Project 1: CloudLab and SDN Basic

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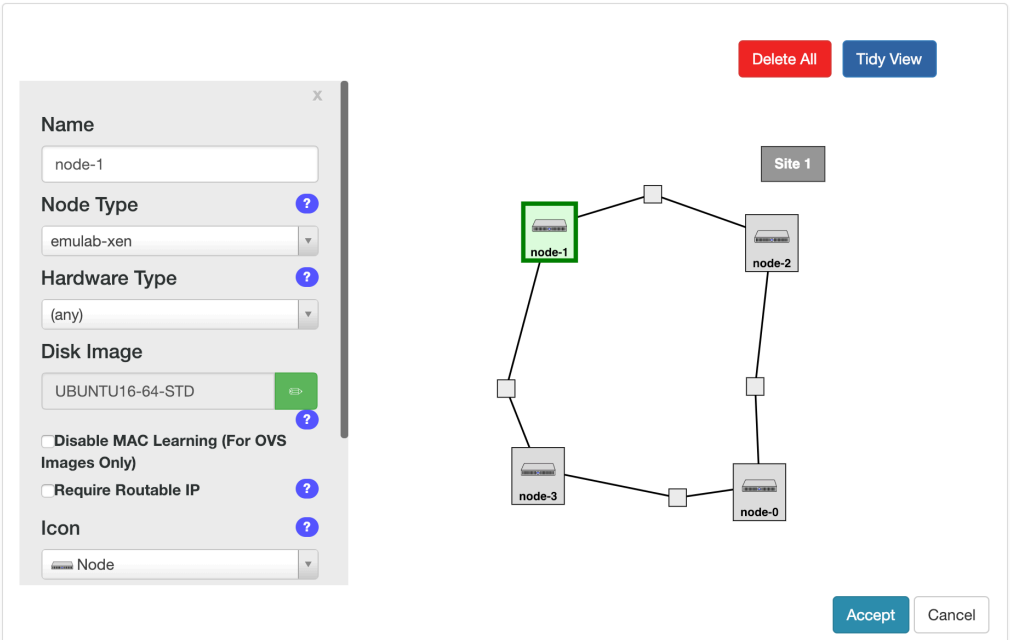
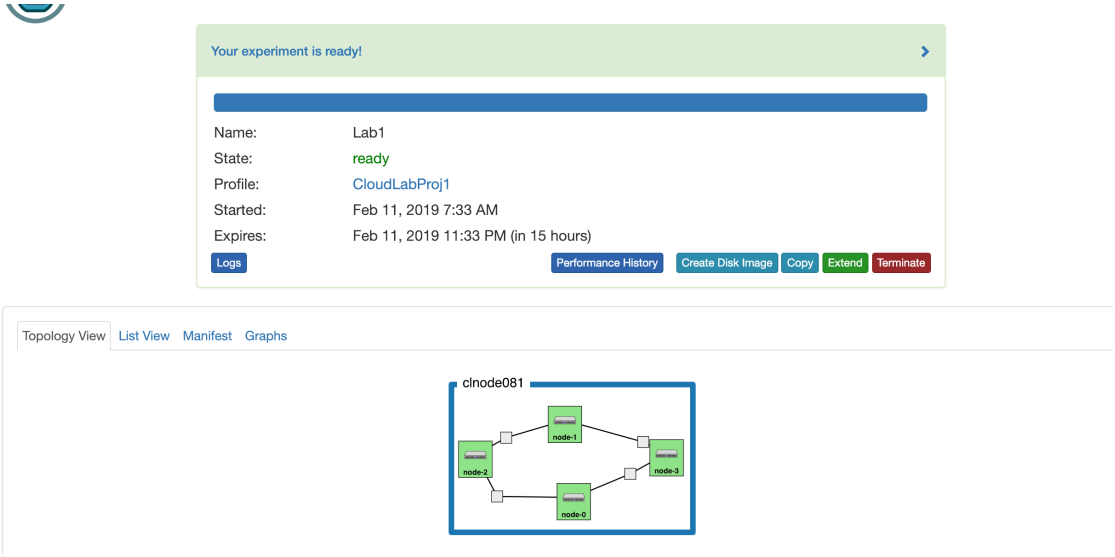
Part 1

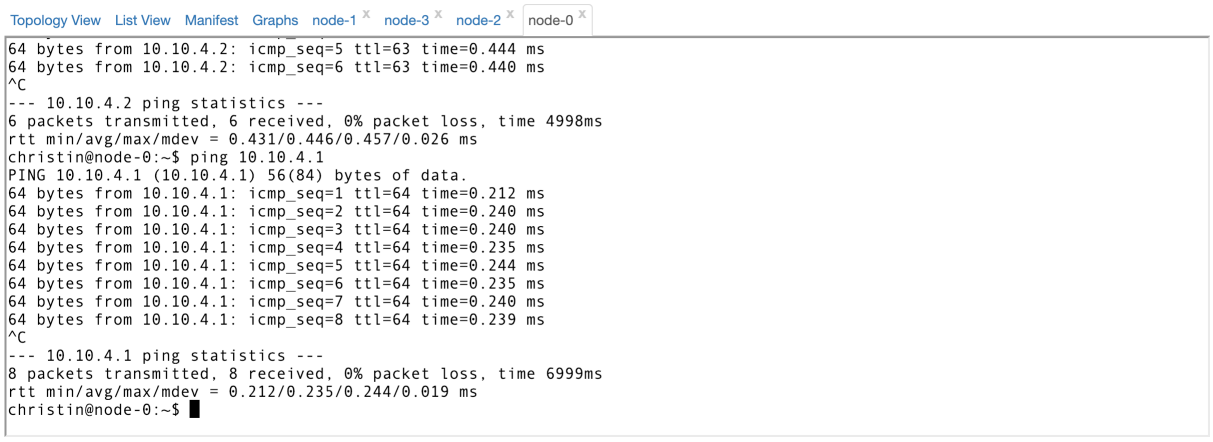
Step 1- Create Profile : The profile is created. The profile consists of 4 Xen VMs with UBUNTU16 as Operating System. Hardware type is not selected and is set to any. Node type is set as emulab-xen. The 4 nodes are connected with links. The Link type is Ethernet.

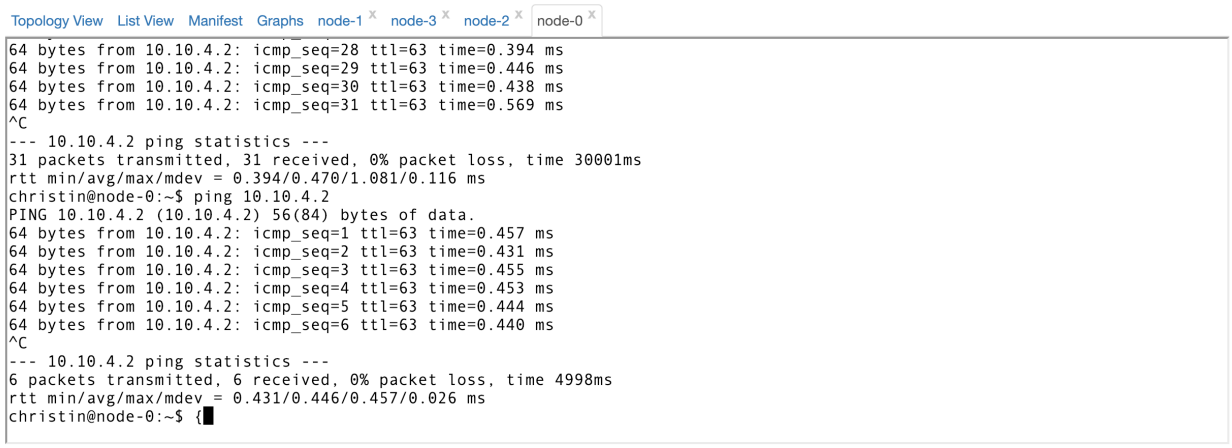


Step 2- Start Experiment: Once the profile is created, I instantiated the profile on the clemson cluster. The profile booted up after some time.



Step 3- Test connectivity through ping: The shell terminals of each node was opened and the ip address was found using ifconfig. Later, from node 0 all the other nodes were pinged to check the connectivity

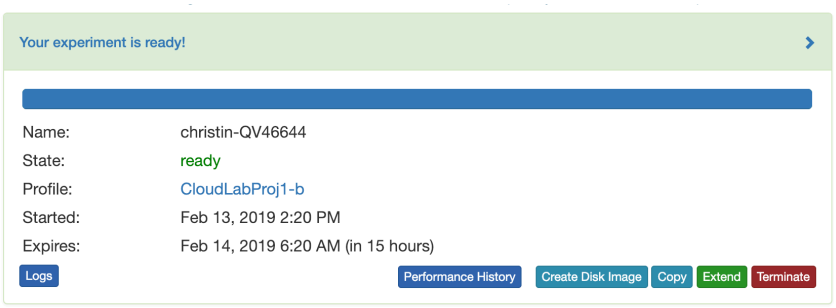


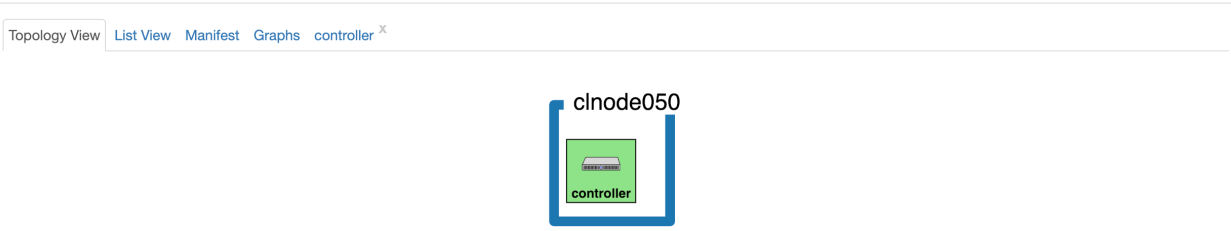


Step 4 - Terminate the experiment: The experiment is terminated after the experiment is complete.

Part 2:

Step 1 - Create Profile for SDN controller: A new profile is created with a single node. This profile consists of a single XEN VM node with 'Ubuntu 16' as the OS. This profile is then instantiated on the Clemson cluster. The profile completes booting after some time.





Step 2 - Install Floodlight: The shell of the controller node is opened. We install floodlight on this controller by following the steps listed below:

Get sudo user privileges: "sudo su"
Update APT repo: "apt-get update"
Install java 8: "apt-get install default-jdk" and "apt-get install default-jre".
Install dependencies: "apt-get install build-essential ant maven python-dev"

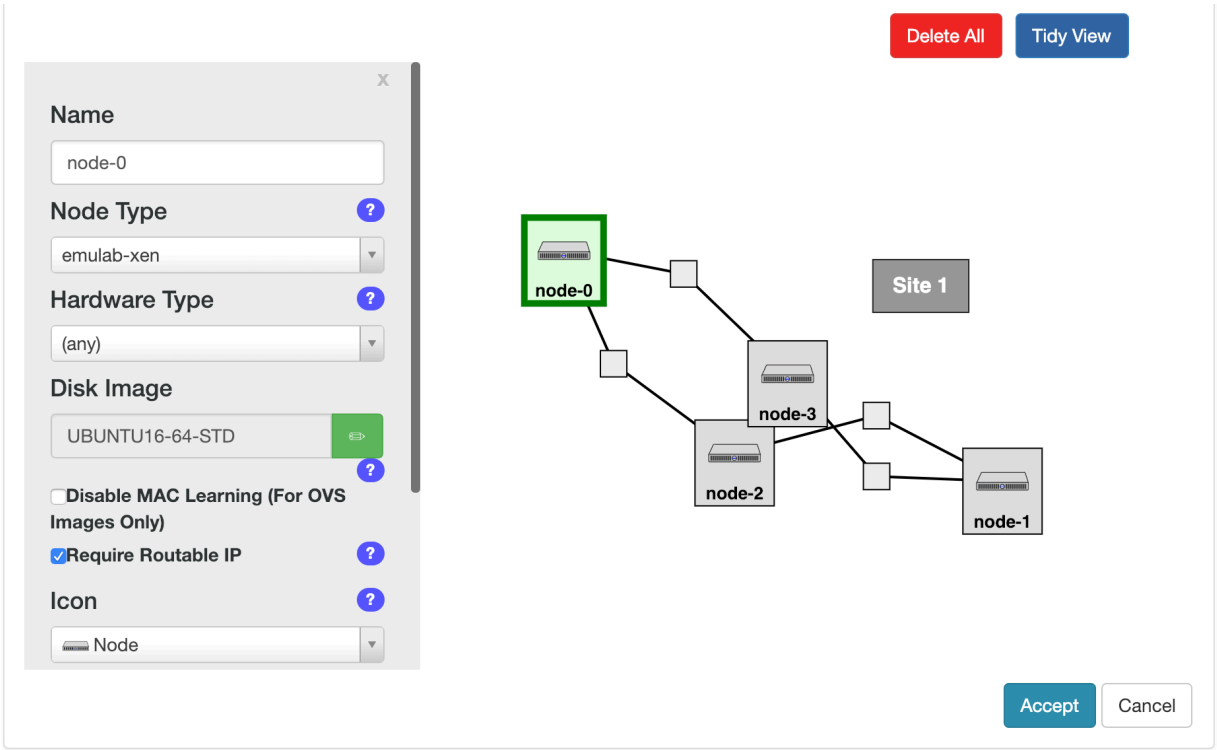
Install Floodlight:
- git clone git://github.com/floodlight/floodlight.git -b v1.2
- cd floodlight
- git submodule init
- git submodule update
- ant
- sudo mkdir /var/lib/floodlight
- sudo chmod 777 /var/lib/floodlight

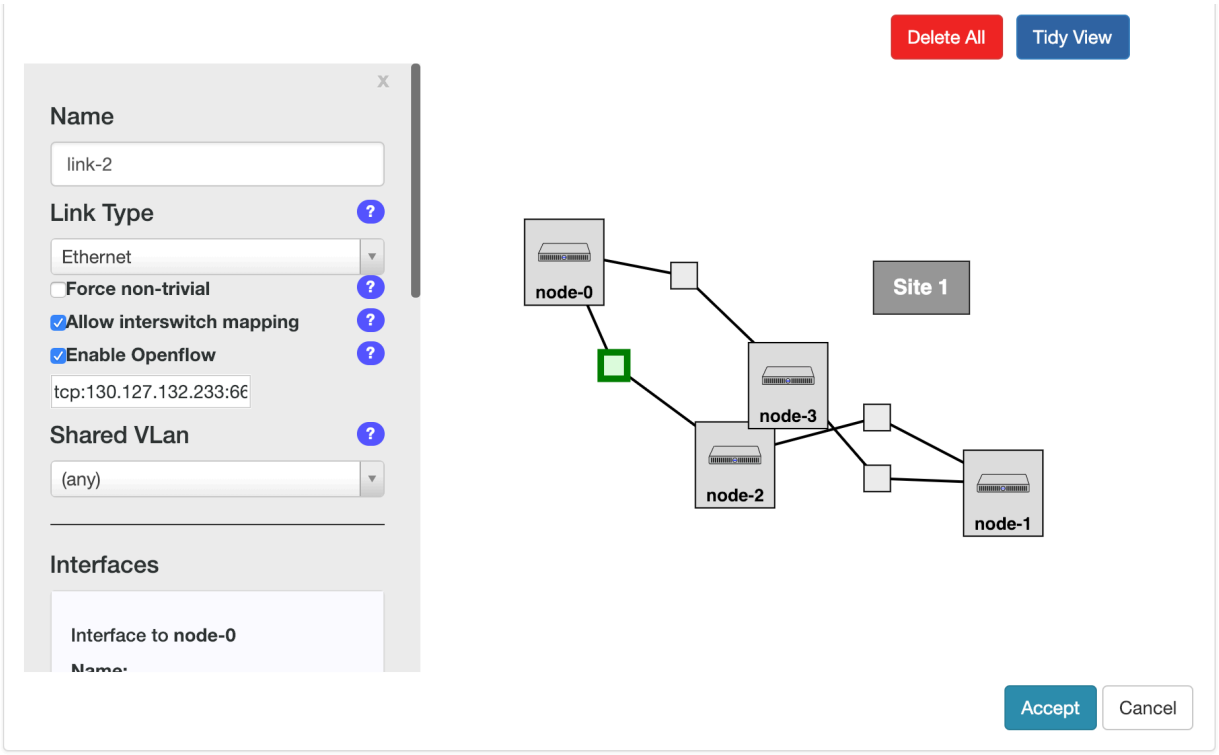
The controller is started using: "java -jar target/floodlight.jar"

Topology View List View Manifest Graphs controller

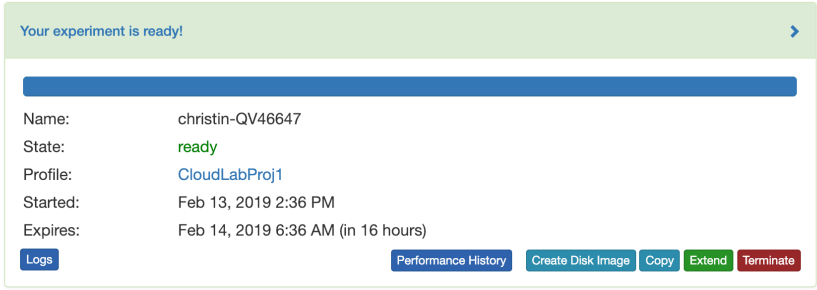
```
root@controller:/users/christin/floodlight# java -jar target/floodlight.jar
12:40:08.182 INFO [n.f.c.m.FloodlightModuleLoader:main] Loading modules from src/main/resources/floodlightdefault.proper
ties
12:40:08.536 WARN [n.f.r.RestApiServer:main] HTTPS disabled; HTTPS will not be used to connect to the REST API.
12:40:08.536 WARN [n.f.r.RestApiServer:main] HTTP enabled; Allowing unsecure access to REST API on port 8080.
12:40:14.996 WARN [n.f.c.i.OFSwitchManager:main] SSL disabled. Using unsecure connections between Floodlight and switche
s.
12:40:14.997 INFO [n.f.c.i.OFSwitchManager:main] Clear switch flow tables on initial handshake as master: TRUE
12:40:14.997 INFO [n.f.c.i.OFSwitchManager:main] Clear switch flow tables on each transition to master: TRUE
12:40:14.997 INFO [n.f.c.i.OFSwitchManager:main] Setting 0x1 as the default max tables to receive table-miss flow
12:40:15.009 INFO [n.f.c.i.OFSwitchManager:main] Setting max tables to receive table-miss flow to 0x1 for DPID 00:00:00:
00:00:00:00:01
12:40:15.009 INFO [n.f.c.i.OFSwitchManager:main] Setting max tables to receive table-miss flow to 0x1 for DPID 00:00:00:
00:00:00:00:02
12:40:15.179 INFO [n.f.c.i.OFSwitchManager:main] Computed OpenFlow version bitmap as [62]
12:40:15.182 INFO [n.f.c.i.Controller:main] OpenFlow port set to 6653
12:40:15.183 INFO [n.f.c.i.Controller:main] Number of worker threads set to 16
12:40:15.184 INFO [n.f.c.i.Controller:main] Controller role set to ACTIVE
12:40:15.266 INFO [n.f.l.i.LinkDiscoveryManager:main] Link latency history set to 10 LLDP data points
12:40:15.266 INFO [n.f.l.i.LinkDiscoveryManager:main] Latency update threshold set to +/-0.5 (50.0%) of rolling historic
al average
12:40:15.281 INFO [n.f.f.Forwarding:main] Default hard timeout not configured. Using 0.
```

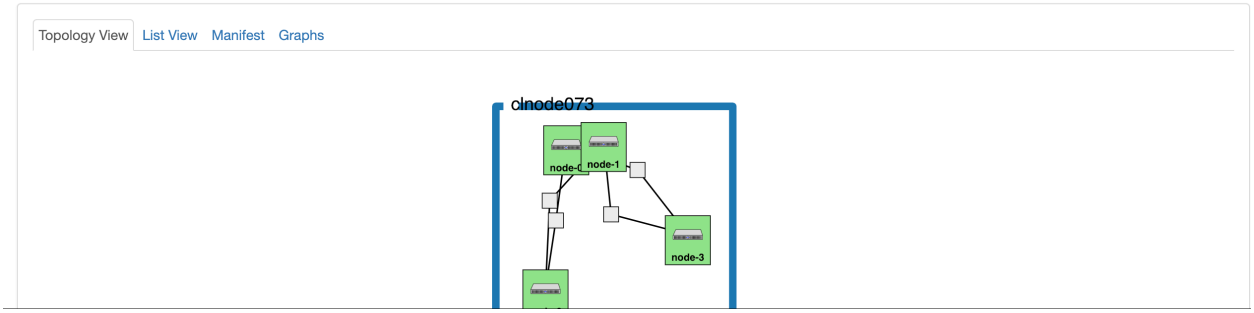
<u>Step 3 - Setup profile for the experiment:</u> A profile is created with 4 Xen VMs and UBUNTU16 as the Operating System. Node type is set as emulab-xen. For the links, link type is seat as Ethernet. The "Require Routable IP" option is checked with the ip address of the controller. The profile is then instantiated.





Step 4 - Start Experiment: The experiment is started on the Clemson cluster. The profile boots after some time.The profile boots up after some time.

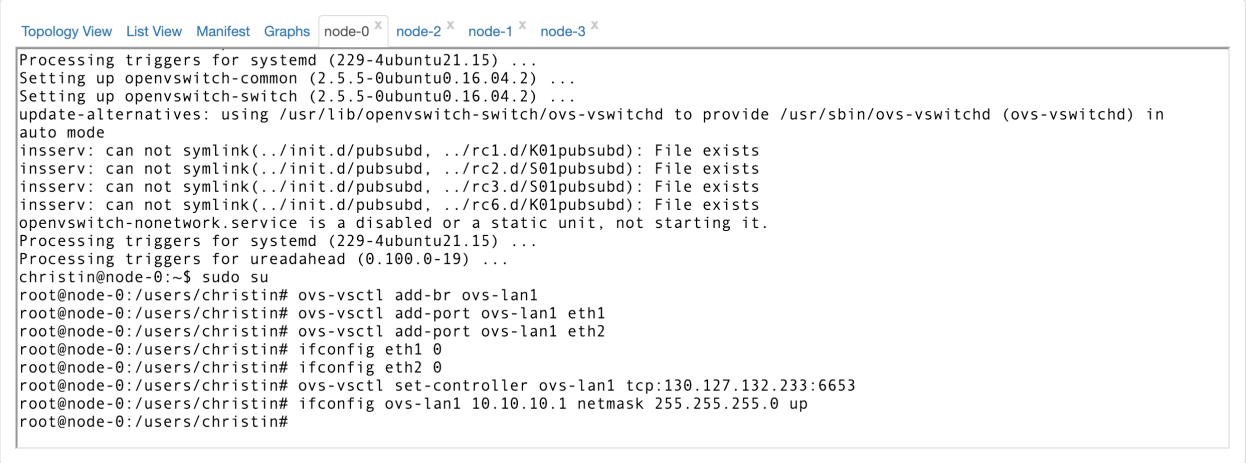


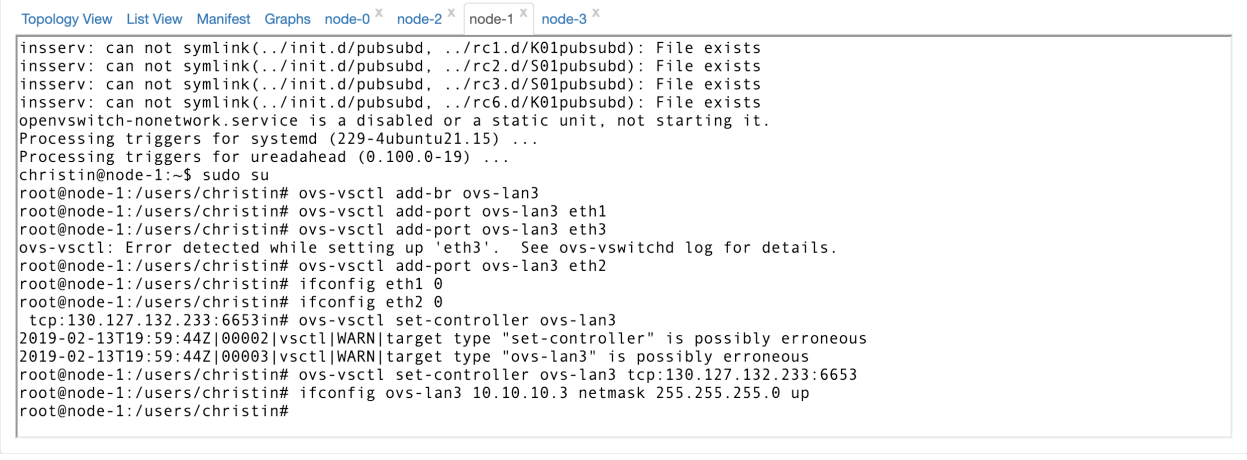


Step 5 - Install OpenVSwitch and setup bridges on all nodes: All the links in our topology are connected to the SDN controller (floodlight). To check what flows are pushed by the controller to route the traffic in the network we setup a bridge on all nodes and connect them to Floodlight controller. Controller will then learn the new topology and send appropriate flow rules.

Install OpenVSwitch: The following commands are run.
"sudo apt-get update"
"sudo apt-get install openvswitch-switch"
The following commands are used to setup a bridge on each node and connect it to SDN controller. The 4 bridges are named "ovs-lan1", "ovs-lan2", "ovs-lan3", "ovs-lan4". The IPs are set as "10.10.10.1", "10.10.10.2", "10.10.10.3", "10.10.10.4".

- sudo su
- ovs-vsctl add-br ovs-lan1
- ovs-vsctl add-port ovs-lan1 eth1
- ovs-vsctl add-port ovs-lan1 eth2
- ifconfig eth1 0
- ifconfig eth2 0
- ovs-vsctl set-controller ovs-lan1 tcp:130.127.132.233:6653
- ifconfig ovs-lan1 10.10.10.1 netmask 255.255.255.0 up





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

```
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
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) ...
christin@node-2:~$ sudo su
root@node-2:/users/christin# ovs-vsctl add-br ovs-lan2
root@node-2:/users/christin# ovs-vsctl add-port ovs-lan2 eth1
root@node-2:/users/christin# ovs-vsctl add-port ovs-lan2 eth2
root@node-2:/users/christin# ifconfig eth1 0
root@node-2:/users/christin# ifconfig eth2 0
root@node-2:/users/christin# ovs-vsctl set-controller ovs-lan2 tcp:130.127.132.233:6653
root@node-2:/users/christin# ifconfig ovs-lan2 10.10.10.2 netmask 255.255.255.0 up
root@node-2:/users/christin#
```

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

```
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
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) ...
christin@node-3:~$ sudo su
root@node-3:/users/christin# ovs-vsctl add-br ovs-lan4
root@node-3:/users/christin# ovs-vsctl add-port ovs-lan4 eth1
root@node-3:/users/christin# ovs-vsctl add-port ovs-lan4 eth2
root@node-3:/users/christin# ifconfig eth1 0
root@node-3:/users/christin# ifconfig eth2 0
root@node-3:/users/christin# ovs-vsctl set-controller ovs-lan4 tcp:130.127.132.233:6653
root@node-3:/users/christin# ifconfig ovs-lan4 10.10.10.4 netmask 255.255.255.0 up
root@node-3:/users/christin#
```

Step 6 - Ping and dump flows: Once all the configuration is finished, ping from node-0 to node-2 starts working. The “tcpdump -i eth1” command is run on node-1 and node-2 to check which path the ping takes. The flow rules are checked on all the 4 nodes using “ovs-ofctl dump-flows ovs-lan1 -O OpenFlow13” by replacing with appropriate bridges that we created on each node

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

```
root@node-0:/users/christin# ifconfig ovs-lan1 10.10.10.1 netmask 255.255.255.0 up
root@node-0:/users/christin# root@node-1:/users/christin# tcpdump -I eth1
bash: root@node-1:/users/christin#: No such file or directory
root@node-0:/users/christin# 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
15:11:47.054779 LLDP, length 61
15:12:02.058716 LLDP, length 61
15:12:02.065052 02:b1:7b:81:b4:55 (oui Unknown) > Broadcast, ethertype Unknown (0x8942), length 83:
        0x0000:  2000 0604 0002 0000 0207 049a 7940 f9d9  ............y@..
        0x0010:  4204 0302 0001 0602 0078 fe0c 0026 e100  B........x...&..
        0x0020:  0000 9a79 40f9 d942 1808 0013 d750 7c9d  ...y@..B.....P|.
        0x0030:  a829 e601 01fe 0c00 26e1 0100 0001 68e8  .)......&.....h.
        0x0040:  7cd6 2d00 00                             |.-..
15:12:02.065814 02:13:59:02:9e:dd (oui Unknown) > Broadcast, ethertype Unknown (0x8942), length 83:
        0x0000:  2000 0604 0002 0000 0207 04de b673 ee69  ............s.i
        0x0010:  4b04 0302 0001 0602 0078 fe0c 0026 e100  K........x...&..
        0x0020:  0000 deb6 73ee 694b 1808 0013 d750 7c9d  ....s.iK.....P|.
        0x0030:  a829 e601 01fe 0c00 26e1 0100 0001 68e8  .)......&.....h.
        0x0040:  7cd6 2d00 00                             |.-..
```

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

```
root@node-1:/users/christin# ovs-ofctl dump-flows ovs-lan3 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=705.621s, table=0, n_packets=48, n_bytes=3867, priority=0 actions=CONTROLLER:65535
root@node-1:/users/christin#
```

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

```
15:15:02.173496 02:b1:7b:81:b4:55 (oui Unknown) > Broadcast, ethertype Unknown (0x8942), length 83:
        0x0000:  2000 0604 0002 0000 0207 049a 7940 f9d9  ............y@..
        0x0010:  4204 0302 0001 0602 0078 fe0c 0026 e100  B........x...&..
        0x0020:  0000 9a79 40f9 d942 1808 0013 d750 7c9d  ...y@..B.....P|.
        0x0030:  a829 e601 01fe 0c00 26e1 0100 0001 68e8  .)......&.....h.
        0x0040:  7f95 be00 00                             .....
15:15:02.174137 02:13:59:02:9e:dd (oui Unknown) > Broadcast, ethertype Unknown (0x8942), length 83:
        0x0000:  2000 0604 0002 0000 0207 04de b673 ee69  ............s.i
        0x0010:  4b04 0302 0001 0602 0078 fe0c 0026 e100  K........x...&..
        0x0020:  0000 deb6 73ee 694b 1808 0013 d750 7c9d  ....s.iK.....P|.
        0x0030:  a829 e601 01fe 0c00 26e1 0100 0001 68e8  .)......&.....h.
        0x0040:  7f95 bf00 00                             .....
15:15:17.113323 LLDP, length 61
^C
30 packets captured
30 packets received by filter
0 packets dropped by kernel
root@node-0:/users/christin# ovs-ofctl dump-flows ovs-lan1 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=990.150s, table=0, n_packets=74, n_bytes=5895, priority=0 actions=CONTROLLER:65535
root@node-0:/users/christin# {
```

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

```
root@node-2:/users/christin# ovs-ofctl dump-flows ovs-lan2 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=823.078s, table=0, n_packets=71, n_bytes=5685, priority=0 actions=CONTROLLER:65535
root@node-2:/users/christin# {
```

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

```
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
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) ...
christin@node-3:~$ sudo su
root@node-3:/users/christin# ovs-vsctl add-br ovs-lan4
root@node-3:/users/christin# ovs-vsctl add-port ovs-lan4 eth1
root@node-3:/users/christin# ovs-vsctl add-port ovs-lan4 eth2
root@node-3:/users/christin# ifconfig eth1 0
root@node-3:/users/christin# ifconfig eth2 0
root@node-3:/users/christin# ovs-vsctl set-controller ovs-lan4 tcp:130.127.132.233:6653
root@node-3:/users/christin# ifconfig ovs-lan4 10.10.10.4 netmask 255.255.255.0 up
root@node-3:/users/christin# ovs-ofctl dump-flows ovs-lan4 -O OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=724.366s, table=0, n_packets=40, n_bytes=3216, priority=0 actions=CONTROLLER:65535
root@node-3:/users/christin# {
```