> feature:install odl-restconf odl-l2switch-switch odl- mdsal-apidocs  
opendaylight-user@root> feature:install odl-l2switch-all
```

```
opendaylight-user@root> feature:install odl-vtn-manager-neutron odl-neutron- service odl-  
neutron-hostconfig-ovs
```

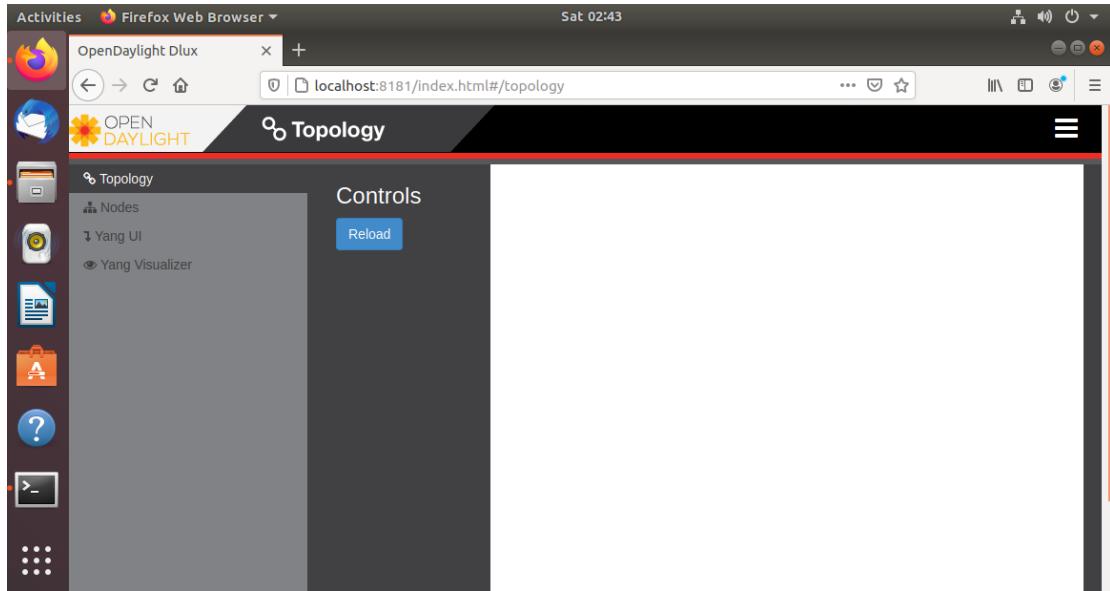
```
opendaylight-user@root>feature:install odl-ovsdb-library odl-restconf-all odl- ovsdb-  
southbound-api odl-ovsdb-southbound-impl odl-ovsdb-southbound-impl- rest
```

```
opendaylight-user@root>feature:install odl-netvirt-openstack
```

```
Activities Terminal Sat 02:41 root@ubuntu: /opt/distribution-karaf-0.4.4-Beryllium-SR4/bin  
File Edit View Search Terminal Help  
Hit '<tab>' for a list of available commands  
and '[cmd] --help' for help on a specific command.  
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown OpenDaylight.  
opendaylight-user@root>feature:install odl-dlux-core odl-dluxapps-nodes odl-dluxapps-topology odl-dluxapps-yangui odl-dlx  
uxapps-yangvisualizer odl-dluxapps-yangman odl-unimgr-dlux odl-dluxapps-yangutils odl-dluxapps-applications  
Error executing command: No feature matching odl-dluxapps-nodes/0.0.0  
opendaylight-user@root>feature:list | grep dlux  
odl-dlux-all | Opendaylight dlux all features | 0.3.4-Beryllium-SR4 | | odl-dlux-0.3.4-Beryllium-SR4  
odl-dlux-core | Opendaylight dlux minimal feature | 0.3.4-Beryllium-SR4 | x | odl-dlux-0.3.4-Beryllium-SR4  
odl-dlux-node | Enable nodes in Opendaylight dlux | 0.3.4-Beryllium-SR4 | | odl-dlux-0.3.4-Beryllium-SR4  
odl-dlux-yangui | Enable Yang UI in Opendaylight dlux | 0.3.4-Beryllium-SR4 | | odl-dlux-0.3.4-Beryllium-SR4  
odl-dlux-yangvisualizer | Enable Yang visualizer in Opendaylight dlux | 0.3.4-Beryllium-SR4 | | odl-dlux-0.3.4-Beryllium-SR4  
odl-snbi-dlux | OpenDaylight :: SNBI :: Dlux | 1.2.4-Beryllium-SR4 | | odl-snbi-1.2.4-Beryllium-SR4  
opendaylight-user@root>^C  
opendaylight-user@root>feature:install odl-dlux-all  
opendaylight-user@root>feature:list | grep dlux  
odl-dlux-all | Opendaylight dlux all features | 0.3.4-Beryllium-SR4 | x | odl-dlux-0.3.4-Beryllium-SR4  
odl-dlux-core | Opendaylight dlux minimal feature | 0.3.4-Beryllium-SR4 | x | odl-dlux-0.3.4-Beryllium-SR4  
odl-dlux-node | Enable nodes in Opendaylight dlux | 0.3.4-Beryllium-SR4 | | odl-dlux-0.3.4-Beryllium-SR4
```

```
Activities Terminal Sat 02:43 root@ubuntu: /opt/distribution-karaf-0.4.4-Beryllium-SR4/bin  
File Edit View Search Terminal Help  
-bulk-o-matic-he odl-l2switch-switch-rest odl-l2switch-switch-ui  
Error executing command: No feature matching odl-openflowplugin-southbound-he/0.0.0  
opendaylight-user@root>feature:install odl-l2switch-all odl-neutron-service odl-l2switch-swit  
ch-rest odl-l2switch-switch-ui odl-vtn-manager-neutron  
Error executing command: No feature Matching odl-neutron-hostconfig-ovs/0.0.0  
opendaylight-user@root>feature:install odl-l2switch-all odl-neutron-service odl-l2switch-switch  
-rest odl-vtn-manager-neutron  
opendaylight-user@root>feature:list | grep neutron  
odl-nic-neutron-integration | 1.1.4-Beryllium-SR4 | | odl-nic-1.1.4-Beryllium-SR4  
| OpenDaylight :: Network Intent Composition :: Neut  
odl-vtn-manager-neutron | 0.4.4-Beryllium-SR4 | x | vtn-manager-0.4.4-Beryllium-SR4  
odl-neutron-service | OpenDaylight :: VTN Manager :: Neutron Interface | 0.6.4-Beryllium-SR4 | x | odl-neutron-0.6.4-Beryllium-SR4  
odl-neutron-northbound-api | OpenDaylight :: Neutron :: API | 0.6.4-Beryllium-SR4 | x | odl-neutron-0.6.4-Beryllium-SR4  
odl-neutron-spi | OpenDaylight :: Neutron :: Northbound | 0.6.4-Beryllium-SR4 | x | odl-neutron-0.6.4-Beryllium-SR4  
odl-neutron-transcriber | OpenDaylight :: Neutron :: Implementation | 0.6.4-Beryllium-SR4 | x | odl-neutron-0.6.4-Beryllium-SR4  
odl-lispflowmapping-neutron | OpenDaylight :: LISP Flow Mapping :: Neutron Integ  
4 | 1.3.4-Beryllium-SR4 | | odl-lispflowmapping-1.3.4-Beryllium-SR4  
odl-groupbasedpolicy-neutronmapper | OpenDaylight :: groupbasedpolicy :: Neutron Mapper  
R4 | 0.3.4-Beryllium-SR4 | | odl-groupbasedpolicy-0.3.4-Beryllium-SR4  
opendaylight-user@root>feature:list | grep switch  
odl-l2switch-all | OpenDaylight :: L2Switch :: All | 0.3.4-Beryllium-SR4 | x | l2switch-0.3.4-Beryllium-SR4  
odl-l2switch-switch | OpenDaylight :: L2Switch :: Switch | 0.3.4-Beryllium-SR4 | x | l2switch-0.3.4-Beryllium-SR4  
odl-l2switch-switch-rest | OpenDaylight :: L2Switch :: Rest | 0.3.4-Beryllium-SR4 | x | l2switch-0.3.4-Beryllium-SR4
```

Even ODL has dashboard DLUX feature which gives GUI web interface to ODL controller at URL **http://localhost:8181/index.html OR http://ip:8181/index.html** on which ODL user can log in (by default username and password is ‘admin’) and check network topology on the browser of the system where ODL is running.



## Practical No: 04

### Aim: Implement OVS

Open vSwitch was created by the team at Nicira, that was later acquired by VMware. OVS was intended to meet the needs of the open source community, since there was no a feature-rich virtual switch offering designed for Linux-based hypervisors, such as KVM and XEN. OVS has quickly become the de facto virtual switch for XEN environments, and it is now playing a large part in other open source projects, like OpenStack.

OVS supports NetFlow, sFlow, port mirroring, VLANs, LACP, etc. From a control and management perspective, Open vSwitch leverages OpenFlow and the Open vSwitch Database (OVSDB) management protocol, which means it can operate both as a soft switch running within the hypervisor, and as the control stack for switching silicon. Other important ways OVS is incorporated in software-defined networking (SDN) include:

- OVS is critical to many SDN deployments in data centers because it ties together all the virtual machines (VMs) within a hypervisor instance on a server
- It is the first entry point for all the VMs sending traffic to the network and is the ingress point into overlay networks running on top of physical networks in the data center
- Using OVS for virtual networking is considered the core element of many datacenter SDN deployments and the main use case is multi-tenant network virtualization
- OVS can also be used to direct traffic between network functions in service chaining use cases

OVS differs from the commercial offerings from VMware and Cisco. One point worth noting about OVS is that there is not a native SDN Controller or manager, like the Virtual Supervisor Manager (VSM) in the Cisco 1000V or vCenter in the case of VMware's distributed switch. Open vSwitch is meant to be controlled and managed by third party controllers and managers.

Once OpenFlow and OVSDB plugins are installed, ODL will start listening for OpenFlow and OVSDB connections at 6653 and 6640 port respectively. This can be checked at controller by running the following commands:

**First run ODL then enter below command in terminal:**

```
>>netstat -a | grep 6653
```

```
>>netstat -a | grep 6640
```

**And install openvswitch**

```
>>sudo apt-get install openvswitch-switch
```

```

Activities Terminal Sat 03:38 rjmscit@ubuntu:~ 
rjmscit@ubuntu:~$ clear
rjmscit@ubuntu:~$ netstat -a | grep 6653
tcp6      0      0 [::]:6653          [::]:*          LISTEN
rjmscit@ubuntu:~$ netstat -a | grep 6640
tcp6      0      0 [::]:6640          [::]:*          LISTEN
unix     3      [ ]           STREAM      CONNECTED  36640
rjmscit@ubuntu:~$ sudo apt-get install openvswitch-switch
[sudo] password for rjmscit:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libpython-stdlib openvswitch-common python python-minimal python-six python2.7 python2.7-minimal
Suggested packages:
  ethtool openvswitch-doc python-doc python-tk python2.7-doc binfmt-support
The following NEW packages will be installed:
  libpython-stdlib openvswitch-common openvswitch-switch python python-minimal python-six python2.7 python2.7-minimal
0 upgraded, 8 newly installed, 0 to remove and 83 not upgraded.
Need to get 4,030 kB of archives.
After this operation, 15.3 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 python2.7-minimal amd64 2.7.17-1~18.04ubuntu1.6 [1,2
91 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 python-minimal amd64 2.7.15-rc1-1 [28.1 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 python2.7 amd64 2.7.17-1~18.04ubuntu1.6 [248 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 libpython-stdlib amd64 2.7.15-rc1-1 [7,620 B]
Get:5 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 python amd64 2.7.15-rc1-1 [140 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 python-six all 1.11.0-2 [113 kB]

```

```

Activities Terminal Sat 03:38 rjmscit@ubuntu:~ 
(Reading database ... 165981 files and directories currently installed.)
Preparing to unpack .../python_2.7.15-rc1-1_amd64.deb ...
Unpacking python (2.7.15-rc1-1) ...
Selecting previously unselected package python-six.
Preparing to unpack .../python-six_1.11.0-2_all.deb ...
Unpacking python-six (1.11.0-2) ...
Selecting previously unselected package openvswitch-common.
Preparing to unpack .../openvswitch-common_2.9.8-0ubuntu0.18.04.2_amd64.deb ...
Unpacking openvswitch-common (2.9.8-0ubuntu0.18.04.2) ...
Selecting previously unselected package openvswitch-switch.
Preparing to unpack .../openvswitch-switch_2.9.8-0ubuntu0.18.04.2_amd64.deb ...
Unpacking openvswitch-switch (2.9.8-0ubuntu0.18.04.2) ...
Setting up python2.7 (2.7.17-1~18.04ubuntu1.6) ...
Setting up libpython-stdlib:amd64 (2.7.15-rc1-1) ...
Setting up python (2.7.15-rc1-1) ...
Setting up python-six (1.11.0-2) ...
Setting up openvswitch-common (2.9.8-0ubuntu0.18.04.2) ...
Setting up openvswitch-switch (2.9.8-0ubuntu0.18.04.2) ...
update-alternatives: using /usr/lib/openvswitch-switch/ovs-vswitchd to provide /usr/sbin/ovs-vswitchd (ovs-vswitchd) in
auto mode
Created symlink /etc/systemd/system/multi-user.target.wants/openvswitch-switch.service → /lib/systemd/system/openvswitch-
switch.service.
Processing triggers for gnome-menus (3.13.3-11ubuntu1.1) ...
Processing triggers for mime-support (3.60ubuntu1) ...
Processing triggers for ureadahead (0.100.0-2) ...
Processing triggers for desktop-file-utils (0.23-1ubuntu3.18.04.2) ...
Processing triggers for systemd (237-3ubuntu10.42) ...
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
rjmscit@ubuntu:~$ 

```

**Now go to bin repository of Karaf and run below command to start openvswitch:**

**>>sudo /etc/init.d/openvswitch-switch start**

**>>sudo /etc/init.d/openvswitch-switch status**

**>>sudo ovs-vsctl show**

```

Activities Terminal Sat 03:48
root@ubuntu: /opt/distribution-karaf-0.4.4-Beryllium-SR4/bin
File Edit View Search Terminal Help
Usage: /etc/init.d/openvswitch-switch {start|stop|restart|force-reload|status|force-stop|force-reload-kmod|load-kmod}
rjmsc@ubuntu:~$ sudo su
root@ubuntu:/home/rjmsc# rjmsc
rjmsc: command not found
root@ubuntu:/home/rjmsc# cd /opt
root@ubuntu:/opt# ls
distribution-karaf-0.4.4-Beryllium-SR4
root@ubuntu:/opt# cd distribution-karaf-0.4.4-Beryllium-SR4/bin
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin#
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin#
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo /etc/init.d/openvswitch-switch
Usage: /etc/init.d/openvswitch-switch {start|stop|restart|force-reload|status|force-stop|force-reload-kmod|load-kmod}
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo /etc/init.d/openvswitch-switch start
[ ok ] Starting openvswitch-switch (via systemctl): openvswitch-switch.service.
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo /etc/init.d/openvswitch-switch status
● openvswitch-switch.service - Open vswitch
   Loaded: loaded (/lib/systemd/system/openvswitch-switch.service; enabled; vendor preset: enabled)
   Active: active (exited) since Sat 2021-05-01 03:33:26 PDT; 9min ago
     Main PID: 81504 (code=exited, status=0/SUCCESS)
        Tasks: 0 (limit: 4633)
       CGroup: /system.slice/openvswitch-switch.service

May 01 03:33:26 ubuntu systemd[1]: Starting Open vSwitch...
May 01 03:33:26 ubuntu systemd[1]: Started Open vSwitch.
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo /etc/init.d/openvswitch-switch status
● openvswitch-switch.service - Open vswitch
   Loaded: loaded (/lib/systemd/system/openvswitch-switch.service; enabled; vendor preset: enabled)
   Active: active (exited) since Sat 2021-05-01 03:33:26 PDT; 12min ago
     Main PID: 81504 (code=exited, status=0/SUCCESS)
        Tasks: 0 (limit: 4633)

```

**At OVS side, below command is run to initiate OVSDB connection with controller:**

**ovs-vsctl set-manager tcp:<controller-IP>:6640**

To confirm that the connection is established, below command can be run which shows 'is\_connected' flag is set to true in the output.

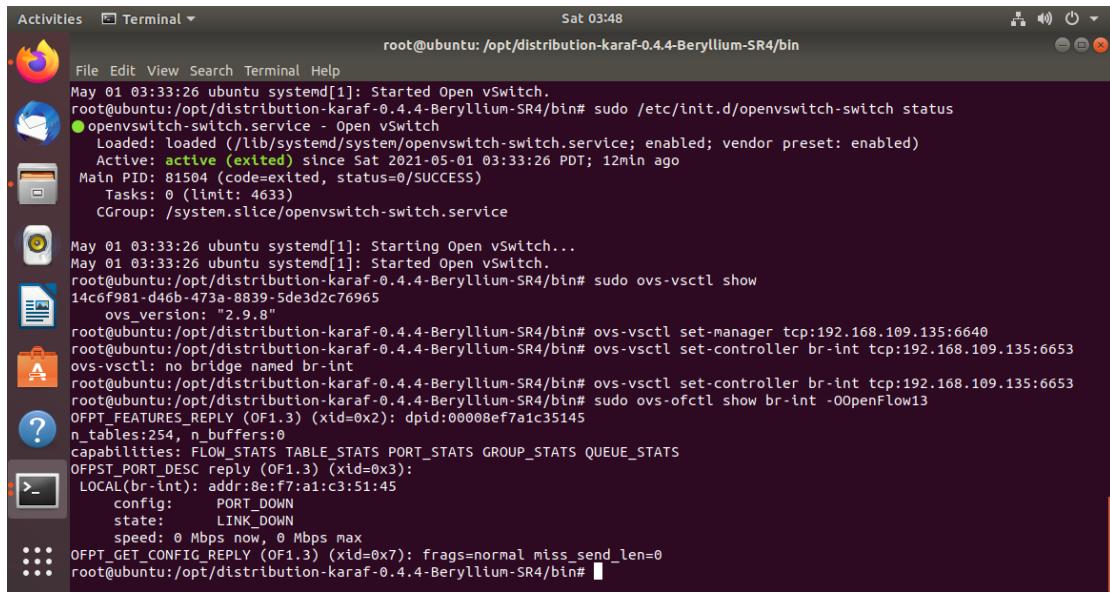
**OpenFlow connection is made on bridge, so either you can create bridge on OVS or ODL can also create bridge on OVS by sending configuration to OVS via OVSDB connection. Over the bridge in OVS, below command can be run to connect bridge to ODL, which establishes establishing OpenFlow connection between ODL and OVS.**

**ovs-vsctl set-controller <bridge name> tcp:<controller-IP>:6653**

**ovs-vsctl set-controller br-int tcp: 192.168.109.135:6653**

**At the OVS side, the following command can be run to show details of bridge.**

**sudo ovs-ofctl show br-int -OOpenFlow13**



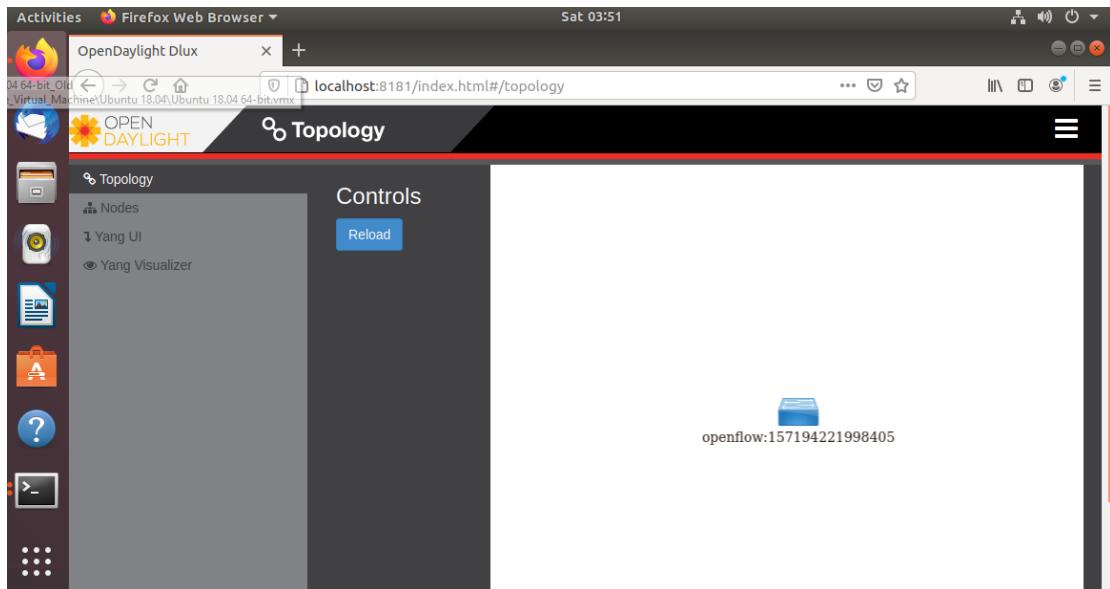
```

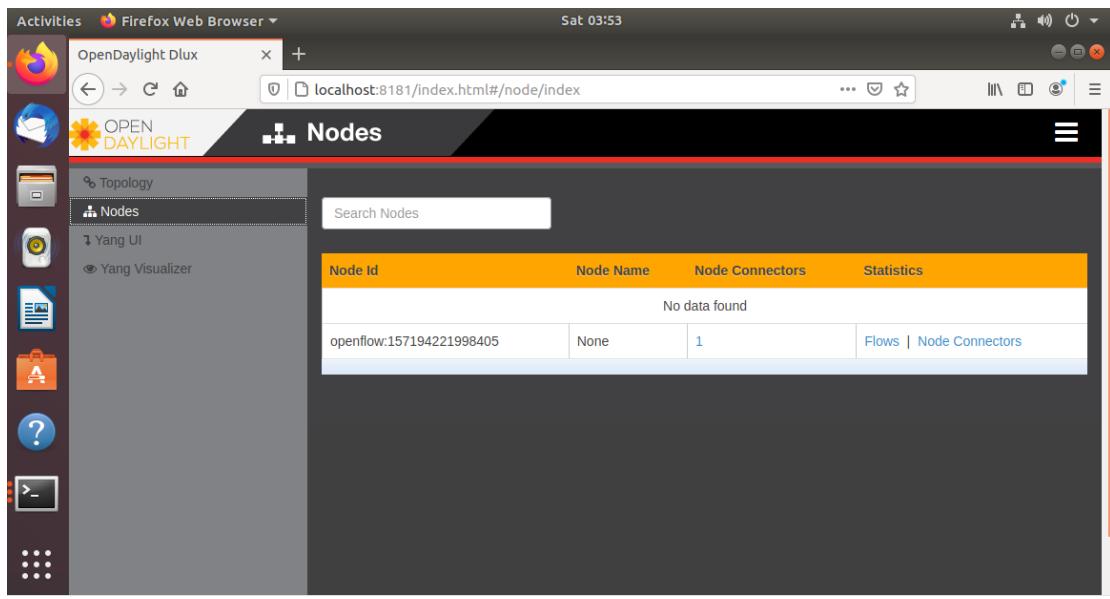
Activities Terminal ▾ Sat 03:48
root@ubuntu: /opt/distribution-karaf-0.4.4-Beryllium-SR4/bin
File Edit View Search Terminal Help
May 01 03:33:26 ubuntu systemd[1]: Started Open vswitch.
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo /etc/init.d/openvswitch-switch status
● openvswitch-switch.service - Open vSwitch
   Loaded: loaded (/lib/systemd/system/openvswitch-switch.service; enabled; vendor preset: enabled)
     Active: active (exited) since Sat 2021-05-01 03:33:26 PDT; 12min ago
       PID: 81504 (code=exited, status=0/SUCCESS)
     Tasks: 0 (limit: 4633)
    CGroup: /system.slice/openvswitch-switch.service

May 01 03:33:26 ubuntu systemd[1]: Starting Open vswitch...
May 01 03:33:26 ubuntu systemd[1]: Started Open vSwitch.
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo ovs-vsctl show
14c6f981-d46b-473a-8839-5de3d2c76965
    ovs_version: "2.9.8"
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# ovs-vsctl set-manager tcp:192.168.109.135:6640
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# ovs-vsctl set-controller br-int tcp:192.168.109.135:6653
ovs-vsctl: no bridge named br-int
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin# sudo ovs-ofctl show br-int -OOpenFlow13
OFPT_FEATURES_REPLY (OF1.3) (xid=0x2): dpid=00008ef7a1c35145
n_tables:254, n_buffers:0
capabilities: FLOW_STATS TABLE_STATS PORT_STATS GROUP_STATS QUEUE_STATS
OFPTST_PORT_DESC reply (OF1.3) (xid=0x3):
  LOCAL(br-int): addr:8e:f7:a1:c3:51:45
    config:      PORT_DOWN
    state:       LINK_DOWN
    speed:      0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (OF1.3) (xid=0x7): frags=normal miss_send_len=0
root@ubuntu:/opt/distribution-karaf-0.4.4-Beryllium-SR4/bin#

```

## Restart odl and login to view OpenFlow switch





## PRACTICAL NO: 05

### Aim: Implement Mininet on ODL

Mininet is a network emulator which creates a network of virtual hosts, switches, controllers, and links. Mininet hosts run standard Linux network software, and its switches support OpenFlow for highly flexible custom routing and Software-Defined Networking.

Mininet supports research, development, learning, prototyping, testing, debugging, and any other tasks that could benefit from having a complete experimental network on a laptop or other PC.

Mininet:

- Provides a simple and inexpensive network testbed for developing OpenFlow applications
- Enables multiple concurrent developers to work independently on the same topology
- Supports system-level regression tests, which are repeatable and easily packaged
- Enables complex topology testing, without the need to wire up a physical network
- Includes a CLI that is topology-aware and OpenFlow-aware, for debugging or running network-wide tests
- Supports arbitrary custom topologies, and includes a basic set of parametrized topologies
- is usable out of the box without programming, but
- also Provides a straightforward and extensible Python API for network creation and experimentation
- Mininet provides an easy way to get correct system behavior (and, to the extent supported by your hardware, performance) and to experiment with topologies.
- Mininet networks run real code including standard Unix/Linux network applications as well as the real Linux kernel and network stack (including any kernel extensions which you may have available, as long as they are compatible with network namespaces.)
- Because of this, the code you develop and test on Mininet, for an OpenFlow controller, modified switch, or host, can move to a real system with minimal changes, for real-world testing, performance evaluation, and deployment. Importantly this means that a design that works in Mininet can usually move directly to hardware switches for line-rate packet forwarding.

```
>> sudo apt update  
>> sudo apt-get install git
```

```
Activities Terminal Sat 04:02 rjmsc1t@ubuntu:~  
File Edit View Search Terminal Help  
rjmsc1t@ubuntu:~$ sudo apt update  
[sudo] password for rjmsc1t:  
Hit:1 http://us.archive.ubuntu.com/ubuntu bionic InRelease  
Get:2 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]  
Get:3 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]  
Hit:4 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease  
Get:5 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]  
Get:6 http://ubuntu.bionic-security/main amd64 DEP-11 Metadata [48.6 kB]  
Get:7 http://us.archive.ubuntu.com/ubuntu bionic-updates/main i386 Packages [1,277 kB]  
Get:8 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 DEP-11 Metadata [60.3 kB]  
Get:9 http://us.archive.ubuntu.com/ubuntu bionic-security/multiverse amd64 DEP-11 Metadata [2,464 kB]  
Get:10 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [2,039 kB]  
Get:11 http://us.archive.ubuntu.com/ubuntu bionic-updates/main i386 Packages [294 kB]  
Get:12 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 Packages [1,734 kB]  
Get:13 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe i386 Packages [1,567 kB]  
Get:14 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 DEP-11 Metadata [289 kB]  
Get:15 http://us.archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 DEP-11 Metadata [2,468 kB]  
Get:16 http://us.archive.ubuntu.com/ubuntu bionic-backports/universe amd64 DEP-11 Metadata [9,292 kB]  
Fetched 7,574 kB in 13s (572 kB/s)  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
83 packages can be upgraded. Run 'apt list --upgradable' to see them.  
rjmsc1t@ubuntu:~$ sudo apt-get install git  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following additional packages will be installed:  
git-man liberror-perl  
Suggested packages:
```

```
Activities Terminal Sat 04:03 rjmsc1t@ubuntu:~  
File Edit View Search Terminal Help  
git-man liberror-perl  
Suggested packages:  
git-daemon-run | git-daemon-sysvinit git-doc git-el git-email git-gui gitk  
gitweb git-cvs git-mediawiki git-svn  
The following NEW packages will be installed:  
git git-man liberror-perl  
0 upgraded, 3 newly installed, 0 to remove and 83 not upgraded.  
Need to get 4,443 kB of archives.  
After this operation, 34.0 MB of additional disk space will be used.  
Do you want to continue? [Y/n] Y  
Get:1 http://us.archive.ubuntu.com/ubuntu bionic/main amd64 liberror-perl all 0.17025-1 [22.8 kB]  
Get:2 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 git-man all 1:2.17.1-1ubuntu0.8 [804 kB]  
Get:3 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 git amd64 1:2.17.1-1ubuntu0.8 [3,916 kB]  
Fetched 4,743 kB in 17s (272 kB/s)  
Selecting previously unselected package liberror-perl.  
(Reading database ... 166130 files and directories currently installed.)  
Preparing to unpack .../liberror-perl_0.17025-1_all.deb ...  
Unpacking liberror-perl (0.17025-1) ...  
Selecting previously unselected package git-man.  
Preparing to unpack .../git-man_1%3a2.17.1-1ubuntu0.8_all.deb ...  
Unpacking git-man (1:2.17.1-1ubuntu0.8) ...  
Selecting previously unselected package git.  
Preparing to unpack .../git_1%3a2.17.1-1ubuntu0.8_amd64.deb ...  
Unpacking git (1:2.17.1-1ubuntu0.8) ...  
Setting up git-man (1:2.17.1-1ubuntu0.8) ...  
Setting up liberror-perl (0.17025-1) ...  
Setting up git (1:2.17.1-1ubuntu0.8) ...  
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...  
rjmsc1t@ubuntu:~$
```

```
>> git clone git://github.com/mininet/mininet  
>> cd mininet
```

The Mininet project provides an install script. Run the script.  
>> ./util/install.sh -a (to install all feature of mininet)

```

Activities Terminal Sat 04:05
rjmscit@ubuntu: ~/mininet

Setting up git-man (1:2.17.1-1ubuntu0.8) ...
Setting up liberror-perl (0.17025-1) ...
Setting up git (1:2.17.1-1ubuntu0.8) ...
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
rjmscit@ubuntu:~$ git clone git://github.com/mininet/mininet
Cloning into 'mininet'...
remote: Enumerating objects: 10165, done.
remote: Counting objects: 100% (11/11), done.
remote: Compressing objects: 100% (8/8), done.
remote: Total 10165 (delta 2), reused 7 (delta 2), pack-reused 10154
Receiving objects: 100% (10165/10165), 3.19 MiB | 933.00 KiB/s, done.
Resolving deltas: 100% (6784/6784), done.
rjmscit@ubuntu:~$ cd mininet/
rjmscit@ubuntu:~/mininet$ ./util/install.sh -a
Detected Linux distribution: Ubuntu 18.04 bionic amd64
sys.version_info(major=2, minor=7, micro=17, releaselevel='final', serial=0)
Detected Python (python) version 2
Installing all packages except for -eix (doxypy, ivs, nox-classic)...
Install Mininet-compatible kernel if necessary
Hit:1 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Hit:2 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Hit:3 http://security.ubuntu.com/ubuntu bionic-security InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:5 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease
Reading package lists... Done
Reading package lists...
Building dependency tree...
Reading state information...
linux-image-5.4.0-42-generic is already the newest version (5.4.0-42.46~18.04.1).
linux-image-5.4.0-42-generic set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 83 not upgraded.

```

```

>> ps aux|grep -i ovs
>> sudo kill -9 7266 7306
>> sudo service openvswitch-switch status
>> sudo service openswitch-switch stop
>> service openvswitch-switch start

```

```

Activities Terminal Thu 06:44
rjmscit@ubuntu: ~

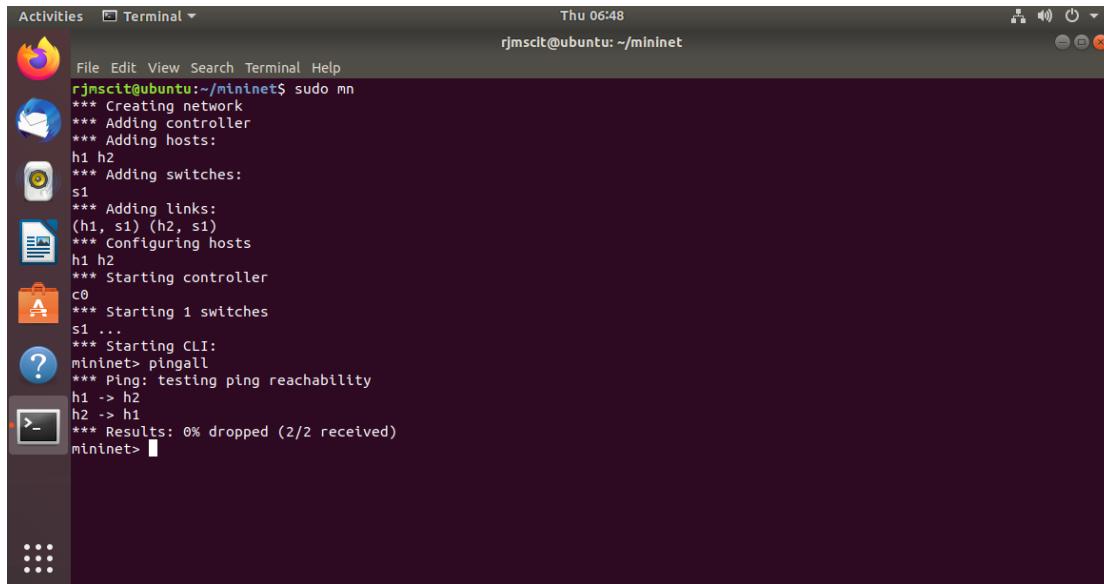
File Edit View Terminal Help
rjmscit@ubuntu:~$ ps aux|grep -i ovs
root      7266  0.0  0.1 21660  4640 ?        S<s  05:40   0:01 ovsdb-server /etc/openvswitch/conf.db -vconsole:emer -vsyslog:err -vfile:info --remote=punix:/var/run/openvswitch/db.sock --private-key=db:Open_vSwitch,SSL,private_key --cert ificate=db:Open_vSwitch,SSL,certificate --bootstrap-ca-cert=db:Open_vSwitch,SSL_ca_cert --no-chdir --log-file=/var/log/o penvswitch/ovsdb-server.log --pidfile=/var/run/openvswitch/ovsdb-server.pid --detach
root      7306  0.4  1.3 396948 53456 ?       S<lsl 05:40   0:17 ovs-vswitchd unix:/var/run/openvswitch/db.sock -vcons ole:emer -vsyslog:err -vfile:info --mlockall --no-chdir --log-file=/var/log/openvswitch/ovs-vswitchd.log --pidfile=/var/run/openvswitch/ovs-vswitchd.pid --detach
rjmscit   8981  0.0  0.0 21540  1120 pts/0    S+   06:43   0:00 grep --color=auto -i ovs
rjmscit@ubuntu:~$ sudo kill -9 7266 7306
[sudo] password for rjmscit:
rjmscit@ubuntu:~$ sudo service openvswitch-switch status
● openvswitch-switch.service - Open vSwitch
   Loaded: loaded (/lib/systemd/system/openvswitch-switch.service; enabled; vendor preset: enabled)
     Active: active (exited) since Thu 2021-05-06 05:40:29 PDT; 1h 3min ago
       Process: 7207 ExecStop=/bin/true (code=exited, status=0/SUCCESS)
      Process: 7390 ExecStart=/bin/true (code=exited, status=0/SUCCESS)
        Main PID: 7390 (code=exited, status=0/SUCCESS)
          Tasks: 0 (limit: 4632)
         CGroup: /system.slice/openvswitch-switch.service

May 06 05:40:29 ubuntu systemd[1]: Starting Open vSwitch...
May 06 05:40:29 ubuntu systemd[1]: Started Open vSwitch.
rjmscit@ubuntu:~$ sudo service openvswitch-switch stop
rjmscit@ubuntu:~$ sudo service openvswitch-switch start
rjmscit@ubuntu:~$ 

```

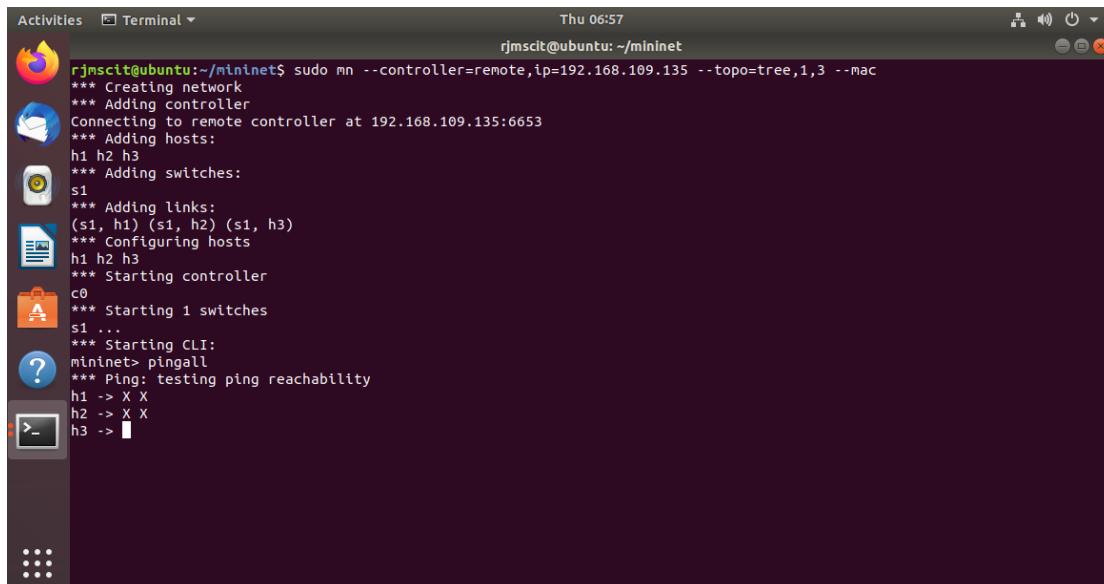
```
>> sudo mn
```

```
>> sudo mn --test pingall
```



```
Activities Terminal Thu 06:48
rjmscit@ubuntu:~/mininet
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
mininet>
```

```
>> sudo mn --controller=remote,ip=192.168.109.135 --topo=tree,1,3 --mac
```



```
Activities Terminal Thu 06:57
rjmscit@ubuntu:~/mininet
*** Creating network
*** Adding controller
Connecting to remote controller at 192.168.109.135:6653
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1
*** Adding links:
(s1, h1) (s1, h2) (s1, h3)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> X X
h2 -> X X
h3 -> [REDACTED]
```

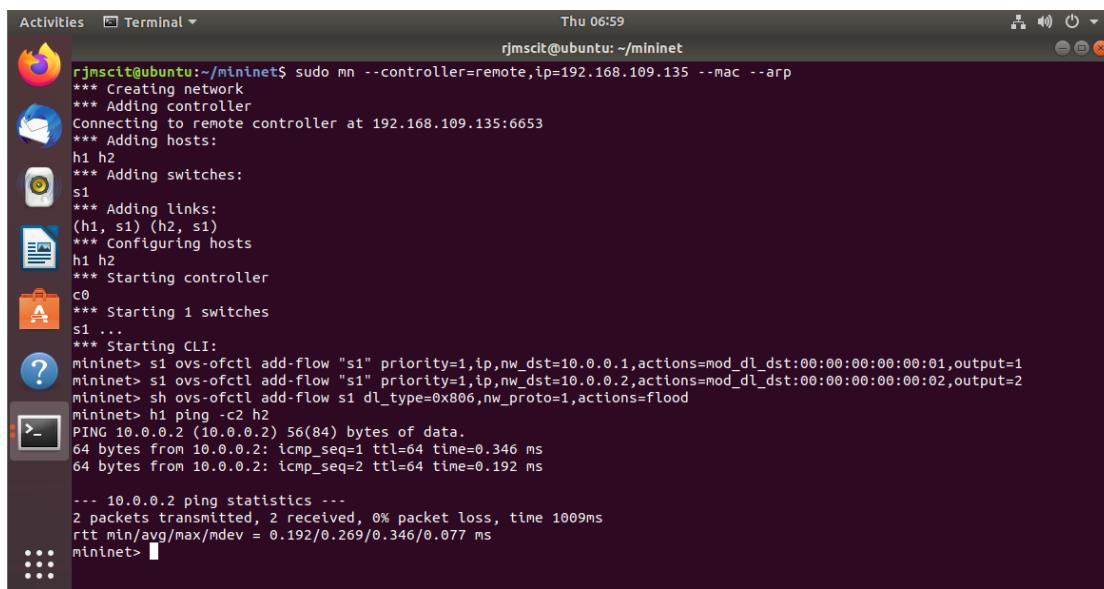
```
sudo mn --controller=remote,ip=192.168.109.135 --mac --arp
```

```
mininet> s1 ovs-ofctl add-flow "s1"
```

```
priority=1,ip,nw_dst=10.0.0.1,actions=mod_dl_dst:00:00:00:00:01,output=1
```

```
mininet> s1 ovs-ofctl add-flow "s1"
priority=1,ip,nw_dst=10.0.0.2,actions=mod_dl_dst:00:00:00:00:02, output=2
```

```
mininet> sh ovs-ofctl add-flow s1 dl_type=0x806,nw_proto=1,actions=flood
mininet> h1 ping -c2 h2
```



The screenshot shows a terminal window on a Ubuntu desktop environment. The terminal title is 'rjmsclt@ubuntu: ~/mininet'. The window displays the following command-line session:

```
Activities Terminal Thu 06:59
rjmsclt@ubuntu:~/mininet$ sudo mn --controller=remote,ip=192.168.109.135 --mac --arp
*** Creating network
*** Adding controller
Connecting to remote controller at 192.168.109.135:6653
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> s1 ovs-ofctl add-flow "s1" priority=1,ip,nw_dst=10.0.0.1,actions=mod_dl_dst:00:00:00:00:01, output=1
mininet> s1 ovs-ofctl add-flow "s1" priority=1,ip,nw_dst=10.0.0.2,actions=mod_dl_dst:00:00:00:00:02, output=2
mininet> sh ovs-ofctl add-flow s1 dl_type=0x806,nw_proto=1,actions=flood
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=0.346 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.192 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1009ms
rtt min/avg/max/mdev = 0.192/0.269/0.346/0.077 ms
mininet>
```

## PRACTICAL NO: 06

### Aim: Install RYU controller with mininet topology

Ryu Controller is an open, software-defined networking (SDN) Controller designed to increase the agility of the network by making it easy to manage and adapt how traffic is handled. In general, the SDN Controller is the brain of the SDN environment, communicating information down to the switches and routers with southbound APIs, and up to the applications and business logic with northbound APIs. The Ryu Controller is supported by NTT and is deployed in NTT cloud data centers as well.

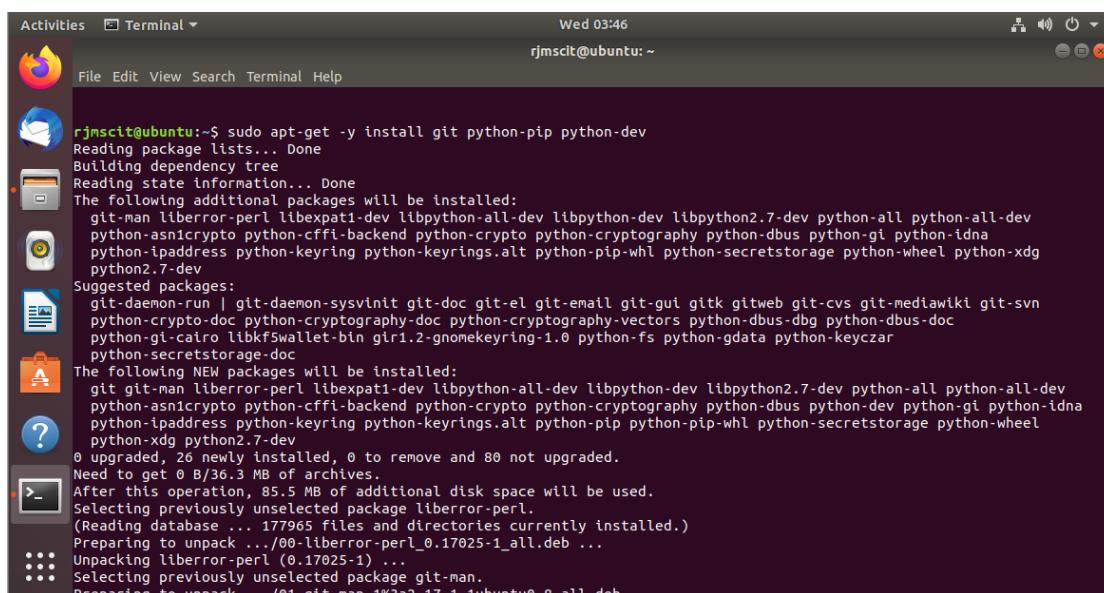
The Ryu Controller provides software components, with well-defined application program interfaces (APIs), that make it easy for developers to create new network management and control applications. This component approach helps organizations customize deployments to meet their specific needs; developers can quickly and easily modify existing components or implement their own to ensure the underlying network can meet the changing demands of their applications.

The Ryu Controller source code is hosted on GitHub and managed and maintained by the open Ryu community. OpenStack, which runs an open collaboration focused on developing a cloud operating system that can control the compute, storage, and networking resources of an organization, supports deployments of Ryu as the Network Controller.

Written entirely in Python, all of Ryu's code is available under the Apache 2.0 license and open for anyone to use. The Ryu Controller supports NETCONF and OF-config network management protocols, as well as OpenFlow, which is one of the first and most widely deployed SDN communications standards. It also supports Nicira extensions.

### **Step 1 -> Install tools**

```
>> sudo apt-get -y install git python-pip python-dev
```

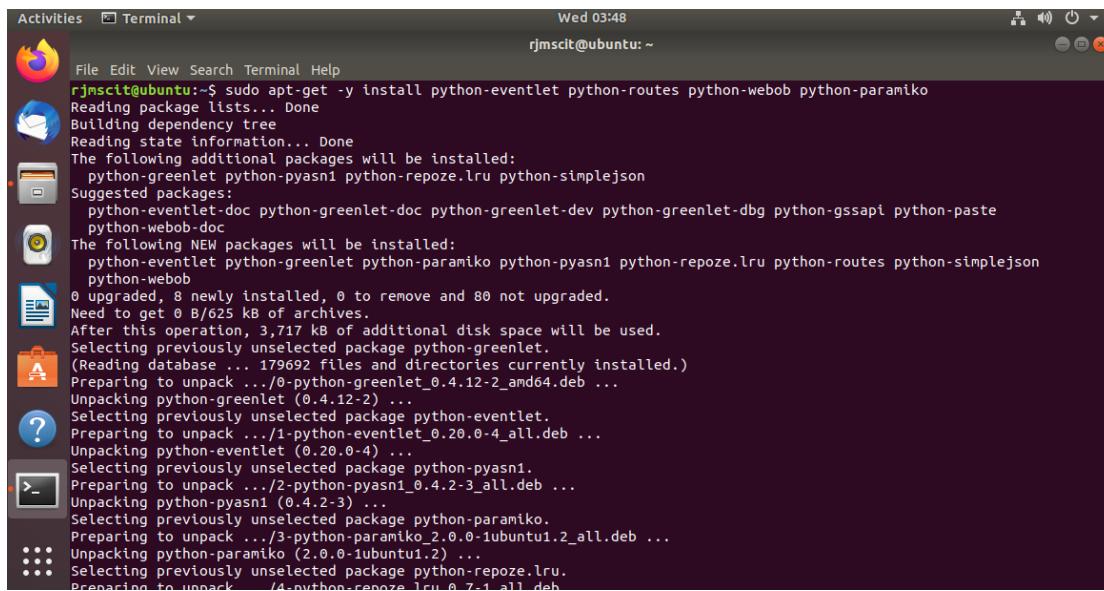


The screenshot shows a terminal window on an Ubuntu desktop. The terminal output is as follows:

```
Activities Terminal Wed 03:46 rjmsc1t@ubuntu:~$ sudo apt-get -y install git python-pip python-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  git-man liberror-perl libexpat1-dev libpython-dev libpython2.7-dev python-all python-all-dev
  python-asn1crypto python-cffi-backend python-crypto python-cryptography python-dbus python-gi python-idna
  python-ipaddress python-keyring python-keyrings.alt python-pip-whl python-secretstorage python-wheel python-xdg
  python2.7-dev
Suggested packages:
  git-daemon-run | git-daemon-sysvinit git-doc git-el git-email git-gui gitk gitweb git-cvs git-mediawiki git-svn
  python-crypto-doc python-cryptography-doc python-cryptography-vectors python-dbus-dbg python-dbus-doc
  python-gi-cairo libkf5wallet-bin gir1.2-gnomekeyring-1.0 python-fs python-gdata python-keyczar
  python-secretstorage-doc
The following NEW packages will be installed:
  git git-man liberror-perl libexpat1-dev libpython-all-dev libpython-dev libpython2.7-dev python-all python-all-dev
  python-asn1crypto python-cffi-backend python-crypto python-cryptography python-dbus python-dev python-gi python-idna
  python-ipaddress python-keyring python-keyrings.alt python-pip python-pip-whl python-secretstorage python-wheel
  python-xdg python2.7-dev
0 upgraded, 26 newly installed, 0 to remove and 80 not upgraded.
Need to get 0 B/36.3 MB of archives.
After this operation, 85.5 MB of additional disk space will be used.
Selecting previously unselected package liberror-perl.
(Reading database ... 177965 files and directories currently installed.)
Preparing to unpack .../0-liberror-perl_0.17025-1_all.deb ...
Unpacking liberror-perl (0.17025-1) ...
Selecting previously unselected package git-man.
Preparing to unpack .../1-git-man_1%3a2.17.1-1ubuntu0.8_all.deb ...
```

## Step 2 -> Install python packages

```
>> sudo apt-get -y install python-eventlet python-routes python-webob python-paramiko
```

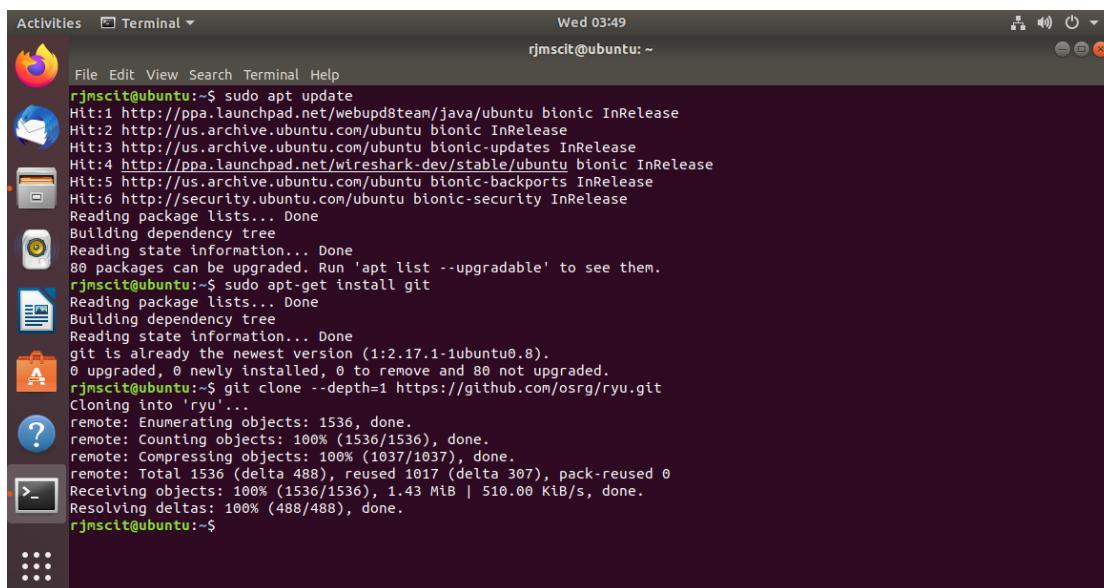


```
Activities Terminal Wed 03:48 rjmsclt@ubuntu:~  
File Edit View Search Terminal Help  
rjmsclt@ubuntu:~$ sudo apt-get -y install python-eventlet python-routes python-webob python-paramiko  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following additional packages will be installed:  
  python-greenlet python-pyasn1 python-repoze.lru python-simplejson  
Suggested packages:  
  python-eventlet-doc python-greenlet-doc python-greenlet-dev python-greenlet-dbg python-gssapi python-paste  
  python-webob-doc  
The following NEW packages will be installed:  
  python-eventlet python-greenlet python-paramiko python-pyasn1 python-repoze.lru python-routes python-simplejson  
  python-webob  
0 upgraded, 8 newly installed, 0 to remove and 80 not upgraded.  
Need to get 0 B/625 kB of archives.  
After this operation, 3,717 kB of additional disk space will be used.  
Selecting previously unselected package python-greenlet.  
(Reading database ... 179692 files and directories currently installed.)  
Preparing to unpack .../0-python-greenlet_0.4.12-2_amd64.deb ...  
Unpacking python-greenlet (0.4.12-2) ...  
Selecting previously unselected package python-eventlet.  
Preparing to unpack .../1-python-eventlet_0.20.0-4_all.deb ...  
Unpacking python-eventlet (0.20.0-4) ...  
Selecting previously unselected package python-pyasn1.  
Preparing to unpack .../2-python-pyasn1_0.4.2-3_all.deb ...  
Unpacking python-pyasn1 (0.4.2-3) ...  
Selecting previously unselected package python-paramiko.  
Preparing to unpack .../3-python-paramiko_2.0.0-1ubuntu1.2_all.deb ...  
Unpacking python-paramiko (2.0.0-1ubuntu1.2) ...  
Selecting previously unselected package python-repoze.lru.  
Preparing to unpack .../4-python-repoze.lru_0.7-1_all.deb
```

## Step 3 -> Clone RYU git Repo

```
>> sudo apt-get install git
```

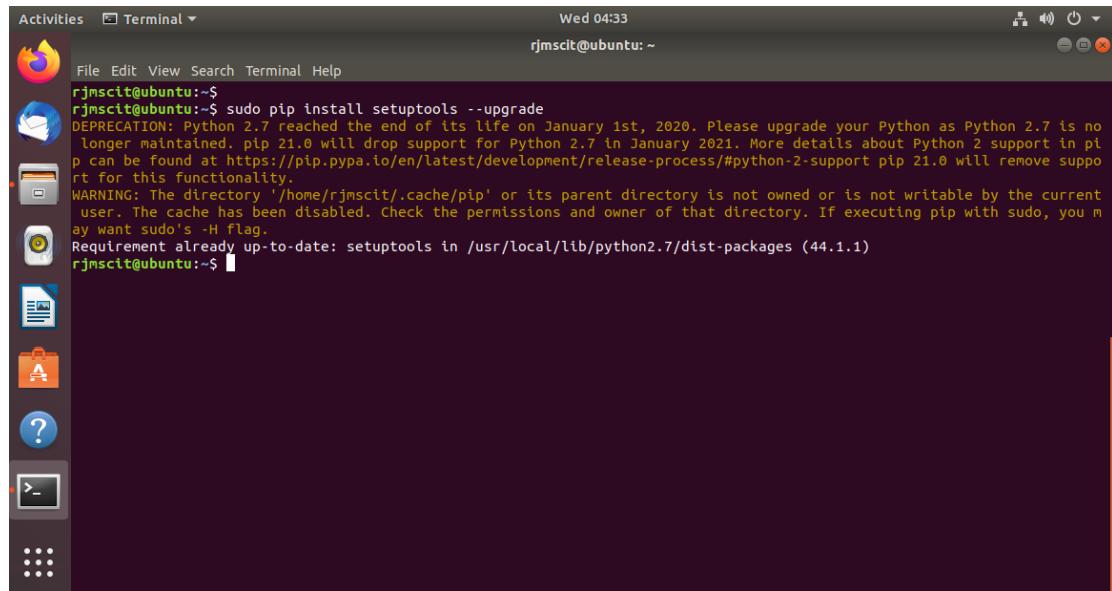
```
>> git clone --depth=1 https://github.com/osrg/ryu.git
```



```
Activities Terminal Wed 03:49 rjmsclt@ubuntu:~  
File Edit View Search Terminal Help  
rjmsclt@ubuntu:~$ sudo apt update  
Hit:1 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease  
Hit:2 http://archive.ubuntu.com/ubuntu bionic InRelease  
Hit:3 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease  
Hit:4 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic InRelease  
Hit:5 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease  
Hit:6 http://security.ubuntu.com/ubuntu bionic-security InRelease  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
80 packages can be upgraded. Run 'apt list --upgradable' to see them.  
rjmsclt@ubuntu:~$ sudo apt-get install git  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
git is already the newest version (1:2.17.1-1ubuntu0.8).  
0 upgraded, 0 newly installed, 0 to remove and 80 not upgraded.  
rjmsclt@ubuntu:~$ git clone --depth=1 https://github.com/osrg/ryu.git  
Cloning into 'ryu'...  
remote: Enumerating objects: 1536, done.  
remote: Counting objects: 100% (1536/1536), done.  
remote: Compressing objects: 100% (1037/1037), done.  
remote: Total 1536 (delta 488), reused 1017 (delta 307), pack-reused 0  
Receiving objects: 100% (1536/1536), 1.43 MiB | 510.00 KiB/s, done.  
Resolving deltas: 100% (488/488), done.  
rjmsclt@ubuntu:~$
```

## Step 4 -> Install RYU

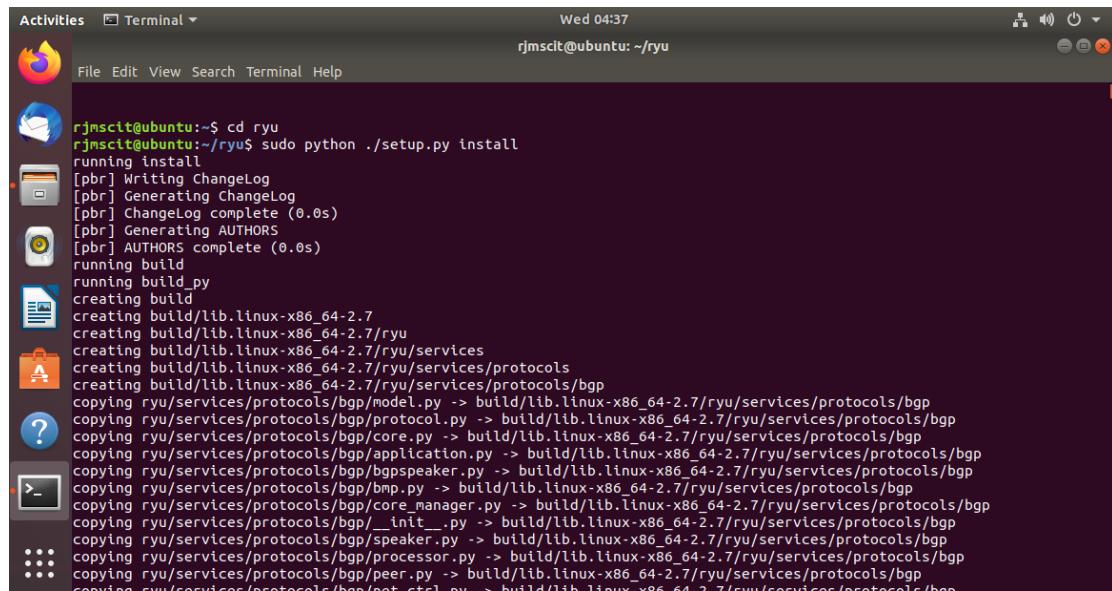
>> sudo pip install setuptools --upgrade



```
Activities Terminal Wed 04:33
rjmscitt@ubuntu:~$ sudo pip install setuptools --upgrade
DEPRECATION: Python 2.7 reached the end of its life on January 1st, 2020. Please upgrade your Python as Python 2.7 is no
longer maintained. pip 21.0 will drop support for Python 2.7 in January 2021. More details about Python 2 support in pi
p can be found at https://pip.pypa.io/en/latest/development/release-process/#python-2-support pip 21.0 will remove suppo
rt for this functionality.
WARNING: The directory '/home/rjmscitt/.cache/pip' or its parent directory is not owned or is not writable by the current
user. The cache has been disabled. Check the permissions and owner of that directory. If executing pip with sudo, you m
ay want sudo's -H flag.
Requirement already up-to-date: setuptools in /usr/local/lib/python2.7/dist-packages (44.1.1)
rjmscitt@ubuntu: $
```

>> cd ryu

>> sudo python ./setup.py install



```
Activities Terminal Wed 04:37
rjmscitt@ubuntu:~/ryu$ cd ryu
rjmscitt@ubuntu:~/ryu$ sudo python ./setup.py install
running install
[pbr] Writing ChangeLog
[pbr] Generating ChangeLog
[pbr] ChangeLog complete (0.0s)
[pbr] Generating AUTHORS
[pbr] AUTHORS complete (0.0s)
running build
running build_py
creating build
creating build/lib.linux-x86_64-2.7
creating build/lib.linux-x86_64-2.7/ryu
creating build/lib.linux-x86_64-2.7/ryu/services
creating build/lib.linux-x86_64-2.7/ryu/services/protocols
creating build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/model.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/protocol.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/core.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/application.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/bgpspeaker.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/bmp.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/core_manager.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/_init_.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/speaker.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/processor.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/peer.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
copying ryu/services/protocols/bgp/act_ctrl.py -> build/lib.linux-x86_64-2.7/ryu/services/protocols/bgp
```

```

Activities Terminal ▾
Wed 04:37
rjmscitr@ubuntu: ~/ryu
File Edit View Search Terminal Help
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/app/simple_switch_15.py to simple_switch_15.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/app/wsgi.py to wsgi.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/app/ofctl_rest.py to ofctl_rest.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/contrib/_init_.py to __init__.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/topology/switches.py to switches.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/topology/api.py to api.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/topology/dumper.py to dumper.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/topology/_init_.py to __init__.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/topology/event.py to event.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/base/app_manager.py to app_manager.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/base/_init_.py to __init__.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/hooks.py to hooks.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/flags.py to flags.pyc
byte-compiling /usr/local/lib/python2.7/dist-packages/ryu/cfg.py to cfg.pyc
running install_data
copying etc/ryu/ryu.conf -> /usr/local/etc/ryu
running install_egg_info
removing '/usr/local/lib/python2.7/dist-packages/ryu-4.34-py2.7.egg-info' (and everything under it)
Copying ryu.egg-info to /usr/local/lib/python2.7/dist-packages/ryu-4.34-py2.7.egg-info
running install_scripts
/usr/local/lib/python2.7/dist-packages/setuptools/command/easy_install.py:2088: EasyInstallDeprecationWarning: Use get_args
warnings.warn("Use get_args", EasyInstallDeprecationWarning)
/usr/local/lib/python2.7/dist-packages/setuptools/command/easy_install.py:2090: EasyInstallDeprecationWarning: Use get_header
    header = cls.get_script_header("", executable, wininst)
Installing ryu-manager script to /usr/local/bin
Installing ryu script to /usr/local/bin
rjmscitr@ubuntu:~/ryu$ █

```

## Step 5 -> Install and Update python packages

**>> sudo pip install six –upgrade**

**>> sudo pip install oslo.config msgpack-python**

**>> sudo pip install eventlet –upgrade**

```

Activities Terminal ▾
Wed 04:41
rjmscitr@ubuntu: ~/ryu
File Edit View Search Terminal Help
header = cls.get_script_header("", executable, wininst)
Installing ryu-manager script to /usr/local/bin
Installing ryu script to /usr/local/bin
rjmscitr@ubuntu:~/ryu$ sudo pip install six --upgrade
DEPRECATION: Python 2.7 reached the end of its life on January 1st, 2020. Please upgrade your Python as Python 2.7 is no
longer maintained. pip 21.0 will drop support for Python 2.7 in January 2021. More details about Python 2 support in pi
p can be found at https://pip.pypa.io/en/latest/development/release-process/#python-2-support pip 21.0 will remove suppo
rt for this functionality.
WARNING: The directory '/home/rjmscitr/.cache/pip' or its parent directory is not owned or is not writable by the current
user. The cache has been disabled. Check the permissions and owner of that directory. If executing pip with sudo, you m
ay want sudo's -H flag.
Requirement already up-to-date: six in /usr/local/lib/python2.7/dist-packages (1.15.0)
rjmscitr@ubuntu:~/ryu$ sudo pip install oslo.config msgpack-python
No handlers could be found for logger "pyp._internal.network.auth"
DEPRECATION: Python 2.7 reached the end of its life on January 1st, 2020. Please upgrade your Python as Python 2.7 is no
longer maintained. pip 21.0 will drop support for Python 2.7 in January 2021. More details about Python 2 support in pi
p can be found at https://pip.pypa.io/en/latest/development/release-process/#python-2-support pip 21.0 will remove suppo
rt for this functionality.
WARNING: The directory '/home/rjmscitr/.cache/pip' or its parent directory is not owned or is not writable by the current
user. The cache has been disabled. Check the permissions and owner of that directory. If executing pip with sudo, you m
ay want sudo's -H flag.
Requirement already satisfied: oslo.config in /usr/local/lib/python2.7/dist-packages (7.0.0)
Requirement already satisfied: msgpack-python in /usr/local/lib/python2.7/dist-packages (0.5.6)
Requirement already satisfied: netaddr>=0.7.18 in /usr/local/lib/python2.7/dist-packages (from oslo.config) (0.8.0)
Requirement already satisfied: oslo.i18n>=3.15.3 in /usr/local/lib/python2.7/dist-packages (from oslo.config) (3.25.1)
Requirement already satisfied: stevedore>=1.20.0 in /usr/local/lib/python2.7/dist-packages (from oslo.config) (1.32.0)
Requirement already satisfied: six>=1.10.0 in /usr/local/lib/python2.7/dist-packages (from oslo.config) (1.15.0)
Requirement already satisfied: debtcollector>=1.2.0 in /usr/local/lib/python2.7/dist-packages (from oslo.config) (1.22.0)
Requirement already satisfied: ffc3986>=1.2.0 in /usr/local/lib/python2.7/dist-packages (from oslo.config) (1.4.0)

```

```

Activities Terminal ▾ Wed 04:42
rjmscitt@ubuntu: ~/ryu$ sudo pip install eventlet --upgrade
DEPRECATION: Python 2.7 reached the end of its life on January 1st, 2020. Please upgrade your Python as Python 2.7 is no
longer maintained. pip 21.0 will drop support for Python 2.7 in January 2021. More details about Python 2 support in pi
p can be found at https://pip.pypa.io/en/latest/development/release-process/#python-2-support pip 21.0 will remove suppo
rt for this functionality.
WARNING: The directory '/home/rjmscitt/.cache/pip' or its parent directory is not owned or is not writable by the current
user. The cache has been disabled. Check the permissions and owner of that directory. If executing pip with sudo, you m
ay want sudo's -H flag.
Collecting eventlet
  Downloading eventlet-0.30.2-py2.py3-none-any.whl (224 kB)
Requirement already satisfied, skipping upgrade: monotonic>=1.4; python_version < "3.5" in /usr/local/lib/python2.7/dist
-packages (from eventlet) (1.6)
Requirement already satisfied, skipping upgrade: greenlet>=0.3 in /usr/local/lib/python2.7/dist-packages (from eventlet)
(1.0.0)
Requirement already satisfied, skipping upgrade: six>=1.10.0 in /usr/local/lib/python2.7/dist-packages (from eventlet) (
1.15.0)
Requirement already satisfied, skipping upgrade: dnspython<2.0.0,>=1.15.0 in /usr/local/lib/python2.7/dist-packages (fro
m eventlet) (1.16.0)
Installing collected packages: eventlet
  Attempting uninstall: eventlet
    Found existing installation: eventlet 0.30.1
    Uninstalling eventlet-0.30.1:
      Successfully uninstalled eventlet-0.30.1
ERROR: pip's legacy dependency resolver does not consider dependency conflicts when selecting packages. This behaviour i
s the source of the following dependency conflicts.
ryu 4.34 requires eventlet==0.30.1, but you'll have eventlet 0.30.2 which is incompatible.
Successfully installed eventlet-0.30.2
rjmscitt@ubuntu:~/ryu$ 

```

## Step 6 -> Test ryu-manager

>>sudo pip install -r tools/pip-requirements

```

Activities Terminal ▾ Wed 04:43
rjmscitt@ubuntu: ~/ryu$ 
File Edit View Search Terminal Help
s is the source of the following dependency conflicts.
ryu 4.34 requires eventlet==0.30.1, but you'll have eventlet 0.30.2 which is incompatible.
Successfully installed eventlet-0.30.2
rjmscitt@ubuntu:~/ryu$ sudo pip install -r tools/pip-requirements
DEPRECATION: Python 2.7 reached the end of its life on January 1st, 2020. Please upgrade your Python as Python 2.7 is no
longer maintained. pip 21.0 will drop support for Python 2.7 in January 2021. More details about Python 2 support in pi
p can be found at https://pip.pypa.io/en/latest/development/release-process/#python-2-support pip 21.0 will remove suppo
rt for this functionality.
WARNING: The directory '/home/rjmscitt/.cache/pip' or its parent directory is not owned or is not writable by the current
user. The cache has been disabled. Check the permissions and owner of that directory. If executing pip with sudo, you m
ay want sudo's -H flag.
Requirement already satisfied: pip==20.3.4 in /usr/local/lib/python2.7/dist-packages (from -r tools/..../pip-requirements.
txt (line 1)) (20.3.4)
Collecting eventlet==0.30.1
  Downloading eventlet-0.30.1-py2.py3-none-any.whl (224 kB)
Requirement already satisfied: msgpack>=0.4.0 in /usr/local/lib/python2.7/dist-packages (from -r tools/pip-requirements (lin
e 6)) (1.0.2)
Requirement already satisfied: netaddr in /usr/local/lib/python2.7/dist-packages (from -r tools/pip-requirements (line 7)) (0
.8.0)
Requirement already satisfied: oslo.config>=2.5.0 in /usr/local/lib/python2.7/dist-packages (from -r tools/pip-requirements
(line 8)) (7.0.0)
Requirement already satisfied: ovs>=2.6.0 in /usr/local/lib/python2.7/dist-packages (from -r tools/pip-requirements (line 9))
(2.13.3)
Requirement already satisfied: routes in /usr/lib/python2.7/dist-packages (from -r tools/pip-requirements (line 10)) (2.4.1)
Requirement already satisfied: six>=1.4.0 in /usr/local/lib/python2.7/dist-packages (from -r tools/pip-requirements (line 11))
(1.15.0)
Requirement already satisfied: tinyrpc==0.9.4 in /usr/local/lib/python2.7/dist-packages (from -r tools/pip-requirements (lin
e 12)) (0.9.4)
Requirement already satisfied: webob>=1.2 in /usr/lib/python2.7/dist-packages (from -r tools/pip-requirements (line 13)) (1

```

>> sudo python setup.py install

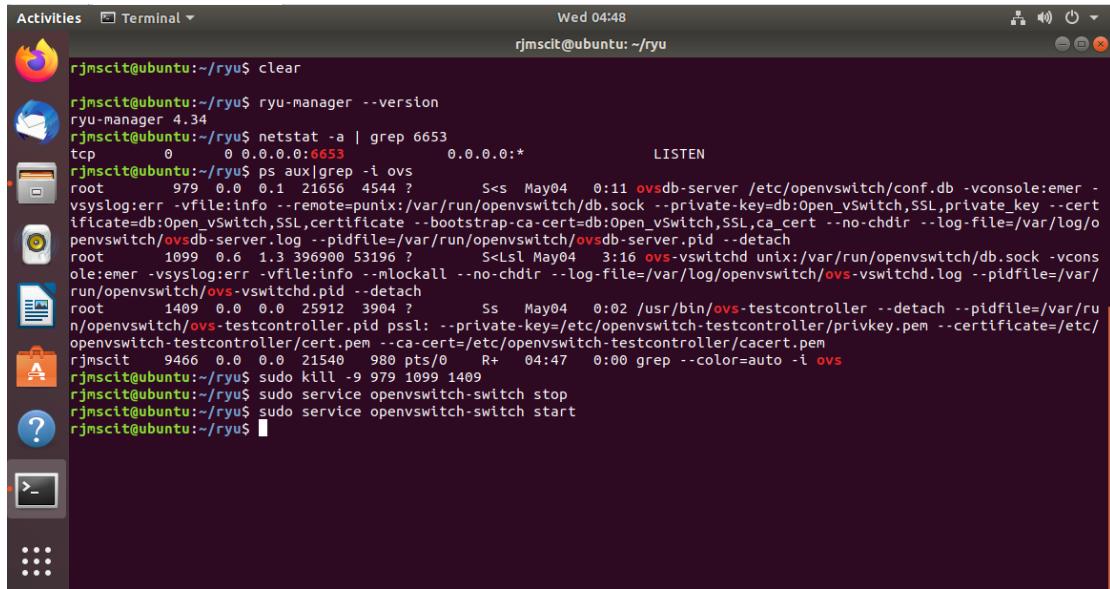
```
Activities Terminal ▾ Wed 04:43
rjmscit@ubuntu:~/ryu$ sudo python setup.py install
running install
[pbr] Writing ChangeLog
[pbr] Generating ChangeLog
[pbr] ChangeLog complete (0.0s)
[pbr] Generating AUTHORS
[pbr] AUTHORS complete (0.0s)
running build
running build_py
running egg_info
writing requirements to ryu.egg-info/requirements.txt
writing ryu.egg-info/PKG-INFO
writing top-level names to ryu.egg-info/top_level.txt
writing dependency links to ryu.egg-info/dependency_links.txt
writing entry points to ryu.egg-info/entry_points.txt
writing pbr to ryu.egg-info/pbr.json
[pbr] Processing SOURCES.txt
[pbr] In git context, generating filelist from git
warning: no previously-included files found matching '.gitreview'
warning: no previously-included files matching '*.pyc' found anywhere in distribution
reading manifest template 'MANIFEST.in'
warning: no previously-included files matching '*' found under directory 'doc/build'
warning: no previously-included files matching '*' found anywhere in distribution
warning: no previously-included files matching '*.pyc' found anywhere in distribution
warning: no previously-included files matching '.gitignore' found anywhere in distribution
writing manifest file 'ryu.egg-info/SOURCES.txt'
running install_lib
running install_data
running install_egg_info
removing '/usr/local/lib/python2.7/dist-packages/ryu-4.34-py2.7.egg-info' (and everything under it)
```

>> ryu-manager --version

```
Activities Terminal ▾ Wed 04:45
rjmscit@ubuntu:~/ryu$ ryu-manager --version
ryu-manager 4.34
rjmscit@ubuntu:~/ryu$
```

As we already perform OVS/ODL practical therefore ports are already in use, we need to kill them,

```
>> netstat -a | grep 6653
>> ps aux|grep -i ovs
>> sudo kill -9 970 1029 1223 11131
>> sudo service openvswitch-switch stop
>> sudo service openvswitch-switch start
```



```

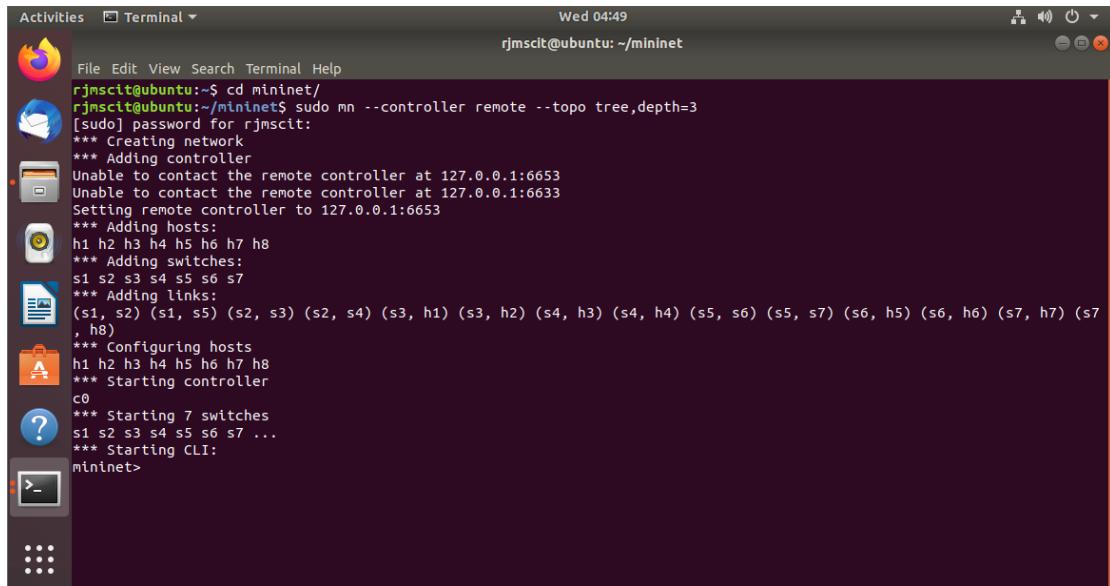
Activities Terminal ▾ Wed 04:48
rjmscit@ubuntu:~/ryu$ clear
rjmscit@ubuntu:~/ryu$ ryu-manager --version
ryu-manager 4.34
rjmscit@ubuntu:~/ryu$ netstat -a | grep 6653
tcp        0      0 0.0.0.0:6653          0.0.0.0:*
                                              LISTEN
rjmscit@ubuntu:~/ryu$ ps aux|grep -i ovs
root      979  0.1 21656 4544 ?        Ss May04  0:11 ovsdb-server /etc/openvswitch/conf.db -vconsole:emer -
vsyslog:err -vfile:info --remote=punix:/var/run/openvswitch/db.sock -private-key=db:Open_vswitch,SSL,private_key --cert
ificate=db:Open_vswitch,SSL,certificate --bootstrap-ca-cert=db:Open_vswitch,SSL,ca_cert --no-chdir --log-file=/var/log/o
penvswitch/ovsdb-server.log --pidfile=/var/run/openvswitch/ovsdb-server.pid --detach
root     1099  0.6 1.3 396900 53196 ?      S<Sl May04  3:16 ovs-vswitchd unix:/var/run/openvswitch/db.sock -vcons
ole:emer -vsyslog:err -vfile:info --mlockall --no-chdir --log-file=/var/log/openvswitch/ovs-vswitchd.log --pidfile=/var/
run/openvswitch/ovs-vswitchd.pid --detach
root     1409  0.0 25912 3904 ?        Ss May04  0:02 /usr/bin/ovs-testcontroller --detach --pidfile=/var/ru
n/openvswitch/ovs-testcontroller.pid pssl: --private-key=/etc/openvswitch-testcontroller/privkey.pem --certificate=/etc/
openvswitch-testcontroller/cert.pem --ca-cert=/etc/openvswitch-testcontroller/cacert.pem
rjmscit  9466  0.0 21540   980 pts/0    R+   04:47 0:00 grep --color=auto -i ovs
rjmscit@ubuntu:~/ryu$ sudo kill -9 979 1099 1409
rjmscit@ubuntu:~/ryu$ sudo service openvswitch-switch stop
rjmscit@ubuntu:~/ryu$ sudo service openvswitch-switch start
rjmscit@ubuntu:~/ryu$ 

```

## **Topology Viewer**

**Run mininet in new terminal (or join your real environment):**

**>> sudo mn --controller remote --topo tree,depth=3**



```

Activities Terminal ▾ Wed 04:49
rjmscit@ubuntu:~/mininet$ File Edit View Search Terminal Help
rjmscit@ubuntu:~/mininet$ cd mininet/
rjmscit@ubuntu:~/mininet$ sudo mn --controller remote --topo tree,depth=3
[sudo] password for rjmscit:
*** 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 h4 h5 h6 h7 h8
*** Adding switches:
s1 s2 s3 s4 s5 s6 s7
*** Adding links:
(s1, s2) (s1, s5) (s2, s3) (s2, s4) (s3, h1) (s3, h2) (s4, h3) (s4, h4) (s5, s6) (s5, s7) (s6, h5) (s6, h6) (s7, h7) (s7, h8)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
c0
*** Starting 7 switches
s1 s2 s3 s4 s5 s6 s7 ...
*** Starting CLI:
mininet>

```

**>> PYTHONPATH=. ./bin/ryu run --observe-links ryu/app/gui\_topology/gui\_topology.py**

```

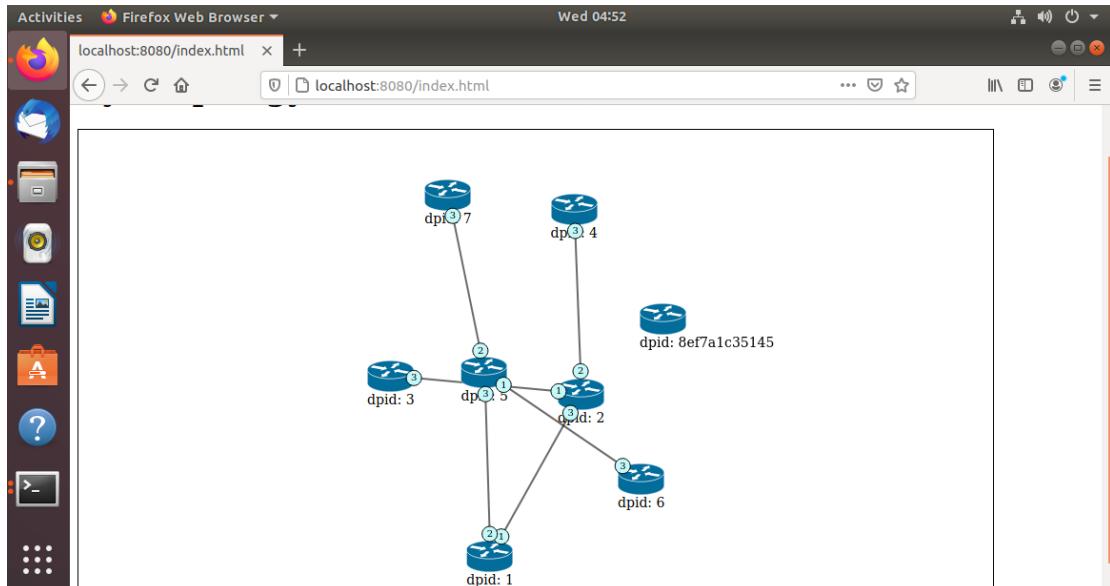
Activities Terminal ▾ Wed 04:50
rjmscitr@ubuntu:~/ryu
vsyslog:err -vfile:info --remote=punix:/var/run/openvswitch/db.sock --private-key=db:Open_vSwitch,SSL,private_key --certificate=db:Open_vSwitch,SSL,certificate --bootstrap-ca-cert=db:Open_vSwitch,SSL,ca_cert --no-chdir --log-file=/var/log/o
penvswitch/ovsdb-server.log --pidfile=/var/run/openvswitch/ovsdb-server.pid --detach
root      1099  0.6  1.3 396900 53196 ?          S<Ls May04  3:16 ovs-vswitchd unix:/var/run/openvswitch/db.sock -vcons
ole:emr -vsyslog:err -vfile:info --mlockall --no-chdir --log-file=/var/log/openvswitch/ovs-vswitchd.log --pidfile=/var/
run/openvswitch/ovs-vswitchd.pid --detach
root      1409  0.0  0.0 25912 3904 ?          Ss May04  0:02 /usr/bin/ovs-testcontroller --detach --pidfile=/var/
run/openvswitch/ovs-testcontroller.pid pssl: --private-key=/etc/openvswitch-testcontroller/privkey.pem --certificate=/etc/
openvswitch-testcontroller/cert.pem --ca-cert=/etc/openvswitch-testcontroller/cacert.pem
rjmscitr  9466  0.0  0.0 21540  980 pts/0   R+  04:47  0:00 grep --color=auto -i ovs
rjmscitr@ubuntu:~/ryu$ sudo kill -9 979 1099 1409
rjmscitr@ubuntu:~/ryu$ sudo service openvswitch-switch stop
rjmscitr@ubuntu:~/ryu$ sudo service openvswitch-switch start
rjmscitr@ubuntu:~/ryu$ PYTHONPATH=. ./bin/ryu run --observe-links ryu/app/gui_topology/gui_topology.py
loading app ryu/app/gui_topology/gui_topology.py
loading app ryu.app.rest_topology
loading app ryu.app.ws_topology
loading app ryu.app.ofctl_rest
loading app ryu.controller.ofp_handler
instantiating app None of Switches
creating context switches
instantiating app None of DPSet
creating context dpset
creating context wsq
instantiating app ryu.app.rest_topology of TopologyAPI
instantiating app ryu.app.ws_topology of WebSocketTopology
instantiating app ryu.app.ofctl_rest of RestStatsApi
instantiating app ryu.controller.ofp_handler of OFPHandler
instantiating app ryu/app/gui_topology/gui_topology.py of GUIServerApp
(10280) wsgi starting up on http://0.0.0.0:8080

```

**Now open Mozilla and run below URL:**

>> **localhost:8080/index.html**

**Output:**



## PRACTICAL NO: 07

### Aim: Install floodlight on Ubuntu

Floodlight Controller is an SDN Controller developed by an open community of developers, many of which from Big Switch Networks, that uses with the OpenFlow protocol to orchestrate traffic flows in a software-defined networking (SDN) environment. OpenFlow is one of the first and most widely used SDN standards; it defines the open communications protocol in an SDN environment that allows the SDN Controller (brains of the network) to speak to the forwarding plane (switches, routers, etc.) to make changes to the network.

The SDN Controller is responsible for maintaining all of the network rules and providing the necessary instructions to the underlying infrastructure on how traffic should be handled. This enables businesses to better adapt to their changing needs and have better control over their networks.

The Floodlight Controller can be advantageous for developers because it offers them the ability to easily adapt software and develop applications and is written in Java. Included are representational state transfer application program interfaces (REST APIs) that make it easier to program interface with the product, and the Floodlight website offers coding examples that aid developers in building the product.

Tested with both physical and virtual OpenFlow-compatible switches, the Floodlight Controller can work in a variety of environments and can coincide with what businesses already have at their disposal. It can also support networks where groups of OpenFlow-compatible switches are connected through traditional, non-OpenFlow switches.

The Floodlight Controller is compatible with OpenStack, a set of software tools that help build and manage cloud computing platforms for both public and private clouds. Floodlight can be run as the network backend for OpenStack using a Neutron plugin that exposes a networking-as-a-service model with a REST API that Floodlight offers.

### Floodlight Controller:

The Floodlight Open SDN Controller is an enterprise-class, Apache-licensed, Java- based OpenFlow Controller and intended to run with standard JDK tools and ant.

### Highlights:

- Easy to set up with minimal dependencies
- Supports a broad range of virtual and physical OpenFlow switches
- Can handle mixed OpenFlow and non- OpenFlow networks.
- It can manage multiple “islands” of OpenFlow hardware switches
- Designed to be high-performance

## Installation:

### ***Prerequisites:***

- Java development kit
    - JDK 8 for Floodlight master and above
    - JDK 7 for Floodlight v1.2 and below
  - Ant to build
  - Python development package

-To download dependencies for Floodlight master and above:

```
>> sudo apt-get install build-essential ant maven python-dev
```

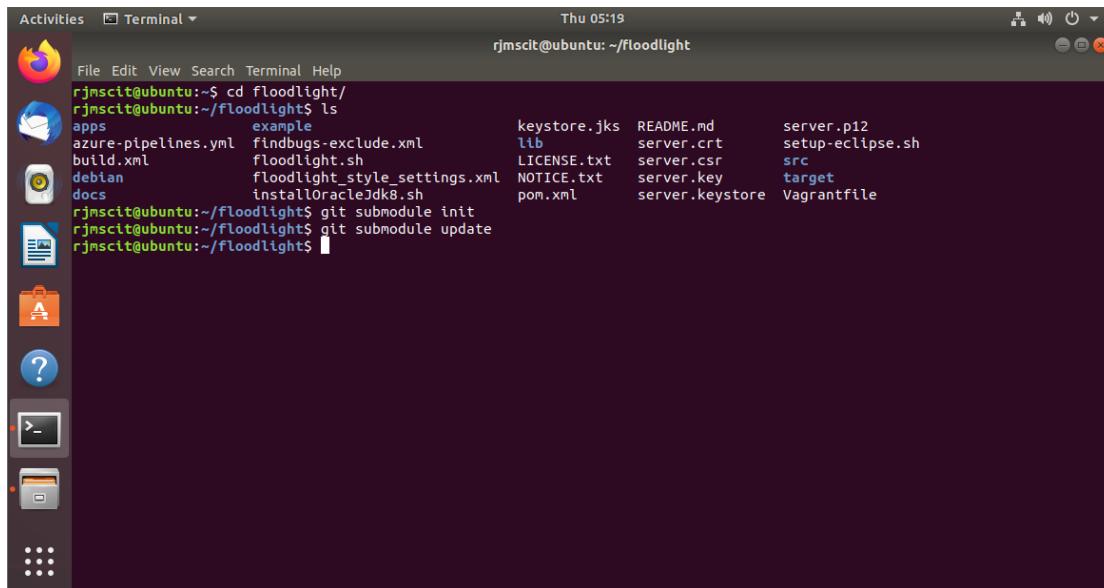
Activities Terminal ▾ Wed 08:49  
Firefox Web Browser Terminal Help rjmsc1@ubuntu: ~

```
rjmsc1@ubuntu:~$ sudo apt-get install build-essential ant maven python-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
build-essential is already the newest version (12.4ubuntu1).
build-essential set to manually installed.
python-dev is already the newest version (2.7.15~rc1-1).
The following additional packages will be installed:
  ant-optimal.libcassandra-alliance.java libapache-pom.java libatinject-jsr330-api.java libcdi-api.java libcommons-cli.java
  libcommons-io.java libcommons-lang3.java libcommons-parent.java libgeronimo-annotation-1.3-spec.java
  libgeronimo-interceptor-3.0-spec.java libguava.java libguice.java libhawtjni-runtime.java libjansi.java
  libjansi-native.java libjsr305.java libmaven-parent.java libmaven-resolver.java libmaven-shared-utils.java
  libmaven3-core.java libplexus-cipher.java libplexus-classworlds.java libplexus-component-annotations.java
  libplexus-interpolation.java libplexus-sec-dispatcher.java libplexus-utils2.java libstisu-inject.java
  libstisu-plexus.java libstif4j.java libwagon-file.java libwagon-http-shaded.java libwagon-provider-api.java
Suggested packages:
  ant-doc antlr javacc junit junit4 python libactivation-java libbccel-java libbsf-java libcommons-logging-java
  libcommons-net-java libmail-java libjaxp1.3-java libjdepend-java libjsch-java liblog4j1.2-java liboro-java
  libregexp-java libxalan2-java libxml1-commons-resolver1.1-java libbz2-java libcassandra-alliance-java-doc
  libatinject-jsr330-api.java-doc libservlet3.1-java libcommons-io.java-doc libcommons-lang3.java-doc libasm-java
  libcglib-java libjsr305.java-doc libmaven-shared-utils.java-doc liblogback-java libplexus-cipher.java-doc
  libplexus-classworlds.java-doc libplexus-interpolation.java-doc libplexus-sec-dispatcher.java-doc
  libplexus-utils2.java-doc testing
The following NEW packages will be installed:
  ant ant-optimal.libcassandra-alliance.java libapache-pom.java libatinject-jsr330-api.java libcdi-api.java
  libcommons-cli.java libcommons-io.java libcommons-lang3.java libcommons-parent.java
  libgeronimo-annotation-1.3-spec.java libgeronimo-interceptor-3.0-spec.java libguava.java libguice.java
  libhawtjni-runtime.java libjansi.java libjansi-native.java libjsr305.java libmaven-parent.java
  libmaven-resolver.java libmaven-shared-utils.java libmaven3-core.java libplexus-cipher.java
  libplexus-classworlds.java libplexus-component-annotations.java libplexus-interpolation.java
```

```
Activities Terminal Wed 08:54
rjmscit@ubuntu: ~

File Edit View Search Terminal Help
Setting up libaopalliance-java (20070526-6) ...
Setting up libgeronimo-annotation-1.3-spec-java (1.0-1) ...
Setting up libcommons-cli-java (1.4-1) ...
Setting up libplexus-sec-dispatcher-java (1.4-3) ...
Setting up libjansi-java (1.16-1) ...
Setting up ant-optional (1.10.5-3~18.04) ...
Setting up libguava-java (19.0-1) ...
Setting up libwagon-file-java (3.0.0-2) ...
Setting up libcommons-parent-java (43-1) ...
Setting up libcdi-api-java (1.2-2) ...
Setting up libcommons-lang3-java (3.8-1~18.04.2) ...
Setting up libcommons-io-java (2.6-2) ...
Setting up libguice-java (4.0-4) ...
Setting up libmaven-shared-utils-java (3.3.0-1~18.04) ...
Setting up libisu-inject-java (0.3.2-2) ...
Setting up libisu-plexus-java (0.3.3-3) ...
Setting up libmaven3-core-java (3.6.0-1~18.04.1) ...
Setting up maven (3.6.0-1~18.04.1) ...
update-alternatives: using /usr/share/maven/bin/mvn to provide /usr/bin/mvn (mvn) in auto mode
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
rjmscit@ubuntu:~$ sudo git clone git://github.com/floodlight/floodlight.git
Cloning into 'floodlight'...
remote: Enumerating objects: 52975, done.
remote: Counting objects: 100% (18/18), done.
remote: Compressing objects: 100% (8/8), done.
remote: Total 52975 (delta 12), reused 10 (delta 10), pack-reused 52957
Receiving objects: 100% (52975/52975), 384.02 MiB | 1.75 MiB/s, done.
Resolving deltas: 100% (34324/34324), done.
rjmscit@ubuntu:~$
```

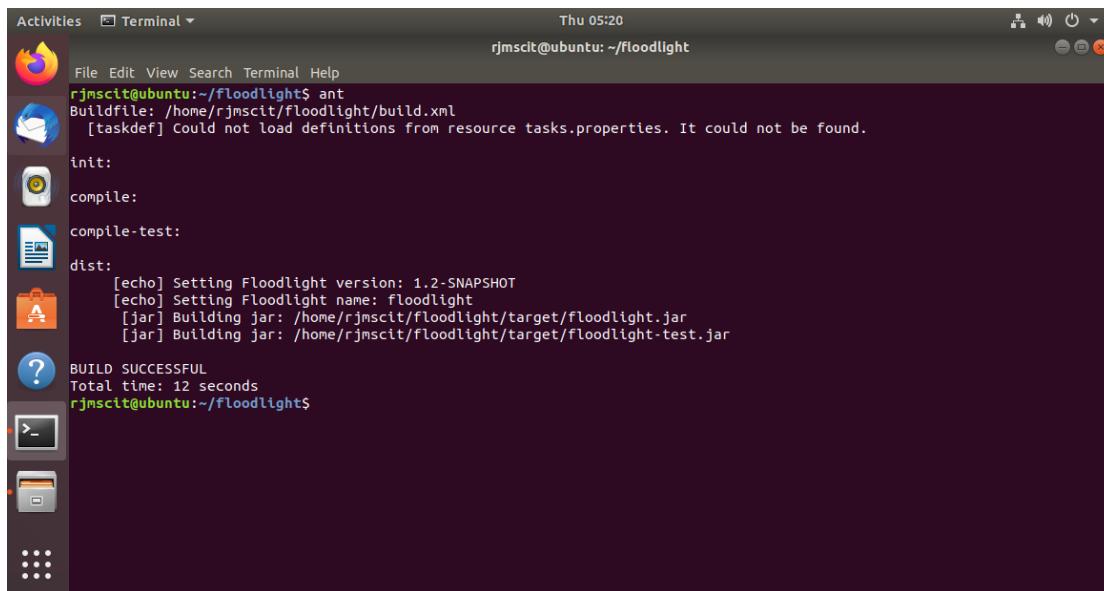
```
>> cd floodlight  
>> git submodule init  
>> git submodule update
```



A screenshot of a Linux desktop environment showing a terminal window. The terminal title is "Terminal". The command history shows:

```
rjmscit@ubuntu:~/floodlight$ cd floodlight/  
rjmscit@ubuntu:~/floodlight$ ls  
apps example keystore.jks README.md server.p12  
azure-pipelines.yml findbugs-exclude.xml lib server.crt setup-eclipse.sh  
build.xml floodlight.sh LICENSE.txt server.csr src  
debian floodlight_style_settings.xml NOTICE.txt server.key target  
docs installOracleJdk8.sh pom.xml server.keystore Vagrantfile  
rjmscit@ubuntu:~/floodlight$ git submodule init  
rjmscit@ubuntu:~/floodlight$ git submodule update  
rjmscit@ubuntu:~/floodlight$
```

```
>> ant
```



A screenshot of a Linux desktop environment showing a terminal window. The terminal title is "Terminal". The command history shows:

```
rjmscit@ubuntu:~/floodlight$ ant  
Buildfile: /home/rjmscit/floodlight/build.xml  
[taskdef] Could not load definitions from resource tasks.properties. It could not be found.  
  
init:  
compile:  
compile-test:  
dist:  
[echo] Setting Floodlight version: 1.2-SNAPSHOT  
[echo] Setting Floodlight name: floodlight  
[jar] Building jar: /home/rjmscit/floodlight/target/floodlight.jar  
[jar] Building jar: /home/rjmscit/floodlight/target/floodlight-test.jar  
  
BUILD SUCCESSFUL  
Total time: 12 seconds  
rjmscit@ubuntu:~/floodlight$
```

```
>> sudo mkdir /var/lib/floodlight  
>> sudo chmod 777 /var/lib/floodlight  
>> cd /home/floodlight/  
>> java -jar target/floodlight.jar
```

```

Activities Terminal Thu 05:30
rjmscit@ubuntu: ~/floodlight

File Edit View Search Terminal Help
azule-pipelines.yml findbugs-exclude.xml lib server.crt setup-eclipse.sh
build.xml floodlight.sh LICENSE.txt server.csr src
debian floodlight_style_settings.xml NOTICE.txt server.key target
docs installOracleJdk8.sh pom.xml server.keystore Vagrantfile
rjmscit@ubuntu:~/floodlight$ sudo mkdir /var/lib/floodlight
rjmscit@ubuntu:~/floodlight$ sudo chmod 777 /var/lib/floodlight
rjmscit@ubuntu:~/floodlight$ cd /home/floodlight/
bash: cd: /home/floodlight/: No such file or directory
rjmscit@ubuntu:~/floodlight$ cd /home/rjmscit/
rjmscit@ubuntu:~/floodlight$ java -jar target/floodlight.jar
2021-05-06 05:28:54.334 INFO [n.f.c.m.FloodlightModuleLoader] Loading modules from src/main/resources/floodlightdefault.properties
2021-05-06 05:28:54.496 WARN [n.f.r.RestApiServer] HTTPS disabled; HTTPS will not be used to connect to the REST API.
2021-05-06 05:28:54.496 WARN [n.f.r.RestApiServer] HTTP enabled; Allowing unsecure access to REST API on port 8080.
2021-05-06 05:28:54.496 WARN [n.f.r.RestApiServer] CORS access control allow ALL origins: true
2021-05-06 05:28:54.673 WARN [n.f.c.i.OFSwitchManager] SSL disabled. Using unsecure connections between Floodlight and switches.
2021-05-06 05:28:54.674 INFO [n.f.c.i.OFSwitchManager] Clear switch flow tables on initial handshake as master: TRUE
2021-05-06 05:28:54.674 INFO [n.f.c.i.OFSwitchManager] Clear switch flow tables on each transition to master: TRUE
2021-05-06 05:28:54.674 INFO [n.f.c.i.OFSwitchManager] Setup default rules for all tables on switch connect: true
2021-05-06 05:28:54.679 INFO [n.f.c.i.OFSwitchManager] Setting 0x1 as the default max tables to receive table-miss flow
2021-05-06 05:28:54.720 INFO [n.f.c.i.OFSwitchManager] OpenFlow version OF_15 will be advertised to switches. Supported fallback versions [OF_10, OF_11, OF_12, OF_13, OF_14, OF_15]
2021-05-06 05:28:54.722 INFO [n.f.c.i.OFSwitchManager] Listening for OpenFlow switches on [0.0.0.0]:6653
2021-05-06 05:28:54.722 INFO [n.f.c.i.OFSwitchManager] Openflow socket config: 1 boss thread(s), 16 worker thread(s), 6000 ms TCP connection timeout, max 1000 connection backlog, 4194304 byte TCP send buffer size
2021-05-06 05:28:54.724 INFO [n.f.c.i.Controller] ControllerId set to 1
2021-05-06 05:28:54.724 INFO [n.f.c.i.Controller] Shutdown when controller transitions to STANDBY HA role: true
2021-05-06 05:28:54.724 WARN [n.f.c.i.Controller] Controller will automatically deserialize all Ethernet packet in mass

```

>> sudo mn --controller=remote,ip=103.242.117.180,port=6653 --topo=single,3

```

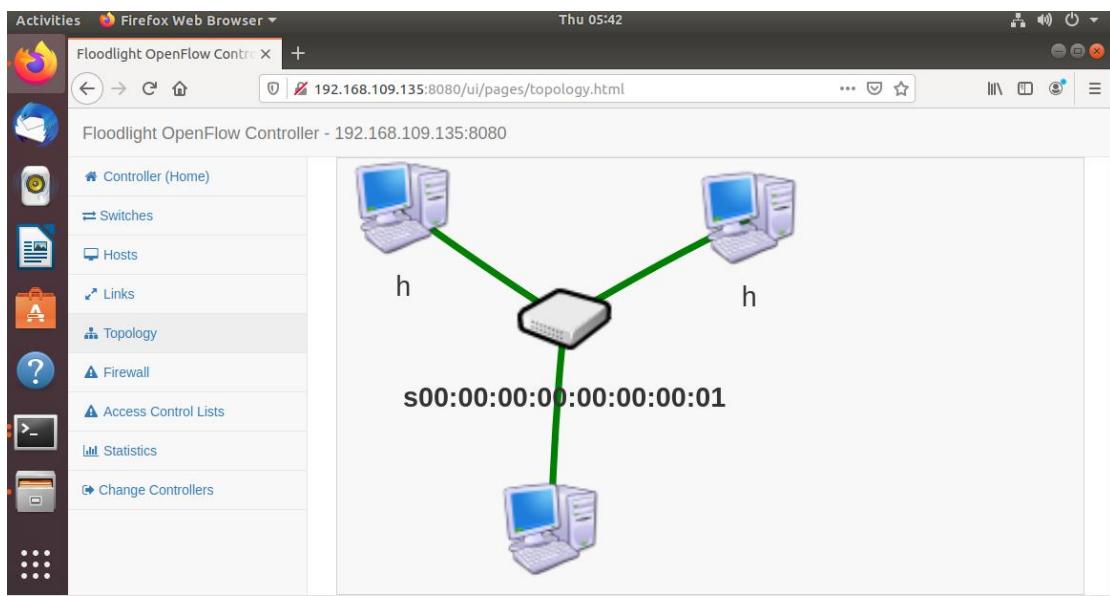
Activities Terminal Thu 05:36
rjmscit@ubuntu: ~/floodlight

File Edit View Search Terminal Help
rjmscit@ubuntu:~/floodlight$ sudo mn --controller=remote,ip=192.168.109.135,port=6653 --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 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3
h2 -> h1 h3
h3 -> h1 h2
*** Results: 0% dropped (6/6 received)
mininet>

```

We created a single topology with 3 host 1 switch and one controller. This can be view in the following URL. Go to web browser and type,

>>http:// 192.168.109.135:8080/ui/index.html



## PRACTICAL NO: 08

### **Aim: Install ONOS controller on Ubuntu**

Open Network Operating System (ONOS®) is the leading open source SDN controller for building next-generation SDN/NFV solutions.

ONOS was designed to meet the needs of operators wishing to build carrier-grade solutions that leverage the economics of white box merchant silicon hardware while offering the flexibility to create and deploy new dynamic network services with simplified programmatic interfaces. ONOS supports both configuration and real-time control of the network, eliminating the need to run routing and switching control protocols inside the network fabric. By moving intelligence into the ONOS cloud controller, innovation is enabled and end-users can easily create new network applications without the need to alter the dataplane systems.

The ONOS platform includes:

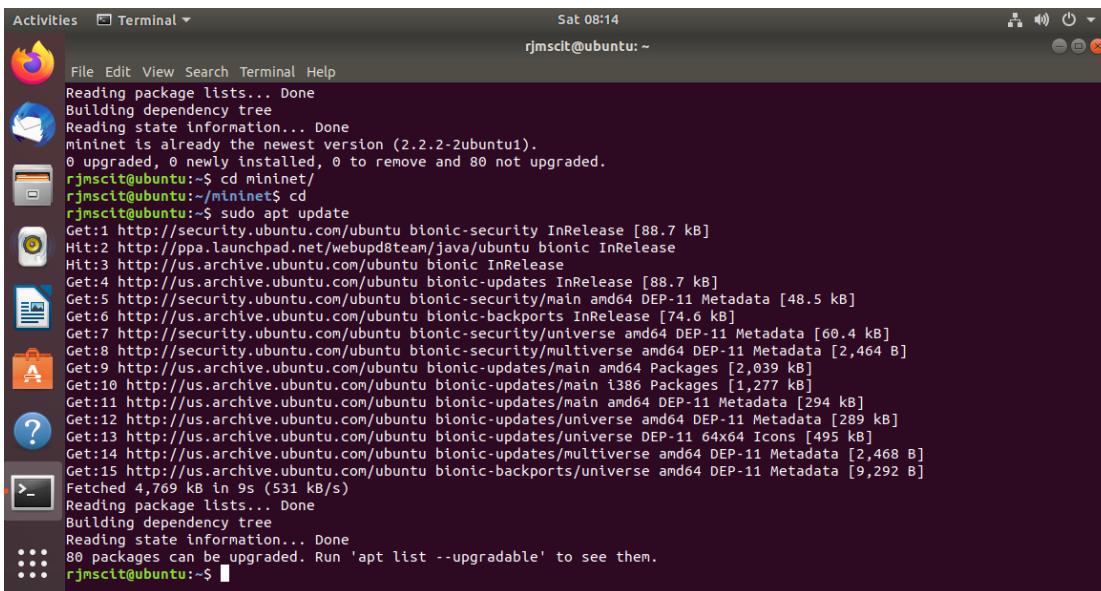
- A platform and a set of applications that act as an extensible, modular, distributed SDN controller.
- Simplified management, configuration and deployment of new software, hardware & services.
- A scale-out architecture to provide the resiliency and scalability required to meet the rigors of production carrier environments.

ONOS (Open Network Operating System) is an operating system (OS) designed to help network service providers build carrier-grade software-defined networks architected for high scalability, availability and performance. Although specifically designed to address the needs of service providers, ONOS can also act as a software-defined networking (SDN) control plane for enterprise campus local area networks (LANs) and data center networks.

### **Check java version and set it to java 8**

**Java -version**

>> sudo apt update

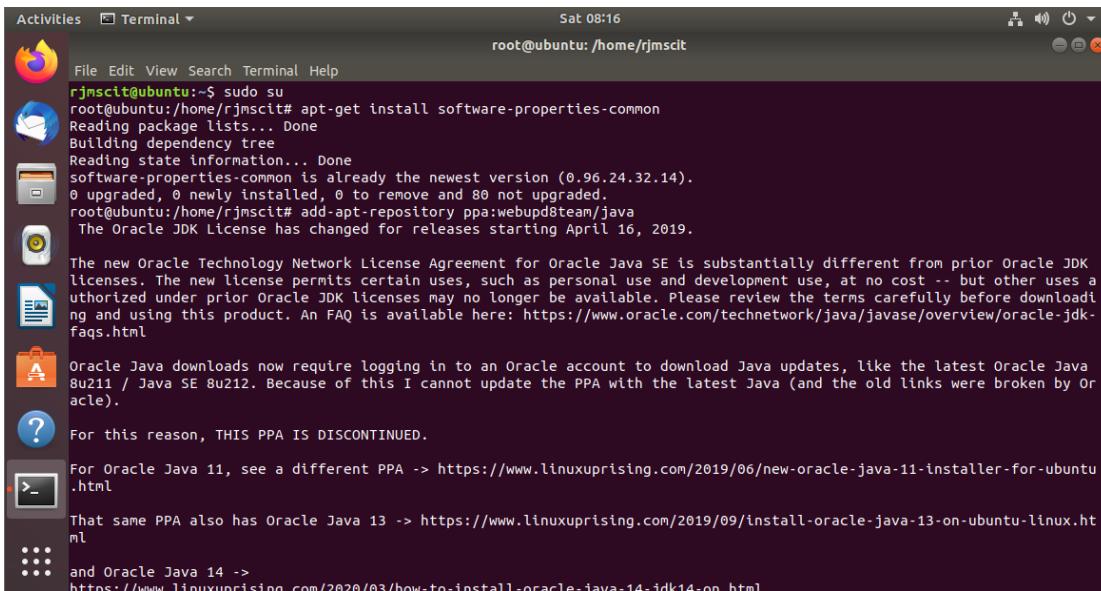


```
Activities Terminal Sat 08:14
rjmscitr@ubuntu: ~

File Edit View Search Terminal Help
Reading package lists... Done
Building dependency tree
Reading state information... Done
mininet is already the newest version (2.2.2-2ubuntu1).
0 upgraded, 0 newly installed, 0 to remove and 80 not upgraded.
rjmscitr@ubuntu:~$ cd mininet/
rjmscitr@ubuntu:~/mininet$ cd
rjmscitr@ubuntu:~$ sudo apt update
Get:1 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Hit:2 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Get:4 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:5 http://security.ubuntu.com/ubuntu bionic-security/main amd64 DEP-11 Metadata [48.5 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:7 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 DEP-11 Metadata [60.4 kB]
Get:8 http://security.ubuntu.com/ubuntu bionic-security/multiverse amd64 DEP-11 Metadata [2,464 B]
Get:9 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [2,039 kB]
Get:10 http://us.archive.ubuntu.com/ubuntu bionic-updates/main i386 Packages [1,277 kB]
Get:11 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 DEP-11 Metadata [294 kB]
Get:12 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 DEP-11 Metadata [289 kB]
Get:13 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe DEP-11 64x64 Icons [495 kB]
Get:14 http://us.archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 DEP-11 Metadata [2,468 B]
Get:15 http://us.archive.ubuntu.com/ubuntu bionic-backports/universe amd64 DEP-11 Metadata [9,292 B]
Fetched 4,769 kB in 9s (531 kB/s)
Reading package lists... Done
Building dependency tree
Reading state information... Done
80 packages can be upgraded. Run 'apt list --upgradable' to see them.
rjmscitr@ubuntu:~$
```

>> apt-get install software-properties-common

>> add-apt-repository ppa:webupd8team/java



```
Activities Terminal Sat 08:16
root@ubuntu:/home/rjmscitr

File Edit View Search Terminal Help
rjmscitr@ubuntu:~$ sudo su
root@ubuntu:/home/rjmscitr# apt-get install software-properties-common
Reading package lists... Done
Building dependency tree
Reading state information... Done
software-properties-common is already the newest version (0.96.24.32.14).
0 upgraded, 0 newly installed, 0 to remove and 80 not upgraded.
root@ubuntu:/home/rjmscitr# add-apt-repository ppa:webupd8team/java
The Oracle JDK License has changed for releases starting April 16, 2019.

The new Oracle Technology Network License Agreement for Oracle Java SE is substantially different from prior Oracle JDK licenses. The new license permits certain uses, such as personal use and development use, at no cost -- but other uses are unauthorized under prior Oracle JDK licenses may no longer be available. Please review the terms carefully before downloading and using this product. An FAQ is available here: https://www.oracle.com/technetwork/java/javase/overview/oracle-jdk-faqs.html

Oracle Java downloads now require logging in to an Oracle account to download Java updates, like the latest Oracle Java 8u211 / Java SE 8u212. Because of this I cannot update the PPA with the latest Java (and the old links were broken by Oracle).

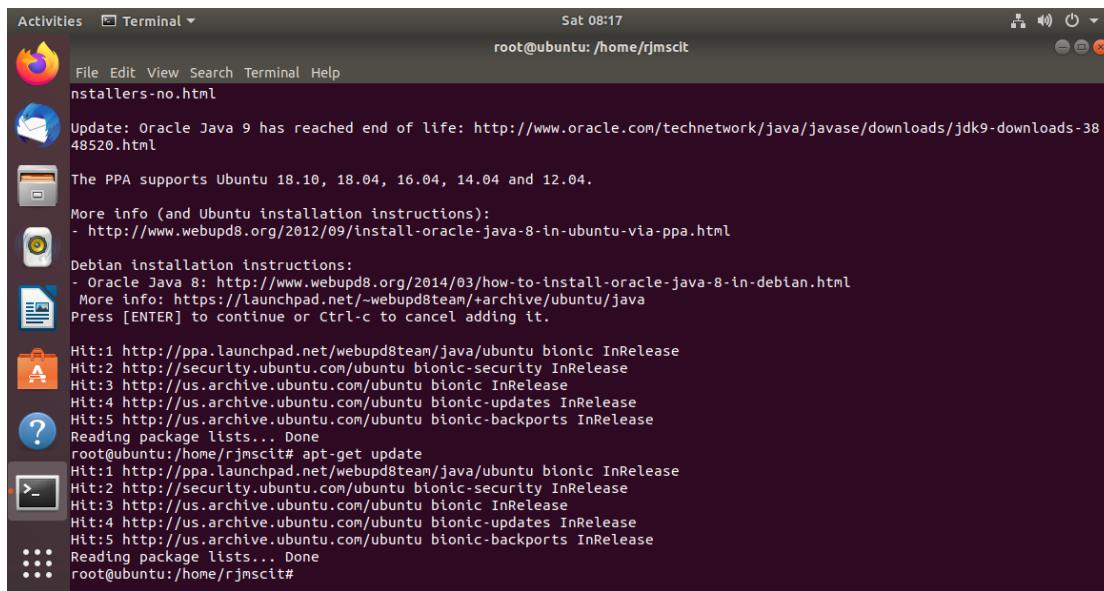
For this reason, THIS PPA IS DISCONTINUED.

For Oracle Java 11, see a different PPA -> https://www.linuxuprising.com/2019/06/new-oracle-java-11-installer-for-ubuntu.html

That same PPA also has Oracle Java 13 -> https://www.linuxuprising.com/2019/09/install-oracle-java-13-on-ubuntu-linux.html

and Oracle Java 14 ->
https://www.linuxuprising.com/2020/03/how-to-install-oracle-java-14-jdk14-on.html
```

>> apt-get update

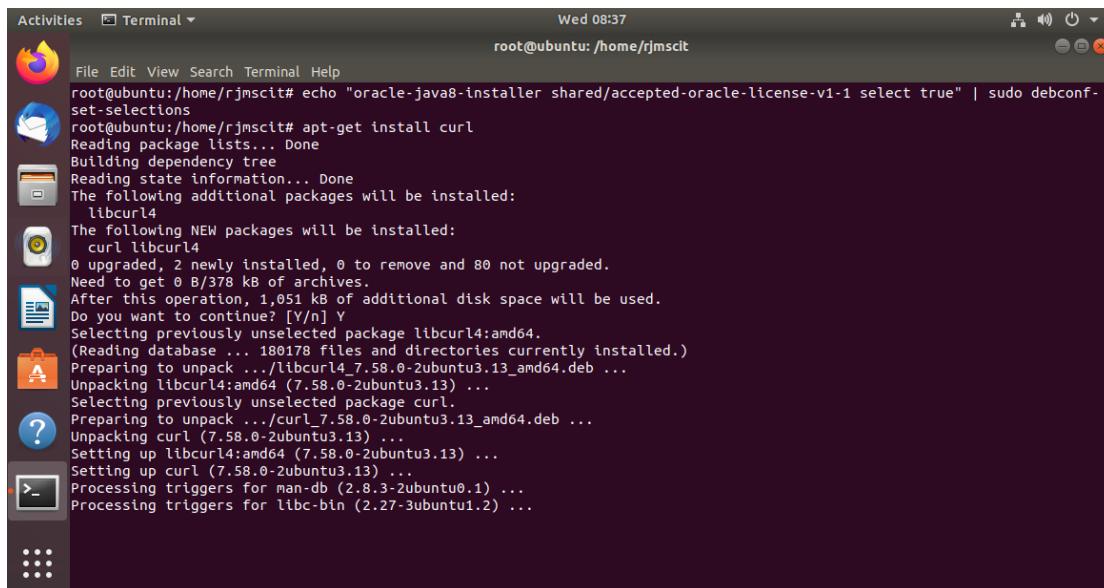


```
Activities Terminal Sat 08:17
root@ubuntu: /home/rjmsc1t
File Edit View Search Terminal Help
installers-no.html
UpToDate: Oracle Java 9 has reached end of life: http://www.oracle.com/technetwork/java/javase/downloads/jdk9-downloads-3848520.html
The PPA supports Ubuntu 18.10, 18.04, 16.04, 14.04 and 12.04.
More info (and Ubuntu installation instructions):
- http://www.webupd8.org/2012/09/install-oracle-java-8-in-ubuntu-via-ppa.html
Debian installation instructions:
- Oracle Java 8: http://www.webupd8.org/2014/03/how-to-install-oracle-java-8-in-debian.html
More info: https://launchpad.net/~webupd8team/+archive/ubuntu/java
Press [ENTER] to continue or Ctrl-c to cancel adding it.

Hit:1 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Hit:2 http://security.ubuntu.com/ubuntu bionic-security InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:5 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease
Reading package lists... Done
root@ubuntu:/home/rjmsc1t# apt-get update
Hit:1 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Hit:2 http://security.ubuntu.com/ubuntu bionic-security InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:5 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease
Reading package lists... Done
root@ubuntu:/home/rjmsc1t#
```

>> echo "oracle-java8-installer shared/accepted-oracle-license-v1-1 select true" | sudo debconf-set-selections

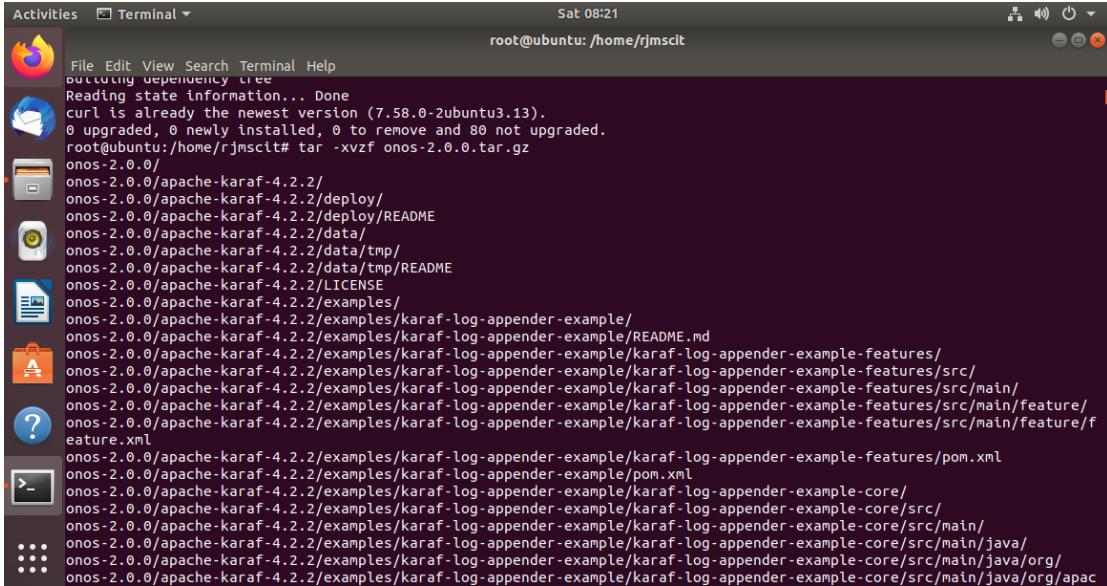
>> apt-get install curl



```
Activities Terminal Wed 08:37
root@ubuntu: /home/rjmsc1t
File Edit View Search Terminal Help
root@ubuntu:/home/rjmsc1t# echo "oracle-java8-installer shared/accepted-oracle-license-v1-1 select true" | sudo debconf-set-selections
root@ubuntu:/home/rjmsc1t# apt-get install curl
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libcurl4
The following NEW packages will be installed:
  curl libcurl4
0 upgraded, 2 newly installed, 0 to remove and 80 not upgraded.
Need to get 0 B/378 kB of archives.
After this operation, 1,051 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Selecting previously unselected package libcurl4:amd64.
(Reading database ... 180178 files and directories currently installed.)
Preparing to unpack .../libcurl4_7.58.0-2ubuntu3.13_amd64.deb ...
Unpacking libcurl4:amd64 (7.58.0-2ubuntu3.13) ...
Selecting previously unselected package curl.
Preparing to unpack .../curl_7.58.0-2ubuntu3.13_amd64.deb ...
Unpacking curl (7.58.0-2ubuntu3.13) ...
Setting up libcurl4:amd64 (7.58.0-2ubuntu3.13) ...
Setting up curl (7.58.0-2ubuntu3.13) ...
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
Processing triggers for libc-bin (2.27-3ubuntu1.2) ...
```

**Move ONOS software setup from Main system to Virtual system and extract from below command:**

```
>> tar -xvf onos-2.0.0.tar.gz
```



```
Sat 08:21
root@ubuntu: /home/rjmcsit

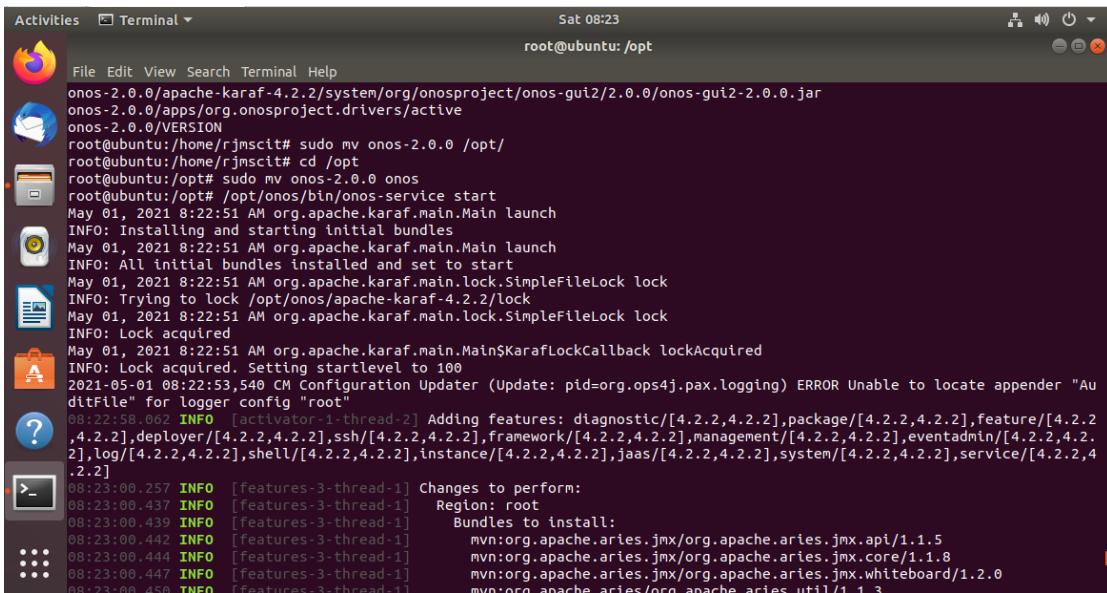
File Edit View Search Terminal Help
Building dependency tree
Reading state information... Done
curl is already the newest version (7.58.0-2ubuntu3.13).
0 upgraded, 0 newly installed, 0 to remove and 80 not upgraded.
root@ubuntu:/home/rjmcsit# tar -xvf onos-2.0.0.tar.gz
onos-2.0.0/
onos-2.0.0/apache-karaf-4.2.2/
onos-2.0.0/apache-karaf-4.2.2/deploy/
onos-2.0.0/apache-karaf-4.2.2/deploy/README
onos-2.0.0/apache-karaf-4.2.2/data/
onos-2.0.0/apache-karaf-4.2.2/data/tmp/
onos-2.0.0/apache-karaf-4.2.2/data/tmp/README
onos-2.0.0/apache-karaf-4.2.2/LICENSE
onos-2.0.0/apache-karaf-4.2.2/examples/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/README.md
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-features/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-features/src/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-features/src/main/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-features/src/main/feature/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-features/src/main/feature/feature.xml
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-features/pom.xml
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/pom.xml
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-core/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-core/src/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-core/src/main/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-core/src/main/java/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-core/src/main/java/org/
onos-2.0.0/apache-karaf-4.2.2/examples/karaf-log-appender-example/karaf-log-appender-example-core/src/main/java/org/apac
```

```
>> sudo mv onos-2.0.0 /opt/
```

```
>> cd /opt
```

```
>> sudo mv onos-2.0.0 onos
```

```
>> /opt/onos/bin/onos-service start
```



```
Sat 08:23
root@ubuntu: /opt

File Edit View Search Terminal Help
onos-2.0.0/apache-karaf-4.2.2/system/org/onosproject/onos-gui2/2.0.0/onos-gui2-2.0.0.jar
onos-2.0.0/apps/org.onosproject.drivers/active
onos-2.0.0/VERSION
root@ubuntu:/home/rjmcsit# sudo mv onos-2.0.0 /opt/
root@ubuntu:/home/rjmcsit# cd /opt
root@ubuntu:/opt# sudo mv onos-2.0.0 onos
root@ubuntu:/opt# /opt/onos/bin/onos-service start
May 01, 2021 8:22:51 AM org.apache.karaf.main.Main launch
INFO: Installing and starting initial bundles
May 01, 2021 8:22:51 AM org.apache.karaf.main.Main launch
INFO: All initial bundles installed and set to start
May 01, 2021 8:22:51 AM org.apache.karaf.main.lock.SimpleFileLock lock
INFO: Trying to lock /opt/onos/apache-karaf-4.2.2/lock
May 01, 2021 8:22:51 AM org.apache.karaf.main.lock.SimpleFileLock lock
INFO: Lock acquired
May 01, 2021 8:22:51 AM org.apache.karaf.main.Main$KarafLockCallback lockAcquired
INFO: Lock acquired. Setting startlevel to 100
2021-05-01 08:22:53,540 CM Configuration Updater (Update: pid=org.ops4j.pax.logging) ERROR Unable to locate appender "Auditfile" for logger config "root"
08:22:58.062 INFO [activator-1-thread-2] Adding features: diagnostic/[4.2.2,4.2.2],package/[4.2.2,4.2.2],feature/[4.2.2,4.2.2],deployer/[4.2.2,4.2.2],ssh/[4.2.2,4.2.2],framework/[4.2.2,4.2.2],management/[4.2.2,4.2.2],eventadmin/[4.2.2,4.2.2],log/[4.2.2,4.2.2],shell/[4.2.2,4.2.2],instance/[4.2.2,4.2.2],jaas/[4.2.2,4.2.2],system/[4.2.2,4.2.2],service/[4.2.2,4.2.2]
08:23:00.257 INFO [features-3-thread-1] Changes to perform:
08:23:00.437 INFO [features-3-thread-1] Region: root
08:23:00.439 INFO [features-3-thread-1] Bundles to install:
08:23:00.442 INFO [features-3-thread-1] mvn:org.apache.aries.jmx/org.apache.aries.jmx.apl/1.1.5
08:23:00.444 INFO [features-3-thread-1] mvn:org.apache.aries.jmx/org.apache.aries.jmx.core/1.1.8
08:23:00.447 INFO [features-3-thread-1] mvn:org.apache.aries.jmx/org.apache.aries.jmx.whiteboard/1.2.0
08:23:00.450 INFO [features-3-thread-1] mvn:org.apache.aries/org.apache.aries.util/1.1.3
```

then open mozilla and run below URL to see ouput:

>> 127.0.0.1:8181/onos/ui/index.html

user:onos

pass:rocks

