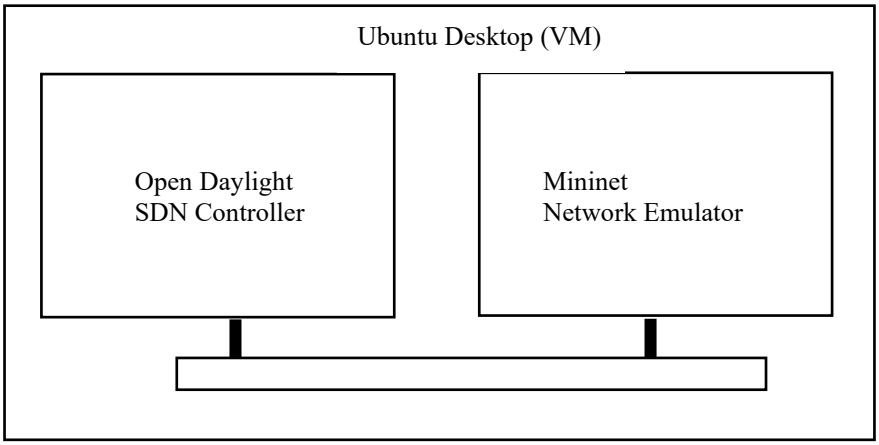
OpenFlow Configuration Lab

Objective: As part of this hands-on module, you will be using the Mininet network emulator on the allocated Virtual Machine to you. You will then configure a standalone OpenFlow network using Mininet. Next, you will use the OpenDaylight controller on the same VM. Finally, you will configure the Mininet network to use an OpenDaylight controller, add flow entries and observe the exchange of OpenFlow messages between the controller and the virtual switches.

Prerequisites: Knowledge of virtualisation, UNIX and OpenFlow.

Part – 01 – Setup the environment in your Local PC



1. Download following resources to your local PC.
    a. Ubuntu Lab VM – use the following url to download the OVA file: https://dms.uom.lk/s/tT4oNTZPfLTBFge
    b. Latest VirtualBox software – Use https://www.virtualbox.org/ to download the compatible version to your local PC.

2. Install the VirtualBox software with the default configuration. If you have already installed the VirtualBox into your PC, you can skip this step.

3. Import the SDN-Lab-OVA file to VirtualBox
    a. Double click on the downloaded OVA file and select "**Generate new MAC addresses…**" from the dropdown menu under "**MAC Address Policy**" option. Then click "**Import**".
    b. In VirtualBox, right click on SDN-lab-OVA and go to "**Settings**"
    c. Click on "**Network**" and choose "**Host-only Adapter**" from '**Attached To:**' drop down. Make sure you the relevant host only adapter name is selected (ex. VirtualBox Host-Only Ethernet Adapter)
    d. Click 'OK'.
    e. Go to the Network Adapter Settings in your Local (Physical) PC (Ex. If it is Windows – Network and Sharing Centre -> Change Adapter Settings)
    f. Find the relevant Network Adapter which is attached to VirtulaBox Host-Only Adapter you have selected (Ex. VirtualBox Host-Only Ethernet Adapter). Then change the IPv4

Addresses to Manual Option and set an IP Address in private IP range (ex. 192.168.56.1/24)

4. Come back to VirtualBox and power on the SDN-Lab-OVA ubuntu PC (select the OVA and click on green arrow on top).
    a. Use the username `sdn` and password `SDN@123` to login to the VM
    b. Change the IP address of the VM to make sure that your Host-Only local adapter and VM's Adapter are in same network (ex. You can set 192.168.56.100/24 as the IP of the VM). To do that you can use the options in top right side of the Ubuntu PC.

Part 02 – Complete the Lab activity

Lab Notes

To emulate an OpenFlow network, we will use one virtual machine:

- Use two different terminal windows to run Mininet emulator and OpenDaylight controller
- Install Wireshark to your VM from the Internet for PDU analysis
- Change the screen resolution of the Ubuntu VM as per your preference (Optional)

Usernames & Passwords

- OpenDaylight Default Username & Password: `admin`

Lab Exercise

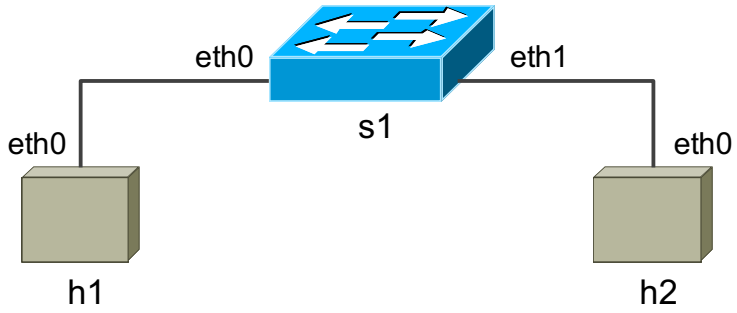
Part 1.
Build a standalone Mininet network (Use a ssh session or terminal window in remote VM)

Installation and configuration steps:

1. Create a simple network on the Mininet: Open a Terminal Window and type;

    ```
    sudo mn --mac --controller="none"
    ```

    The above command creates a network with:
    - 1 switch, s1
    - 2 hosts, h1 and h2
    - h1 eth0 connected to s1 eth0
    - h2 eth0 connected to s1 eth1
    - no OpenFlow controller



The above command will put you into the Mininet shell:

```
mininet>
```

2. Try the following commands in the Mininet CLI to get an understanding of the network:

```
mininet> nodes

mininet> net

mininet> dump
```

3. Attempt pings between the hosts

```
mininet> h1 ping h2

mininet> h2 ping h1
```

Do the pings succeed ? Why ? No
From 10.0.0.1 icmp_seq=107 Destination Host Unreachable

4. Check the flow table of the switch:

```
mininet> dpctl dump-flows
```

There is no flow
*** s1 ----------

Can you explain the reason for what you see ?

5. Exit from the Mininet CLI:

```
mininet> exit
```

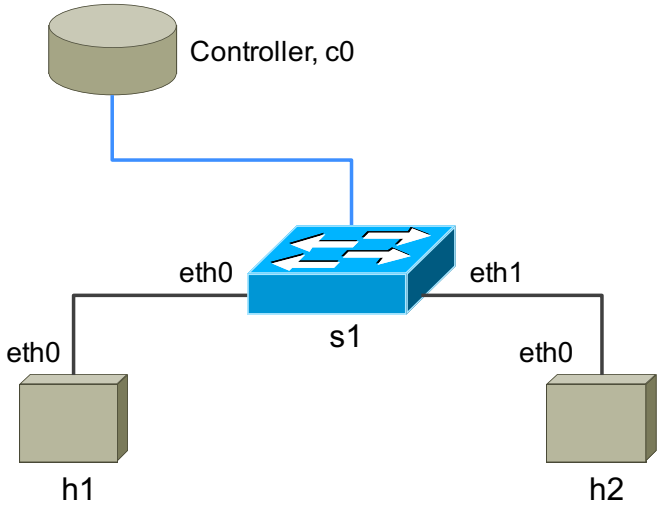
6. Create another simple network on the Mininet VM but this time use the default controller.

```
sudo mn --mac
```

The above command creates a network with:

- 1 switch, s1

- 2 hosts, h1 and h2
- h1 eth0 connected to s1 eth0
- h2 eth0 connected to s1 eth1
- the default OpenFlow controller for Mininet



The above command will put you into the Mininet shell:

```
mininet>
```

7. Try the following commands in the Mininet CLI to get an understanding of the network:

```
mininet> nodes
```

```
mininet> net
```

```
mininet> dump
```

8. Check the flow table of the switch:

```
mininet> dpctl dump-flows
```

Can you explain the reason for what you see ?

9. Attempt pings between the hosts

```
mininet> h1 ping h2
```

```
mininet> h2 ping h1
```

Do the pings succeed ? Why do you think that is the case ?

10. Check the flow table of the switch again:

```
mininet> dpctl dump-flows
```

What do you see now ? Analyse the entries in the table.

11. Wait for the flows to timeout. That is, wait until the output of the following command is again empty.

```
mininet> dpctl dump-flows
```

12. We will now enable snooping to see the message flow between the switch and controller.

```
mininet> dpctl snoop &
```

13. Wait for the flows to timeout. That is, wait until the output of the following command is again empty.

```
mininet> dpctl dump-flows
```

14. Check the flow table again.

```
mininet> dpctl dump-flows
```

What do you see now ?

15. Pings between the hosts again

```
mininet> h1 ping h2
```

```
mininet> h2 ping h1
```

16. Check the flow table npw.

```
mininet> dpctl dump-flows
```

What do you see now ?

17. Exit from the Mininet CLI:

```
mininet> exit
```

Part 2.

Connect Mininet network to Opendaylight controller (Use a new ssh session or new terminal window in the remote VM)

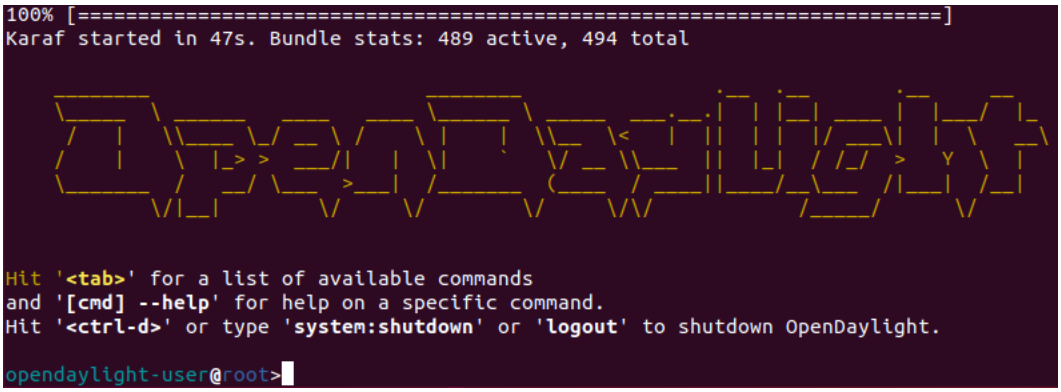
1. Check the IP address configuration of the Ubuntu VM from :

```
ip addr show
```

2. Open a New terminal window in Ubuntu VM and Run OpenDaylight:

```
sudo ./karaf-0.7.2/bin/karaf
```

The above command will take you to the OpenDaylight shell:



1. Install OpenDaylight features:

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

The above command will take some time so please be patient. It installs some of the key features that we will require for our lab:

- odl-restconf: Enables the RESTCONF northbound API
- odl-l2switch-switch: Provides an implementation of an Ethernet learning switch
- odl-mdsal-apidocs: Enables access to YANG API
- odl-dlux-all: GUI for OpenDaylight

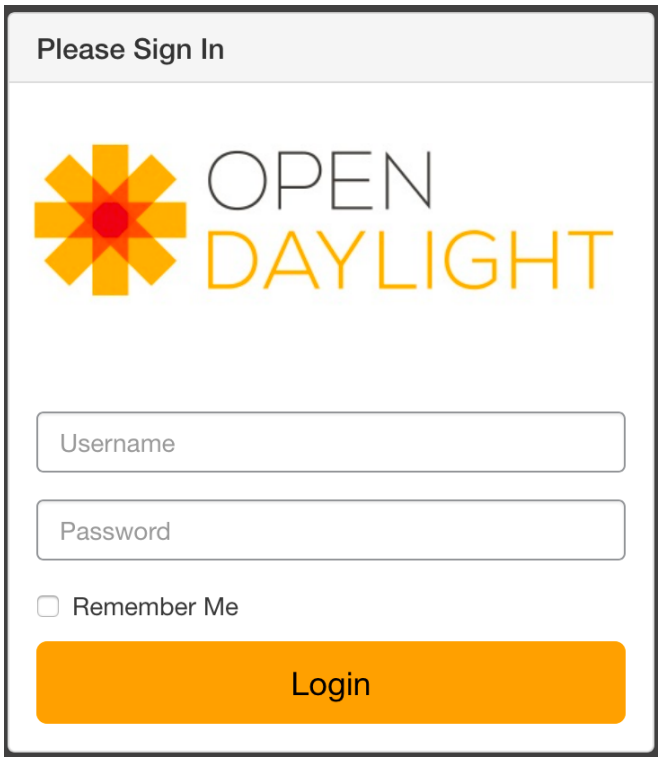
Verify the installed features:

```
opendaylight-user@root> feature:list --installed
```

2. Open up OpenDaylight GUI. (wait 2-3 minutes after launching ODL from command line to load all necessary services)

Browse to the following URL on any browser in your PC (If you are using VNC, use the browser in Ubuntu). Use the Local IP address (LAN) assigned to your server: (`ip addr show`)

```
http://[ip address of the VM]:8181/index.html
```



Login using the following credentials:

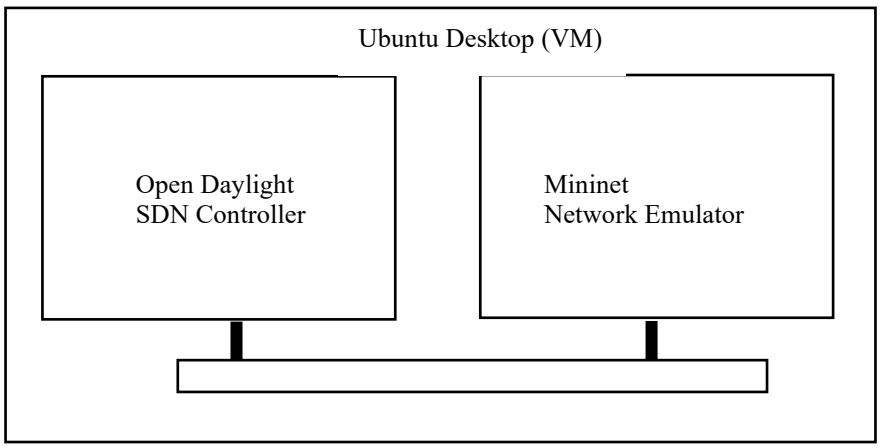
- `Username: admin`
- `Password: admin`

3. Log out of OpenDaylight (for your information only):

```
opendaylight-user@root> system:shutdown
```

Part 3. Build a simple Mininet network using the OpenDaylight OpenFlow controller

The objective of this exercise is to connect a Mininet network with an OpenDaylight controller



Installation and configuration steps:

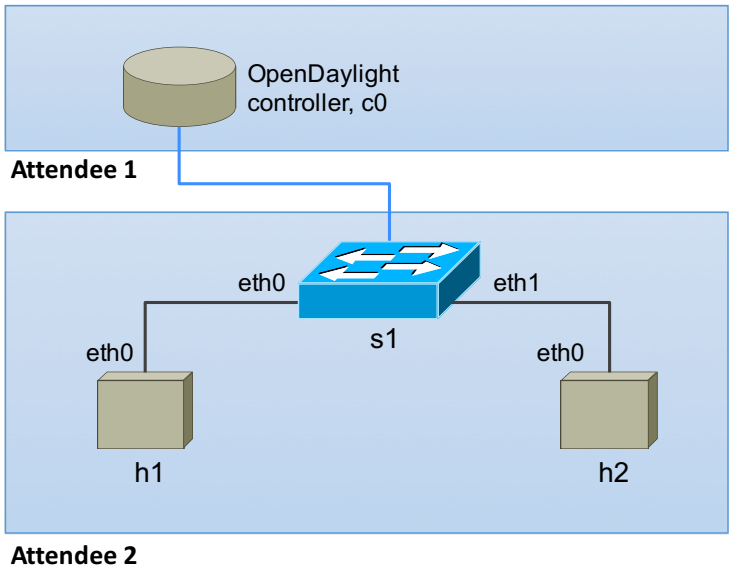
1. Start Wireshark in the Ubuntu VM and select interface corresponding to your LAN

2. Create a display filter within Wireshark for *openflow_v4*

3. Create a simple network on the Mininet VM:

```
mininet@mininet-vm:~$ sudo mn --mac
      --controller=remote,ip=xxxx.xxx.xx.x,port=6633
      --switch ovs,protocols=OpenFlow13
```

The above command creates a network with:
- 1 switch, s1
- 2 hosts, h1 and h2
- h1 eth0 connected to s1 eth0
- h2 eth0 connected to s1 eth1
- Remote OpenFlow controller @xxxx.xxx.xx.x



The above command will put you into the mininet CLI:

```
mininet>
```

4. Check the flow table of the switch:

```
mininet> dpctl dump-flows --protocols=OpenFlow13
```

Can you explain what you see ?

5. Open up OpenDaylight GUI.

   Browse to the following URL on any browser (use the IP address assigned on your system):

   ```
   http://[ip address of the VM]:8181/index.html
   ```

   View the topology.

6. At this point, stop the Wireshark capture and analyse the OpenFlow messages that have been sniffed. In particular, attempt to relate the FLOW_MOD messages with the contents of the flow table that you displayed earlier.

7. Re-start the Wireshark capture.

8. Attempt pinging between h1 and h2

   ```
   mininet> h1 ping h2
   ```

   Do the pings succeed ? Why do you think that is the case ?

9. Check the flow table of the switch again:

   ```
   mininet> dpctl dump-flows
   ```

   What do you see now ? Analyse the entries in the table.

10. Open up OpenDaylight GUI again:

    ```
    http://[ip address of the VM]:8181/index.html
    ```

    Reload the topology.

    Has anything changed ?

11. At this point, stop the Wireshark capture and analyse the OpenFlow messages that have been sniffed. In particular, pay attention to the Packet-In and Flow_Mod messages.

12. Exit from the Mininet CLI:

    ```
    mininet> exit
    ```

13. If time permits, repeat the above steps for the following topologies:

```
sudo mn --mac --topo=tree,3 --
controller=remote,ip=xxxx.xxx.xx.x,port=6633 --switch
ovs,protocols=OpenFlow13

sudo mn --mac --topo=linear,4 --controller=remote,ip=
xxxx.xxx.xx.x,port=6633 --switch ovs,protocols=OpenFlow13
```