

Data Center Networking Technology

Project 2

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Outline

- Project Info
- Descriptions and Objectives
- Project Content
- Step-by-Step Instructions
- Demo
- Reference

Project Info

Goal:

- In this project, student will learn how to use Mininet and a SDN controller (Ryu) to emulate a simple network system

Project assigned: 03/08/2022

Project deadline: 03/22/2022 17:00

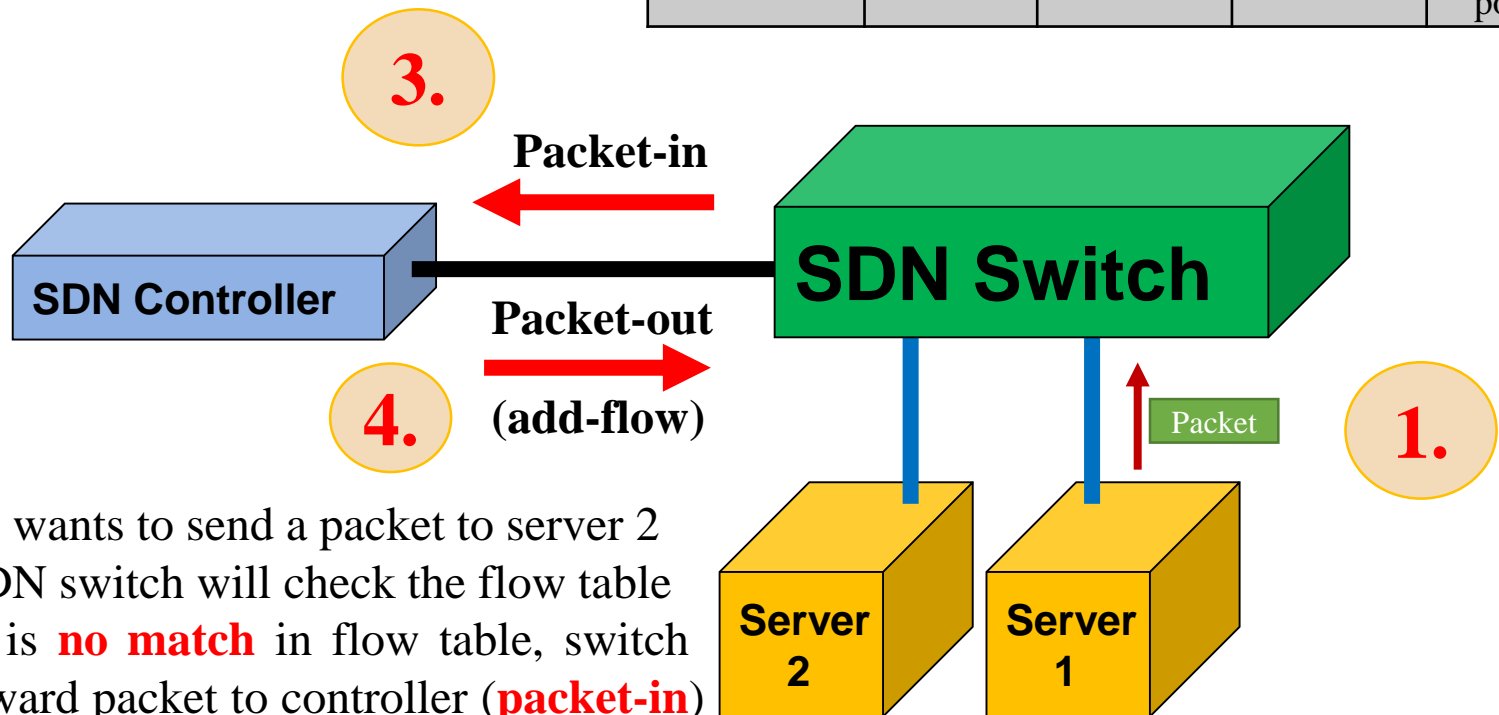
Descriptions and Objectives (1/3)

2.

About SDN Switch:

Flow table in switch

Ingress Port	Ethec Src	Ether Dst	...	Action
Port 1	192.168.14.3	*		Output port=2

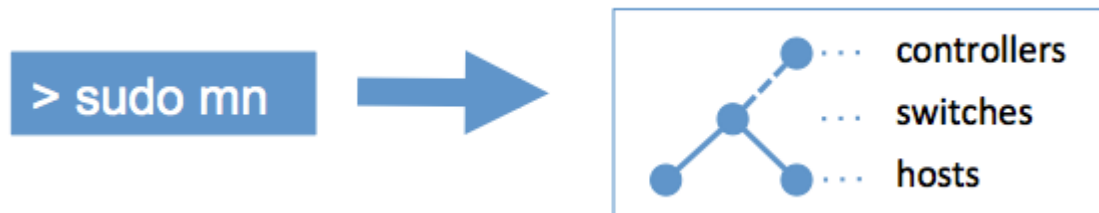


1. Server 1 wants to send a packet to server 2
2. First, SDN switch will check the flow table
3. If there is **no match** in flow table, switch will forward packet to controller (**packet-in**)
4. Controller will decide the **action** and send packet back to switch (**packet-out**), it can also add new flow entry in switch's flow table

Descriptions and Objectives (2/3)

About Mininet:

- Mininet creates a realistic **virtual network**, running real kernel, switch and application code
- It runs a collection of end-hosts, switches, routers, and links on a single Linux kernel
- The switches are OpenFlow-enabled



Descriptions and Objectives (3/3)

About SDN Controller Ryu:

- RYU supports the OpenFlow 1.0, 1.2, 1.3, 1.4 and 1.5
- RYU can work in conjunction with OpenStack for cloud computing
- Written in Python



Project Content

1. Create a VM which runs Ubuntu 18.04
2. Install Mininet
3. Install Ryu
4. Run Mininet and Ryu to emulate a simple SDN network system
5. Study SDN controller's sample code

Step-by-Step Instructions (1/11)

Step 1: Create a VM running Ubuntu 18.04

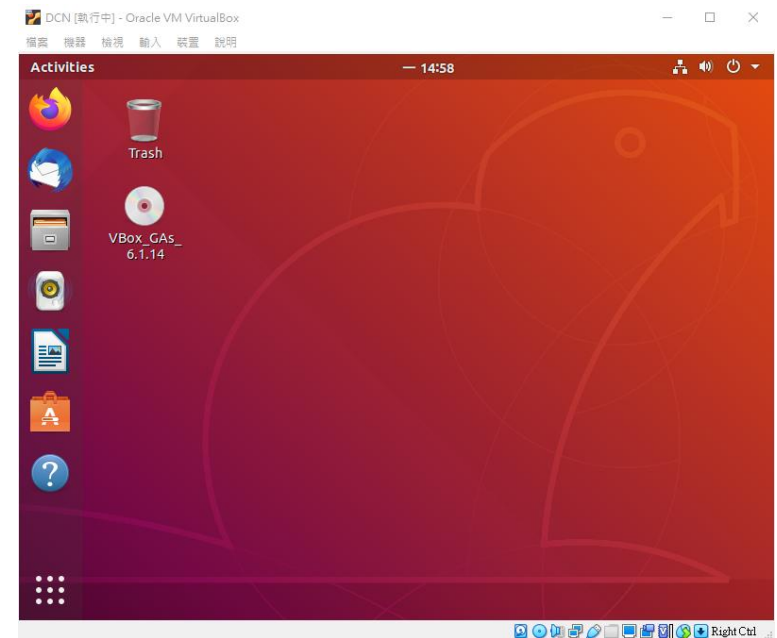
1. Go to <https://www.virtualbox.org/wiki/Downloads> and download VirtualBox

2. Go to <http://releases.ubuntu.com/18.04/> download the Ubuntu 18.04 desktop ISO file

3. Use Virtual Box to install Ubuntu ISO file

4. Following is the reference video

https://www.youtube.com/watch?v=Mf_EergfWbE



Step-by-Step Instructions (2/11)

Step 2: Install Mininet

Open a new terminal and enter the following commands

1. Install git

```
sudo apt-get install -y git
```

2. Clone the mininet repository with git

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

3. Install mininet (takes 3-7 minutes)

```
cd mininet/util
```

```
sudo ./install.sh -a
```

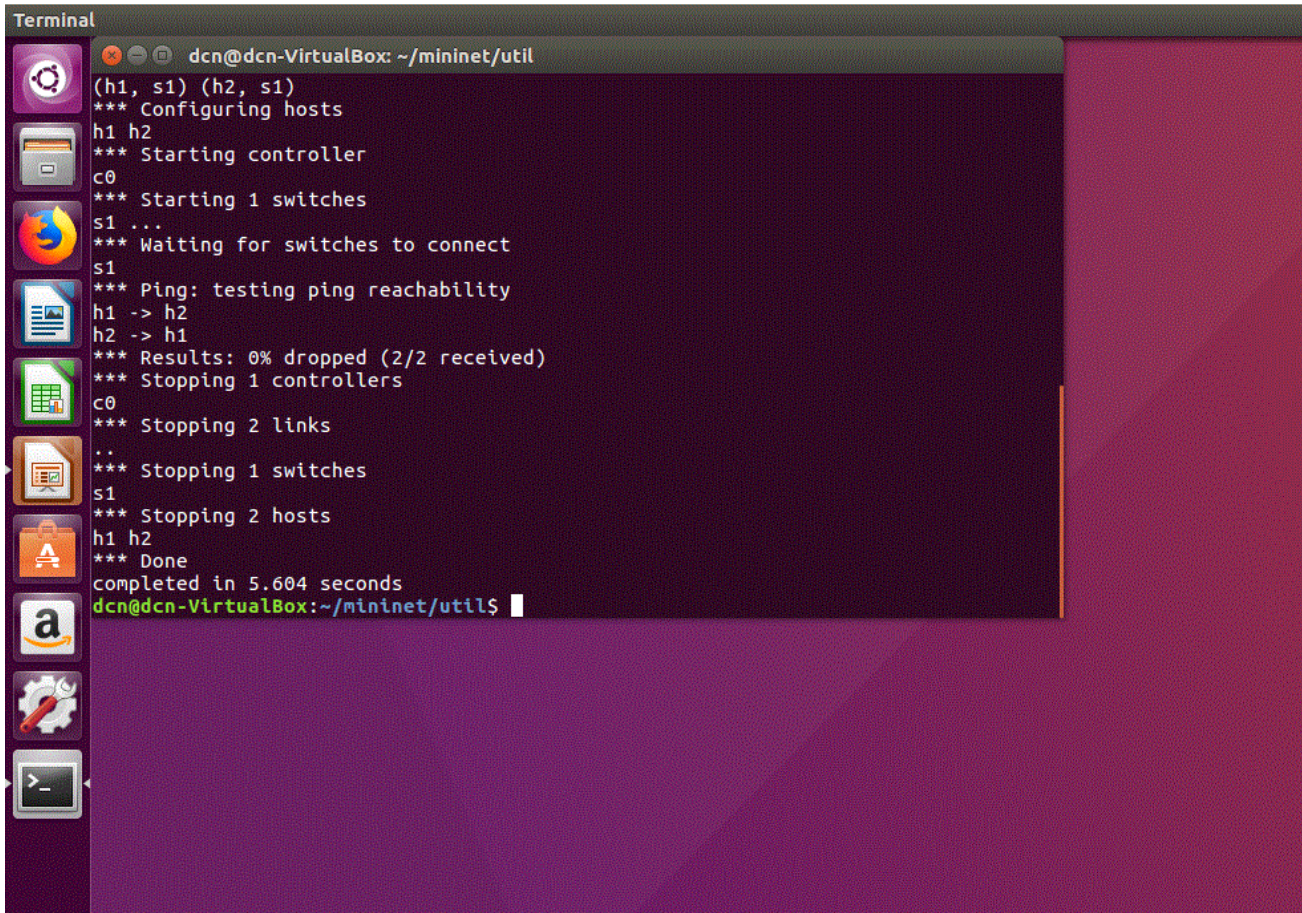
4. Test the mininet installation and then close the terminal

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

Step-by-Step Instructions (3/11)

Step 2: Install Mininet

- You should see the following screen for a successful install

A terminal window titled "Terminal" with a dark background and a vertical toolbar on the left. The toolbar contains icons for various applications: a gear, a folder, a web browser, a document, a spreadsheet, a presentation, a shopping bag, an Amazon logo, a wrench and screwdriver, and a terminal icon. The terminal text shows the execution of a Mininet script. It starts with "(h1, s1) (h2, s1)", followed by "Configuring hosts", "Starting controller", "Starting 1 switches", "Waiting for switches to connect", "Ping: testing ping reachability", "Results: 0% dropped (2/2 received)", "Stopping 1 controllers", "Stopping 2 links", "Stopping 1 switches", "Stopping 2 hosts", and "Done". It concludes with "completed in 5.604 seconds" and the prompt "dcn@dcn-VirtualBox:~/mininet/util\$".

```
Terminal
dcn@dcn-VirtualBox: ~/mininet/util
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Waiting for switches to connect
s1
*** Ping: testing ping reachability
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 5.604 seconds
dcn@dcn-VirtualBox:~/mininet/util$
```

Step-by-Step Instructions (4/11)

Step 3: Install Ryu

Open a new terminal and enter the following commands

1. Install required packages

```
sudo apt-get install -y python3-pip
```

2. Download and install ryu

```
git clone git://github.com/osrg/ryu.git  
cd ryu  
sudo pip3 install .
```

3. Test (the result is on next page)

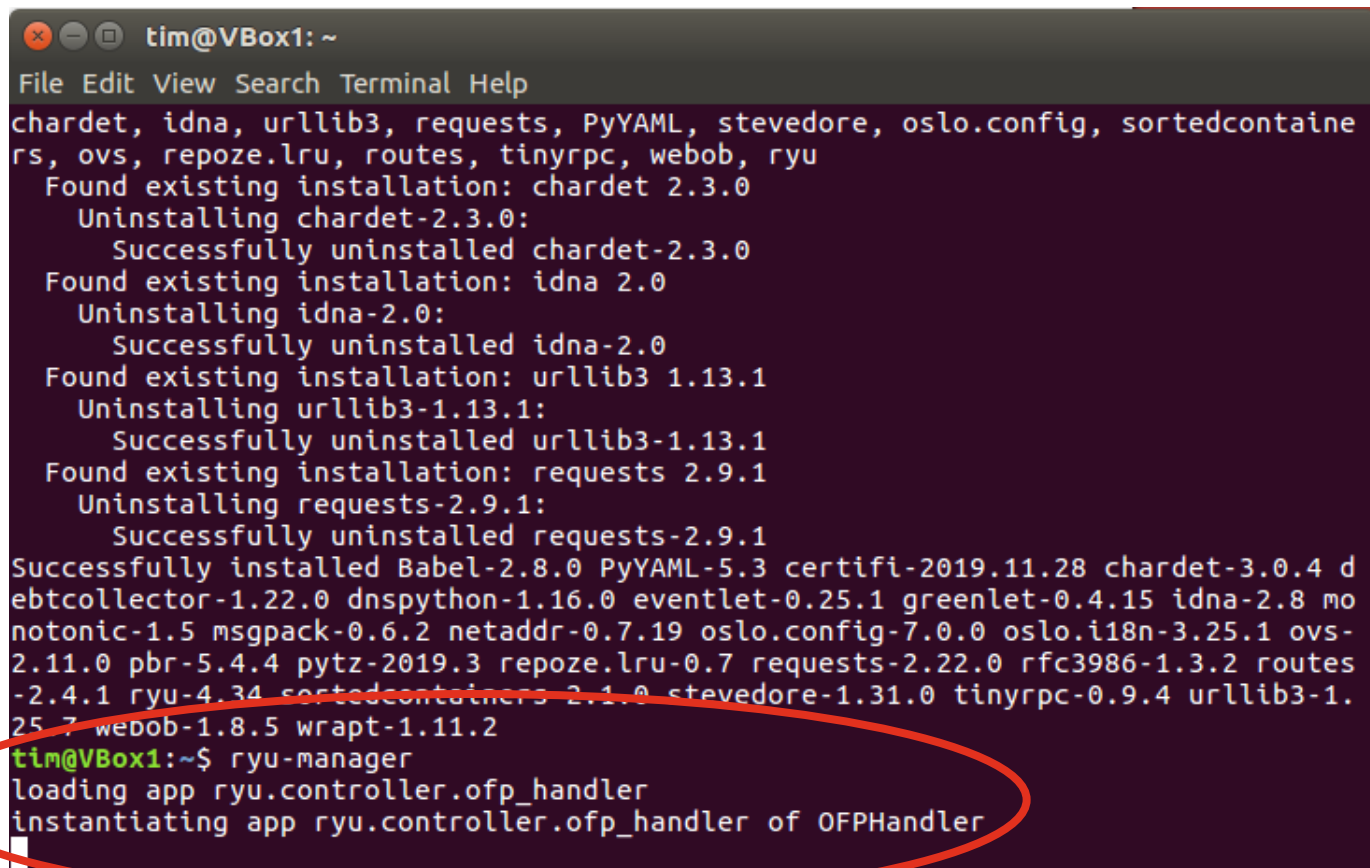
```
ryu-manager
```

4. Press “Ctrl+C” to leave ryu-manger and then close the terminal

Step-by-Step Instructions (5/11)

Step 3: Install Ryu

- If you can see this output, then Ryu is installed
- Quit **ryu-manager** by pressing “Ctrl+C” and close the terminal afterwards



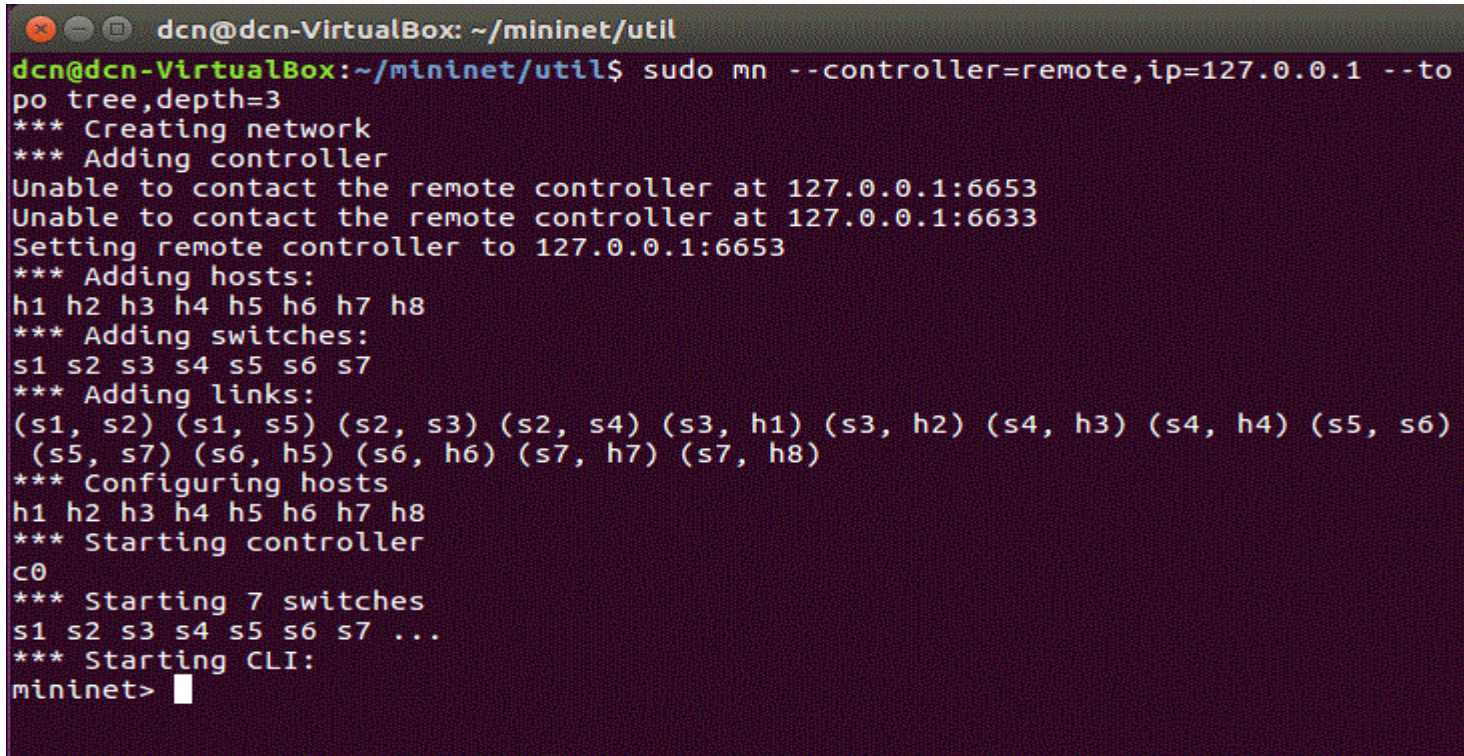
```
tim@VBox1: ~  
File Edit View Search Terminal Help  
chardet, idna, urllib3, requests, PyYAML, stevedore, oslo.config, sortedcontainers,  
rs, ovs, repoze.lru, routes, tinyrpc, webob, ryu  
Found existing installation: chardet 2.3.0  
Uninstalling chardet-2.3.0:  
Successfully uninstalled chardet-2.3.0  
Found existing installation: idna 2.0  
Uninstalling idna-2.0:  
Successfully uninstalled idna-2.0  
Found existing installation: urllib3 1.13.1  
Uninstalling urllib3-1.13.1:  
Successfully uninstalled urllib3-1.13.1  
Found existing installation: requests 2.9.1  
Uninstalling requests-2.9.1:  
Successfully uninstalled requests-2.9.1  
Successfully installed Babel-2.8.0 PyYAML-5.3 certifi-2019.11.28 chardet-3.0.4 d  
ebcollector-1.22.0 dnspython-1.16.0 eventlet-0.25.1 greenlet-0.4.15 idna-2.8 mo  
notonic-1.5 msgpack-0.6.2 netaddr-0.7.19 oslo.config-7.0.0 oslo.i18n-3.25.1 ovs-  
2.11.0 pbr-5.4.4 pytz-2019.3 repoze.lru-0.7 requests-2.22.0 rfc3986-1.3.2 routes  
-2.4.1 ryu-4.34 sortedcontainers-2.1.0 stevedore-1.31.0 tinyrpc-0.9.4 urllib3-1.  
25.7 webob-1.8.5 wrapt-1.11.2  
tim@VBox1:~$ ryu-manager  
loading app ryu.controller.ofp_handler  
instantiating app ryu.controller.ofp_handler of OFPHandler
```


Step-by-Step Instructions (6/11)

Step 4: Run Mininet and Ryu to emulate a simple SDN network system

1. **Open a new terminal** and run mininet

```
sudo mn --controller=remote,ip=127.0.0.1 \
--topo tree,depth=3
```

A terminal window titled 'dcn@dcn-VirtualBox: ~/mininet/util' showing the execution of the 'mn' command. The output displays the creation of a network with 8 hosts (h1-h8), 7 switches (s1-s7), and a controller (c0). It lists the links between switches and hosts, and shows the starting of the controller, switches, and CLI.

```
dcn@dcn-VirtualBox: ~/mininet/util
dcn@dcn-VirtualBox:~/mininet/util$ sudo mn --controller=remote,ip=127.0.0.1 --topo tree,depth=3
*** 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> █
```

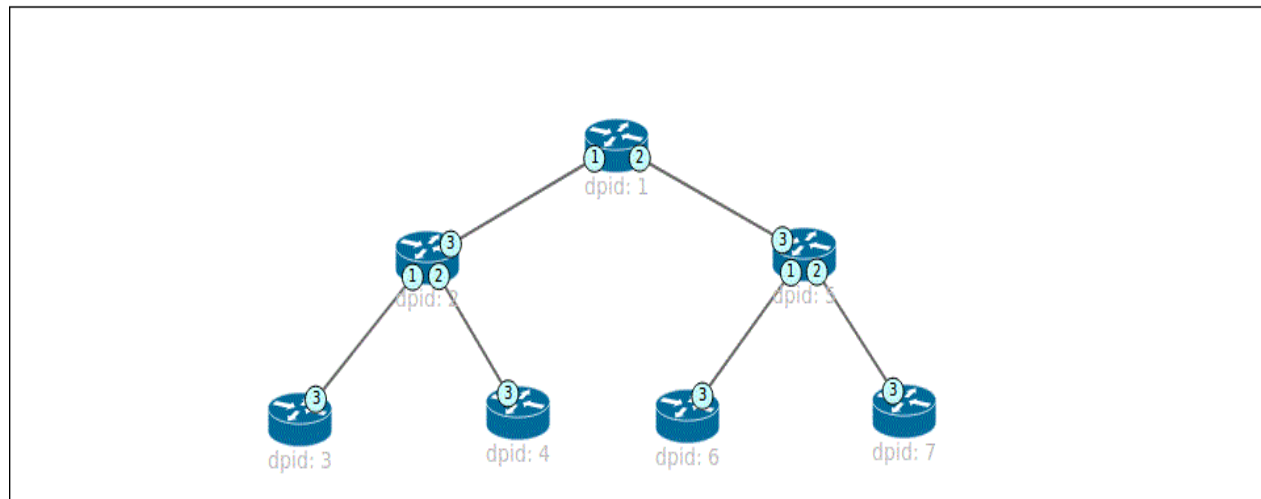
Step-by-Step Instructions (7/11)

Step 4: Run Mininet and Ryu to emulate a simple SDN network system

```
sudo mn --controller=remote,ip=127.0.0.1 --topo tree,depth=3
```

- The command above will create the tree topology below

Ryu Topology Viewer



Step-by-Step Instructions (8/11)

Step 4: Run Mininet and Ryu to emulate a simple SDN network system

2. **Open another new terminal** and go to Ryu installation folder

- Get the Ryu installation directory:

```
pip3 show ryu
```

- Go to the specified directory, e.g.:

```
cd /usr/local/lib/python3.6/dist-packages
```

```
yuho@DCN:~$ pip3 show ryu
Name: ryu
Version: 4.34
Summary: Component-based Software-defined Networking Framework
Home-page: https://ryu-sdn.org
Author: Ryu project team
Author-email: ryu-devel@lists.sourceforge.net
License: Apache License 2.0
Location: /usr/local/lib/python3.6/dist-packages
Requires: eventlet, msgpack, netaddr, oslo.config, ovs, packaging, routes, six,
          tinypc, webob
yuho@DCN:~$
```

Step-by-Step Instructions (9/11)

Step 4: Run Mininet and Ryu to emulate a simple SDN network system

3. Check for Ryu installation folder existence

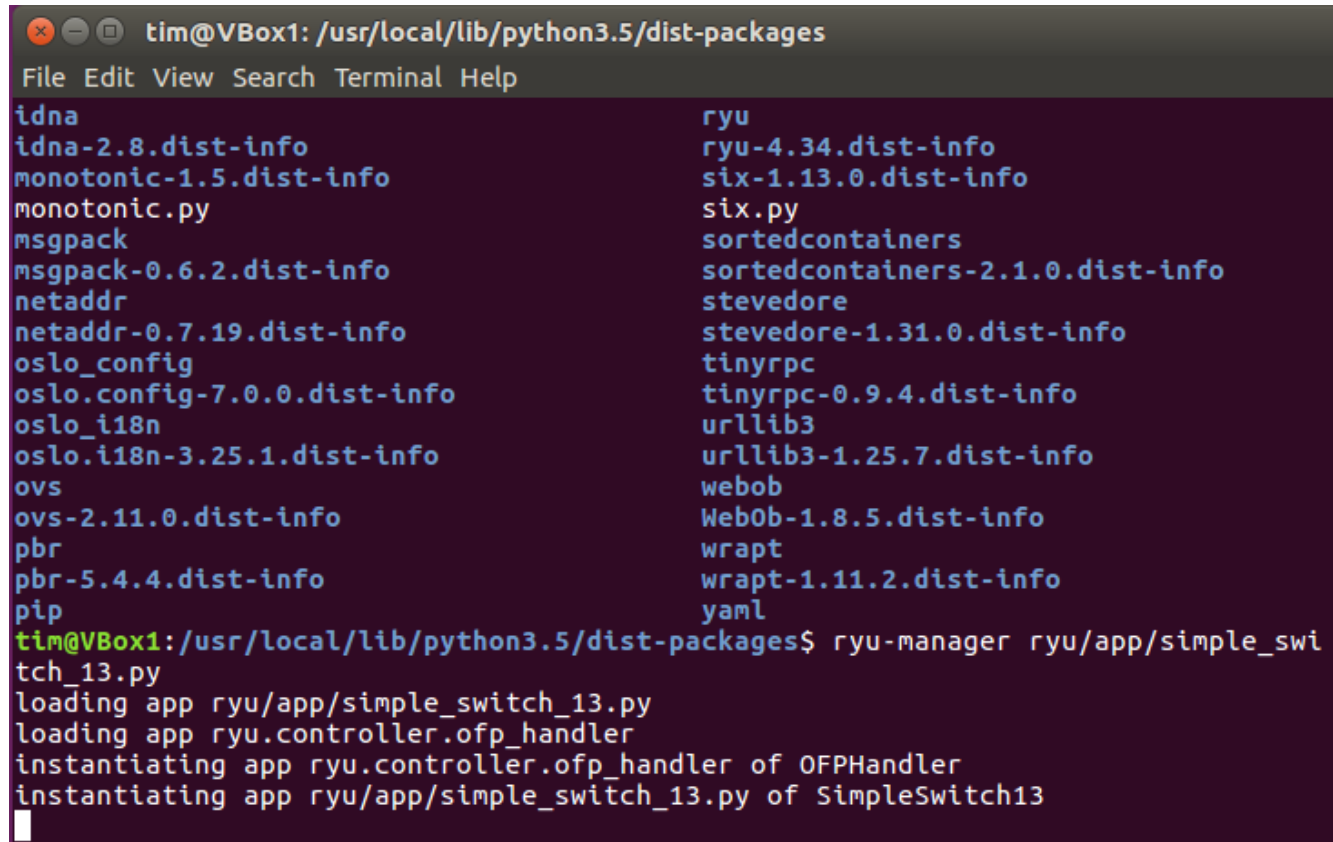
- You can see the Ryu folder (using '**ls**' command)

```
tim@VBox1:/usr/local/lib/python3.5/dist-packages$ ls
babel                                pip-19.3.1.dist-info
Babel-2.8.0.dist-info                __pycache__
certifi                              pytz
certifi-2019.11.28.dist-info         pytz-2019.3.dist-info
chardet                              PyYAML-5.3.dist-info
chardet-3.0.4.dist-info              repoze
debtcollector                        repoze.lru-0.7.dist-info
debtcollector-1.22.0.dist-info       repoze.lru-0.7-py3.6-nspkg.pth
dns                                  requests
dnspython-1.16.0.dist-info           requests-2.22.0.dist-info
eventlet                             rfc3986
eventlet-0.25.1.dist-info            rfc3986-1.3.2.dist-info
greenlet-0.4.15.dist-info            routes
greenlet.cpython-35m-x86_64-linux-gnu.so Routes-2.4.1.dist-info
idna                                  ryu
idna-2.8.dist-info                  ryu-4.34.dist-info
monotonic-1.5.dist-info              six-1.13.0.dist-info
monotonic.py                         six.py
```


Step-by-Step Instructions (10/11)

Step 4: Run Mininet and Ryu to emulate a simple SDN network system

4. Run controller sample code : **simple_switch_13.py**
ryu-manager ryu/app/simple_switch_13.py



```
tim@VBox1: /usr/local/lib/python3.5/dist-packages
File Edit View Search Terminal Help
idna
idna-2.8.dist-info
monotonic-1.5.dist-info
monotonic.py
msgpack
msgpack-0.6.2.dist-info
netaddr
netaddr-0.7.19.dist-info
oslo_config
oslo.config-7.0.0.dist-info
oslo_i18n
oslo.i18n-3.25.1.dist-info
ovs
ovs-2.11.0.dist-info
pbr
pbr-5.4.4.dist-info
pip
ryu
ryu-4.34.dist-info
six-1.13.0.dist-info
six.py
sortedcontainers
sortedcontainers-2.1.0.dist-info
stevedore
stevedore-1.31.0.dist-info
tinyrpc
tinyrpc-0.9.4.dist-info
urllib3
urllib3-1.25.7.dist-info
webob
WebOb-1.8.5.dist-info
wrapt
wrapt-1.11.2.dist-info
yaml
tim@VBox1:/usr/local/lib/python3.5/dist-packages$ ryu-manager ryu/app/simple_sw
tch_13.py
loading app ryu/app/simple_switch_13.py
loading app ryu.controller.ofp_handler
instantiating app ryu.controller.ofp_handler of OFPHandler
instantiating app ryu/app/simple_switch_13.py of SimpleSwitch13
```

Step-by-Step Instructions (11/11)

Step 4: Run Mininet and Ryu to emulate a simple SDN network system

5. In the mininet terminal use ‘**pingall**’ command to test

- Every host should successfully ping to each other
- You should also see ‘packet in’ command in the ryu-manager

```
tim@VBox1: ~  
File Edit View Search Terminal Help  
*** 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> pingall  
*** Ping: testing ping reachability  
h1 -> h2 h3 h4 h5 h6 h7 h8  
h2 -> h1 h3 h4 h5 h6 h7 h8  
h3 -> h1 h2 h4 h5 h6 h7 h8  
h4 -> h1 h2 h3 h5 h6 h7 h8  
h5 -> h1 h2 h3 h4 h6 h7 h8  
h6 -> h1 h2 h3 h4 h5 h7 h8  
h7 -> h1 h2 h3 h4 h5 h6 h8  
h8 -> h1 h2 h3 h4 h5 h6 h7  
*** Results: 0% dropped (56/56 received)  
mininet> ☐
```

```
tim@VBox1: /usr/local/lib/python3.5/dist-packages  
File Edit View Search Terminal Help  
packet in 5 d6:f0:8f:aa:a4:17 33:33:00:00:00:fb 3  
packet in 6 d6:f0:8f:aa:a4:17 33:33:00:00:00:fb 3  
packet in 7 d6:f0:8f:aa:a4:17 33:33:00:00:00:fb 3  
packet in 2 36:e4:c7:4c:09:a3 33:33:00:00:00:02 2  
packet in 3 36:e4:c7:4c:09:a3 33:33:00:00:00:02 3  
packet in 1 36:e4:c7:4c:09:a3 33:33:00:00:00:02 1  
packet in 5 36:e4:c7:4c:09:a3 33:33:00:00:00:02 3  
packet in 6 d6:cb:06:ea:b8:8b 33:33:00:00:00:02 2  
packet in 7 36:e4:c7:4c:09:a3 33:33:00:00:00:02 3  
packet in 6 36:e4:c7:4c:09:a3 33:33:00:00:00:02 3  
packet in 4 2e:87:eb:cc:be:33 33:33:00:00:00:02 2  
packet in 5 d6:cb:06:ea:b8:8b 33:33:00:00:00:02 1  
packet in 2 2e:87:eb:cc:be:33 33:33:00:00:00:02 2  
packet in 1 d6:cb:06:ea:b8:8b 33:33:00:00:00:02 2  
packet in 7 d6:cb:06:ea:b8:8b 33:33:00:00:00:02 3  
packet in 3 2e:87:eb:cc:be:33 33:33:00:00:00:02 3
```

DEMO

- We will have DEMO on **03/22 Tuesday**
 - Please go to [this link](#) and choose the time that you prefer
 - Demo location will be written there too
- TA will ask questions about controller sample code (**simple_switch_13.py**)
 - This is to make sure you understand the controller program
 - You will need to learn and review the logic of the code
- **03/15 Tues** at ED302 13:20 – 14:10 we have help session
 - Students who have problems or questions can attend
- Email TA, if you have any questions

Reference:

- Mininet: <http://mininet.org/>
- Ryu: <http://osrg.github.io/ryu/>
- Ryu book <http://osrg.github.io/ryu-book/en/Ryubook.pdf>
(There is detailed explanations for sample code in chap. 2)