ICT1010 Computer Networks

2021-2022 Trimester 2

Laboratory 8
Software Defined Networks (SDN) – Control & Data Plane

LEARNING OUTCOMES

Upon completion of this laboratory exercise, you should be able to:

- Understand the concept of software defined networking
- Configure flow rules using REST APIs from the Floodlight controller
- Configure flow rules from Pica8 GUI

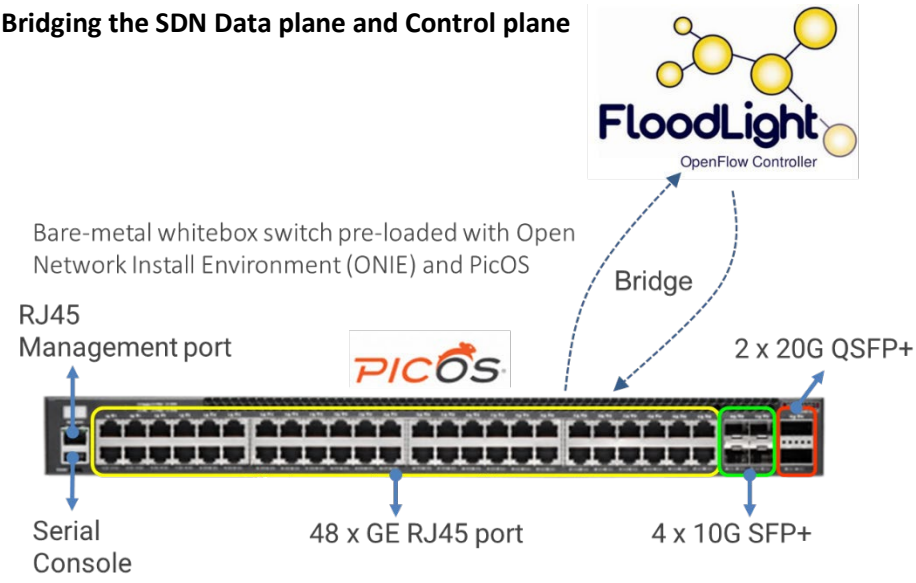
REQUIRED HARDWARE

- 2 x Cisco 2960X/plus
- 2 x Ports of Pica8 SDN switch accessed via floor patch-point
- 4 x Laptops

REQUIRED SOFTWARE

- Tera Term 4.104 http://ttssh2.osdn.jp/index.html.en
- VMware Workstation Pro software (Trial 30 days)

PART1: Bridging the SDN Data plane and Control plane



PART 1A: SSH into the SDN switch

To login into the SDN switch you are required to connect to the **ICT WiFi**. When working as a team, use only one PC (PC3) to login into the SDN switch. At the end of the Part 1A, ensure that your switch is running in the OVS/OpenFlow mode.

1.1.1 Ensure that you are connected to the ICT WIFI network.

1.1.2 Open Tera Term and SSH into the SDN switch 172.18.50.2**1** or 172.18.50.2**3** using your respective Rack credentials.

Lab	**MR7A**	**MR7B**
SDN switch IP	172.18.50.23	172.18.50.21

a. **Username: RACKy**

b. **Password: Pica8@sdnRy** (Please note, do NOT login using other team's credentials)

i. Where **y** is your rack number

ii. What is your rack number?

1.1.3 Each Rack is assigned 2 ports from the SDN switch through the patch point on the floor panel (light blue cable) NL1-BSxx or NL2-BSxx. The even numbered BS-xx is connected to the even port on the SDN switch (say ge-1/1/p) and odd numbered BS-xx is connected to the odd port on the SDN switch (say ge-1/1/p+1) (See the below Topology).

1.1.4 If your rack number, **y** is odd, you are assigned the ports

MR7A	**MR7B**
ge1/1/x	**ge1/1/**(x-28)
ge1/1/(x+1)	**ge1/1/**(x+1-28)

Where x=3y - 2

1.1.5 If your rack number, **y** is even, you are assigned the ports

MR7A	**MR7B**
ge1/1/(x+1)	**ge1/1/**(x+1-28)
ge1/1/(x+2)	**ge1/1/**(x+2-28)

Where x=3y - 2

Topology:

1.1.6 Once you setup the above topology, ensure that your switch is in the OVS mode. In the linux bash shell, run:

…@PICOS-OVS:~$ **picos status**

a. What do you observe in the output?

The following output shows the Switch is in L2/L3 mode:

- ***xorplus.service - Xorplus Management Daemon***

Loaded: loaded (/lib/systemd/system/xorplus.service; enabled)
Active: active …
……

The following output shows the Switch is in OVS mode:

- ***ovs.target - OVS Manage System***
  Loaded: loaded (/lib/systemd/system/ovs.target; enabled)
  Active: active …

1.1.7 The Open vSwitch version available on a PicOS switch can be determined using the **ovs-appctl version** command from the Linux shell.

PART 1B: RDP into the FloodlightGI VM (SDN controller)

The SDN controller is the brain of the software defined network. To RDP into the FloodlightGI controller VM you are required to connect to the ICT WiFi and install the VMWare workstation Pro (trial). When working as a team, use only one PC (PC4) to login into the FloodlightGI SDN controller. At the end of the Part 1B, power up your FloodlightGI controller VM and verify its IP address to bridge with the dataplane (Pica8 OVS).

1.2.1 Install VMware Workstation Pro software (Trial 30 days) in your laptop for Windows. If you are using Mac OS, install VMware Fusion.
Windows: https://www.vmware.com/go/getworkstation-win
Mac OS: https://www.vmware.com/go/getfusion

1.2.2 In order to connnect into the remote server from the VMware workstation, ensure that you are connected to the ICT WIFI network. Connect the remote server and enter the following:

Server IP	172.18.50.8
Username	sdn-user
Password	P@ssw0rd

1.2.3 Power on your assigned Floodlight Golden Image VM - *FloodlightNewGI-VMz with the assigned IP 172.18.50.z*

a. z = 30 + y; where y is your rack number

1.2.4 Login into your respective FloodLight VM's

a. Username: floodlight
b. Password: floodlight

1.2.5 Go to Application > Accessories > Terminal. Enter the linux command *ifconfig* and verify the IP address of your controller.

PART 1C: Bridging the data and control plane

1.3.1 Go to your Teraterm window of your SDN switch to create a new bridge and add your assigned ports and Floodlight controller IP to it.

1.3.2 Step1: To create a new bridge, issue the command:

```
ovs-vsctl add-br <enter bridge_name> -- set bridge <enter bridge_name>
  datapath_type=pica8
```

Note: Give a meaningful name to the bridge, e.g., RACKy-br; where y is your rack number

1.3.3 Step2: Add your assigned ports to the bridge. To add a port ge-1/1/_ to the bridge <bridge_name> issue the command:

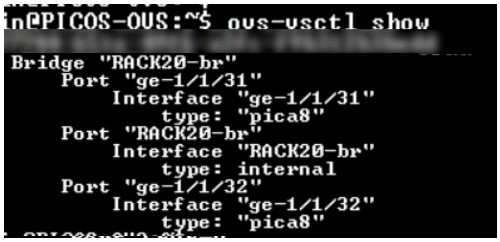
ovs-vsctl add-port <bridge_name> ge-1/1/_ -- set interface ge-1/1/_ type=pica8

1.3.4 Step3: Set the bridge to support the protocol - OpenFlow version 1.3, to enable the control plane and data plane communication.

ovs-vsctl set bridge <bridge_name> protocols=OpenFlow13

Verify your configuration to show the database content using the command:

ovs-vsctl show



Can you see your configured bridge name?

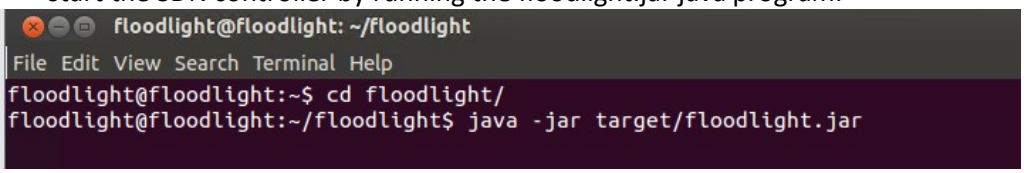
1.3.5 Step4: Add the floodlight controller to the bridge using the command:

ovs-vsctl set-controller <bridge_name> tcp:<Floodlight_controller_IP>:6653

Verify your configuration to show the bridge database

Is the Floodlight controller connected?

1.3.6 Open the Terminal from your assigned Floodlight VM and go inside the folder floodlight to start the SDN controller by running the floodlight.jar java program.

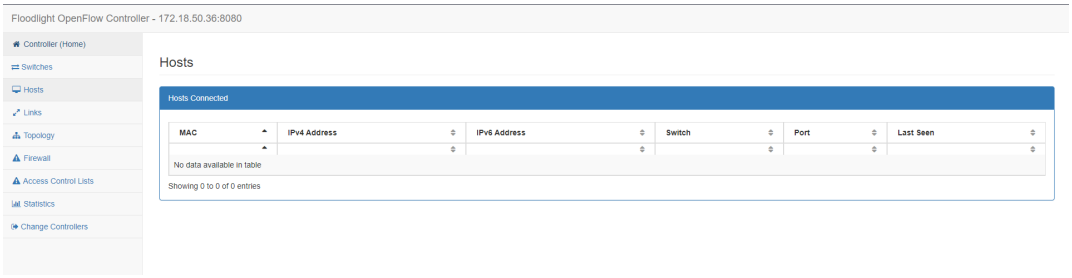


What do you observe in the terminal when the Floodlight controller is started?

1.3.7 Enter **ovs-vsctl show** on Teraterm now. *Is the Floodlight controller connected now?*

1.3.8 The Floodlight Controller comes with a web-based GUI. The GUI can be accessed from your browser to the following URL on port 8080:
http://<controller-ip>:8080/ui/pages/index.html

a. *What is the other port number that you observe in the dashboard? What is that port used for?*
b. *Are the SDN switches visible?*
c. *Are the end hosts visible?*



1.3.9 Check the port status and port statistics of your SDN switch in Teraterm

ovs-ofctl show <bridge_name>

What do you observe?

1.3.10 Ping from PC1 to PC2. Is the ping successful?

1.3.11 Dump the flow table in the Teraterm terminal

ovs-ofctl dump-flows <bridge_name>

Do you observe any flow entry?

PART2A: Adding a flow rule from the Floodlight controller using REST API

There are different ways of adding flow rules to the flow-table (similar to the traditional routing table) from the SDN Controller or OpenFlow. In order to ping from PC1 to PC2, we need to add two flow rules for each direction (i.e., PC1 → PC2 and PC2 → PC1). We will first add a one-way flow rule using the Floodlight REST API from the SDN controller from PC4.

2.1.1 In the Floodlight controller VM, open a new terminal to get the switch DPID using the Floodlight REST API.

```
curl http://<controller-ip>:8080/wm/core/controller/switches/json
| python -m json.tool
```

This is the Datapath ID (DPID) of your switch.

Is there an alternative way to get the switch DPID?

2.1.2 Use this DPID to add a flow between PC1-PC2. The port number **p** is the SDN switch ports allocated to you (refer to Part 1A and the topology in page 2).

```
curl -X POST -d '{"switch":"<enter DPID>", "name":"flow-pc1-pc2",
"cookie":"0",
"priority":"32768", "in_port":"p","active":"true",
"actions":"output=p+1"}' http://<enter
controller_ip>:8080/wm/staticentrypusher/json
```

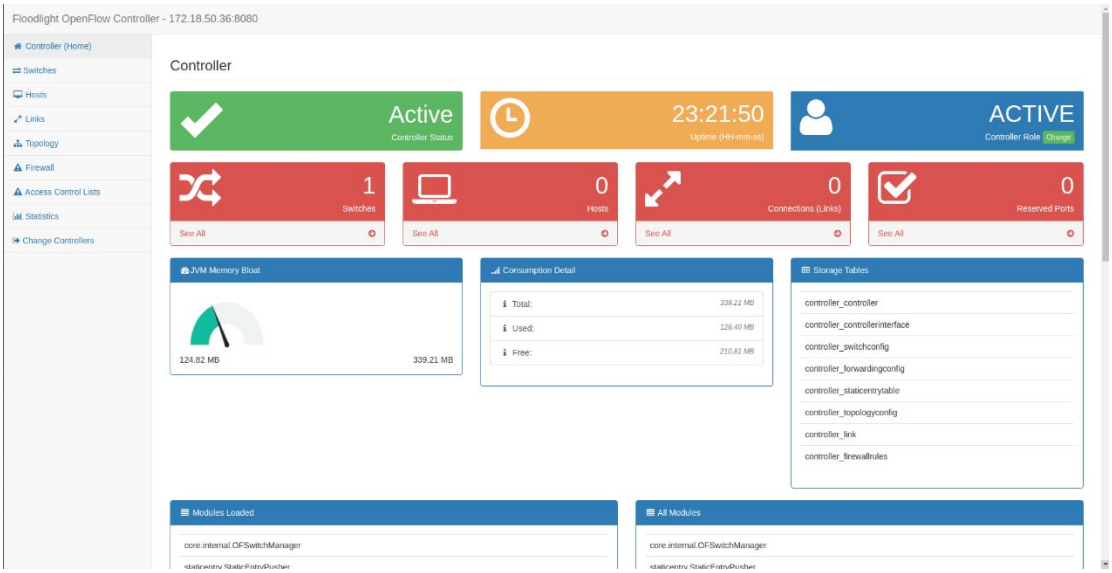
2.1.3 Dump the flow table from your teraterm switch terminal. Do you observe any flows-entry in the table?

2.1.4 Ping from PC1 to PC2. Is the ping successful? Why or why not?

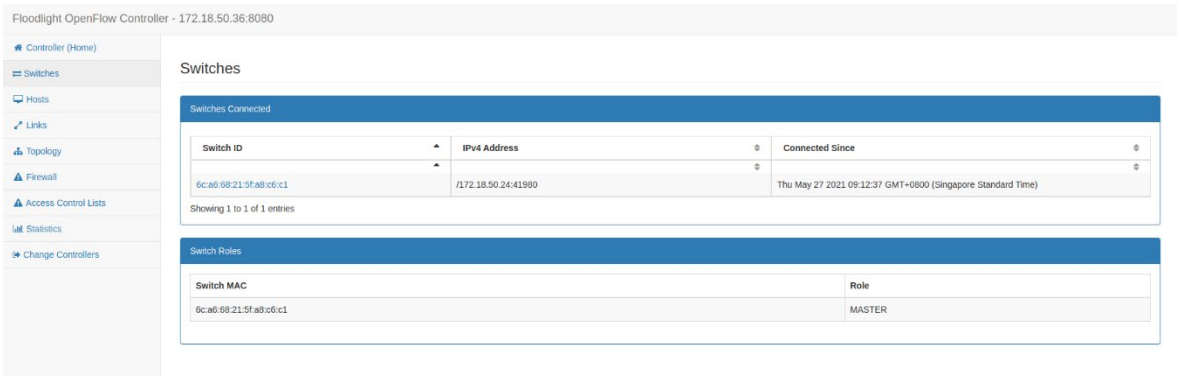
PART2B: Adding a return flow rule from Floodlight GUI

2.2.1 Use PC3 to login to the floodlight GUI by typing the floodlight VM IP address in the web browser.

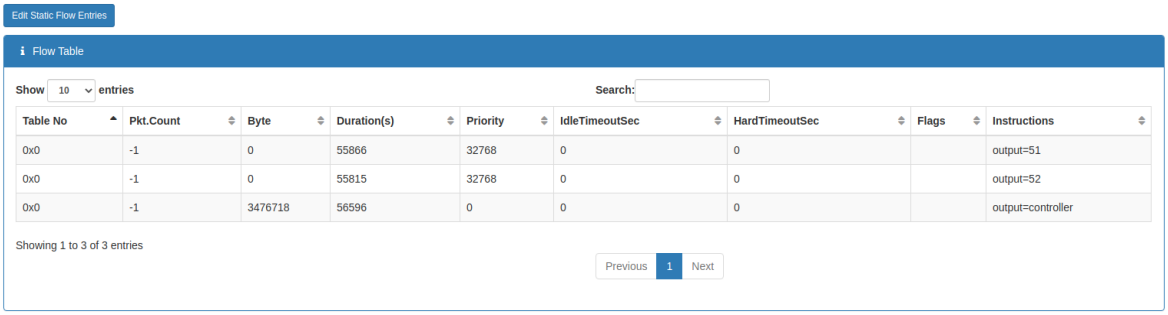
http://<controller-ip>:8080/ui/pages/index.html



2.2.2 Click “Switches” from the sidebar followed by clicking your switch ID from the list.



2.2.3 Scroll down to find the flow table and click the “Edit Static Flow Entries” button



2.2.4 Select the “Add New” button to add a new flow and fill in the details according to Part 2A step 2.1.2.

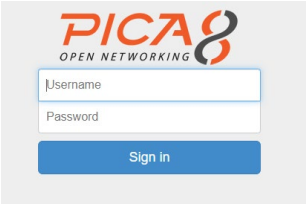
2.2.5 Dump the flow table from your teraterm switch terminal. Do you observe any flows-entry in the table?

2.2.6 Ping from PC1 to PC2. Is the ping successful? (If not troubleshoot)

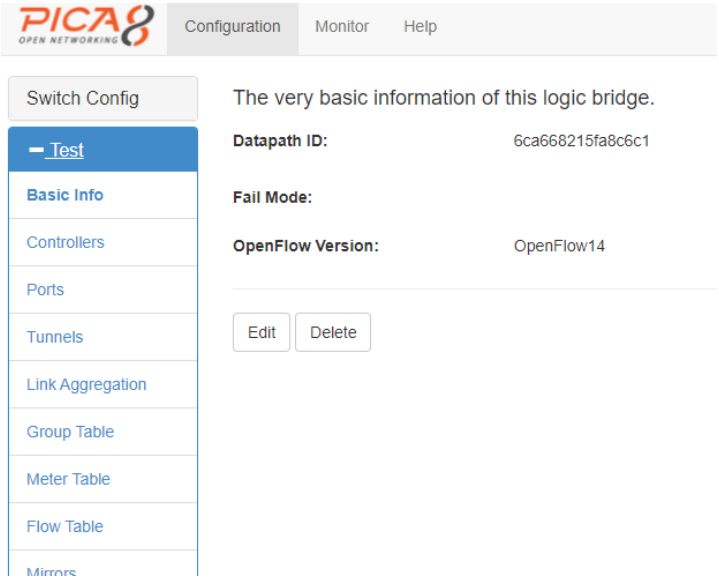
PART2C: Adding a meter rule from Pica8 GUI (Optional)

OpenFlow 1.3 introduces meters to the OpenFlow protocol. Meters complement the queue framework already in place in OpenFlow by allowing for the rate-monitoring of traffic prior to output. More specifically, with meters, we can monitor the ingress rate of traffic as defined by a flow.

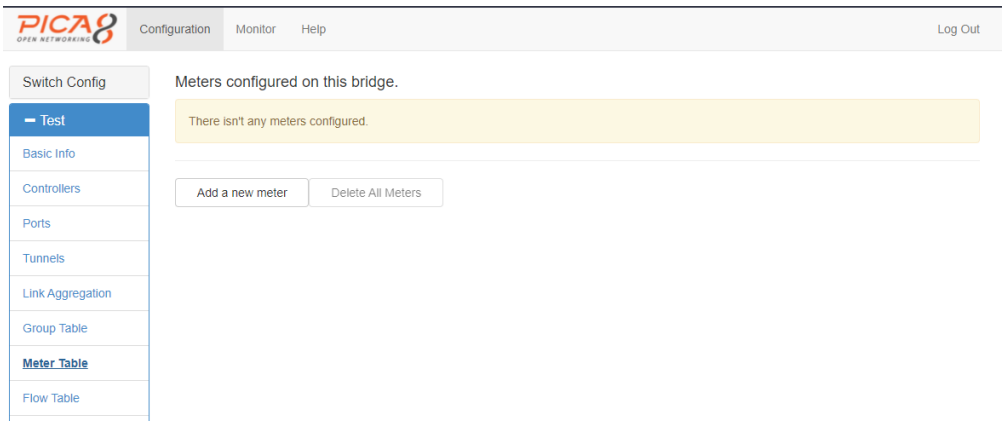
2.3.1 Login to the web interface of the switch using the IP address



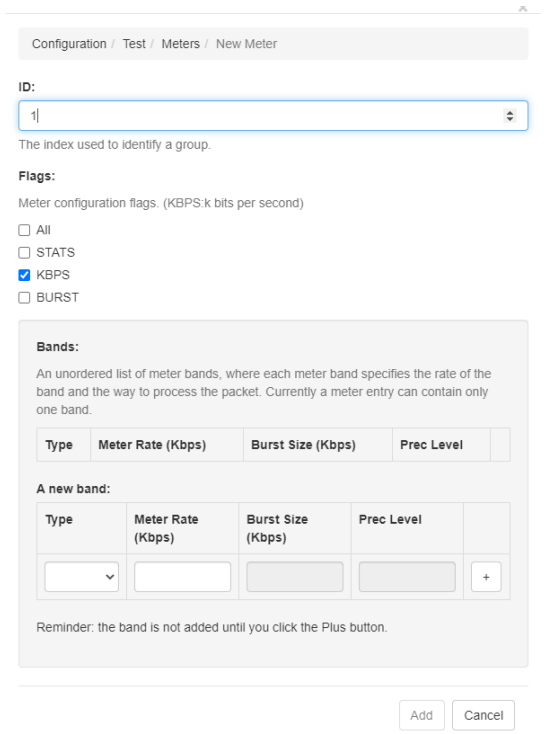
2.3.2 Select your bridge from the sidebar



2.3.3 Select “Meter Table” from the sidebar. There will not be any meters configured. We will add a new meter in the next step.



2.3.4 Click "**Add a new meter**"



The meter table has 2 options to handle packets – *DROP* and *DSCP_REMARK*.
(i) *DROP* will specify a rule to cap the bandwidth specified in the Meter Rate field. This meter rule will then be associated with a flow rule to specific end hosts. For example, a flow rule with a destination of 10.1.1.2 can be associated with a meter rule capped at 20 Gbps while another flow rule with a destination of 192.168.0.1 will be associated with a drop meter capped at 2 Gbps.

(ii) *DSCP_REMARK* can mark the packets in the flow table, in order to prioritise the UDP packets to a specific host destination IP (for example).

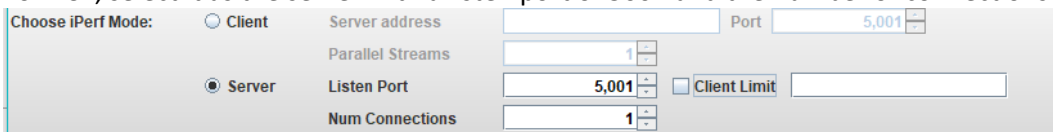
Define a meter to limit bandwidth to 3 Mbps (300000 Kbps). Input this into the Meter Rate field and select DROP as the type.

2.3.5 Finally map this meter ID '1' to the flow rule for the traffic from PC1 to PC2 by adding the necessary options to the flow rules in your flow table.

2.3.6 To test the meters, download jperf on both PC1 and PC2 from this link: https://sourceforge.net/projects/iperf/files/latest/download

2.3.7 After downloading, unzip and double click jperf.bat.

2.3.8 For PC1, select it as the server with a listen port of 5001 and the number of connections of 1.

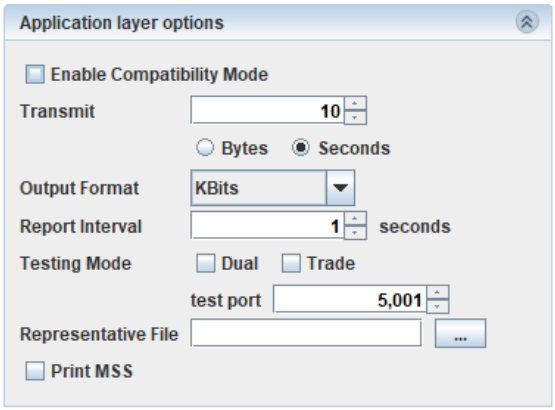


2.3.9 Click the left most icon to start the server.

2.3.10 On PC2, run jperf and select the client option and input the IP address of PC1 along with the port.

2.3.11 Under the application layer options, change the value of Transmit 60 seconds to allow the

traffic test to run for 1 minute so we can observe the bandwidth cap flow rule.



2.3.12 What is the average bandwidth that you observe from the graph?

(i) before applying the meter to the flow rule

(ii) after applying the meter to the flow rule

PART3: Teardown

2.3.1 Delete the bridge to clean up your configurations.

```
ovs-vsctl --if-exists del-br <bridge name>
```

2.3.2 Are there other means to delete the bridge?

2.3.3 Enter **`ovs-vsctl show`** on switch Teraterm now. Is your bridge deleted?

Explore Further….

- Explore other OpenFlow commands from the Pica8 documentation https://docs.pica8.com/display/picos2102cg/Introduction+to+OpenFlow
- You can explore other Floodlight APIs https://floodlight.atlassian.net/wiki/spaces/floodlightcontroller/pages/1343518/Static+Entry+Pusher+API
- You can also download the Floodlight VM and explore the controller functionalities with the data plane running on *Mininet Emulation Platform.*

https://medium.com/@click4abhishekagarwal/getting-started-with-sdn-597663e5caef