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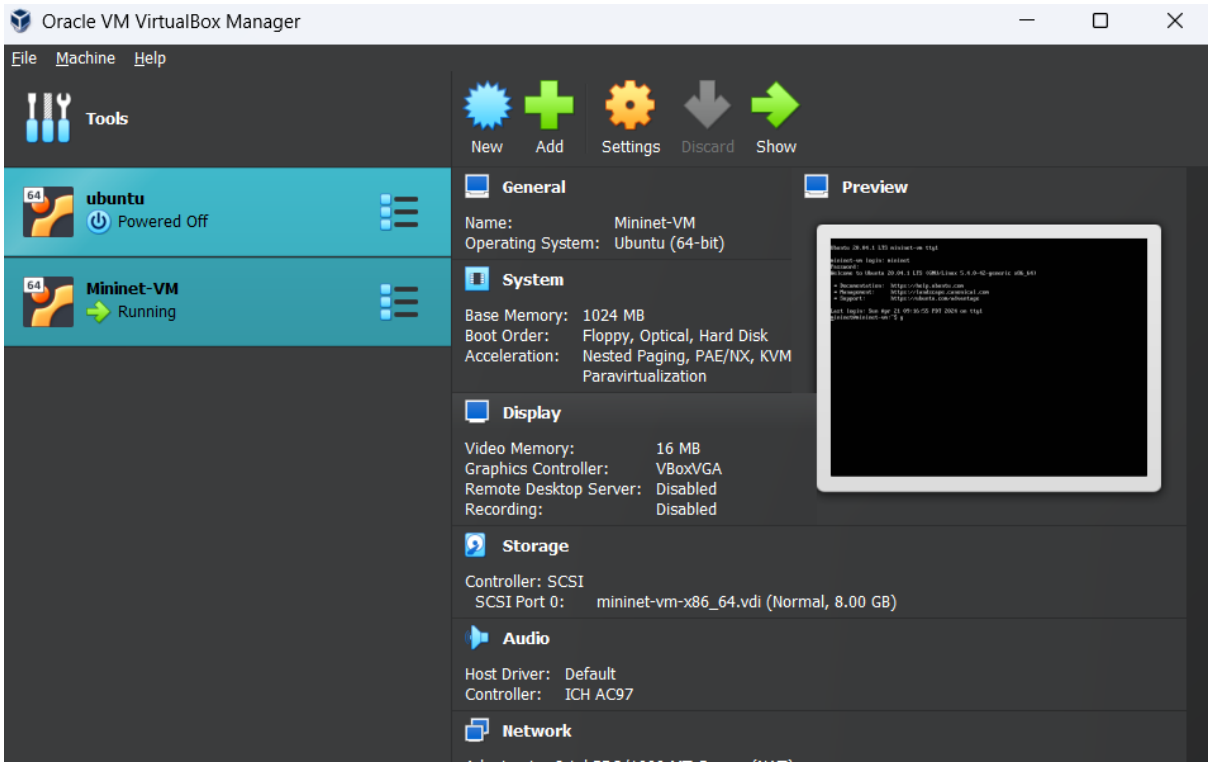
Lab 10: Setting up a Virtual Network using Mininet

Objective: The objective of this lab exercise is to create a realistic virtual network using Mininet, a tool for emulating network environments. By the end of this exercise, students should be able to set up a virtual network, run real kernel, switch, and application code, and understand the basic workflow of Mininet.

Outcomes:

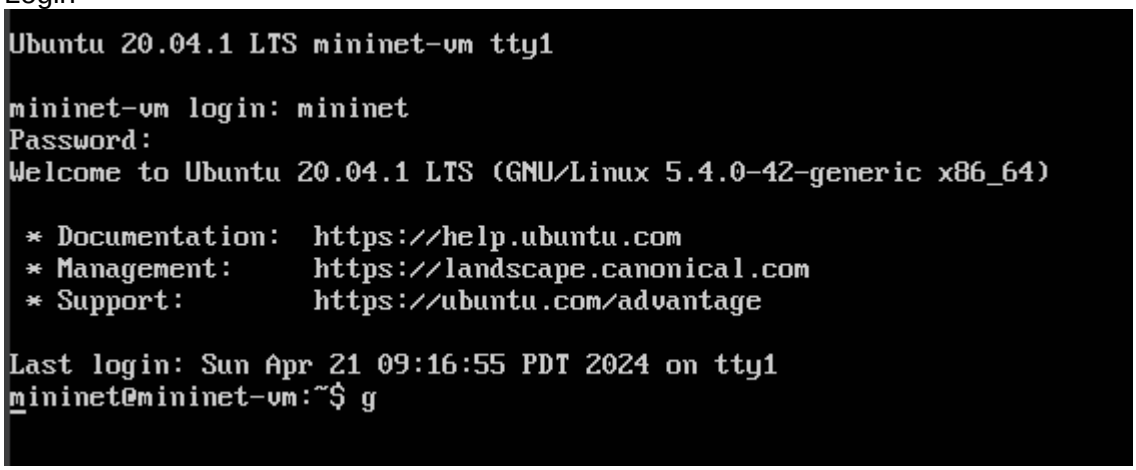
1. Understand the basics of Software Defined Networking (SDN).
2. Learn how to install and configure Mininet.
3. Create a virtual network with hosts, switches, and controllers.
4. Run real kernel, switch, and application code within the virtual network.

Step 1 - Downloading VM Image and running it in Virtual Box



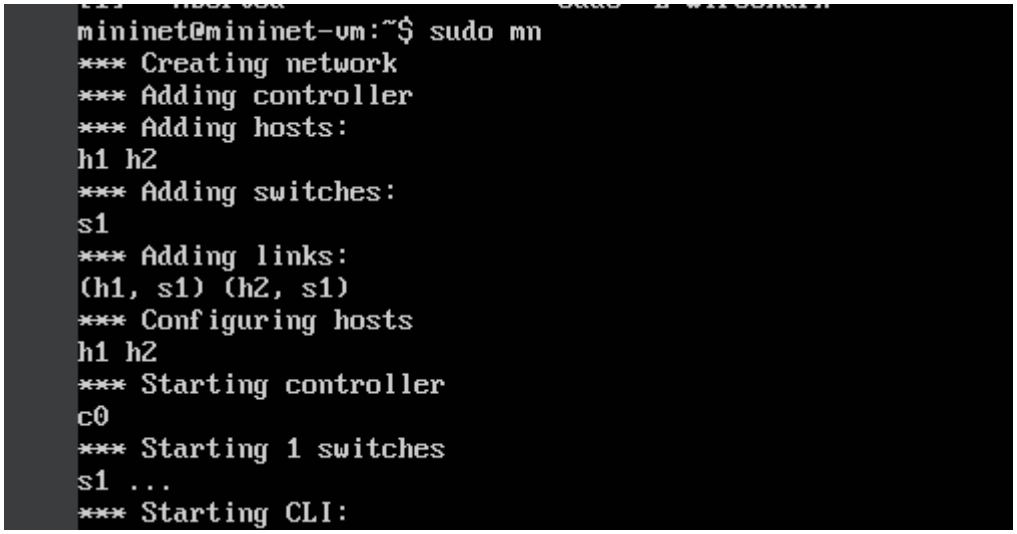
Step 2 - Setting up the VM

1. Login -



2. Installing wireshark in mininet -

3. Interact with host and switches



```
*** Starting CLI:
mininet> h1 ifconfig -a
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.0.1  netmask 255.0.0.0  broadcast 10.255.255.255
        ether aa:54:46:14:ae:ae  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

4. Printing process list of host and switch

```
mininet> h1 ps -a
    PID TTY          TIME CMD
    648 tty1     00:00:00 bash
   2953 tty1     00:00:00 sudo
   2954 tty1     00:00:00 mn
   3009 pts/0    00:00:00 controller
   3022 pts/1    00:00:00 ps
mininet> s1 ps -a
    PID TTY          TIME CMD
    648 tty1     00:00:00 bash
   2953 tty1     00:00:00 sudo
   2954 tty1     00:00:00 mn
   3009 pts/0    00:00:00 controller
   3024 pts/3    00:00:00 ps
mininet> _
```

5. Ping from 1 host to another

```
mininet> h1 ping -c 1 h2
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=5.61 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 5.606/5.606/5.606/0.000 ms
mininet> _
```

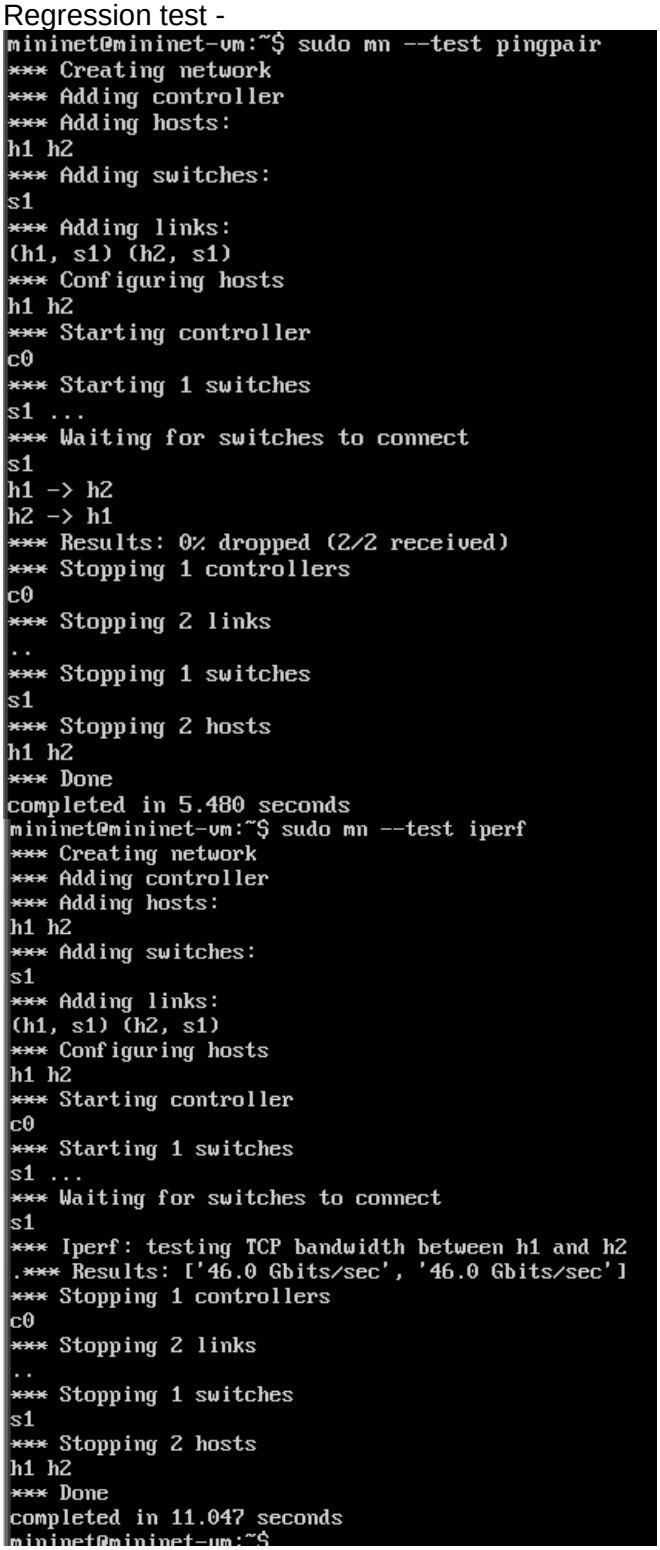
6. Ping all -

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
mininet>
```

7. Web server and client -

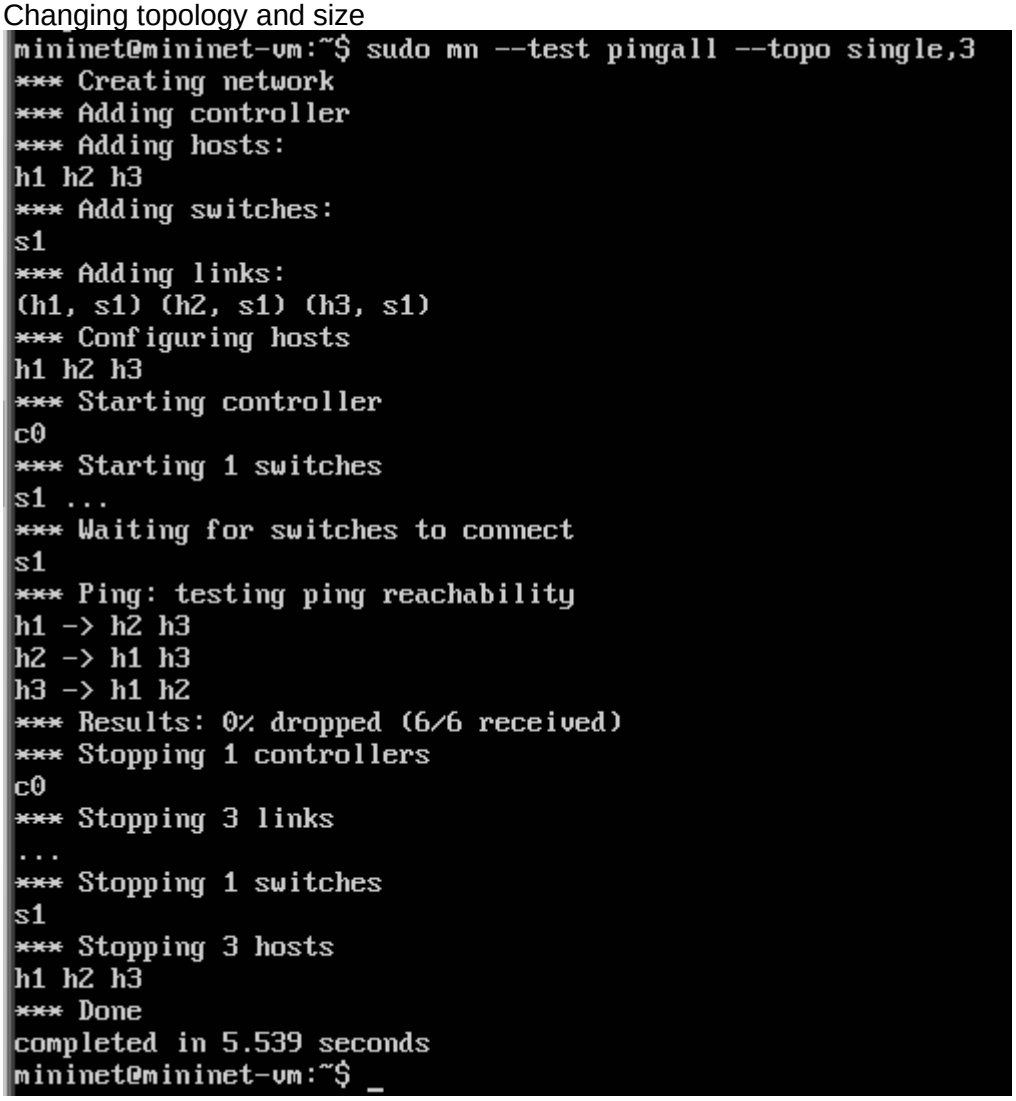
```
 "-//W3C//DTD HTML 4.01//EN" "http://www.w3.org/TR/html4/strict.dtd">
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=iso8859-1">
<title>Directory listing for /</title>
</head>
<body>
<h1>Directory listing for /</h1>
<hr>
<ul>
<li><a href="-h1">-h1</a></li>
<li><a href=".bash_history">.bash_history</a></li>
<li><a href=".bash_logout">.bash_logout</a></li>
<li><a href=".bashrc">.bashrc</a></li>
<li><a href=".cache/">.cache/</a></li>
<li><a href=".gitconfig">.gitconfig</a></li>
<li><a href=".profile">.profile</a></li>
<li><a href=".sudo_as_admin_successful">.sudo_as_admin_successful</a></li>
<li><a href=".wget-hsts">.wget-hsts</a></li>
<li><a href=".wireshark/">.wireshark/</a></li>
<li><a href="mininet/">mininet/</a></li>
<li><a href="oflops/">oflops/</a></li>
<li><a href="oftest/">oftest/</a></li>
<li><a href="openflow/">openflow/</a></li>
<li><a href="pox/">pox/</a></li>
</ul>
<hr>
</body>
</html>
-                   100%[===================>]     958  --.-KB/s    in 0s

2024-04-23 07:45:20 (369 MB/s) - written to stdout [958/958]

mininet> h1 python -m http.server 80 &
Serving HTTP on 0.0.0.0 port 80 (http://0.0.0.0:80/) ...
10.0.0.2 - - [23/Apr/2024 07:45:20] "GET / HTTP/1.1" 200 -
mininet>
```

8. Regression test -



```
mininet@mininet-vm:~$ sudo mn --test pingpair
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Waiting for switches to connect
s1
h1 -> h2
h2 -> h1
*** Results: 0% dropped (2/2 received)
*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 5.480 seconds
mininet@mininet-vm:~$ sudo mn --test iperf
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Waiting for switches to connect
s1
*** Iperf: testing TCP bandwidth between h1 and h2
.*** Results: ['46.0 Gbits/sec', '46.0 Gbits/sec']
*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 11.047 seconds
mininet@mininet-vm:~$
```

9. Changing topology and size



10. Link variations -

```
mininet@mininet-vm:~$ sudo mn --link tc,bw=10,delay=10ms
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(10.00Mbit 10ms delay) (10.00Mbit 10ms delay) (h1, s1) (10.00Mbit 10ms delay) (10.00Mbit 10ms delay)
 (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...(10.00Mbit 10ms delay) (10.00Mbit 10ms delay)
*** Starting CLI:
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['9.47 Mbits/sec', '11.8 Mbits/sec']
mininet> h1 ping -c10 h2
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=41.6 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=41.9 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=42.1 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=41.0 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=40.9 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=40.9 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=42.2 ms
^C
--- 10.0.0.2 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6009ms
rtt min/avg/max/mdev = 40.863/41.515/42.167/0.540 ms
mininet>
```

Environment setup -

1. Installing the required repositories using git clone

```
  git-mediawiki git-svn glibc-doc
The following packages will be upgraded:
  git libc-dev-bin libc6 libc6-dev
4 upgraded, 0 newly installed, 0 to remove and 342 not upgraded.
Need to get 9,918 kB of archives.
After this operation, 305 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc6-dev amd64 2.31-0ubuntu9.15
[2,519 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc-dev-bin amd64 2.31-0ubuntu9.
15 [71.8 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc6 amd64 2.31-0ubuntu9.15 [2,7
23 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 git amd64 1:2.25.1-1ubuntu3.11 [4
,605 kB]
Fetched 9,918 kB in 5s (1,966 kB/s)
Preconfiguring packages ...
(Reading database ... 101741 files and directories currently installed.)
Preparing to unpack .../libc6-dev_2.31-0ubuntu9.15_amd64.deb ...
Unpacking libc6-dev:amd64 (2.31-0ubuntu9.15) over (2.31-0ubuntu9.2) ...
Preparing to unpack .../libc-dev-bin_2.31-0ubuntu9.15_amd64.deb ...
Unpacking libc-dev-bin (2.31-0ubuntu9.15) over (2.31-0ubuntu9.2) ...
Preparing to unpack .../libc6_2.31-0ubuntu9.15_amd64.deb ...
Unpacking libc6:amd64 (2.31-0ubuntu9.15) over (2.31-0ubuntu9.2) ...
Setting up libc6:amd64 (2.31-0ubuntu9.15) ...
(Reading database ... 101741 files and directories currently installed.)
Preparing to unpack .../git_1%3a2.25.1-1ubuntu3.11_amd64.deb ...
Unpacking git (1:2.25.1-1ubuntu3.11) over (1:2.25.1-1ubuntu3) ...
Setting up git (1:2.25.1-1ubuntu3.11) ...
Setting up libc-dev-bin (2.31-0ubuntu9.15) ...
Setting up libc6-dev:amd64 (2.31-0ubuntu9.15) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9) ...
fatal: destination path 'openflow' already exists and is not an empty directory.
mininet@mininet-vm:~/mininet$ cd ~
mininet@mininet-vm:~$ git clone http://github.com/noxrepo/pox
fatal: destination path 'pox' already exists and is not an empty directory.
mininet@mininet-vm:~$ git clone git://github.com/dound/ltprotocol.git
```

```
mininet@mininet-vm:~$ git clone https://github.com/dound/ltprotocol.git
Cloning into 'ltprotocol'...
remote: Enumerating objects: 183, done.
remote: Counting objects: 100% (183/183), done.
remote: Compressing objects: 100% (93/93), done.
remote: Total 183 (delta 68), reused 183 (delta 68), pack-reused 0
Receiving objects: 100% (183/183), 24.45 KiB | 676.00 KiB/s, done.
Resolving deltas: 100% (68/68), done.
mininet@mininet-vm:~$ cd ~
mininet@mininet-vm:~$ git clone https://huangty@bitbucket.org/huangty/cs144_lab3.git
Cloning into 'cs144_lab3'...
remote: Enumerating objects: 207, done.
remote: Counting objects: 100% (207/207), done.
remote: Compressing objects: 100% (203/203), done.
remote: Total 207 (delta 91), reused 0 (delta 0), pack-reused 0
Receiving objects: 100% (207/207), 95.08 KiB | 885.00 KiB/s, done.
Resolving deltas: 100% (91/91), done.
mininet@mininet-vm:~$ cd cd144_lab3/
-bash: cd: cd144_lab3/: No such file or directory
mininet@mininet-vm:~$ cd cd144_lab3
-bash: cd: cd144_lab3: No such file or directory
mininet@mininet-vm:~$ cd cs144_lab3/
mininet@mininet-vm:~/cs144_lab3$ git checkout --
```

Errors in python files

```
8e9407cd52960c
Best match: ltprotocol 0.2.1
Processing ltprotocol-0.2.1.tar.gz
Writing /tmp/easy_install-bv29jlwr/ltprotocol-0.2.1/setup.cfg
Running ltprotocol-0.2.1/setup.py -q bdist_egg --dist-dir /tmp/easy_install-bv29jlwr/ltprotocol-0.2.
1/egg-dist-tmp-8c8u2dva
zip_safe flag not set; analyzing archive contents...
Moving ltprotocol-0.2.1-py3.8.egg to /usr/local/lib/python3.8/dist-packages
Adding ltprotocol 0.2.1 to easy-install.pth file

Installed /usr/local/lib/python3.8/dist-packages/ltprotocol-0.2.1-py3.8.egg
Searching for zope-interface>=5
Reading https://pypi.org/simple/zope-interface/
No local packages or working download links found for zope-interface>=5
error: Could not find suitable distribution for Requirement.parse('zope-interface>=5')
mininet@mininet-vm:~/cs144_lab3$ cat ~/cd144_lab3/IP_CONFIG
cat: /home/mininet/cd144_lab3/IP_CONFIG: No such file or directory
mininet@mininet-vm:~/cs144_lab3$ ./config.sh
running develop
running egg_info
writing cs144.egg-info/PKG-INFO
writing dependency_links to cs144.egg-info/dependency_links.txt
writing requirements to cs144.egg-info/requires.txt
writing top-level names to cs144.egg-info/top_level.txt
reading manifest file 'cs144.egg-info/SOURCES.txt'
writing manifest file 'cs144.egg-info/SOURCES.txt'
running build_ext
Creating /usr/local/lib/python3.8/dist-packages/cs144.egg-link (link to .)
cs144 0.0.0 is already the active version in easy-install.pth

Installed /home/mininet/cs144_lab3/pox_module
Processing dependencies for cs144==0.0.0
Searching for zope-interface>=5
Reading https://pypi.org/simple/zope-interface/
No local packages or working download links found for zope-interface>=5
error: Could not find suitable distribution for Requirement.parse('zope-interface>=5')
mininet@mininet-vm:~/cs144_lab3$
```

```
mininet@mininet-vm:~/cs144_lab3$ ./run_mininet.sh
  File "lab3.py", line 104
    print host.name, routerip
          ^
SyntaxError: Missing parentheses in call to 'print'. Did you mean print(host.name, routerip)?
mininet@mininet-vm:~/cs144_lab3$ _
```

```
mininet@mininet-vm:~/cs144_lab3$ ./run_pox.sh
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
Traceback (most recent call last):
  File "/home/mininet/pox/pox/boot.py", line 74, in do_import2
    __import__(name, level=0)
ModuleNotFoundError: No module named 'pox.cs144'
Could not import module: cs144.ofhandler
mininet@mininet-vm:~/cs144_lab3$ ./sr_solution
Using VNS sr stub code revised 2009-10-14 (rev 0.20)
Loading routing table from server, clear local routing table.
Loading routing table
---------------------------------------------
Destination     Gateway         Mask    Iface
10.0.1.100              10.0.1.100      255.255.255.255 eth3
192.168.2.2             192.168.2.2     255.255.255.255 eth1
172.64.3.10             172.64.3.10     255.255.255.255 eth2
---------------------------------------------
Client mininet connecting to Server localhost:8888
Requesting topology 0
connect(..):sr_client.c::sr_connect_to_server(..): Connection refused
mininet@mininet-vm:~/cs144_lab3$ _
```

```
[3]+  Stopped                 sudo mn
mininet@mininet-vm:~/cs144_lab3$ cd ~/cs144_lab3/router/
mininet@mininet-vm:~/cs144_lab3/router$ make
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sha1.c  > .sha1.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_arpcache.c  > .sr_arpcache.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_dumper.c  > .sr_dumper.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_utils.c  > .sr_utils.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_vns_comm.c  > .sr_vns_comm.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_rt.c  > .sr_rt.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_if.c  > .sr_if.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_main.c  > .sr_main.d
gcc -MM -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_router.c  > .sr_router.d
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_router.c -o sr_router.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_main.c -o sr_main.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_if.c -o sr_if.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_rt.c -o sr_rt.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_vns_comm.c -o sr_vns_comm.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_utils.c -o sr_utils.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_dumper.c -o sr_dumper.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sr_arpcache.c -o sr_arpcache.o
gcc -c -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ sha1.c -o sha1.o
gcc -g -Wall -ansi -D_DEBUG_ -D_GNU_SOURCE -D_LINUX_ -o sr sr_router.o sr_main.o sr_if.o sr_rt.o sr_
vns_comm.o sr_utils.o sr_dumper.o sr_arpcache.o sha1.o -lnsl -lresolv -lm -lpthread
mininet@mininet-vm:~/cs144_lab3/router$ ./sr
Using VNS sr stub code revised 2009-10-14 (rev 0.20)
Loading routing table from server, clear local routing table.
Loading routing table
---------------------------------------------
Destination     Gateway         Mask    Iface
10.0.1.100              10.0.1.100      255.255.255.255 eth3
192.168.2.2             192.168.2.2     255.255.255.255 eth1
172.64.3.10             172.64.3.10     255.255.255.255 eth2
---------------------------------------------
Client mininet connecting to Server localhost:8888
Requesting topology 0
connect(..):sr_client.c::sr_connect_to_server(..): Connection refused
mininet@mininet-vm:~/cs144_lab3/router$ _
```

Example 2

```
Using VNS sr stub code revised 2009-10-14 (rev 0.20)
Loading routing table from server, clear local routing table.
Loading routing table
-----------------------------------------
Destination     Gateway         Mask    Iface
10.0.1.100              10.0.1.100      255.255.255.255 eth3
192.168.2.2             192.168.2.2     255.255.255.255 eth1
172.64.3.10             172.64.3.10     255.255.255.255 eth2
-----------------------------------------
Client mininet connecting to Server localhost:8888
Requesting topology 0
connect(..):sr_client.c::sr_connect_to_server(..): Connection refused
mininet@mininet-vm:~/cs144_lab3/router$ cd ~
mininet@mininet-vm:~$ git clone https://huangty@bitbucket.org/huangty/cs144_lab5.git
Cloning into 'cs144_lab5'...
remote: Enumerating objects: 111, done.
remote: Counting objects: 100% (111/111), done.
remote: Compressing objects: 100% (104/104), done.
remote: Total 111 (delta 32), reused 0 (delta 0), pack-reused 0
Receiving objects: 100% (111/111), 211.43 KiB | 1.50 MiB/s, done.
Resolving deltas: 100% (32/32), done.
mininet@mininet-vm:~$ cd cs144_lab5
mininet@mininet-vm:~/cs144_lab5$ git checkout --track remotes/origin/standalone
Branch 'standalone' set up to track remote branch 'standalone' from 'origin'.
Switched to a new branch 'standalone'
mininet@mininet-vm:~/cs144_lab5$ pwd
/home/mininet/cs144_lab5
mininet@mininet-vm:~/cs144_lab5$ rm router
rm: cannot remove 'router': Is a directory
mininet@mininet-vm:~/cs144_lab5$ cp -r ~/cs144_lab3/router ./
mininet@mininet-vm:~/cs144_lab5$ tar xf sr_nat_table.tar
mininet@mininet-vm:~/cs144_lab5$ mv sr_nat.x ./router/
mv: cannot stat 'sr_nat.x': No such file or directory
mininet@mininet-vm:~/cs144_lab5$ mv sr_nat.c ./router/
mininet@mininet-vm:~/cs144_lab5$ mv sr_nat.h ./router/
mininet@mininet-vm:~/cs144_lab5$ cp ./rtable ./router
mininet@mininet-vm:~/cs144_lab5$ _
```

Error in python file

```
pkill -9 -f .ssh/mn
rm -f ~/.ssh/mn/*
*** Cleanup complete.
  File "lab5.py", line 106
    print host.name, routerip
          ^
SyntaxError: Missing parentheses in call to 'print'. Did you mean print(host.name, routerip)?
mininet@mininet-vm:~/cs144_lab5$ ./run_mininet.sh
*** Removing excess controllers/ofprotocols/ofdatapaths/pings/noxes
killall controller ofprotocol ofdatapath ping nox_corelt-nox_core ovs-openflowd ovs-controllerovs-te
stcontroller udpbwtest mnexec ivs ryu-manager 2> /dev/null
killall -9 controller ofprotocol ofdatapath ping nox_corelt-nox_core ovs-openflowd ovs-controllerovs
-testcontroller udpbwtest mnexec ivs ryu-manager 2> /dev/null
pkill -9 -f "sudo mnexec"
*** Removing junk from /tmp
rm -f /tmp/vconn* /tmp/vlogs* /tmp/*.out /tmp/*.log
*** Removing old X11 tunnels
*** Removing excess kernel datapaths
ps ax | egrep -o 'dp[0-9]+' | sed 's/dp/nl:/'
***  Removing OVS datapaths
ovs-vsctl --timeout=1 list-br
ovs-vsctl --timeout=1 list-br
*** Removing all links of the pattern foo-ethX
ip link show | egrep -o '([-_.[:alnum:]]+-eth[[:digit:]]+)'
ip link show
*** Killing stale mininet node processes
pkill -9 -f mininet:
*** Shutting down stale tunnels
pkill -9 -f Tunnel=Ethernet
pkill -9 -f .ssh/mn
rm -f ~/.ssh/mn/*
*** Cleanup complete.
  File "lab5.py", line 106
    print host.name, routerip
          ^
SyntaxError: Missing parentheses in call to 'print'. Did you mean print(host.name, routerip)?
mininet@mininet-vm:~/cs144_lab5$
```

Conclusion –
In this experiment, I learned how to set up virtual networks using Mininet, a tool for emulating network environments. I understood how Software Designed Networks work. I learned how to install and configure Mininet for creation of virtual networks with hosts, switches and controllers.