Installing necessary software:-

Please install the following software-

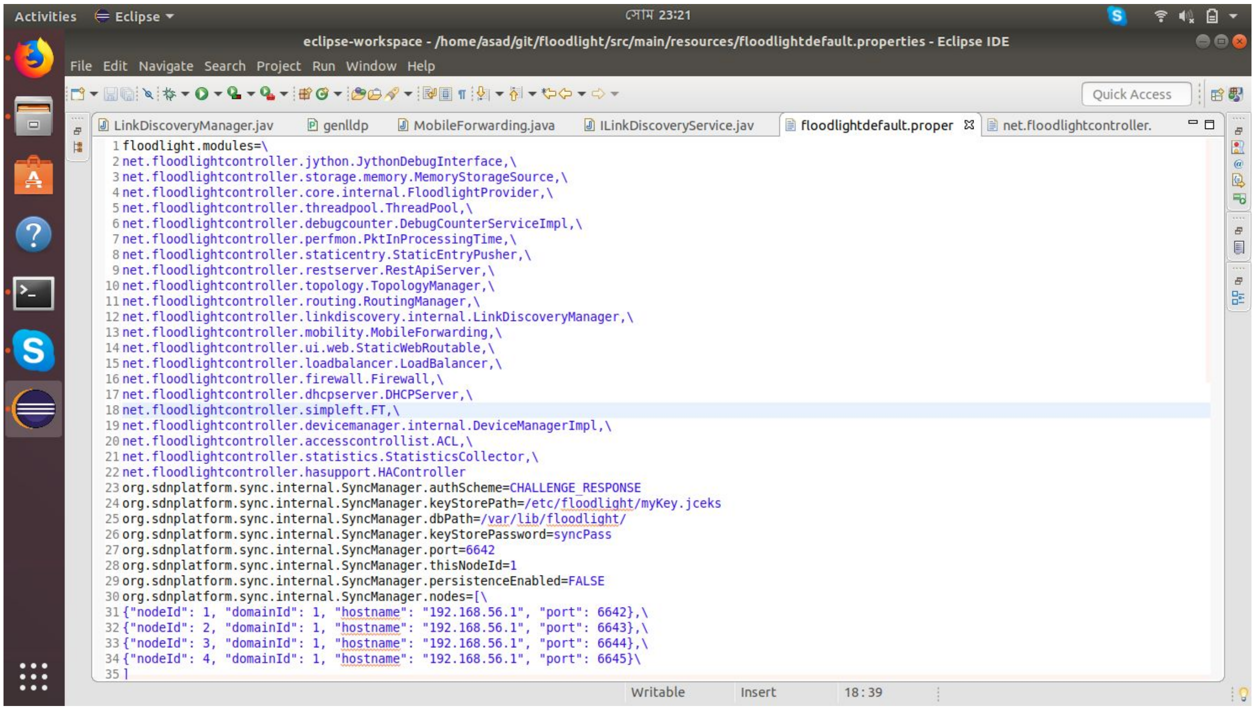
1. Mininet WiFi
2. Floodlight SDN controller (must install from source)
3. Eclipse IDE
4. Java SE 8
5. Python 2.7
6. Scapy

Installing the project:-

The project contains two modules for the Floodlight SDN controller and a script for enabling LLDP for mobile hosts. To install the floodlight modules, just put the java files in appropriate directory in floodlight source code and then enable the modules. The files that need to be placed in floodlight source directory are following-

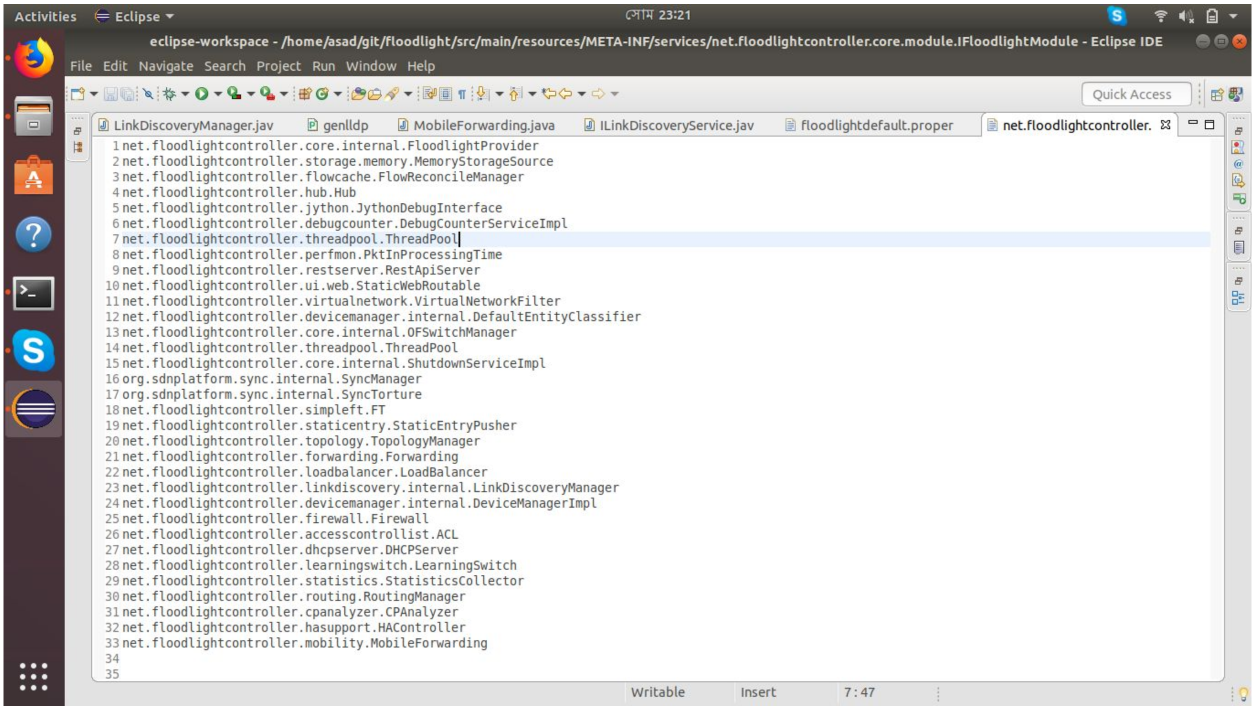
1. ILinkDiscoveryService.java [put in ‘floodlight/src/main/java/net/floodlightcontroller/linkdiscovery’]
2. LinkDiscoveryManager.java [put in ‘floodlight/src/main/java/net/floodlightcontroller/linkdiscovery/internal’]
3. MobileForwarding.java [put in ‘floodlight/src/main/java/net/floodlightcontroller/mobility’] You need to make a folder named ‘mobility’ at ‘floodlight/src/main/java/net/floodlightcontroller’

Now, enable these modules by using two configuration files. The appropriate directory for each configuration file is given in following screenshot.


Activities
Eclipse
সোম 23:21
eclipse-workspace - /home/asad/git/floodlight/src/main/resources/floodlightdefault.properties - Eclipse IDE
File Edit Navigate Search Project Run Window Help
Quick Access
LinkDiscoveryManager.jav
genlldp
MobileForwarding.java
ILinkDiscoveryService.jav
floodlightdefault.proper
net.floodlightcontroller.
Writable
Insert
18 : 39

```
floodlight.modules=\
net.floodlightcontroller.jython.JythonDebugInterface,\
net.floodlightcontroller.storage.memory.MemoryStorageSource,\
net.floodlightcontroller.core.internal.FloodlightProvider,\
net.floodlightcontroller.threadpool.ThreadPool,\
net.floodlightcontroller.debugcounter.DebugCounterServiceImpl,\
net.floodlightcontroller.perfmon.PktInProcessingTime,\
net.floodlightcontroller.staticentry.StaticEntryPusher,\
net.floodlightcontroller.restserver.RestApiServer,\
net.floodlightcontroller.topology.TopologyManager,\
net.floodlightcontroller.routing.RoutingManager,\
net.floodlightcontroller.linkdiscovery.internal.LinkDiscoveryManager,\
net.floodlightcontroller.mobility.MobileForwarding,\
net.floodlightcontroller.ui.web.StaticWebRoutable,\
net.floodlightcontroller.loadbalancer.LoadBalancer,\
net.floodlightcontroller.firewall.Firewall,\
net.floodlightcontroller.dhcpserver.DHCPServer,\
net.floodlightcontroller.simpleft.FT,\
net.floodlightcontroller.devicemanager.internal.DeviceManagerImpl,\
net.floodlightcontroller.accesscontrollist.ACL,\
net.floodlightcontroller.statistics.StatisticsCollector,\
net.floodlightcontroller.hasupport.HAController
org.sdnplatform.sync.internal.SyncManager.authScheme=CHALLENGE_RESPONSE
org.sdnplatform.sync.internal.SyncManager.keyStorePath=/etc/floodlight/myKey.jceks
org.sdnplatform.sync.internal.SyncManager.dbPath=/var/lib/floodlight/
org.sdnplatform.sync.internal.SyncManager.keyStorePassword=syncPass
org.sdnplatform.sync.internal.SyncManager.port=6642
org.sdnplatform.sync.internal.SyncManager.thisNodeId=1
org.sdnplatform.sync.internal.SyncManager.persistenceEnabled=FALSE
org.sdnplatform.sync.internal.SyncManager.nodes=[\
{"nodeId": 1, "domainId": 1, "hostname": "192.168.56.1", "port": 6642},\
{"nodeId": 2, "domainId": 1, "hostname": "192.168.56.1", "port": 6643},\
{"nodeId": 3, "domainId": 1, "hostname": "192.168.56.1", "port": 6644},\
{"nodeId": 4, "domainId": 1, "hostname": "192.168.56.1", "port": 6645}\
]
```

Fig. 1: First configuration file

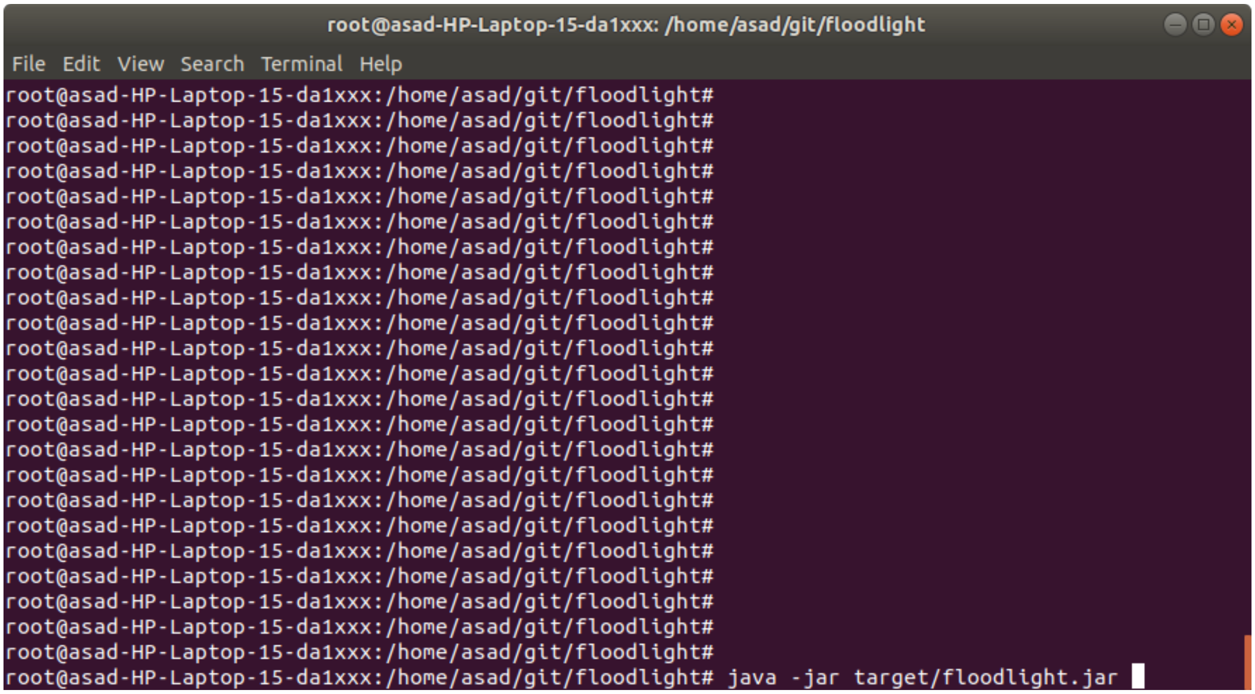

Activities
Eclipse
সোম 23:21
eclipse-workspace - /home/asad/git/floodlight/src/main/resources/META-INF/services/net.floodlightcontroller.core.module.IFloodlightModule - Eclipse IDE
File Edit Navigate Search Project Run Window Help
Quick Access
LinkDiscoveryManager.jav
genlldp
MobileForwarding.java
ILinkDiscoveryService.jav
floodlightdefault.proper
net.floodlightcontroller.
Writable
Insert
7 : 47

```
net.floodlightcontroller.core.internal.FloodlightProvider
net.floodlightcontroller.storage.memory.MemoryStorageSource
net.floodlightcontroller.flowcache.FlowReconcileManager
net.floodlightcontroller.hub.Hub
net.floodlightcontroller.jython.JythonDebugInterface
net.floodlightcontroller.debugcounter.DebugCounterServiceImpl
net.floodlightcontroller.threadpool.ThreadPool
net.floodlightcontroller.perfmon.PktInProcessingTime
net.floodlightcontroller.restserver.RestApiServer
net.floodlightcontroller.ui.web.StaticWebRoutable
net.floodlightcontroller.virtualnetwork.VirtualNetworkFilter
net.floodlightcontroller.devicemanager.internal.DefaultEntityClassifier
net.floodlightcontroller.core.internal.OFSwitchManager
net.floodlightcontroller.threadpool.ThreadPool
net.floodlightcontroller.core.internal.ShutdownServiceImpl
org.sdnplatform.sync.internal.SyncManager
org.sdnplatform.sync.internal.SyncTorture
net.floodlightcontroller.simpleft.FT
net.floodlightcontroller.staticentry.StaticEntryPusher
net.floodlightcontroller.topology.TopologyManager
net.floodlightcontroller.forwarding.Forwarding
net.floodlightcontroller.loadbalancer.LoadBalancer
net.floodlightcontroller.linkdiscovery.internal.LinkDiscoveryManager
net.floodlightcontroller.devicemanager.internal.DeviceManagerImpl
net.floodlightcontroller.firewall.Firewall
net.floodlightcontroller.accesscontrollist.ACL
net.floodlightcontroller.dhcpserver.DHCPServer
net.floodlightcontroller.learningswitch.LearningSwitch
net.floodlightcontroller.statistics.StatisticsCollector
net.floodlightcontroller.routing.RoutingManager
net.floodlightcontroller.cpanalyzer.CPAnalyzer
net.floodlightcontroller.hasupport.HAController
net.floodlightcontroller.mobility.MobileForwarding


```

Fig. 2: Second configuration file

Running the experiment:-

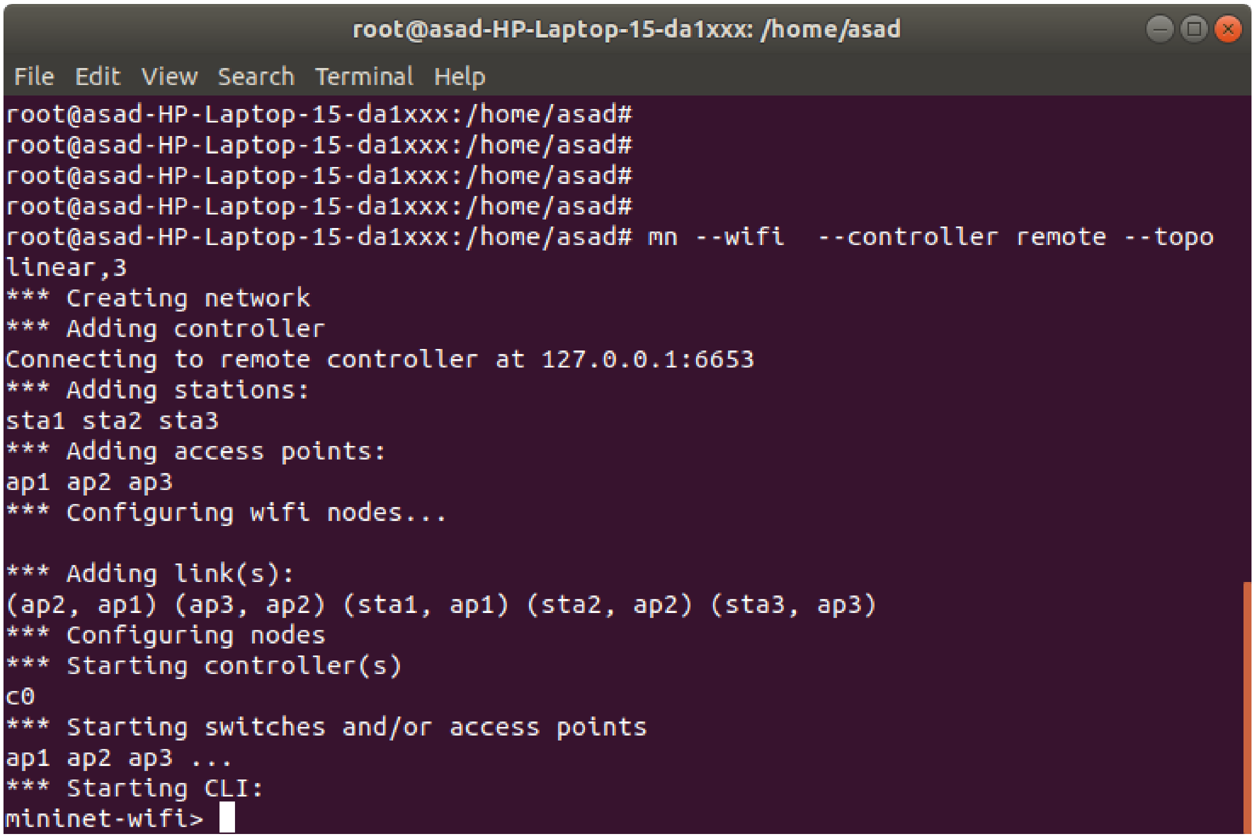
1. First, start the floodlight controller by using the following command: java -jar target/floodlight.jar [Note: you should first cd to floodlight root directory before running this]



root@asad-HP-Laptop-15-da1xxx: /home/asad/git/floodlight
File Edit View Search Terminal Help

```
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight#
root@asad-HP-Laptop-15-da1xxx:/home/asad/git/floodlight# java -jar target/floodlight.jar
```

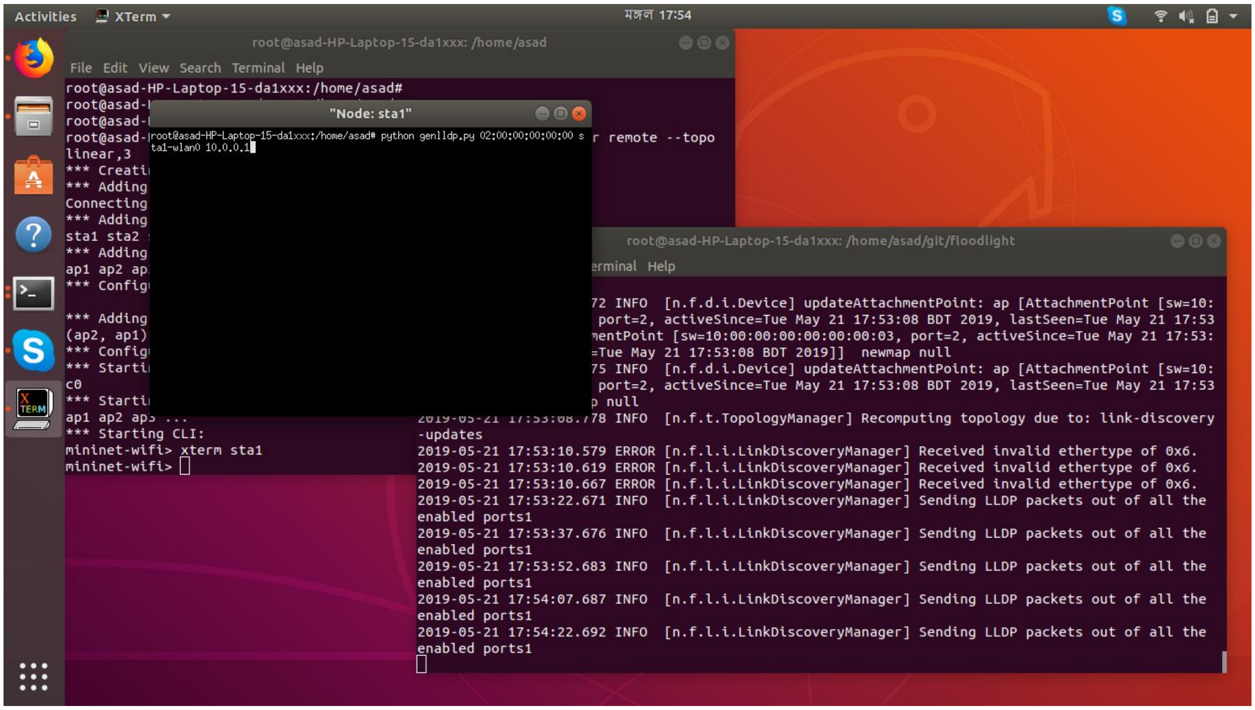
2. Now start mininet: mn --wifi --controller remote --topo linear,3



root@asad-HP-Laptop-15-da1xxx: /home/asad
File Edit View Search Terminal Help

```
root@asad-HP-Laptop-15-da1xxx:/home/asad#
root@asad-HP-Laptop-15-da1xxx:/home/asad#
root@asad-HP-Laptop-15-da1xxx:/home/asad#
root@asad-HP-Laptop-15-da1xxx:/home/asad#
root@asad-HP-Laptop-15-da1xxx:/home/asad# mn --wifi  --controller remote --topo
linear,3
*** Creating network
*** Adding controller
Connecting to remote controller at 127.0.0.1:6653
*** Adding stations:
sta1 sta2 sta3
*** Adding access points:
ap1 ap2 ap3
*** Configuring wifi nodes...

*** Adding link(s):
(ap2, ap1) (ap3, ap2) (sta1, ap1) (sta2, ap2) (sta3, ap3)
*** Configuring nodes
*** Starting controller(s)
c0
*** Starting switches and/or access points
ap1 ap2 ap3 ...
*** Starting CLI:
mininet-wifi>
```

3. Now to enable LLDP in the wifi stations run a command in each of them. But before that you can run a ping just for cross checking.

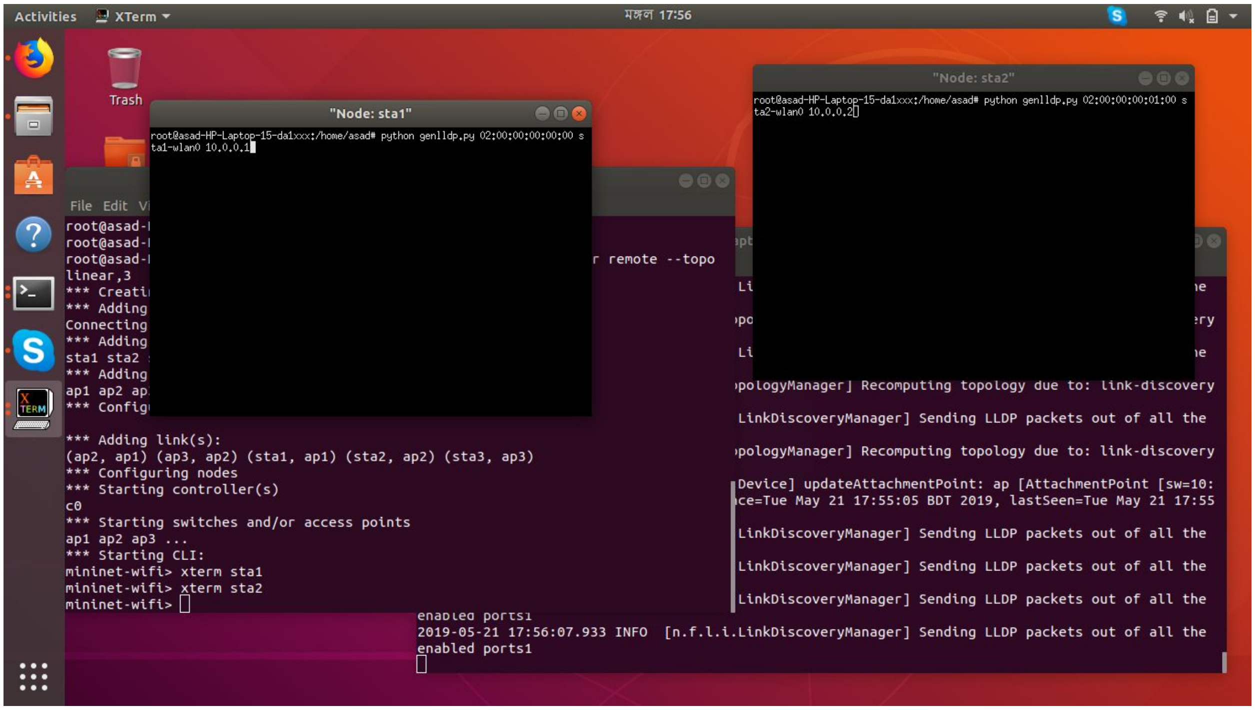

Activities
XTerm
मङ्गल 17:54
root@asad-HP-Laptop-15-da1xxx: /home/asad
File Edit View Search Terminal Help
"Node: sta1"
root@asad-HP-Laptop-15-da1xxx: /home/asad/git/floodlight
erminal Help

```
root@asad-HP-Laptop-15-da1xxx:/home/asad# python genlldp.py 02:00:00:00:00:00 s
ta1-wlan0 10.0.0.1
```

```
root@asad-HP-Laptop-15-da1xxx:/home/asad#
root@asad-
root@asad-
root@asad-                                                            r remote --topo
linear,3
*** Creati
*** Adding
Connecting
*** Adding
sta1 sta2
*** Adding
ap1 ap2 ap
*** Config

*** Adding
(ap2, ap1)
*** Config
*** Starti
c0
*** Starti
ap1 ap2 ap3 ...
*** Starting CLI:
mininet-wifi> xterm sta1
mininet-wifi> 
```

```
72 INFO  [n.f.d.i.Device] updateAttachmentPoint: ap [AttachmentPoint [sw=10:
 port=2, activeSince=Tue May 21 17:53:08 BDT 2019, lastSeen=Tue May 21 17:53
mentPoint [sw=10:00:00:00:00:00:00:03, port=2, activeSince=Tue May 21 17:53:
=Tue May 21 17:53:08 BDT 2019]]  newmap null
75 INFO  [n.f.d.i.Device] updateAttachmentPoint: ap [AttachmentPoint [sw=10:
 port=2, activeSince=Tue May 21 17:53:08 BDT 2019, lastSeen=Tue May 21 17:53
p null
2019-05-21 17:53:08.778 INFO  [n.f.t.TopologyManager] Recomputing topology due to: link-discovery
-updates
2019-05-21 17:53:10.579 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethertype of 0x6.
2019-05-21 17:53:10.619 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethertype of 0x6.
2019-05-21 17:53:10.667 ERROR [n.f.l.i.LinkDiscoveryManager] Received invalid ethertype of 0x6.
2019-05-21 17:53:22.671 INFO  [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
2019-05-21 17:53:37.676 INFO  [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
2019-05-21 17:53:52.683 INFO  [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
2019-05-21 17:54:07.687 INFO  [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
2019-05-21 17:54:22.692 INFO  [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
```

You will see that ping is not successful. This is because the algorithm depends on LLDP and it is not enabled on the wifi mobile nodes yet. To enable LLDP in the hosts, run a python script in each of them (using appropriate command line argument for each). Example command for sta1: python genlldp.py 02:00:00:00:00:00 sta1-wlan0 10.0.0.1 See screenshot for details.



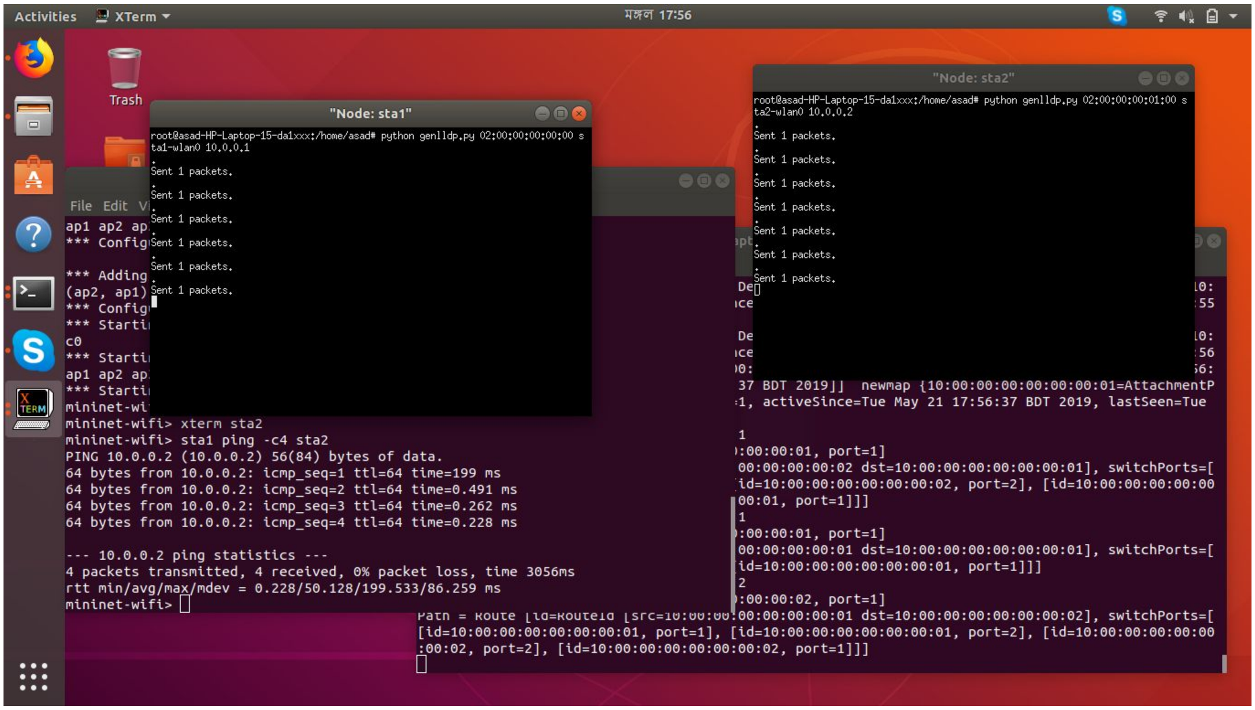
```
root@asad-HP-Laptop-15-da1xxx:/home/asad# python genlldp.py 02:00:00:00:00:00 s
ta1-wlan0 10.0.0.1
```

```
root@asad-HP-Laptop-15-da1xxx:/home/asad# python genlldp.py 02:00:00:00:01:00 s
ta2-wlan0 10.0.0.2
```

```
root@asad-
root@asad-
root@asad-                                                            r remote --topo
linear,3
*** Creati
*** Adding
Connecting
*** Adding
sta1 sta2
*** Adding
ap1 ap2 ap
*** Config

*** Adding link(s):
(ap2, ap1) (ap3, ap2) (sta1, ap1) (sta2, ap2) (sta3, ap3)
*** Configuring nodes
*** Starting controller(s)
c0
*** Starting switches and/or access points
ap1 ap2 ap3 ...
*** Starting CLI:
mininet-wifi> xterm sta1
mininet-wifi> xterm sta2
mininet-wifi> 
```

```
Li                                                                        he
pol                                                                       ery
Li                                                                        he
pologyManager] Recomputing topology due to: link-discovery
LinkDiscoveryManager] Sending LLDP packets out of all the
pologyManager] Recomputing topology due to: link-discovery
Device] updateAttachmentPoint: ap [AttachmentPoint [sw=10:
ce=Tue May 21 17:55:05 BDT 2019, lastSeen=Tue May 21 17:55
LinkDiscoveryManager] Sending LLDP packets out of all the
LinkDiscoveryManager] Sending LLDP packets out of all the
LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
2019-05-21 17:56:07.933 INFO  [n.f.l.i.LinkDiscoveryManager] Sending LLDP packets out of all the
enabled ports1
```

4. Now that lldp is enabled on sta1 and sta2, you should run the ping again.
5. Now, you will see that ping is successful this time. If you look at the floodlight terminal now, you will see messaging showing detected destination switch, the installed path in the network and more useful messages.



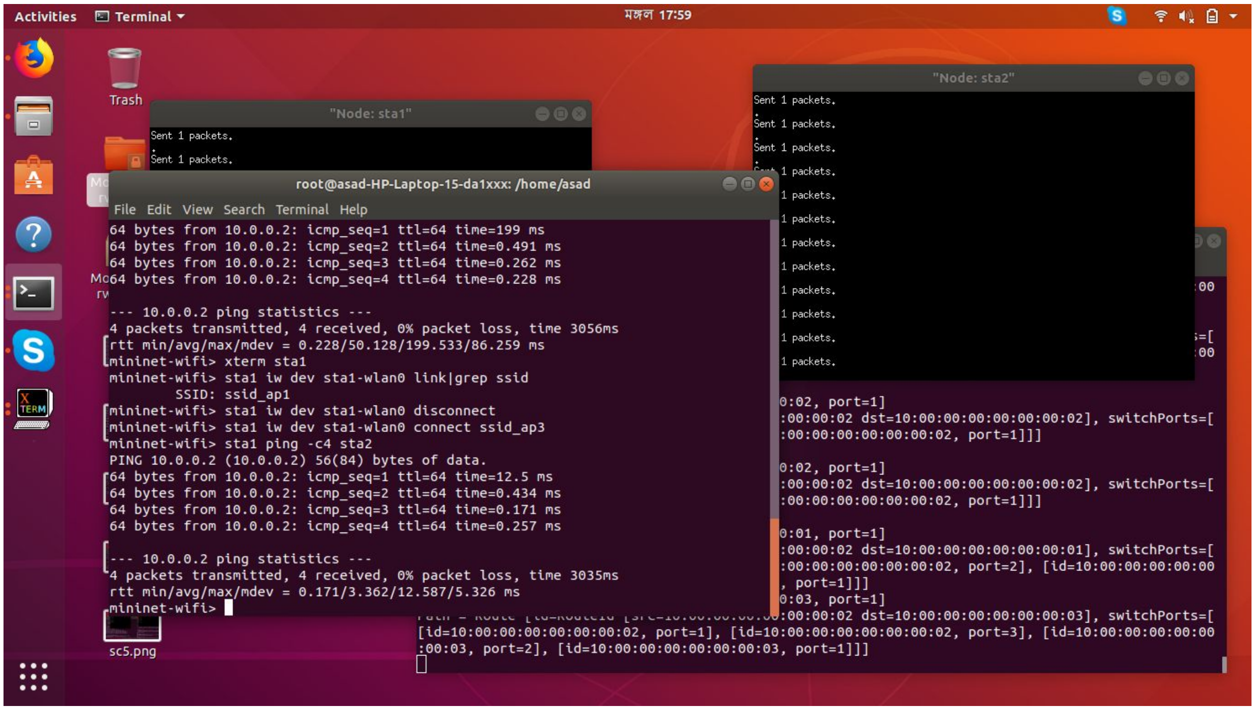
```
root@asad-HP-Laptop-15-da1xxx:/home/asad# python genlldp.py 02:00:00:00:00:00 s
ta1-wlan0 10.0.0.1
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
```

```
root@asad-HP-Laptop-15-da1xxx:/home/asad# python genlldp.py 02:00:00:00:01:00 s
ta2-wlan0 10.0.0.2
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
```

```
ap1 ap2 ap
*** Config

*** Adding
(ap2, ap1)
*** Config
*** Starti
c0
*** Starti
ap1 ap2 ap
*** Starti
mininet-wi
mininet-wifi> xterm sta2
mininet-wifi> sta1 ping -c4 sta2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=199 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.491 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.262 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.228 ms

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3056ms
rtt min/avg/max/mdev = 0.228/50.128/199.533/86.259 ms
mininet-wifi>
```

```
De                                                                          10:
ice                                                                         :55

De                                                                          10:
ice                                                                         :56
00:                                                                         56:
37 BDT 2019]]  newmap {10:00:00:00:00:00:00:01=AttachmentP
1, activeSince=Tue May 21 17:56:37 BDT 2019, lastSeen=Tue

1
:00:00:01, port=1]
00:00:00:00:02 dst=10:00:00:00:00:00:00:01], switchPorts=[
id=10:00:00:00:00:00:00:02, port=2], [id=10:00:00:00:00:00
00:01, port=1]]]
1
:00:00:01, port=1]
00:00:00:00:01 dst=10:00:00:00:00:00:00:01], switchPorts=[
id=10:00:00:00:00:00:00:01, port=1]]]
2
:00:00:02, port=1]
Path = Route [id=RouteId [src=10:00:00:00:00:00:00:01 dst=10:00:00:00:00:00:00:02], switchPorts=[
[id=10:00:00:00:00:00:00:01, port=1], [id=10:00:00:00:00:00:00:01, port=2], [id=10:00:00:00:00:00
:00:02, port=2], [id=10:00:00:00:00:00:00:02, port=1]]]
```

6. To see if node mobility is handled successfully you can now connect one of the mobile hosts to a different access point. To do so, you need three steps-
   a. Check which access point a host is currently connected to: sta1 iw dev sta1-wlan0 link
   b. Disconnect the host from current access point: sta1 iw dev sta1-wlan0 disconnect
   c. Connect the host to a different access point: sta1 iw dev sta1-wlan0 connect ssid_ap2



```
Sent 1 packets.
.
Sent 1 packets.
```

```
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
.
Sent 1 packets.
1 packets.
1 packets.
1 packets.
1 packets.
1 packets.
1 packets.
1 packets.
1 packets.
```

root@asad-HP-Laptop-15-da1xxx: /home/asad

```
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=199 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.491 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.262 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.228 ms

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3056ms
rtt min/avg/max/mdev = 0.228/50.128/199.533/86.259 ms
mininet-wifi> xterm sta1
mininet-wifi> sta1 iw dev sta1-wlan0 link|grep ssid
        SSID: ssid_ap1
mininet-wifi> sta1 iw dev sta1-wlan0 disconnect
mininet-wifi> sta1 iw dev sta1-wlan0 connect ssid_ap3
mininet-wifi> sta1 ping -c4 sta2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=12.5 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.434 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.171 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.257 ms

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3035ms
rtt min/avg/max/mdev = 0.171/3.362/12.587/5.326 ms
mininet-wifi> 
```

```
:00
s=[
:00
0:02, port=1]
:00:00:02 dst=10:00:00:00:00:00:00:02], switchPorts=[
:00:00:00:00:00:00:02, port=1]]]

0:02, port=1]
:00:00:02 dst=10:00:00:00:00:00:00:02], switchPorts=[
:00:00:00:00:00:00:02, port=1]]]

0:01, port=1]
:00:00:02 dst=10:00:00:00:00:00:00:01], switchPorts=[
:00:00:00:00:00:00:02, port=2], [id=10:00:00:00:00:00
, port=1]]]
0:03, port=1]
:00:00:02 dst=10:00:00:00:00:00:00:03], switchPorts=[
[id=10:00:00:00:00:00:00:02, port=1], [id=10:00:00:00:00:00:00:02, port=3], [id=10:00:00:00:00:00
:00:03, port=2], [id=10:00:00:00:00:00:00:03, port=1]]]
```

7. Now run ping again and check floodlight messages to see the difference.