

# Project 1

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## Part 1: CloudLab

### Task:

To create a simple network topology in CloudLab. This simple topology includes four instances of XEN VM linked together. Next a topology should be instantiated. After this, ping test is carried out to see if topology is created successfully. This project is divided into 3 steps:

- I. Creating a profile
- II. Starting the experiment
- III. Testing the connectivity by pinging all nodes.

The steps along with the screenshots are as attached.

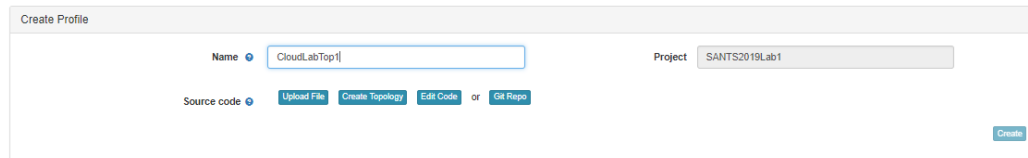
#### I. Creating a profile

The profile is created as explained and the screenshot is as attached.

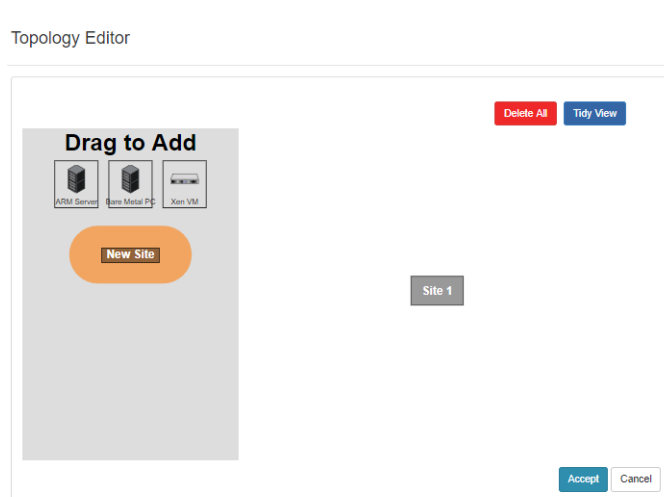
To create a profile the following steps are followed.

1. In the experiments tab, “Create Experiment Profile” is chosen.

When the dialogue box opens, the details as shown below are input:

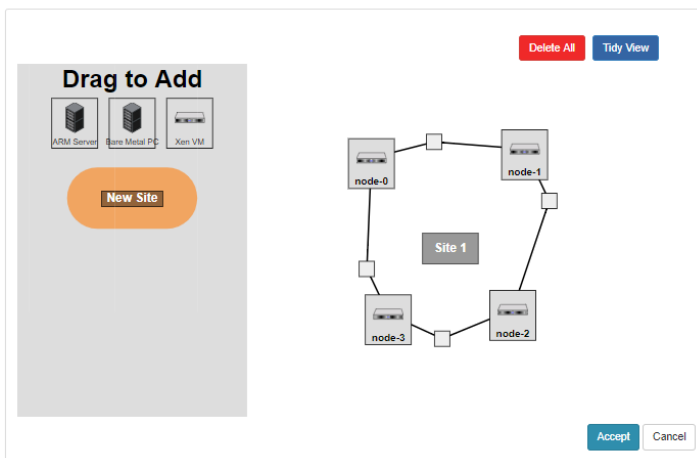


2. “Create topology” is selected as we are not importing or editing from any other source. Topology editor opens as shown below:



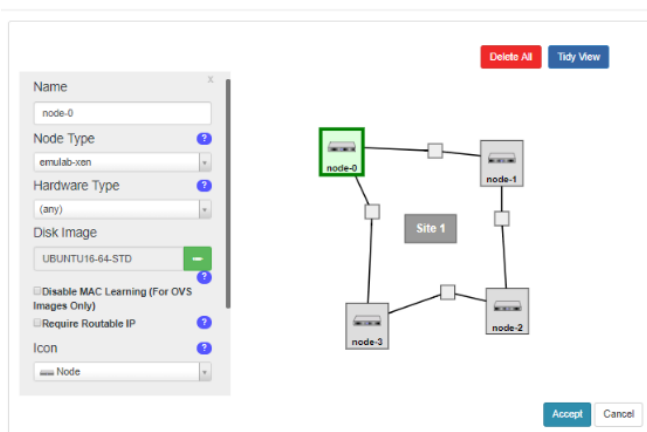
3. Four Xen VMs are dragged and dropped on the editor and connected as shown below. We see there will be 4 links connecting all the four nodes.

Topology Editor

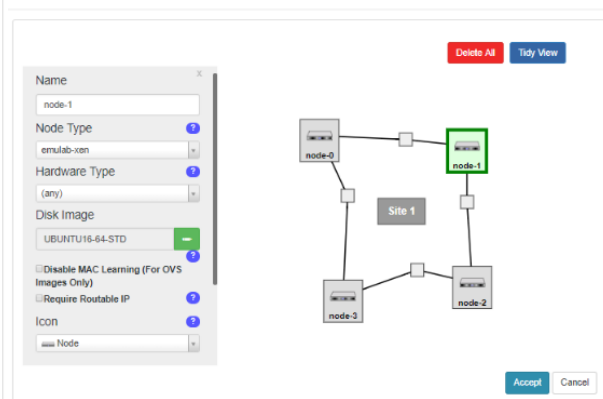


4. For each of the node, the following details are given:
  - a. Node Type: emulab-xen
  - b. Hardware Type: (any)
  - c. Disk Image: UBUNTU16-64-STD

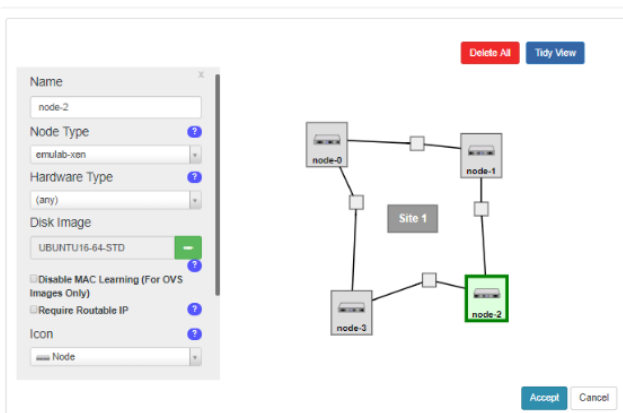
Topology Editor



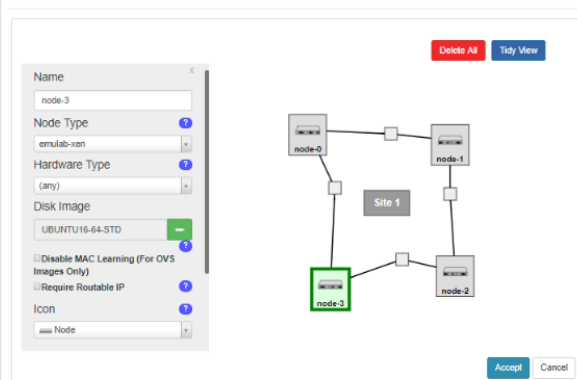
Topology Editor



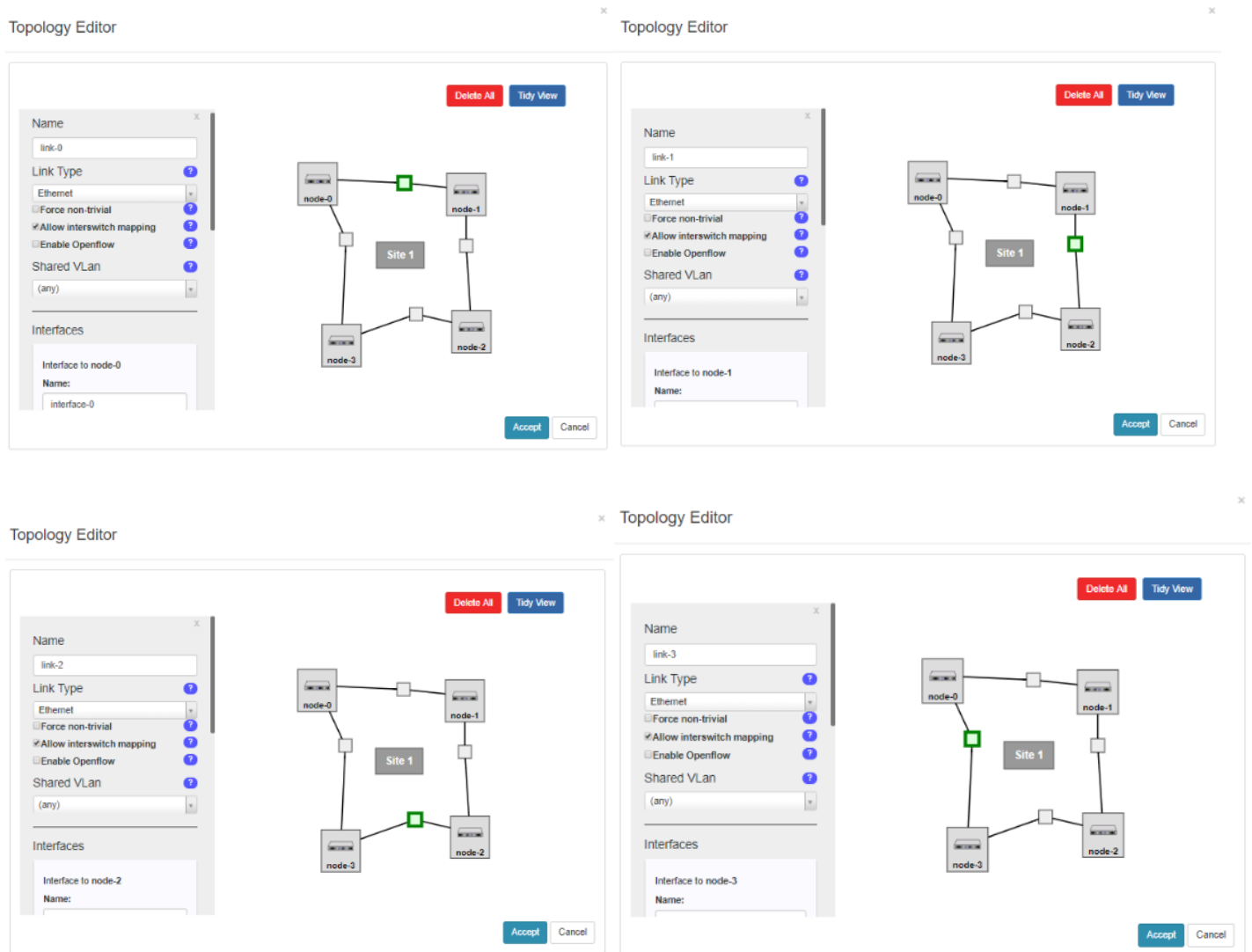
Topology Editor



Topology Editor



5. For each of the links, the following details are selected:
  - a. Link Type: Ethernet
  - b. Select Allow interswitch mapping



6. The description and optional instructions are provided. After everything is done we proceed to create .

Create Profile

Name: CloudLabTop1 Project: SANTS2019Lab1

Source code: [Edit Topology](#) [Edit Code](#) or [Git Repo](#)

Description: Lab to create simple network topology that includes four instances of XEN VM (Virtual Machine) linked together.

Instructions: Provide optional instructions for users of your profile.

[Show/Edit Tour](#)

Who can instantiate your profile?

☐ Anyone

☒ Only members of your project

☐ Allow members of your project to modify this profile.

[Create](#)

## II. Starting the project

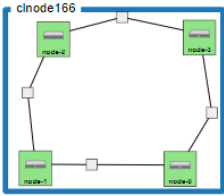
### Topology View Screenshot:

Your experiment is ready!

Name: Krupa-QV46479  
State: ready  
Profile: CloudLabTopo1  
Started: Feb 10, 2019 3:05 PM  
Expires: Feb 11, 2019 7:05 AM (in 15 hours)

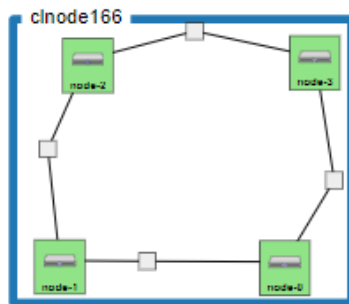
Logs Performance History Create Disk Image Copy Extend Terminate

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3



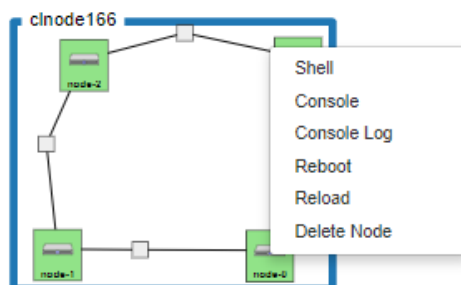
Click on a node for more options. Click and drag to move things around.

Reload Topo Run Linktest Refresh Status



## III. Testing Connectivity

1. To test connecting we need the IP address of each node. Therefore first each node is selected to access "Shell".



2. In the shell “ifconfig” is typed to find the IP address of the node.

```
Topology View List View Manifest Graphs node-0 X
Welcome to Ubuntu 16.04.1 LTS (GNU/Linux 4.4.0-142-generic x86_64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:       https://ubuntu.com/advantage
New release '16.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Sun Feb 10 15:25:21 2019 from 155.98.33.74
Krupa@node-0:~$ ifconfig
```

By performing this step, the IP addresses of all the nodes are found out which are as below:

- a. Node0: 10.10.4.2
- b. Node1: 10.10.2.1
- c. Node2: 10.10.3.1
- d. Node3: 10.10.4.1

```
Topology View List View Manifest Graphs node-0 X node-1 X node-2 X node-3 X
Krupa@node-0:~$ ifconfig
eth0      Link encap:Ethernet  Hwaddr 02:23:5c:e7:e6:af
          inet addr:172.17.166.1  Bcast:172.31.255.255  Mask:255.240.0.0
          inet6 addr: fe80::23:5c:ff:fe7:e6af/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:648094 errors:0 dropped:3131 overruns:0 frame:0
          TX packets:2245 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:30352962 (30.3 MB)  TX bytes:272843 (272.8 KB)

eth1      Link encap:Ethernet  Hwaddr 02:8d:40:19:e4:2b
          inet6 addr: fe80::8d:40:ff:fe19:e42b/64 Scope:Link255.255.0

          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:375 errors:0 dropped:0 overruns:0 frame:0
          collisions:0 txqueuelen:1000 ed:0 overruns:0 carrier:0

          RX bytes:30283 (30.2 KB)  TX bytes:10984 (10.9 KB)

          inet addr:10.10.4.2  Bcast:10.10.4.255  Mask:255.255.255.0
```

```
Topology View List View Manifest Graphs node-0 X node-1 X node-2 X node-3 X
Krupa@node-1:~$ ifconfig
eth0      Link encap:Ethernet  Hwaddr 02:e8:eb:ff:17:dc
          inet addr:172.17.166.2  Bcast:172.31.255.255  Mask:255.240.0.0
          inet6 addr: fe80::e8:eb:ff:fe17:dc/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:655974 errors:0 dropped:3174 overruns:0 frame:0
          TX packets:1107 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:30715950 (30.7 MB)  TX bytes:129371 (129.3 KB)

eth1      Link encap:Ethernet  Hwaddr 02:9a:72:a6:9b:11
          inet6 addr: fe80::9a:72:ff:fea6:9b11/64 Scope:Link255.255.0

          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:142 errors:0 dropped:0 overruns:0 frame:0
          collisions:0 txqueuelen:1000 ed:0 overruns:0 carrier:0

          RX bytes:10584 (10.5 KB)  TX bytes:33101 (33.1 KB)

          inet addr:10.10.2.1  Bcast:10.10.2.255  Mask:255.255.255.0
```

```
Topology View List View Manifest Graphs node-0 X node-1 X node-2 X node-3 X
Krupa@node-2:~$ ifconfig
eth0      Link encap:Ethernet  Hwaddr 02:72:f8:2e:c5:0f
          inet addr:172.17.166.3  Bcast:172.31.255.255  Mask:255.240.0.0
          inet6 addr: fe80::72:f8:ff:fe2e:c50f/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:655621 errors:0 dropped:3172 overruns:0 frame:0
          TX packets:1100 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:30699435 (30.6 MB)  TX bytes:128983 (128.9 KB)

eth1      Link encap:Ethernet  Hwaddr 02:37:3e:68:8c:44
          inet6 addr: fe80::37:3e:ff:fe68:8c44/64 Scope:Link255.255.0

          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:40 errors:0 dropped:0 overruns:0 frame:0
          collisions:0 txqueuelen:1000 ed:0 overruns:0 carrier:0

          RX bytes:2200 (2.2 KB)  TX bytes:23609 (23.6 KB)

          inet addr:10.10.3.1  Bcast:10.10.3.255  Mask:255.255.255.0
```

```
Topology View List View Manifest Graphs node-0 X node-1 X node-2 X node-3 X
Krupa@node-3:~$ ifconfig
eth0      Link encap:Ethernet  Hwaddr 02:67:5f:84:b2:67
          inet addr:172.17.166.4  Bcast:172.31.255.255  Mask:255.240.0.0
          inet6 addr: fe80::67:5f:ff:fe84:b267/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:658476 errors:0 dropped:3187 overruns:0 frame:0
          TX packets:1089 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:30832071 (30.8 MB)  TX bytes:128899 (128.8 KB)

eth1      Link encap:Ethernet  Hwaddr 02:1a:f9:71:15:db
          inet6 addr: fe80::1a:f9:ff:fe71:15db/64 Scope:Link255.255.0

          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:56 errors:0 dropped:0 overruns:0 frame:0
          collisions:0 txqueuelen:1000 ed:0 overruns:0 carrier:0

          RX bytes:3552 (3.5 KB)  TX bytes:23609 (23.6 KB)

          inet addr:10.10.4.1  Bcast:10.10.4.255  Mask:255.255.255.0
```

3. Now to check connectivity, ping test is carried out. In this, from a shell of node the command – “ping (ip address)” is executed. For example, to test connectivity from node0 to node1, “ping 10.10.2.1” is executed .

The following screenshots show the connectivity tests performed on node0 to all other nodes.

Topology ViewList ViewManifest Graphsnode-0node-1node-2node-3

```
inet6 addr: ::1/128 Scope:Host
RX packets:24 errors:0 dropped:0 overruns:0 frame:0

TX packets:24 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:1560 (1.5 KB) TX bytes:1560 (1.5 KB)

Krupa@node-0:~$ ping 10.10.2.1
PING 10.10.2.1 (10.10.2.1) 56(84) bytes of data.
64 bytes from 10.10.2.1: icmp_seq=2 ttl=64 time=0.197 ms

64 bytes from 10.10.2.1: icmp_seq=3 ttl=64 time=0.288 ms
64 bytes from 10.10.2.1: icmp_seq=4 ttl=64 time=0.204 ms
64 bytes from 10.10.2.1: icmp_seq=6 ttl=64 time=0.329 ms

64 bytes from 10.10.2.1: icmp_seq=7 ttl=64 time=0.172 ms
64 bytes from 10.10.2.1: icmp_seq=8 ttl=64 time=0.319 ms
64 bytes from 10.10.2.1: icmp_seq=10 ttl=64 time=0.225 ms
```

Topology ViewList ViewManifest Graphsnode-0node-1node-2node-3

```
PING 10.10.3.1 (10.10.3.1) 56(84) bytes of data.
64 bytes from 10.10.3.1: icmp_seq=1 ttl=63 time=0.574 ms
64 bytes from 10.10.3.1: icmp_seq=2 ttl=63 time=0.472 ms
64 bytes from 10.10.3.1: icmp_seq=3 ttl=63 time=0.335 ms
64 bytes from 10.10.3.1: icmp_seq=4 ttl=63 time=0.428 ms
64 bytes from 10.10.3.1: icmp_seq=5 ttl=63 time=0.507 ms
64 bytes from 10.10.3.1: icmp_seq=6 ttl=63 time=0.298 ms
64 bytes from 10.10.3.1: icmp_seq=7 ttl=63 time=0.537 ms
64 bytes from 10.10.3.1: icmp_seq=8 ttl=63 time=0.492 ms
64 bytes from 10.10.3.1: icmp_seq=9 ttl=63 time=0.270 ms
64 bytes from 10.10.3.1: icmp_seq=10 ttl=63 time=0.555 ms
64 bytes from 10.10.3.1: icmp_seq=11 ttl=63 time=0.322 ms
64 bytes from 10.10.3.1: icmp_seq=12 ttl=63 time=0.315 ms
64 bytes from 10.10.3.1: icmp_seq=13 ttl=63 time=0.296 ms
64 bytes from 10.10.3.1: icmp_seq=14 ttl=63 time=0.456 ms
64 bytes from 10.10.3.1: icmp_seq=15 ttl=63 time=0.418 ms
64 bytes from 10.10.3.1: icmp_seq=16 ttl=63 time=0.405 ms
64 bytes from 10.10.3.1: icmp_seq=17 ttl=63 time=0.547 ms
64 bytes from 10.10.3.1: icmp_seq=18 ttl=63 time=0.261 ms
```

Topology ViewList ViewManifest Graphsnode-0node-1node-2node-3

```
Krupa@node-0:~$ ping 10.10.4.1
PING 10.10.4.1 (10.10.4.1) 56(84) bytes of data.
64 bytes from 10.10.4.1: icmp_seq=1 ttl=64 time=0.277 ms
64 bytes from 10.10.4.1: icmp_seq=2 ttl=64 time=0.238 ms
64 bytes from 10.10.4.1: icmp_seq=3 ttl=64 time=0.333 ms
64 bytes from 10.10.4.1: icmp_seq=4 ttl=64 time=0.267 ms
64 bytes from 10.10.4.1: icmp_seq=5 ttl=64 time=0.245 ms
64 bytes from 10.10.4.1: icmp_seq=6 ttl=64 time=0.304 ms
64 bytes from 10.10.4.1: icmp_seq=7 ttl=64 time=0.319 ms
64 bytes from 10.10.4.1: icmp_seq=8 ttl=64 time=0.262 ms
64 bytes from 10.10.4.1: icmp_seq=9 ttl=64 time=0.241 ms
64 bytes from 10.10.4.1: icmp_seq=10 ttl=64 time=0.254 ms
64 bytes from 10.10.4.1: icmp_seq=11 ttl=64 time=0.245 ms
64 bytes from 10.10.4.1: icmp_seq=12 ttl=64 time=0.248 ms
64 bytes from 10.10.4.1: icmp_seq=13 ttl=64 time=0.314 ms
64 bytes from 10.10.4.1: icmp_seq=14 ttl=64 time=0.250 ms
64 bytes from 10.10.4.1: icmp_seq=15 ttl=64 time=0.251 ms
64 bytes from 10.10.4.1: icmp_seq=16 ttl=64 time=0.178 ms
```

The following screenshots show the connectivity tests performed on node1 to all other nodes.

Topology ViewList ViewManifest Graphsnode-0node-1node-2node-3

```
64 bytes from 10.10.4.2: icmp_seq=2 ttl=64 time=0.224 ms
64 bytes from 10.10.4.2: icmp_seq=3 ttl=64 time=0.147 ms
64 bytes from 10.10.4.2: icmp_seq=4 ttl=64 time=0.166 ms
64 bytes from 10.10.4.2: icmp_seq=5 ttl=64 time=0.300 ms
64 bytes from 10.10.4.2: icmp_seq=6 ttl=64 time=0.330 ms
64 bytes from 10.10.4.2: icmp_seq=7 ttl=64 time=0.274 ms
64 bytes from 10.10.4.2: icmp_seq=8 ttl=64 time=0.223 ms
64 bytes from 10.10.4.2: icmp_seq=9 ttl=64 time=0.224 ms
64 bytes from 10.10.4.2: icmp_seq=10 ttl=64 time=0.271 ms
64 bytes from 10.10.4.2: icmp_seq=11 ttl=64 time=0.230 ms
64 bytes from 10.10.4.2: icmp_seq=12 ttl=64 time=0.257 ms
64 bytes from 10.10.4.2: icmp_seq=13 ttl=64 time=0.273 ms
64 bytes from 10.10.4.2: icmp_seq=14 ttl=64 time=0.326 ms
64 bytes from 10.10.4.2: icmp_seq=15 ttl=64 time=0.342 ms
64 bytes from 10.10.4.2: icmp_seq=16 ttl=64 time=0.221 ms
64 bytes from 10.10.4.2: icmp_seq=17 ttl=64 time=0.227 ms
64 bytes from 10.10.4.2: icmp_seq=18 ttl=64 time=0.222 ms
64 bytes from 10.10.4.2: icmp_seq=20 ttl=64 time=0.288 ms

64 bytes from 10.10.4.2: icmp_seq=21 ttl=64 time=0.263 ms
64 bytes from 10.10.4.2: icmp_seq=22 ttl=64 time=0.313 ms
```

Topology ViewList ViewManifest Graphsnode-0node-1node-2node-3

```
Krupa@node-1:~$ ping 10.10.3.1
PING 10.10.3.1 (10.10.3.1) 56(84) bytes of data.
64 bytes from 10.10.3.1: icmp_seq=1 ttl=64 time=0.319 ms
64 bytes from 10.10.3.1: icmp_seq=2 ttl=64 time=0.202 ms
64 bytes from 10.10.3.1: icmp_seq=3 ttl=64 time=0.229 ms
64 bytes from 10.10.3.1: icmp_seq=4 ttl=64 time=0.320 ms
64 bytes from 10.10.3.1: icmp_seq=5 ttl=64 time=0.196 ms
64 bytes from 10.10.3.1: icmp_seq=6 ttl=64 time=0.188 ms
64 bytes from 10.10.3.1: icmp_seq=7 ttl=64 time=0.288 ms
64 bytes from 10.10.3.1: icmp_seq=8 ttl=64 time=0.241 ms
64 bytes from 10.10.3.1: icmp_seq=9 ttl=64 time=0.324 ms
64 bytes from 10.10.3.1: icmp_seq=10 ttl=64 time=0.327 ms
64 bytes from 10.10.3.1: icmp_seq=11 ttl=64 time=0.197 ms
64 bytes from 10.10.3.1: icmp_seq=12 ttl=64 time=0.329 ms
64 bytes from 10.10.3.1: icmp_seq=13 ttl=64 time=0.198 ms
64 bytes from 10.10.3.1: icmp_seq=14 ttl=64 time=0.320 ms
```

Topology ViewList ViewManifest Graphsnode-0node-1node-2node-3

```
Krupa@node-1:~$ ping 10.10.4.1
PING 10.10.4.1 (10.10.4.1) 56(84) bytes of data.
64 bytes from 10.10.4.1: icmp_seq=1 ttl=63 time=0.477 ms
64 bytes from 10.10.4.1: icmp_seq=2 ttl=63 time=0.395 ms
64 bytes from 10.10.4.1: icmp_seq=3 ttl=63 time=0.494 ms
64 bytes from 10.10.4.1: icmp_seq=4 ttl=63 time=0.468 ms
64 bytes from 10.10.4.1: icmp_seq=5 ttl=63 time=0.461 ms
64 bytes from 10.10.4.1: icmp_seq=6 ttl=63 time=0.541 ms
64 bytes from 10.10.4.1: icmp_seq=7 ttl=63 time=0.361 ms
64 bytes from 10.10.4.1: icmp_seq=8 ttl=63 time=0.458 ms
64 bytes from 10.10.4.1: icmp_seq=9 ttl=63 time=0.466 ms
64 bytes from 10.10.4.1: icmp_seq=10 ttl=63 time=0.637 ms
64 bytes from 10.10.4.1: icmp_seq=11 ttl=63 time=0.301 ms
64 bytes from 10.10.4.1: icmp_seq=12 ttl=63 time=0.512 ms
64 bytes from 10.10.4.1: icmp_seq=13 ttl=63 time=0.508 ms
```

The following screenshots show the connectivity tests performed on node2 to all other nodes.

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3

Krupa@node-2:~\$ ping 10.10.4.2  
PING 10.10.4.2 (10.10.4.2) 56(84) bytes of data.  
64 bytes from 10.10.4.2: icmp\_seq=1 ttl=63 time=0.461 ms  
64 bytes from 10.10.4.2: icmp\_seq=2 ttl=63 time=0.460 ms  
64 bytes from 10.10.4.2: icmp\_seq=3 ttl=63 time=0.446 ms  
64 bytes from 10.10.4.2: icmp\_seq=4 ttl=63 time=0.409 ms  
64 bytes from 10.10.4.2: icmp\_seq=5 ttl=63 time=0.527 ms  
64 bytes from 10.10.4.2: icmp\_seq=6 ttl=63 time=0.446 ms  
64 bytes from 10.10.4.2: icmp\_seq=7 ttl=63 time=0.336 ms  
64 bytes from 10.10.4.2: icmp\_seq=8 ttl=63 time=0.376 ms  
64 bytes from 10.10.4.2: icmp\_seq=9 ttl=63 time=0.424 ms  
64 bytes from 10.10.4.2: icmp\_seq=10 ttl=63 time=0.489 ms  
64 bytes from 10.10.4.2: icmp\_seq=11 ttl=63 time=0.476 ms  
64 bytes from 10.10.4.2: icmp\_seq=12 ttl=63 time=0.549 ms  
64 bytes from 10.10.4.2: icmp\_seq=13 ttl=63 time=0.427 ms  
64 bytes from 10.10.4.2: icmp\_seq=14 ttl=63 time=0.378 ms  
64 bytes from 10.10.4.2: icmp\_seq=15 ttl=63 time=0.531 ms  
64 bytes from 10.10.4.2: icmp\_seq=16 ttl=63 time=0.480 ms

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3

PING 10.10.2.1 (10.10.2.1) 56(84) bytes of data.  
64 bytes from 10.10.2.1: icmp\_seq=1 ttl=64 time=0.222 ms  
64 bytes from 10.10.2.1: icmp\_seq=2 ttl=64 time=0.219 ms  
64 bytes from 10.10.2.1: icmp\_seq=3 ttl=64 time=0.183 ms  
64 bytes from 10.10.2.1: icmp\_seq=4 ttl=64 time=0.288 ms  
64 bytes from 10.10.2.1: icmp\_seq=5 ttl=64 time=0.146 ms  
64 bytes from 10.10.2.1: icmp\_seq=6 ttl=64 time=0.291 ms  
64 bytes from 10.10.2.1: icmp\_seq=7 ttl=64 time=0.260 ms  
64 bytes from 10.10.2.1: icmp\_seq=8 ttl=64 time=0.189 ms  
64 bytes from 10.10.2.1: icmp\_seq=9 ttl=64 time=0.140 ms  
64 bytes from 10.10.2.1: icmp\_seq=10 ttl=64 time=0.144 ms  
64 bytes from 10.10.2.1: icmp\_seq=11 ttl=64 time=0.147 ms  
64 bytes from 10.10.2.1: icmp\_seq=12 ttl=64 time=0.272 ms  
64 bytes from 10.10.2.1: icmp\_seq=13 ttl=64 time=0.255 ms  
64 bytes from 10.10.2.1: icmp\_seq=14 ttl=64 time=0.147 ms  
64 bytes from 10.10.2.1: icmp\_seq=15 ttl=64 time=0.289 ms  
64 bytes from 10.10.2.1: icmp\_seq=16 ttl=64 time=0.163 ms  
64 bytes from 10.10.2.1: icmp\_seq=17 ttl=64 time=0.145 ms  
64 bytes from 10.10.2.1: icmp\_seq=18 ttl=64 time=0.143 ms  
64 bytes from 10.10.2.1: icmp\_seq=19 ttl=64 time=0.142 ms

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3

64 bytes from 10.10.4.1: icmp\_seq=1 ttl=64 time=0.229 ms  
64 bytes from 10.10.4.1: icmp\_seq=2 ttl=64 time=0.233 ms  
64 bytes from 10.10.4.1: icmp\_seq=3 ttl=64 time=0.318 ms  
64 bytes from 10.10.4.1: icmp\_seq=4 ttl=64 time=0.330 ms  
64 bytes from 10.10.4.1: icmp\_seq=5 ttl=64 time=0.168 ms  
64 bytes from 10.10.4.1: icmp\_seq=6 ttl=64 time=0.332 ms  
64 bytes from 10.10.4.1: icmp\_seq=7 ttl=64 time=0.326 ms  
64 bytes from 10.10.4.1: icmp\_seq=8 ttl=64 time=0.313 ms  
64 bytes from 10.10.4.1: icmp\_seq=9 ttl=64 time=0.308 ms  
64 bytes from 10.10.4.1: icmp\_seq=10 ttl=64 time=0.223 ms  
64 bytes from 10.10.4.1: icmp\_seq=11 ttl=64 time=0.330 ms  
64 bytes from 10.10.4.1: icmp\_seq=12 ttl=64 time=0.204 ms  
64 bytes from 10.10.4.1: icmp\_seq=13 ttl=64 time=0.308 ms  
64 bytes from 10.10.4.1: icmp\_seq=14 ttl=64 time=0.319 ms  
64 bytes from 10.10.4.1: icmp\_seq=15 ttl=64 time=0.300 ms  
64 bytes from 10.10.4.1: icmp\_seq=16 ttl=64 time=0.228 ms  
64 bytes from 10.10.4.1: icmp\_seq=17 ttl=64 time=0.168 ms  
64 bytes from 10.10.4.1: icmp\_seq=18 ttl=64 time=0.333 ms  
64 bytes from 10.10.4.1: icmp\_seq=19 ttl=64 time=0.195 ms

The following screenshots show the connectivity tests performed on node2 to all other nodes.

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3

Krupa@node-3:~\$ ping 10.10.4.2  
PING 10.10.4.2 (10.10.4.2) 56(84) bytes of data.  
64 bytes from 10.10.4.2: icmp\_seq=1 ttl=64 time=0.351 ms  
64 bytes from 10.10.4.2: icmp\_seq=2 ttl=64 time=0.186 ms  
64 bytes from 10.10.4.2: icmp\_seq=3 ttl=64 time=0.295 ms  
64 bytes from 10.10.4.2: icmp\_seq=4 ttl=64 time=0.231 ms  
64 bytes from 10.10.4.2: icmp\_seq=5 ttl=64 time=0.228 ms  
64 bytes from 10.10.4.2: icmp\_seq=6 ttl=64 time=0.275 ms  
64 bytes from 10.10.4.2: icmp\_seq=7 ttl=64 time=0.310 ms  
64 bytes from 10.10.4.2: icmp\_seq=8 ttl=64 time=0.228 ms  
64 bytes from 10.10.4.2: icmp\_seq=9 ttl=64 time=0.225 ms  
64 bytes from 10.10.4.2: icmp\_seq=10 ttl=64 time=0.298 ms  
64 bytes from 10.10.4.2: icmp\_seq=11 ttl=64 time=0.278 ms  
64 bytes from 10.10.4.2: icmp\_seq=12 ttl=64 time=0.297 ms  
64 bytes from 10.10.4.2: icmp\_seq=13 ttl=64 time=0.245 ms  
64 bytes from 10.10.4.2: icmp\_seq=14 ttl=64 time=0.197 ms  
64 bytes from 10.10.4.2: icmp\_seq=15 ttl=64 time=0.311 ms  
64 bytes from 10.10.4.2: icmp\_seq=16 ttl=64 time=0.211 ms

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3

Krupa@node-3:~\$ ping 10.10.2.1  
PING 10.10.2.1 (10.10.2.1) 56(84) bytes of data.  
64 bytes from 10.10.2.1: icmp\_seq=1 ttl=63 time=0.480 ms  
64 bytes from 10.10.2.1: icmp\_seq=2 ttl=63 time=0.516 ms  
64 bytes from 10.10.2.1: icmp\_seq=3 ttl=63 time=0.389 ms  
64 bytes from 10.10.2.1: icmp\_seq=4 ttl=63 time=0.506 ms  
64 bytes from 10.10.2.1: icmp\_seq=5 ttl=63 time=0.361 ms  
64 bytes from 10.10.2.1: icmp\_seq=6 ttl=63 time=0.441 ms  
64 bytes from 10.10.2.1: icmp\_seq=7 ttl=63 time=0.506 ms  
64 bytes from 10.10.2.1: icmp\_seq=8 ttl=63 time=0.422 ms  
64 bytes from 10.10.2.1: icmp\_seq=9 ttl=63 time=0.402 ms  
64 bytes from 10.10.2.1: icmp\_seq=10 ttl=63 time=0.386 ms  
64 bytes from 10.10.2.1: icmp\_seq=11 ttl=63 time=0.389 ms  
64 bytes from 10.10.2.1: icmp\_seq=12 ttl=63 time=0.459 ms  
64 bytes from 10.10.2.1: icmp\_seq=13 ttl=63 time=0.368 ms  
64 bytes from 10.10.2.1: icmp\_seq=14 ttl=63 time=0.378 ms  
64 bytes from 10.10.2.1: icmp\_seq=15 ttl=63 time=0.462 ms  
64 bytes from 10.10.2.1: icmp\_seq=16 ttl=63 time=0.427 ms

Topology View List View Manifest Graphs node-0 node-1 node-2 node-3

Krupa@node-3:~\$ ping 10.10.3.1  
PING 10.10.3.1 (10.10.3.1) 56(84) bytes of data.  
64 bytes from 10.10.3.1: icmp\_seq=1 ttl=64 time=0.249 ms  
64 bytes from 10.10.3.1: icmp\_seq=2 ttl=64 time=0.175 ms  
64 bytes from 10.10.3.1: icmp\_seq=3 ttl=64 time=0.274 ms  
64 bytes from 10.10.3.1: icmp\_seq=4 ttl=64 time=0.251 ms  
64 bytes from 10.10.3.1: icmp\_seq=5 ttl=64 time=0.228 ms  
64 bytes from 10.10.3.1: icmp\_seq=6 ttl=64 time=0.277 ms  
64 bytes from 10.10.3.1: icmp\_seq=7 ttl=64 time=0.226 ms  
64 bytes from 10.10.3.1: icmp\_seq=8 ttl=64 time=0.262 ms  
64 bytes from 10.10.3.1: icmp\_seq=9 ttl=64 time=0.275 ms  
64 bytes from 10.10.3.1: icmp\_seq=10 ttl=64 time=0.224 ms  
64 bytes from 10.10.3.1: icmp\_seq=11 ttl=64 time=0.261 ms  
64 bytes from 10.10.3.1: icmp\_seq=12 ttl=64 time=0.228 ms  
64 bytes from 10.10.3.1: icmp\_seq=13 ttl=64 time=0.214 ms  
64 bytes from 10.10.3.1: icmp\_seq=14 ttl=64 time=0.226 ms  
64 bytes from 10.10.3.1: icmp\_seq=15 ttl=64 time=0.224 ms

# Project 2: SDN Basic

## Task:

To create a basic SDN by using Floodlight in CloudLab

## Steps:

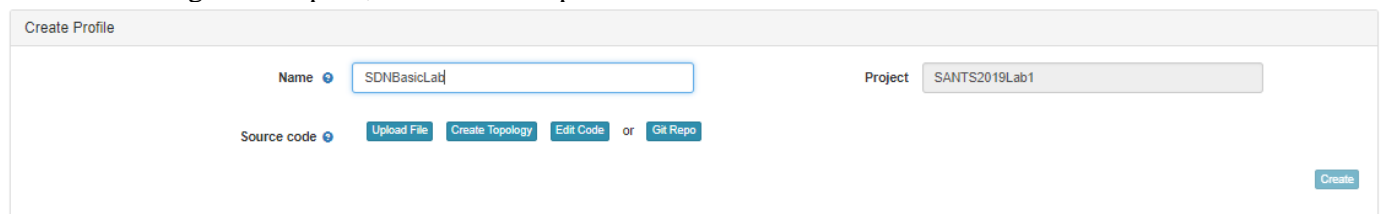
Step1: Create Profile for SDN controller

The profile is created as explained and the screenshot is as attached.

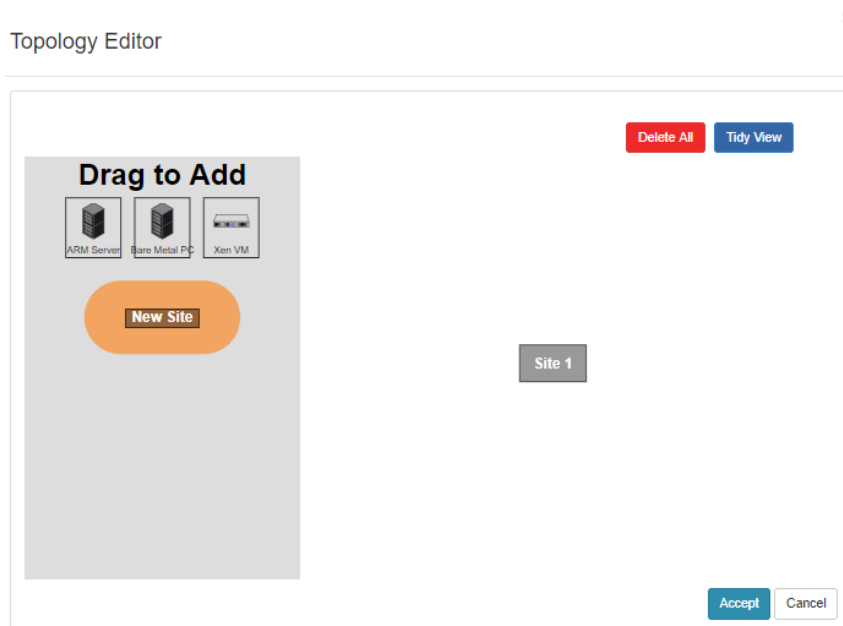
To create a profile the following steps are followed.

1. In the experiments tab, “Create Experiment Profile” is chosen.

When the dialogue box opens, the details are provided as shown below:



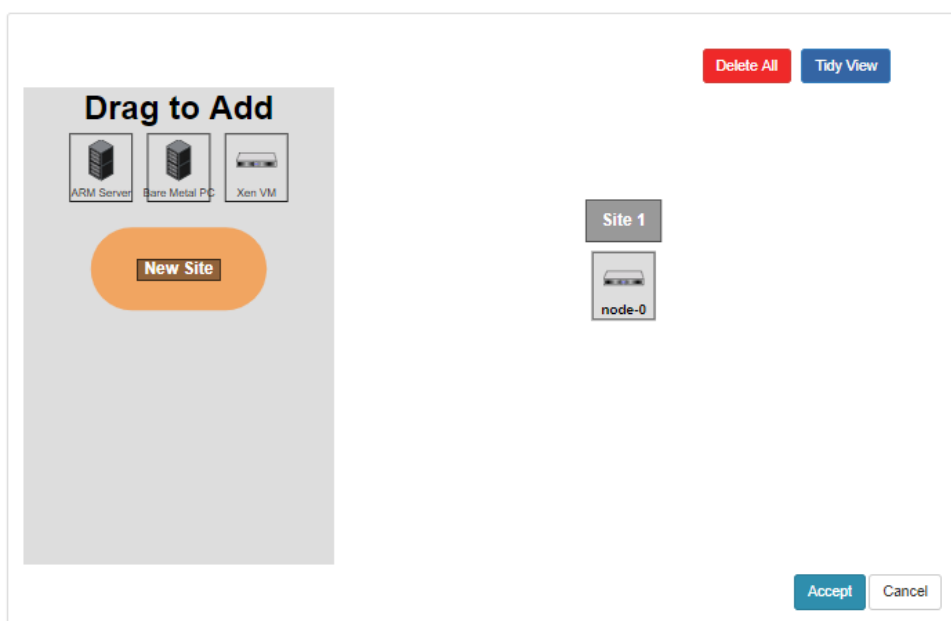
2. “create topology” is selected as we are not importing or editing from any other source. Topology editor opens as shown below:





3. One Xen VMs is dropped on the editor and as shown below:

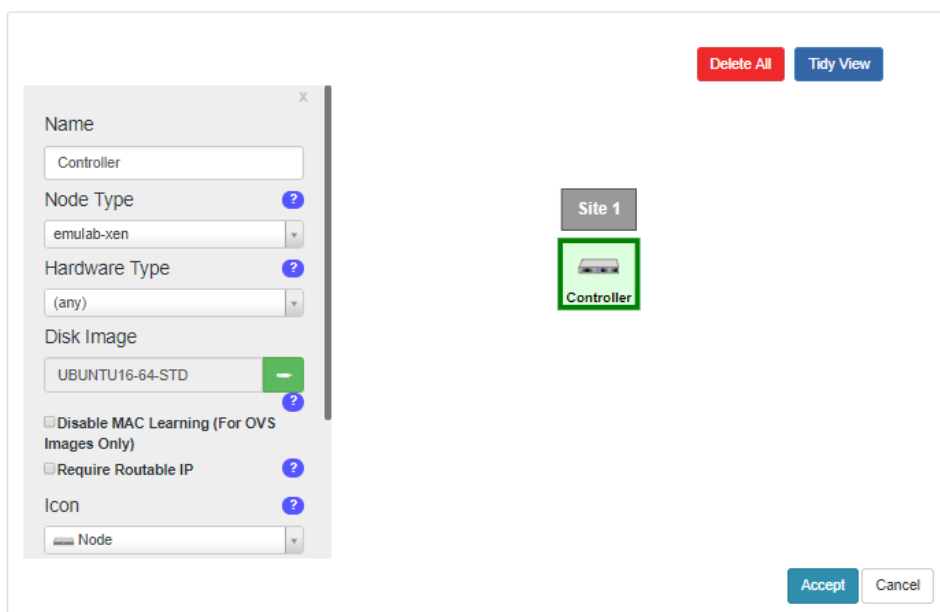
Topology Editor



4. For the node, the details are given as below:

- d. Name: Controller
- e. Node Type: emulab-xen
- f. Hardware Type: (any)
- g. Disk Image: UBUNTU16-64-STD

Topology Editor



5. An appropriate description is provided. After everything is done the profile is created and then instantiated.

The 'Create Profile' form is shown with the following details:

- Name:** SDNBasicLab
- Project:** SANTS2019Lab1
- Source code:** Edit Topology, Edit Code, or Git Repo
- Description:** Lab to create a basic SDN using Floodlight in CloudLab
- Instructions:** Provide optional instructions for users of your profile.
- Who can instantiate your profile?**
  - ☐ Anyone
  - ☒ Only members of your project
  - ☐ Allow members of your project to modify this profile.
- Create** button

6. An available cluster is selected and proceeded.

The 'Finalize' step shows the following configuration:

- Profile:** SDNBasicLab
- Version:** 3
- Name:** Optional
- Cluster:** Cloudlab Clemson
- Advanced Options** (expandable)
- Check Resource Availability** button
- Previous** and **Next** buttons

7. In the shell of the controller and command “ifconfig” is executed to find the ipaddress of the controller.

The 'Controller' tab shows the following terminal output:

```
Welcome to Ubuntu 16.04.1 LTS (GNU/Linux 4.4.0-142-generic x86_64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:        https://ubuntu.com/advantage
New release '18.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Tue Feb 12 19:02:30 2019 from 155.98.33.74
Krupa@controller:~$ ifconfig
```

The output shows the network configuration for the controller, including the IP address 172.17.155.1 for the eth0 interface.

8. The following commands, as given in the manual are carried out. These install floodlight on the controller.

- a. `sudo su` (gives the superuser privileges)

```
Topology View List View Manifest Graphs controller X
Welcome to Ubuntu 16.04.1 LTS (GNU/Linux 4.4.0-142-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage
New release '16.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Wed Feb 13 11:02:48 2019 from 155.98.33.74
Krupa@controller:~$ sudo su
root@controller:/users/Krupa#
```

- b. `apt-get update` (to download packages from their repositories and update them to the latest versions)

```
Topology View List View Manifest Graphs controller X
Get:15 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 Packages [912 kB]
Get:16 http://us.archive.ubuntu.com/ubuntu xenial-updates/restricted amd64 Packages [7,556 B]
Get:17 http://us.archive.ubuntu.com/ubuntu xenial-updates/restricted i386 Packages [7,524 B]
Get:18 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe amd64 Packages [727 kB]
Get:19 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe i386 Packages [666 kB]
Get:20 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe Translation-en [300 kB]
Get:21 http://security.ubuntu.com/ubuntu xenial-security/main i386 Packages [517 kB]
Get:22 http://security.ubuntu.com/ubuntu xenial-security/main Translation-en [254 kB]
Get:23 http://security.ubuntu.com/ubuntu xenial-security/restricted amd64 Packages [7,204 B]
Get:24 http://security.ubuntu.com/ubuntu xenial-security/restricted Translation-en [2,152 B]
Get:25 http://security.ubuntu.com/ubuntu xenial-security/universe amd64 Packages [424 kB]
Get:26 http://security.ubuntu.com/ubuntu xenial-security/universe i386 Packages [369 kB]
Fetched 29.0 MB in 6s (4,625 kB/s)

Reading package lists... Done
root@controller:/users/Krupa#
```

- c. `apt-get install default-jdk` (installs default JDK)

```
Topology View List View Manifest Graphs controller X
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/jhat to provide /usr/bin/jhat (jhat) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/jdb to provide /usr/bin/jdb (jdb) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/wsgen to provide /usr/bin/wsgen (wsgen) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/jcmd to provide /usr/bin/jcmd (jcmd) in auto mode
update-alternatives: using /usr/lib/jvm/java-8-openjdk-amd64/bin/jarsigner to provide /usr/bin/jarsigner (jarsigner) in auto mode
Setting up openjdk-8-jdk:amd64 (8u191-b12-2ubuntu0.16.04.1) ...
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 libc-bin (2.23-0ubuntu10) ...
Processing triggers for ca-certificates (20170717-16.04.1) ...
Updating certificates in /etc/ssl/certs...
Running hooks in /etc/ca-certificates/update.d...
done.
root@controller:/users/Krupa#
```

- d. `apt-get install default-jre` (install default Java Runtime Environment)

```
Topology View List View Manifest Graphs controller X
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 libc-bin (2.23-0ubuntu10) ...
Processing triggers for ca-certificates (20170717-16.04.1) ...
Updating certificates in /etc/ssl/certs...
Running hooks in /etc/ca-certificates/update.d...
done.
root@controller:/users/Krupa# apt-get install default-jre

Reading package lists... Done
Building dependency tree
default-jre is already the newest version (2:1.8-56ubuntu2).
default-jre set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 146 not upgraded.
root@controller:/users/Krupa#
```

- e. apt-get install build-essential ant maven python-dev (to build essential)

```
Topology View List View Manifest Graphs controller x
Setting up libplexus-utils2-java (3.0.22-1) ...
Setting up libplexus-component-annotations-java (1.6-2) ...

Setting up libplexus-cli-java (1.2-5) ...
Setting up libqdox2-java (2.0~M3-2) ...
Setting up libplexus-containers1.5-java (1.6-2) ...

Setting up libsisu-inject-java (0.3.2-1) ...
Setting up libsisu-plexus-java (0.3.2-1) ...
Setting up libmaven3-core-java (3.3.9-3) ...

Setting up libpython2.7-dev:amd64 (2.7.12-1ubuntu0~16.04.4) ...
Setting up libpython-dev:amd64 (2.7.12-1~16.04) ...
Setting up maven (3.3.9-3) ...-1) ...

update-alternatives: using /usr/share/maven/bin/mvn to provide /usr/bin/mvn (mvn) in auto mode
Setting up python2.7-dev (2.7.12-1ubuntu0~16.04.4) ...
root@controller:/users/Krupa# 1~16.04) ...

root@controller:/users/Krupa#
```

- f. git clone git://github.com/floodlight/floodlight.git (cloning repository)

```
Topology View List View Manifest Graphs controller x
Setting up libmaven3-core-java (3.3.9-3) ...

Setting up libpython2.7-dev:amd64 (2.7.12-1ubuntu0~16.04.4) ...
Setting up libpython-dev:amd64 (2.7.12-1~16.04) ...
Setting up maven (3.3.9-3) ...-1) ...

update-alternatives: using /usr/share/maven/bin/mvn to provide /usr/bin/mvn (mvn) in auto mode
Setting up python2.7-dev (2.7.12-1ubuntu0~16.04.4) ...
root@controller:/users/Krupa# 1~16.04) ...

root@controller:/users/Krupa# git clone git://github.com/floodlight/floodlight.git
Cloning into 'floodlight'...
remote: Counting objects: 100% (74/74), done.

remote: Compressing objects: 100% (26/26), done.
remote: Total 52765 (delta 48), reused 54 (delta 46), pack-reused 52691
Resolving deltas: 100% (34237/34237), done.84 MiB | 37.85 MiB/s, done.

Checking connectivity... done.
root@controller:/users/Krupa#
```

- cd floodlight
- git submodule init
- git submodule update

```
Topology View List View Manifest Graphs controller x
Cloning into 'floodlight'...
remote: Counting objects: 100% (74/74), done.

remote: Compressing objects: 100% (26/26), done.
remote: Total 52765 (delta 48), reused 54 (delta 46), pack-reused 52691
Resolving deltas: 100% (34237/34237), done.84 MiB | 37.85 MiB/s, done.

Checking connectivity... done.
root@controller:/users/Krupa# cd floodlight
Submodule 'src/main/resources/web' (https://github.com/floodlight/floodlight-webui) registered for path 'src/main/resources/web'

root@controller:/users/Krupa/floodlight# git submodule update
Cloning into 'src/main/resources/web'...
remote: Total 1325 (delta 0), reused 0 (delta 0), pack-reused 1325

Receiving objects: 100% (1325/1325), 3.70 MiB | 0 bytes/s, done.
Resolving deltas: 100% (360/360), done.
Submodule path 'src/main/resources/web': checked out '580bf06fd86bb7ff270019447f023f9d98e431d9'

root@controller:/users/Krupa/floodlight#
```

- ant

Note: Build may fail if package javafx.util does not exist, as was the case here. so package javafx.util does not exist is installed using “apt install openjfx”.

```
Topology View List View Manifest Graphs controller x

[javac] Note: Recompile with -Xlint:unchecked for details.
[copy] Copying 853 files to /users/Krupa/floodlight/target/bin
compile-test:

[javac] Compiling 105 source files to /users/Krupa/floodlight/target/bin-test
[javac] Note: Some input files use or override a deprecated API.
[javac] Note: /users/Krupa/floodlight/src/test/java/net/floodlightcontroller/core/internal/OFSwitchHandshakeHandlerVer13Test.java uses unchecked or unsafe operations.

[javac] Note: Recompile with -Xlint:unchecked for details.

[echo] Setting Floodlight version: 1.2-SNAPSHOT

[echo] Setting Floodlight name: floodlight
[jar] Building jar: /users/Krupa/floodlight/target/floodlight.jar
[jar] Building jar: /users/Krupa/floodlight/target/floodlight-test.jar

BUILD SUCCESSFUL
Total time: 41 seconds
root@controller:/users/Krupa/floodlight#
```

- `sudo mkdir /var/lib/floodlight`
- `sudo chmod 777 /var/lib/floodlight`

```
Topology View List View Manifest Graphs controller x

compile-test:

[javac] Compiling 105 source files to /users/Krupa/floodlight/target/bin-test
[javac] Note: Some input files use or override a deprecated API.
[javac] Note: /users/Krupa/floodlight/src/test/java/net/floodlightcontroller/core/internal/OFSwit

[javac] Note: Recompile with -Xlint:unchecked for details.

[echo] Setting Floodlight version: 1.2-SNAPSHOT

[echo] Setting Floodlight name: floodlight
[jar] Building jar: /users/Krupa/floodlight/target/floodlight.jar
[jar] Building jar: /users/Krupa/floodlight/target/floodlight-test.jar

BUILD SUCCESSFUL
Total time: 41 seconds
root@controller:/users/Krupa/floodlight# sudo mkdir /var/lib/floodlight

root@controller:/users/Krupa/floodlight# sudo chmod 777 /var/lib/floodlight
root@controller:/users/Krupa/floodlight#
```

## 9. `java -jar target/floodlight.jar` (to start the controller to send packets)

```
Topology View List View Manifest Graphs controller x

2019-02-13 09:29:33.418 INFO [n.f.f.Forwarding] Flows will be removed on link/port down events
2019-02-13 09:29:33.418 INFO [n.f.s.StatisticsCollector] Statistics collection disabled
2019-02-13 09:29:33.421 INFO [n.f.h.HAController] Configuration parameters: {serverPort=127.0.0.1:4242, nodeId=1} 1
2019-02-13 09:29:33.514 INFO [o.s.s.i.SyncManager] [1] Updating sync configuration ClusterConfig [allNodes={1=Node [hostname=192.168.56.1, port=6642, nodeId=1, domainId=1], 2=Node [hostname=192.168.56.1, port=6643, nodeId=2, domainId=1], 3=Node [hostname=192.168.56.1, port=6644, nodeId=3, domainId=1], 4=Node [hostname=192.168.56.1, port=6645, nodeId=4, domainId=1]}, authScheme=C
2019-02-13 09:29:33.751 INFO [o.s.s.i.r.RPCService] Listening for internal floodlight RPC on 0.0.0.0/0.0.0.0:6642
2019-02-13 09:29:33.897 INFO [n.f.h.HAController] LDHAWorker is starting...
2019-02-13 09:29:33.908 INFO [n.f.h.HAController] TopoHAWorker is starting...
2019-02-13 09:29:34.4 INFO [n.f.h.HAController] HAController is starting...es are not set.
2019-02-13 09:29:34.23 INFO [n.f.h.ControllerLogic] [ControllerLogic] Running...
2019-02-13 09:29:34.32 INFO [n.f.h.HAServer] Starting HAServer...
2019-02-13 09:29:34.379 INFO [org.restlet] Starting net.floodlightcontroller.restserver.RestApiServer$RestApplication application
2019-02-13 09:29:40.280 INFO [n.f.j.JythonServer] Starting DebugServer on :6655
2019-02-13 09:29:48.814 INFO [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the enabled ports
2019-02-13 09:30:18.820 INFO [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the enabled ports
```


Now that the controller is ready, we will move ahead to creating a profile for the nodes.

## Step2: Create Profile for SDN controller


To create a profile the following steps are followed.

1. In the experiments tab, "Create Experiment Profile" is chosen.

Create Profile

Name 

Project

Source code 

[Upload File](#)

[Create Topology](#)

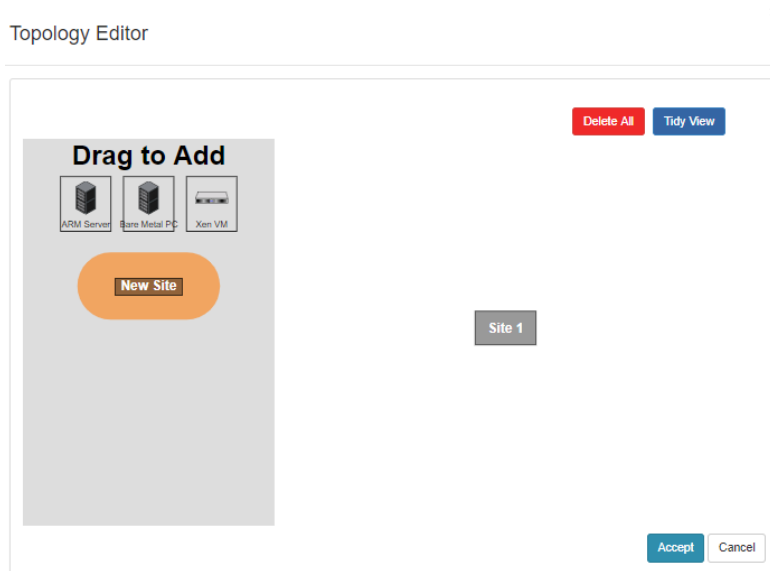
[Edit Code](#)

or

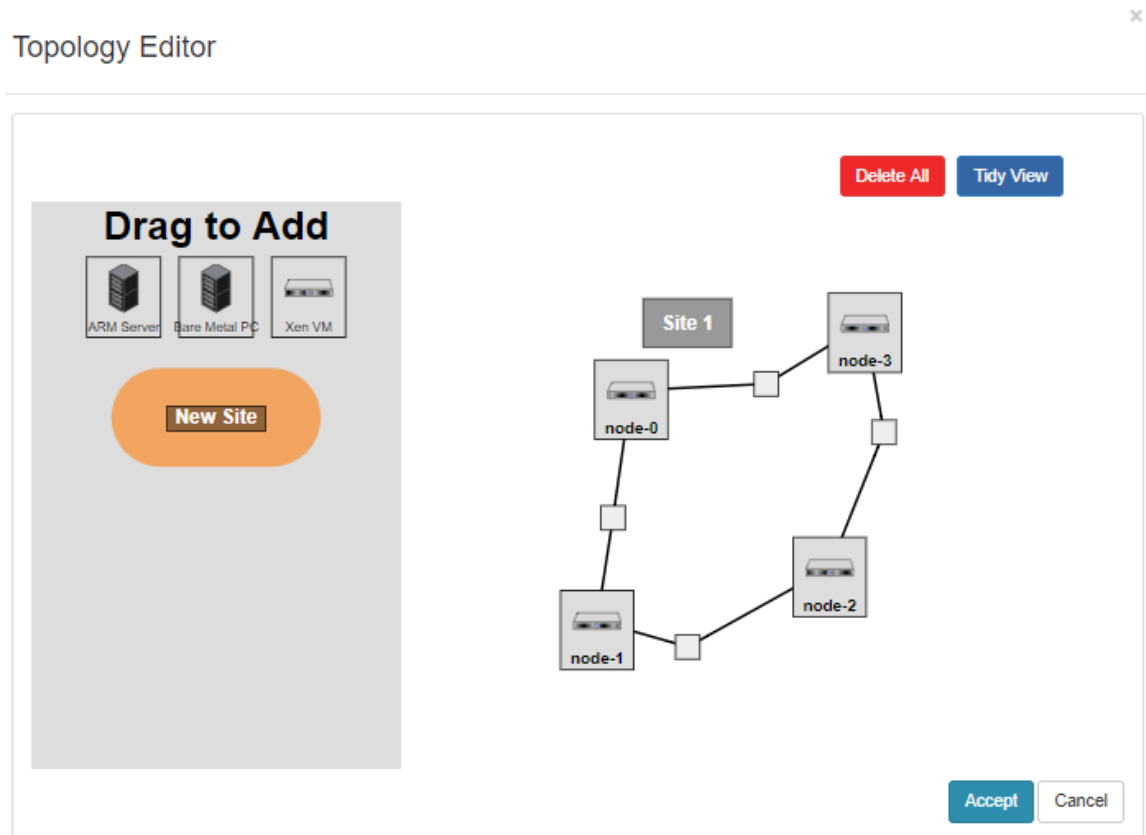
[Git Repo](#)

[Create](#)

2. “create topology” is selected as we are not importing or editing from any other source. Topology editor opens as shown below:

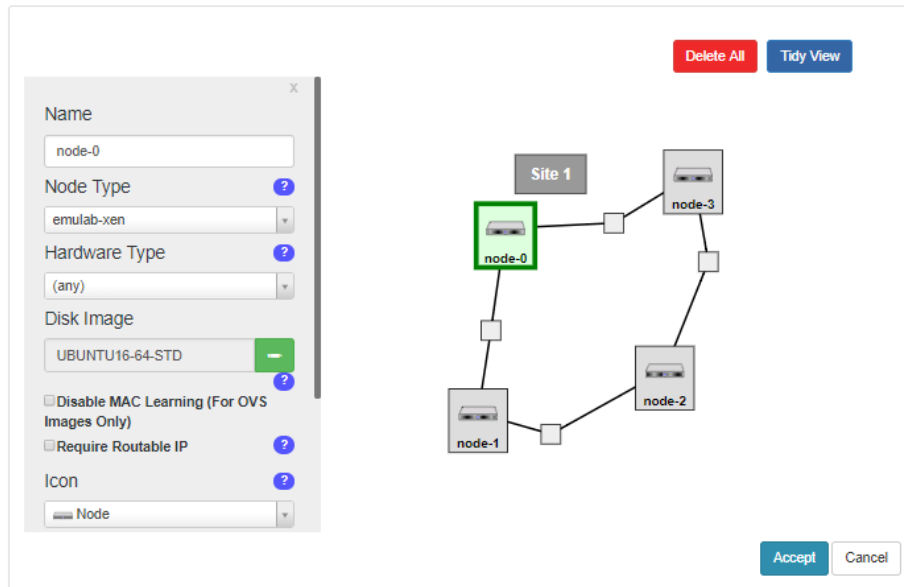


3. Four Xen VMs are imported on to the editor and connected as shown below. We see there will be 4 links connecting all the four nodes.



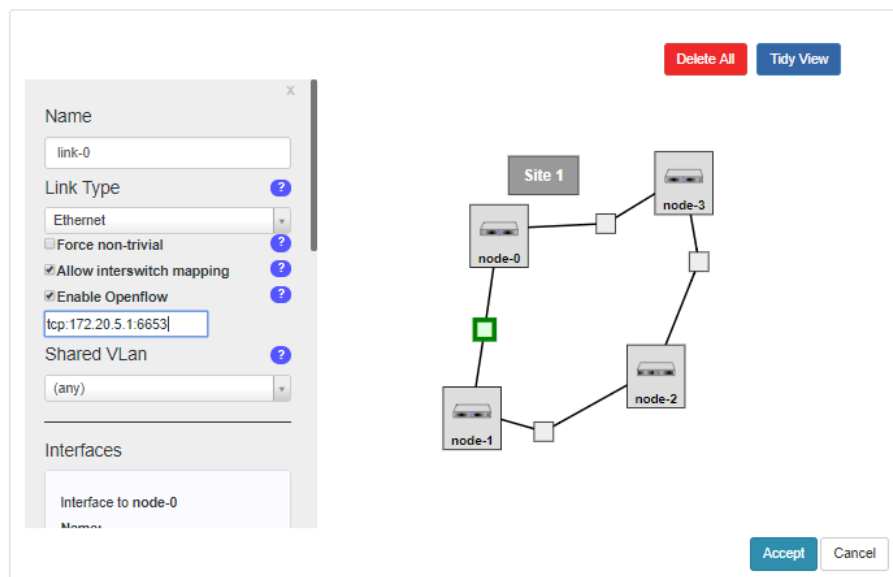
4. For each of the node, the following are selected:
  - a. Node Type: emulab-xen
  - b. Hardware Type: (any)
  - c. Disk Image: UBUNTU16-64-STD

#### Topology Editor



5. For each of the links, the following are selected and accepted:
  - c. Link Type: Ethernet
  - d. Select Allow interswitch mapping
  - e. Select Enable OpenFlow and give IP address of the controller as shown.  
tcp:172.17.55.1:6653

#### Topology Editor



6. An appropriate description is provided. After everything is done, the profile is created and then instantiated.
7. The process as before is followed to find a proper available cluster.
8. OpenVSwitch is installed and bridges on all nodes are setup using the following commands. These are used to connect to the SDN Controller. It is taken care to perform all these steps on all nodes with a unique bridge name and a unique IP address. The following commands are shown by taking node0 as example from the experiment.
  - a. `sudo su` (for availing superuser access)

```

Topology View List View Manifest Graphs node-0 x
Welcome to Ubuntu 16.04.1 LTS (GNU/Linux 4.4.0-142-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage
New release '16.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

node-0:~> sudo su
root@node-0:/users/Krupa#

```

- b. `apt-get update`

```

Topology View List View Manifest Graphs node-0 x
Get:13 http://security.ubuntu.com/ubuntu xenial-security/main Translation-en [234 kB]
Get:14 http://security.ubuntu.com/ubuntu xenial-security/restricted amd64 Packages [7,204 B]
Get:16 http://security.ubuntu.com/ubuntu xenial-security/restricted Translation-en [2,152 B]

Get:17 http://security.ubuntu.com/ubuntu xenial-security/universe amd64 Packages [424 kB]
Get:18 http://security.ubuntu.com/ubuntu xenial-security/universe i386 Packages [369 kB]
Get:20 http://us.archive.ubuntu.com/ubuntu xenial/universe i386 Packages [7,512 kB]

Get:21 http://us.archive.ubuntu.com/ubuntu xenial/universe Translation-en [4,354 kB]
Get:22 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 Packages [912 kB]
Get:24 http://us.archive.ubuntu.com/ubuntu xenial-updates/main Translation-en [368 kB]

Get:25 http://us.archive.ubuntu.com/ubuntu xenial-updates/restricted amd64 Packages [7,556 B]
Get:26 http://us.archive.ubuntu.com/ubuntu xenial-updates/restricted i386 Packages [7,524 B]
Get:28 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe amd64 Packages [727 kB]

Get:29 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe i386 Packages [666 kB]
Get:30 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe Translation-en [300 kB]
Reading package lists... DonekB/s)

root@node-0:/users/Krupa#

```

- c. `apt install openvswitch-switch`

```

Topology View List View Manifest Graphs node-0 x
Selecting previously unselected package openvswitch-switch.
Preparing to unpack .../openvswitch-switch_2.5.5-0ubuntu0.16.04.2_amd64.deb ...
Unpacking openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
Processing triggers for man-db (2.7.5-1) ...
Processing triggers for ureadahead (0.100.0-19) ...
ureadahead will be reprofiled on next reboot
Processing triggers for systemd (229-4ubuntu21.15) ...
Setting up openvswitch-common (2.5.5-0ubuntu0.16.04.2) ...
Setting up openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
update-alternatives: using /usr/lib/openvswitch-switch/ovs-vswitchd to provide /usr/sbin/ovs-vswitchd (ovs-vswitchd) in auto mode
inserv: can not symlink(/usr/lib/openvswitch-switch/ovs-vswitchd): File exists
inserv: can not symlink(/usr/lib/openvswitch-switch/ovs-vswitchd): File exists
inserv: can not symlink(/usr/lib/openvswitch-switch/ovs-vswitchd): File exists
inserv: can not symlink(/usr/lib/openvswitch-switch/ovs-vswitchd): File exists
inserv: can not symlink(/usr/lib/openvswitch-switch/ovs-vswitchd): File exists
openvswitch-nonetwork.service is a disabled or a static unit, not starting it.
Processing triggers for systemd (229-4ubuntu21.15) ...
Processing triggers for ureadahead (0.100.0-19) ...

root@node-0:/users/Krupa#

```

- d. `ovs-vsctl add-br ovs-lan1` (to add a bridge)
- e. `ovs-vsctl add-port ovs-lan1 eth1`



f. ovs-vsctl add-port ovs-lan1 eth2

```
Topology View List View Manifest Graphs node-0 x
Unpacking openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
Processing triggers for man-db (2.7.5-1) ...
Processing triggers for ureadahead (0.100.0-19) ...
ureadahead will be reprofiled on next reboot
Processing triggers for systemd (229-4ubuntu21.15) ...
Setting up openvswitch-common (2.5.5-0ubuntu0.16.04.2) ...
Setting up openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
update-alternatives: using /usr/lib/openvswitch-switch/ovs-vswitchd to provide /i
insserv: can not symlink(/../init.d/pubsubd, ../rc1.d/K01pubsubd): File exists
insserv: can not symlink(/../init.d/pubsubd, ../rc2.d/S01pubsubd): File exists
insserv: can not symlink(/../init.d/pubsubd, ../rc3.d/S01pubsubd): File exists
insserv: can not symlink(/../init.d/pubsubd, ../rc6.d/K01pubsubd): File exists
openvswitch-nonetwork.service is a disabled or a static unit, not starting it.
Processing triggers for systemd (229-4ubuntu21.15) ...
Processing triggers for ureadahead (0.100.0-19) ...
root@node-0:/users/Krupa# ovs-vsctl add-br ovs-lan1
root@node-0:/users/Krupa# ovs-vsctl add-port ovs-lan1 eth1
root@node-0:/users/Krupa# ovs-vsctl add-port ovs-lan1 eth2
root@node-0:/users/Krupa# █
```

g. ifconfig eth1 0

h. ifconfig eth2 0

```
Topology View List View Manifest Graphs node-0 x
Processing triggers for ureadahead (0.100.0-19) ...
ureadahead will be reprofiled on next reboot
Processing triggers for systemd (229-4ubuntu21.15) ...
Setting up openvswitch-common (2.5.5-0ubuntu0.16.04.2) ...
Setting up openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
update-alternatives: using /usr/lib/openvswitch-switch/ovs-vswitchd to provide
insserv: can not symlink(/../init.d/pubsubd, ../rc1.d/K01pubsubd): File exists
insserv: can not symlink(/../init.d/pubsubd, ../rc2.d/S01pubsubd): File exists
insserv: can not symlink(/../init.d/pubsubd, ../rc3.d/S01pubsubd): File exists
insserv: can not symlink(/../init.d/pubsubd, ../rc6.d/K01pubsubd): File exists
openvswitch-nonetwork.service is a disabled or a static unit, not starting it.
Processing triggers for systemd (229-4ubuntu21.15) ...
Processing triggers for ureadahead (0.100.0-19) ...
root@node-0:/users/Krupa# ovs-vsctl add-br ovs-lan1
root@node-0:/users/Krupa# ovs-vsctl add-port ovs-lan1 eth1
root@node-0:/users/Krupa# ovs-vsctl add-port ovs-lan1 eth2
root@node-0:/users/Krupa# ifconfig eth1 0
root@node-0:/users/Krupa# ifconfig eth2 0
root@node-0:/users/Krupa# █
```

i. ovs-vsctl set-controller ovs-lan4 tcp:172.20.5.1:6653

```
Topology View List View Manifest Graphs node-0 x
root@node-0:/users/Krupa# ovs-vsctl set-controller ovs-lan1 tcp:172.20.5.1:6653
root@node-0:/users/Krupa# █
```

j. ifconfig ovs-lan1 10.10.10.1 netmask 255.255.255.0 up

```
Topology View List View Manifest Graphs node-0 x
root@node-0:/users/Krupa# ovs-vsctl set-controller ovs-lan1 tcp:172.20.5.1:6653
root@node-0:/users/Krupa# ifconfig ovs-lan1 10.10.10.1 netmask 255.255.255.0 up
root@node-0:/users/Krupa# █
```

9. The steps from a-j are carried out on all nodes.

10. Ping test can be done using the command “tcpdump -I eth1”. We may get an error saying –“tcpdump: eth1: That device doesn't support monitor mode”

This error can be solved by using “tcpdump -i eth1”

```
Topology View List View Manifest Graphs node-0 node-1 node-2 node-3
root@node-0:/users/Krupa# ovs-ofctl dump-flows ovs-lan1 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=35.761s, table=0, n_packets=2, n_bytes=140, priority=0 actions=CONTROLLER:65535
root@node-0:/users/Krupa# tcpdump -i eth1
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on eth1, link-type EN10MB (Ethernet), capture size 262144 bytes
11:30:13.067824 LLDP, length 61
11:30:13.071612 02:85:d8:5f:d7:b7 (oui Unknown) > Broadcast, ethertype Unknown (0x8942), length 83:
 0x0000: 2000 0604 0002 0000 0207 0442 765a 442d .....BvZD-
 0x0010: 4704 0302 0001 0602 0078 fe0c 0026 e100 G.....X...&..
 0x0020: 0000 4276 5a44 2d47 1808 001a 7e0d 481b ..BvZD-G.....H.
 0x0030: 42d2 e601 01fe 0c00 26e1 0100 0000 0000 B.....&.....
 0x0040: 253a b900 00 .....%:...
11:30:13.073321 02:c4:90:7b:3a:17 (oui Unknown) > Broadcast, ethertype Unknown (0x8942), length 83:
 0x0000: 2000 0604 0002 0000 0207 0442 765a 442d .....BvZD-
 0x0010: 4704 0302 0002 0602 0078 fe0c 0026 e100 G.....X...&..
 0x0020: 0000 4276 5a44 2d47 1808 001a 7e0d 481b ..BvZD-G.....H.
 0x0040: 253a b900 00 .....%:.....&.....
```

11. Finally, the flow rules are checked using the command - ovs-ofctl dump-flows <bridge\_name> -O OpenFlow13.

```
Topology View List View Manifest Graphs node-0 node-1 node-2 node-3
Hit:1 http://us.archive.ubuntu.com/ubuntu xenial InRelease
Selecting previously unselected package openvswitch-switch.
Preparing to unpack ../openvswitch-switch_2.5.5-0ubuntu0.16.04.2_amd64.deb ...
Unpacking openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
Processing triggers for man-db (2.7.5-1) ...
Processing triggers for ureadahead (0.100.0-19) ...
ureadahead will be reprofiled on next reboot
Processing triggers for systemd (229-4ubuntu21.15) ...
Setting up openvswitch-common (2.5.5-0ubuntu0.16.04.2) ...
Setting up openvswitch-switch (2.5.5-0ubuntu0.16.04.2) ...
update-alternatives: using /usr/lib/openvswitch-switch/ovs-vswitchd to provide /usr/sbin/ovs-vswitchd (ovs-vswitchd) in auto mode
insserv: can not symlink(/init.d/pubsubd, ../rc1.d/K01pubsubd): File exists
insserv: can not symlink(/init.d/pubsubd, ../rc2.d/S01pubsubd): File exists
root@node-0:/users/Krupa# ovs-vsctl set-controller ovs-lan1 tcp:172.20.5.1:6653
root@node-0:/users/Krupa# ifconfig ovs-lan1 10.10.10.1 netmask 255.255.255.0 up
root@node-0:/users/Krupa# ovs-ofctl dump-flows ovs-lan1 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=35.761s, table=0, n_packets=2, n_bytes=140, priority=0 actions=CONTROLLER:65535
root@node-0:/users/Krupa#
```

## Explanation of flow rules and tcpdump:

1. tcpdump -I eth1

tcpdump is a packet analyser. When used, it shows the packet being sent or received in a network. It is also used to display TCP/IP address. -I denoted that's eth1 is an interface, So in this command, basically tcpdump is used to monitor the TCP/IP address of the packets and also to analyse/monitor all the packets being transmitted over the network. It outputs all the packets to the interface eth1. Hence this shall help in problems related to packet flow.

2. Flow rules in step 6

The flow rules given in step6 is completely dependent on “ovs-ofctl”. this command is used to monitor and created Openflow switches. This command can also be used to understand the current state of OVS. and also, this works for any available OpenFlow switch. So when“ ovs-ofctl dump-flows <bridge\_name> -O OpenFlow13” is used, it shows the status of the bridge (in our experiment bridge names are provided as lan1, lan2, lan3 and lan4 for node0, node1, node2 and node3 respectively) and helps controller keep a track of the packet flow in the form of flow rules or flow tables..