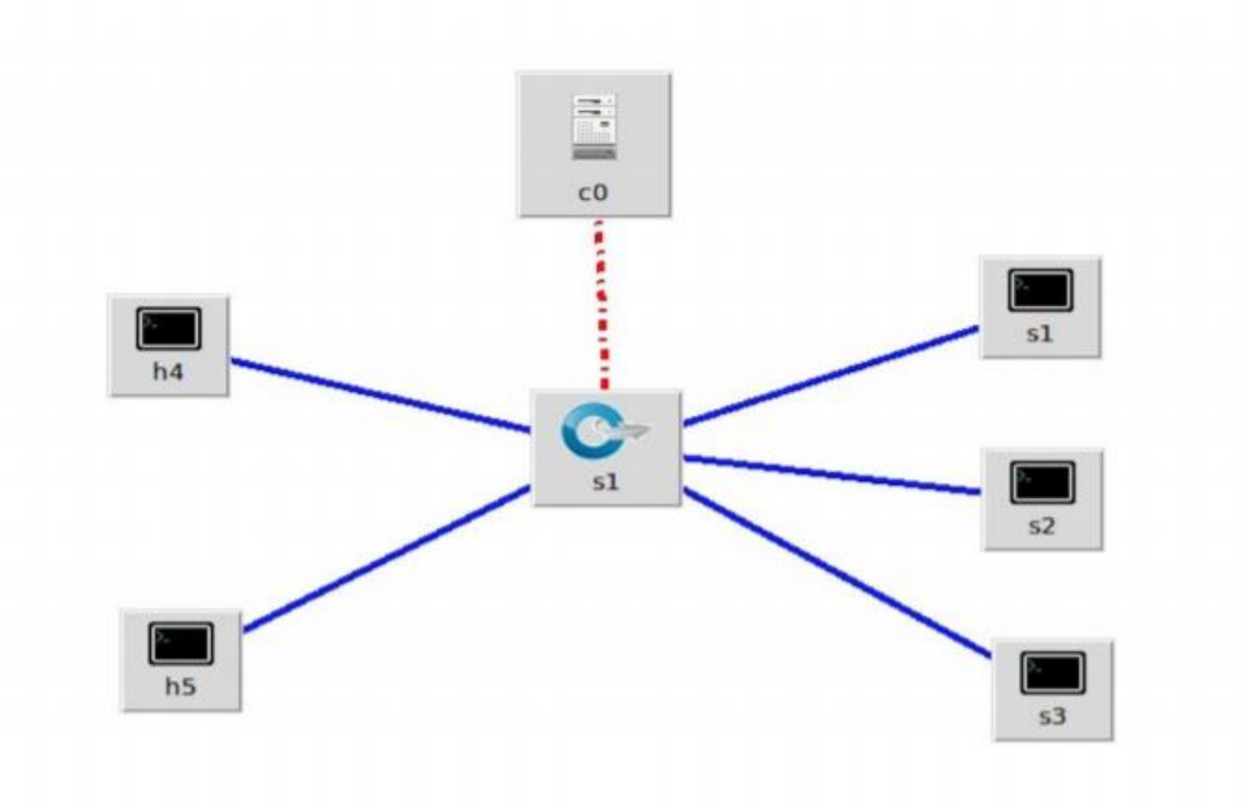
Internet Protocols and Architecture
Project 3

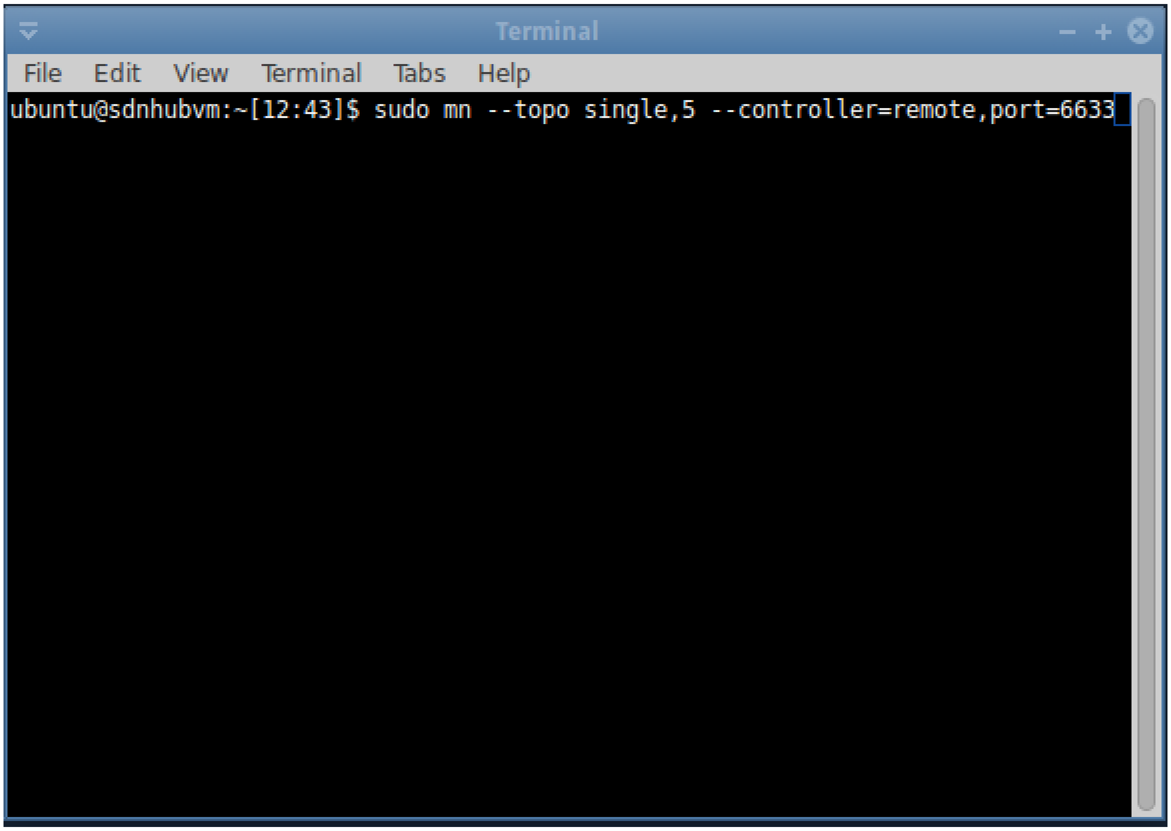
In this project I have designed a network providing server load distribution. Servers are HTTP servers. I implemented the design by creating two hosts, a remote controller (POX controller), a Load balancer and three HTTP Servers. The hosts put up an HTTP request to the load balancer (IP Address: 10.0.1.1 in this case) and the load balancer then schedules the request to the servers in a round robin manner. If the topology is changed, that is, if a server is added or removed, the load balancer dynamically adapts to the change and directs to other servers.

Step 1: Topology design



Step 2:
Created a topology with the help of the following command on the terminal.

sudo mn -- topo single,5 -- controller=remote,port=6633

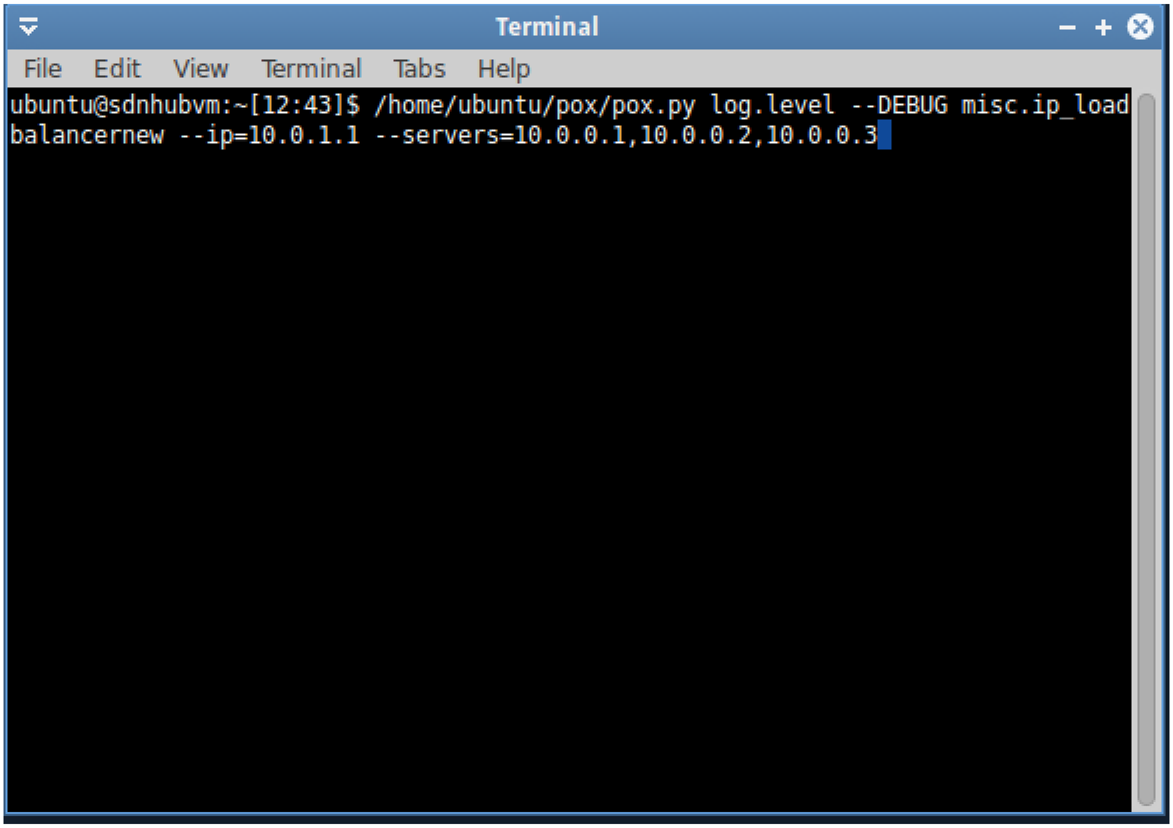


```
ubuntu@sdnhubvm:~[12:43]$ sudo mn --topo single,5 --controller=remote,port=6633
```

Step 3:

Invoking a pox controller and initializing a load balancer python file with IP of load balancer as 10.0.1.1 and 10.0.0.1, 10.0.0.2, 10.0.0.3 which are the IPs of three servers respectively with the command below on another terminal.

/home/ubuntu/pox/pox.py log.level -- DEBUG misc.ip_loadbalancernew -- ip=10.0.1.1 -- servers=10.0.0.1,10.0.0.2,10.0.0.3

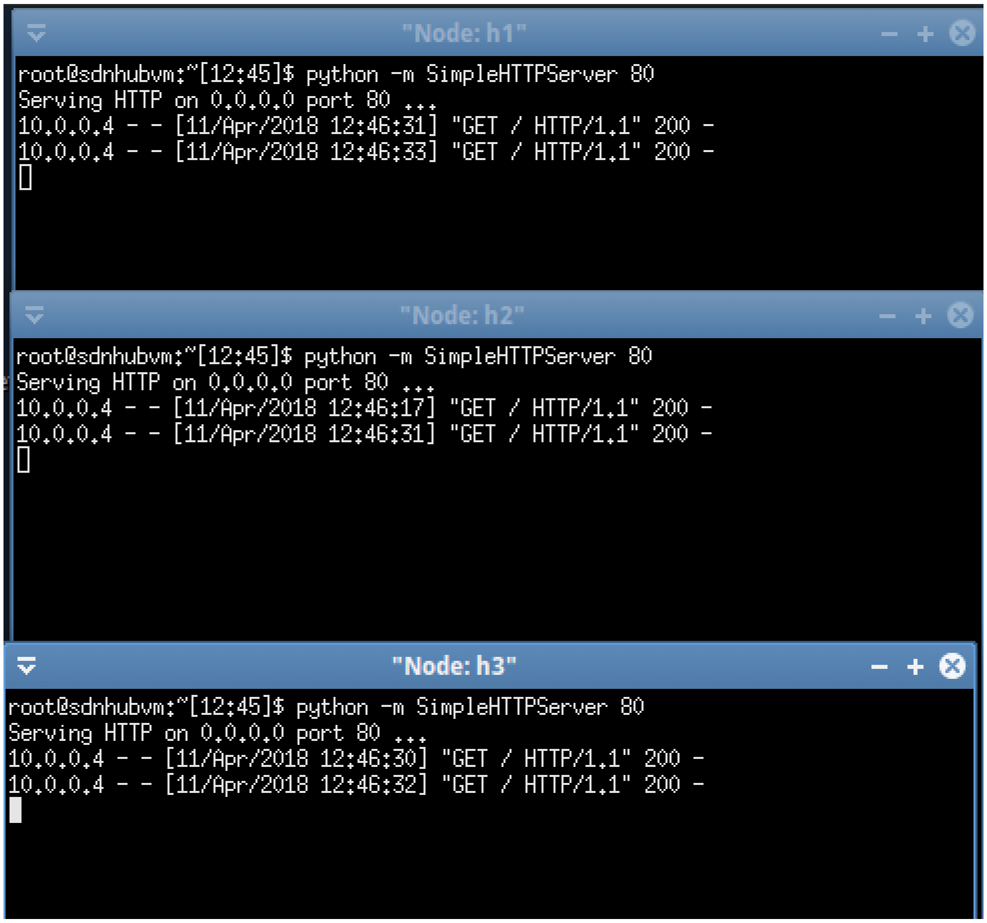


```
ubuntu@sdnhubvm:~[12:43]$ /home/ubuntu/pox/pox.py log.level --DEBUG misc.ip_load
balancernew --ip=10.0.1.1 --servers=10.0.0.1,10.0.0.2,10.0.0.3
```

Step 4:

Making the first 3 nodes h1, h2 and h3 as HTTP servers with following command in xterms of each above-mentioned node in mininet.

python -m SimpleHTTPServer 80



```
root@sdnhubvm:~[12:45]$ python -m SimpleHTTPServer 80
Serving HTTP on 0.0.0.0 port 80 ...
10.0.0.4 - - [11/Apr/2018 12:46:31] "GET / HTTP/1.1" 200 -
10.0.0.4 - - [11/Apr/2018 12:46:33] "GET / HTTP/1.1" 200 -
```

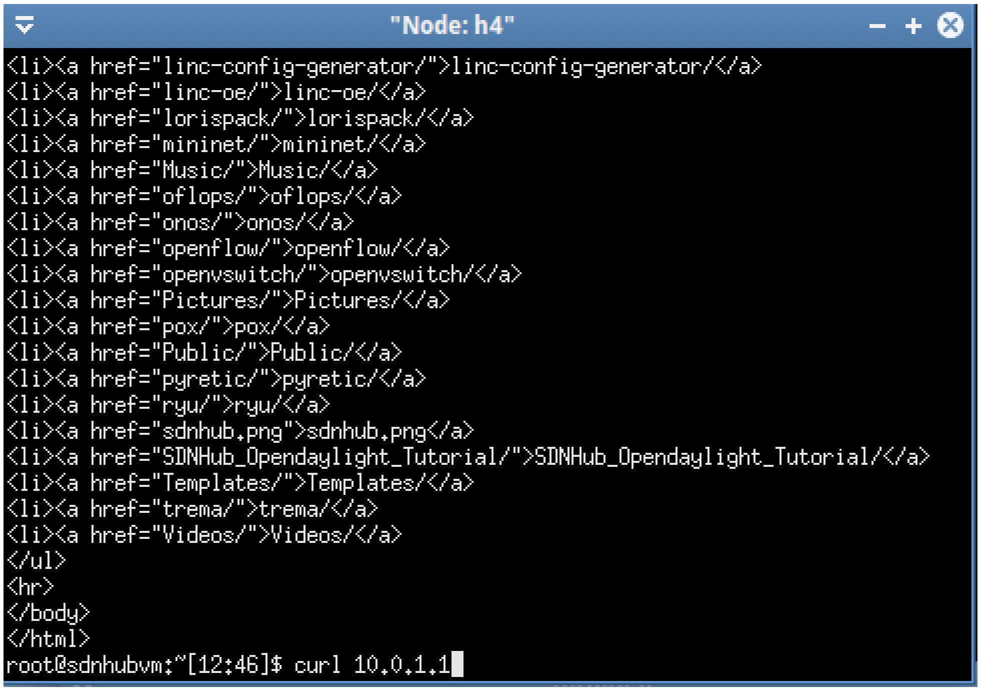
```
root@sdnhubvm:~[12:45]$ python -m SimpleHTTPServer 80
Serving HTTP on 0.0.0.0 port 80 ...
10.0.0.4 - - [11/Apr/2018 12:46:17] "GET / HTTP/1.1" 200 -
10.0.0.4 - - [11/Apr/2018 12:46:31] "GET / HTTP/1.1" 200 -
```

```
root@sdnhubvm:~[12:45]$ python -m SimpleHTTPServer 80
Serving HTTP on 0.0.0.0 port 80 ...
10.0.0.4 - - [11/Apr/2018 12:46:30] "GET / HTTP/1.1" 200 -
10.0.0.4 - - [11/Apr/2018 12:46:32] "GET / HTTP/1.1" 200 -
```

Step 5:

To fetch data from the server, following command should be given on xterm of the hosts which requests the load balancer which in turn directs the traffic to one of the servers.

curl 10.0.1.1 (IP of load balancer)



```
<li><a href="linc-config-generator/">linc-config-generator/</a>
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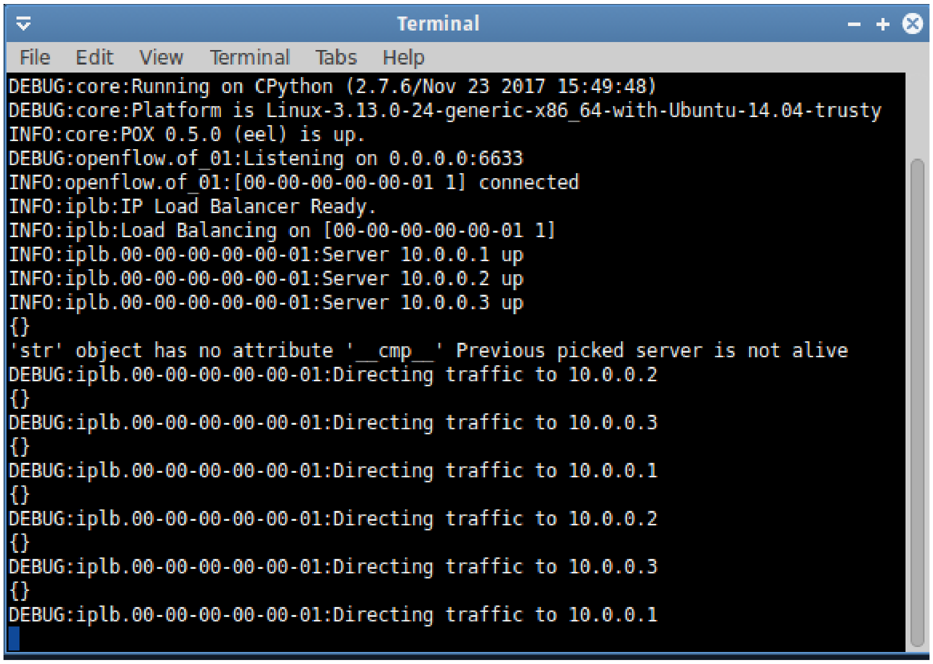
<li><a href="trema/">trema/</a>
<li><a href="Videos/">Videos/</a>
</ul>
<hr>
</body>
</html>
root@sdnhubvm:~[12:46]$ curl 10.0.1.1
```

Step 6:

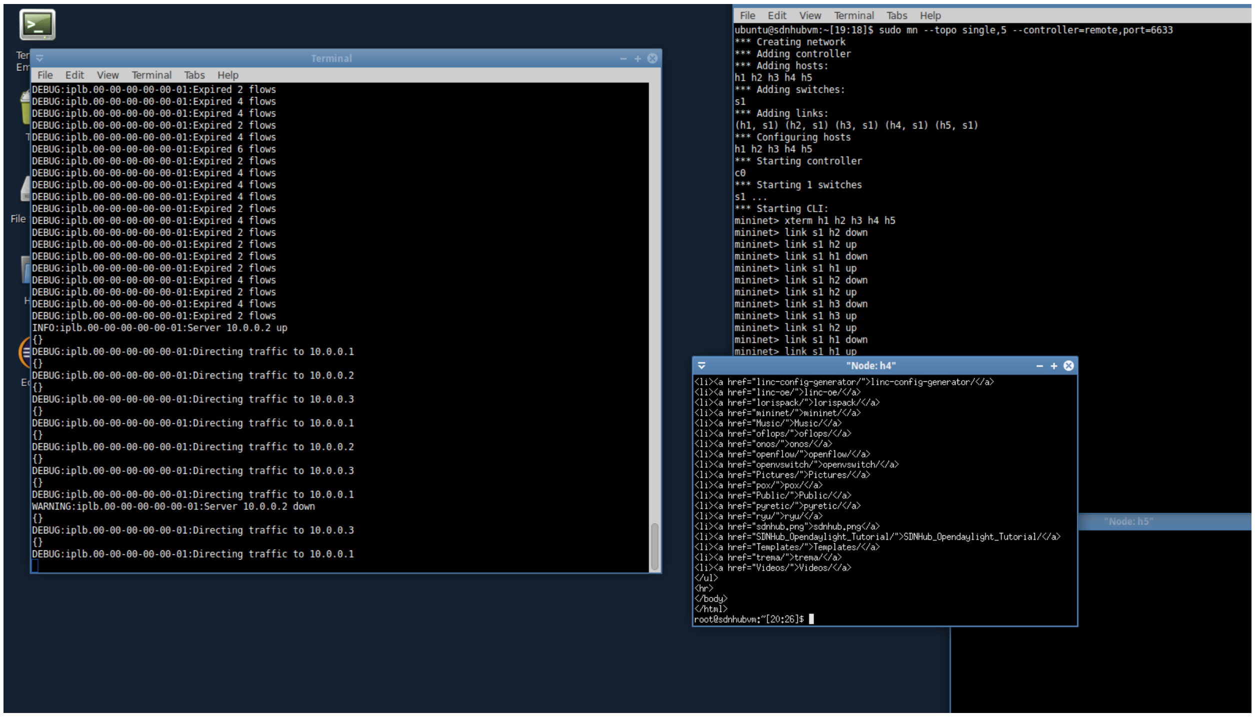
In this step, we observe in the controller terminal the traffic directed to servers during each request by the host. Now the controller directs the traffic to each server in a Round Robin manner. In case where a server is removed, the controller directs the traffic to the remaining servers, thus maintaining the connectivity.



```
DEBUG:core:Running on CPython (2.7.6/Nov 23 2017 15:49:48)
DEBUG:core:Platform is Linux-3.13.0-24-generic-x86_64-with-Ubuntu-14.04-trusty
INFO:core:POX 0.5.0 (eel) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633
INFO:openflow.of_01:[00-00-00-00-00-01 1] connected
INFO:iplb:IP Load Balancer Ready.
INFO:iplb:Load Balancing on [00-00-00-00-00-01 1]
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.1 up
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.2 up
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.3 up
{}
'str' object has no attribute '__cmp__' Previous picked server is not alive
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
```

Output:

Here, the Round Robin sequence is [server 2, server 3, server 1]



```
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 6 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.2 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.2 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
```

```
ubuntu@sdnhubvm:~[19:18]$ sudo mn --topo single,5 --controller=remote,port=6633
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (h4, s1) (h5, s1)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> xterm h1 h2 h3 h4 h5
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h1 down
mininet> link s1 h1 up
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h3 down
mininet> link s1 h3 up
mininet> link s1 h2 up
mininet> link s1 h1 down
mininet> link s1 h1 up
```

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<li><a href="openvswitch/">openvswitch/</a>
<li><a href="Pictures/">Pictures/</a>
<li><a href="pox/">pox/</a>
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<li><a href="sdnhub.png">sdnhub.png</a>
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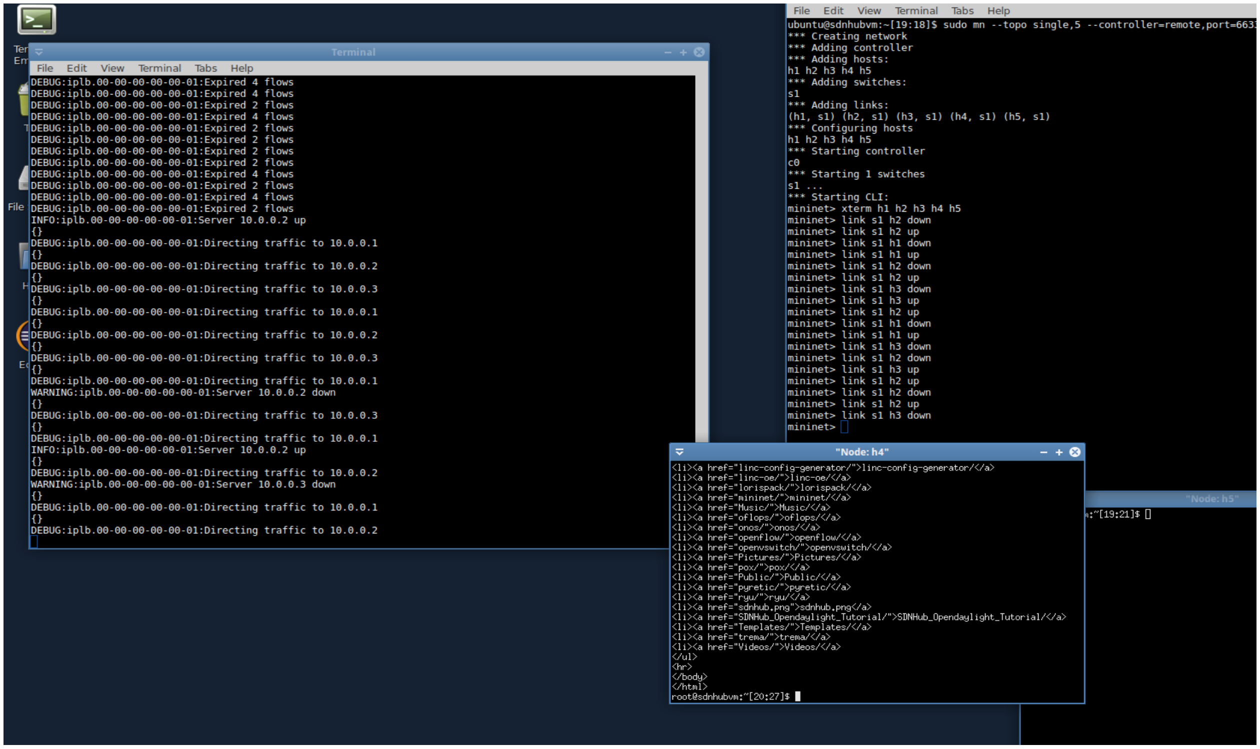
<li><a href="Templates/">Templates/</a>
<li><a href="trema/">trema/</a>
<li><a href="Videos/">Videos/</a>
</ul>
<hr>
</body>
</html>
root@sdnhubvm:~[20:26]$
```

Link to server 2 is down, traffic is directed to Server 3 and server 1.



```
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.2 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.2 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.2 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.3 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
```

```
ubuntu@sdnhubvm:~[19:18]$ sudo mn --topo single,5 --controller=remote,port=663
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (h4, s1) (h5, s1)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> xterm h1 h2 h3 h4 h5
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h1 down
mininet> link s1 h1 up
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h3 down
mininet> link s1 h3 up
mininet> link s1 h2 up
mininet> link s1 h1 down
mininet> link s1 h1 up
mininet> link s1 h3 down
mininet> link s1 h2 down
mininet> link s1 h3 up
mininet> link s1 h2 up
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h3 down
mininet>
```

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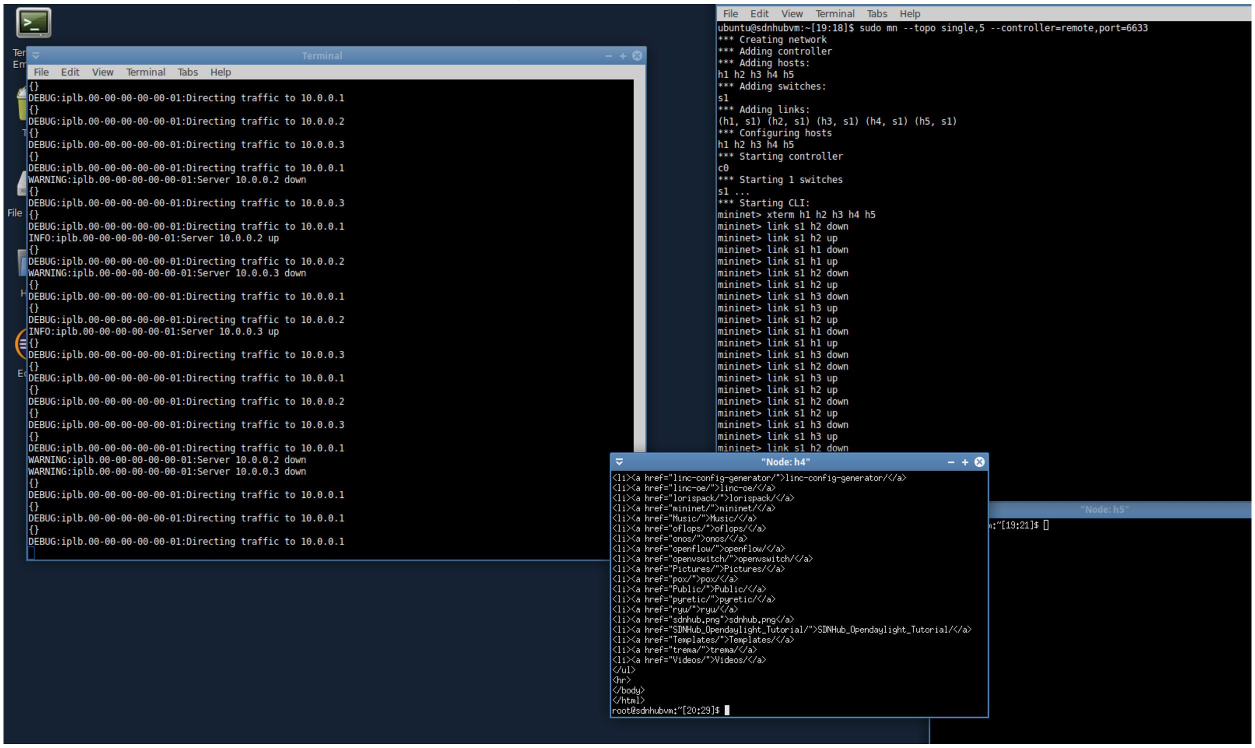
<li><a href="trema/">trema/</a>
<li><a href="Videos/">Videos/</a>
</ul>
<hr>
</body>
</html>
root@sdnhubvm:~[20:27]$
```

```
:~[19:21]$
```

Link to server 2 and server3 is down. So, the traffic is directed to server 1.



```
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.2 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.2 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.3 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.3 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.2 down
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.3 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
```

```
ubuntu@sdnhubvm:~[19:18]$ sudo mn --topo single,5 --controller=remote,port=6633
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (h4, s1) (h5, s1)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> xterm h1 h2 h3 h4 h5
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h1 down
mininet> link s1 h1 up
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h3 down
mininet> link s1 h3 up
mininet> link s1 h2 up
mininet> link s1 h1 down
mininet> link s1 h1 up
mininet> link s1 h3 down
mininet> link s1 h2 down
mininet> link s1 h3 up
mininet> link s1 h2 up
mininet> link s1 h2 down
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mininet> link s1 h3 down
mininet> link s1 h3 up
mininet> link s1 h2 down
```

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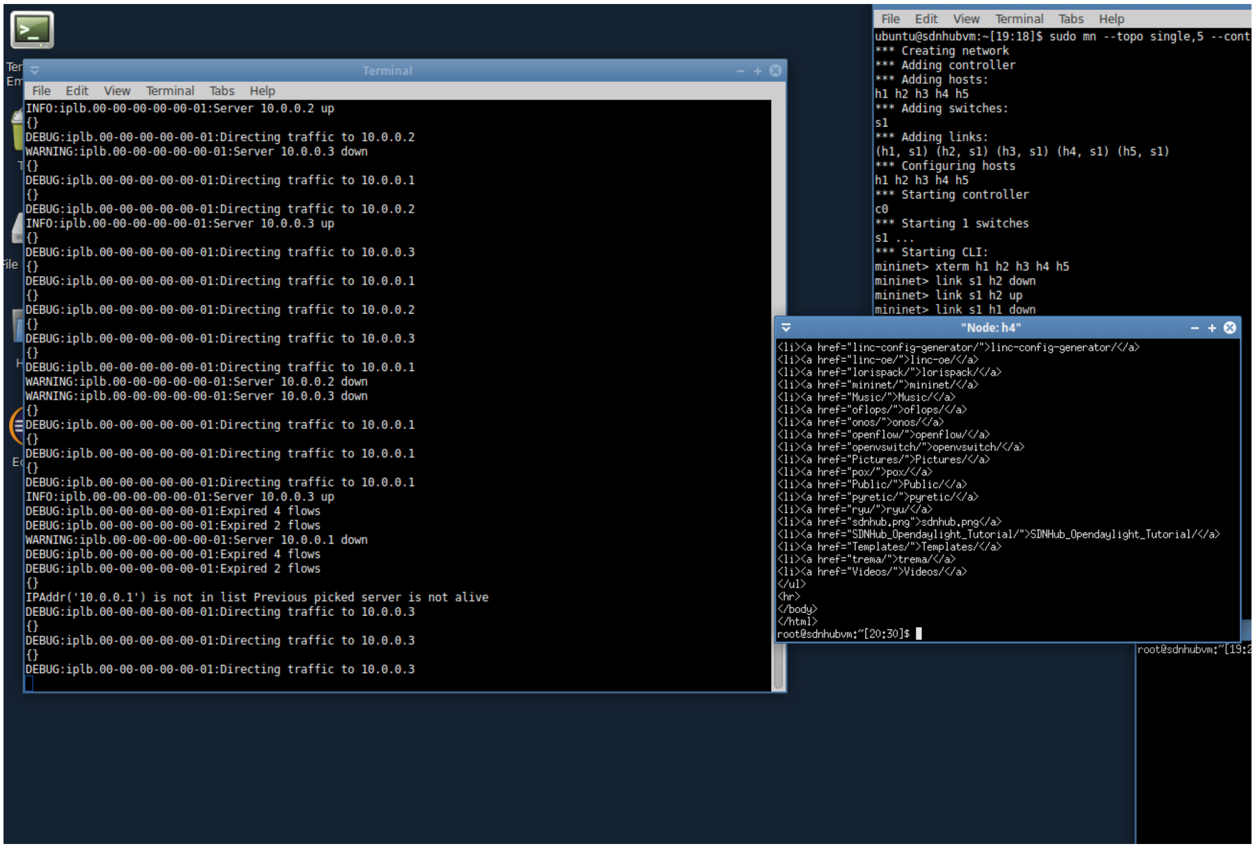
<li><a href="trema/">trema/</a>
<li><a href="Videos/">Videos/</a>
</ul>
<hr>
</body>
</html>
root@sdnhubvm:~[20:29]$
```

```
:~[19:21]$
```



```
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.2 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.3 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.3 up
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.2
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.2 down
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.3 down
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.1
INFO:iplb.00-00-00-00-00-01:Server 10.0.0.3 up
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
WARNING:iplb.00-00-00-00-00-01:Server 10.0.0.1 down
DEBUG:iplb.00-00-00-00-00-01:Expired 4 flows
DEBUG:iplb.00-00-00-00-00-01:Expired 2 flows
{}
IPAddr('10.0.0.1') is not in list Previous picked server is not alive
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
{}
DEBUG:iplb.00-00-00-00-00-01:Directing traffic to 10.0.0.3
```

```
ubuntu@sdnhubvm:~[19:18]$ sudo mn --topo single,5 --cont
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (h4, s1) (h5, s1)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> xterm h1 h2 h3 h4 h5
mininet> link s1 h2 down
mininet> link s1 h2 up
mininet> link s1 h1 down
```

```
<li><a href="linc-config-generator/">linc-config-generator/</a>
<li><a href="linc-oe/">linc-oe/</a>
<li><a href="lorispack/">lorispack/</a>
<li><a href="mininet/">mininet/</a>
<li><a href="Music/">Music/</a>
<li><a href="oflops/">oflops/</a>
<li><a href="onos/">onos/</a>
<li><a href="openflow/">openflow/</a>
<li><a href="openvswitch/">openvswitch/</a>
<li><a href="Pictures/">Pictures/</a>
<li><a href="pox/">pox/</a>
<li><a href="Public/">Public/</a>
<li><a href="pyretic/">pyretic/</a>
<li><a href="ryu/">ryu/</a>
<li><a href="sdnhub.png">sdnhub.png</a>
<li><a href="SDNHub_Opendaylight_Tutorial/">SDNHub_Opendaylight_Tutorial/</a>
<li><a href="Templates/">Templates/</a>
<li><a href="trema/">trema/</a>
<li><a href="Videos/">Videos/</a>
</ul>
<hr>
</body>
</html>
root@sdnhubvm:~[20:30]$
```

```
root@sdnhubvm:~[19:2
```