

MCAL27 - NETWORKING WITH LINUX LAB
2024-2025
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PRACTICAL NO. 1**PROGRAM:**

Installation of ns3 in Linux, NetAnim, Wireshark. Download VMWare Workstation and complete the installation.

OUTPUT:

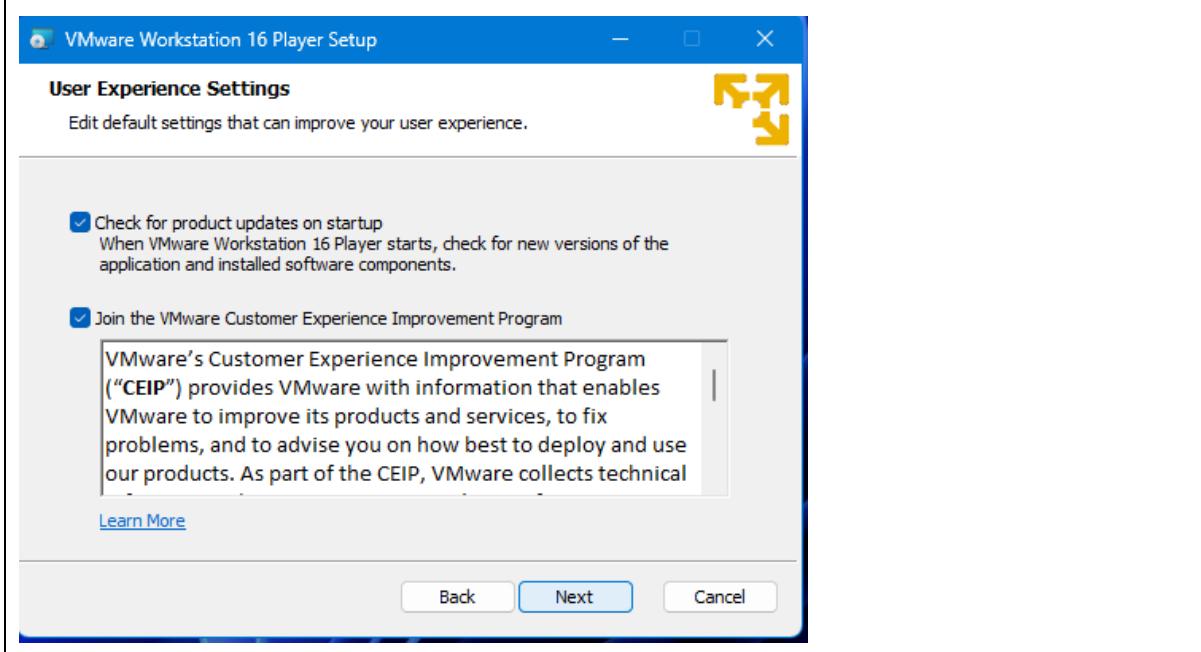
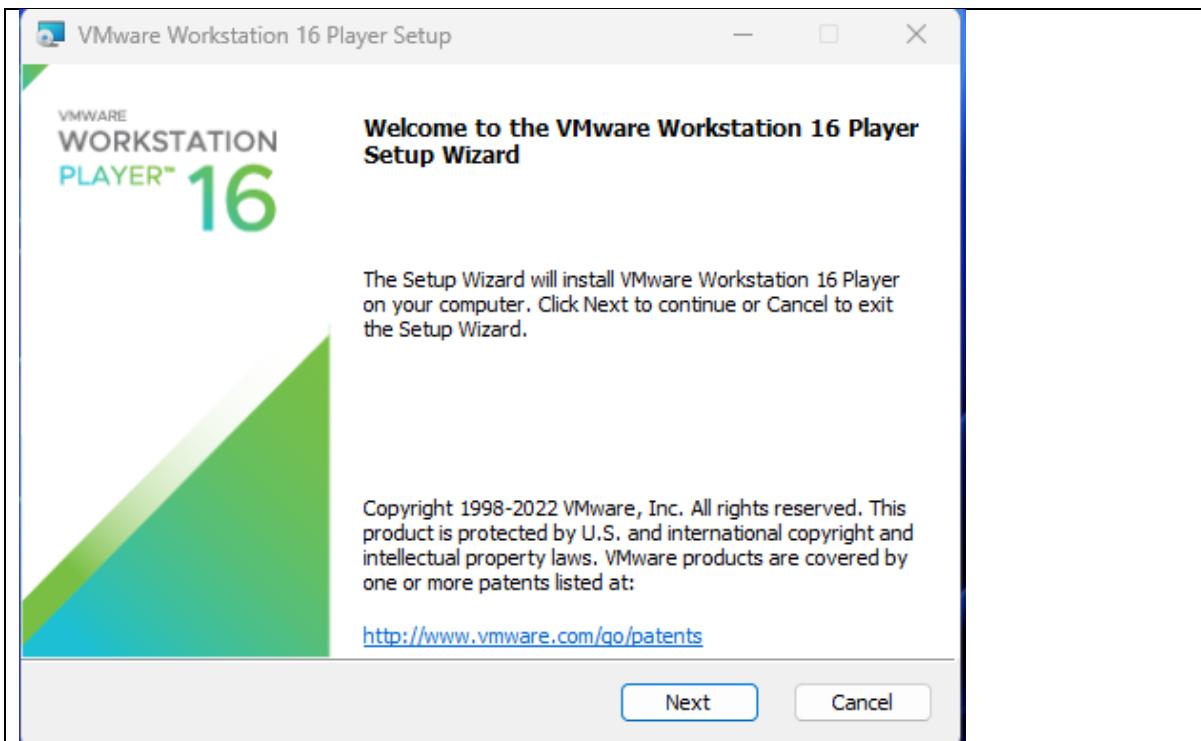
Network simulator is a tool used for simulating the real world network on one computer by writing scripts in C++ or Python. Normally if we want to perform experiments, to see how our network works using various parameters. We don't have required number of computers and routers for making different topologies. Even if we have these resources it is very expensive to build such a network for experiment purposes.

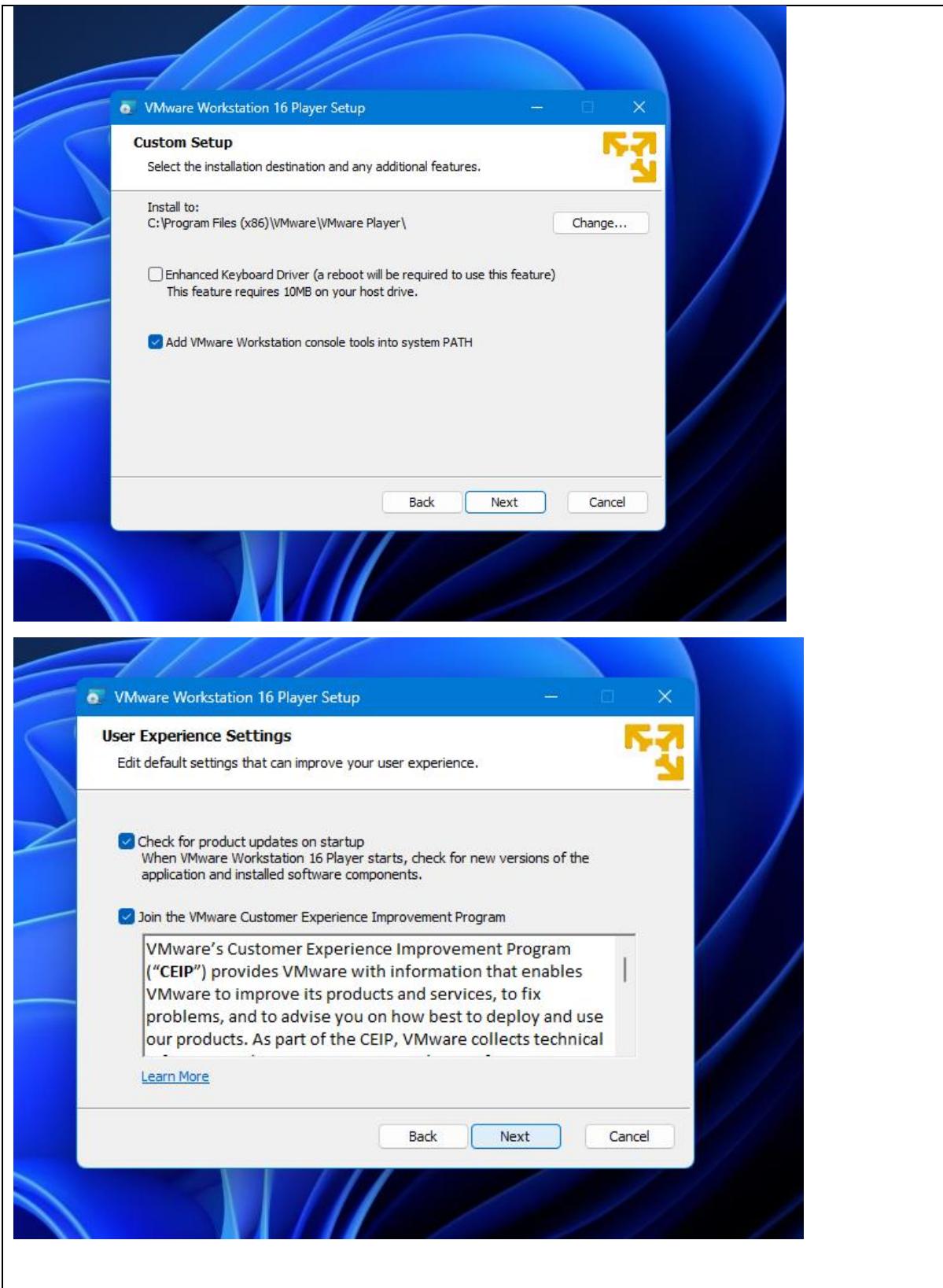
So to overcome these drawbacks we used NS3, which is a discrete event network simulator for Internet. NS3 helps to create various virtual nodes (i.e., computers in real life) and with the help of various Helper classes it allows us to install devices, internet stacks, application, etc to our nodes.

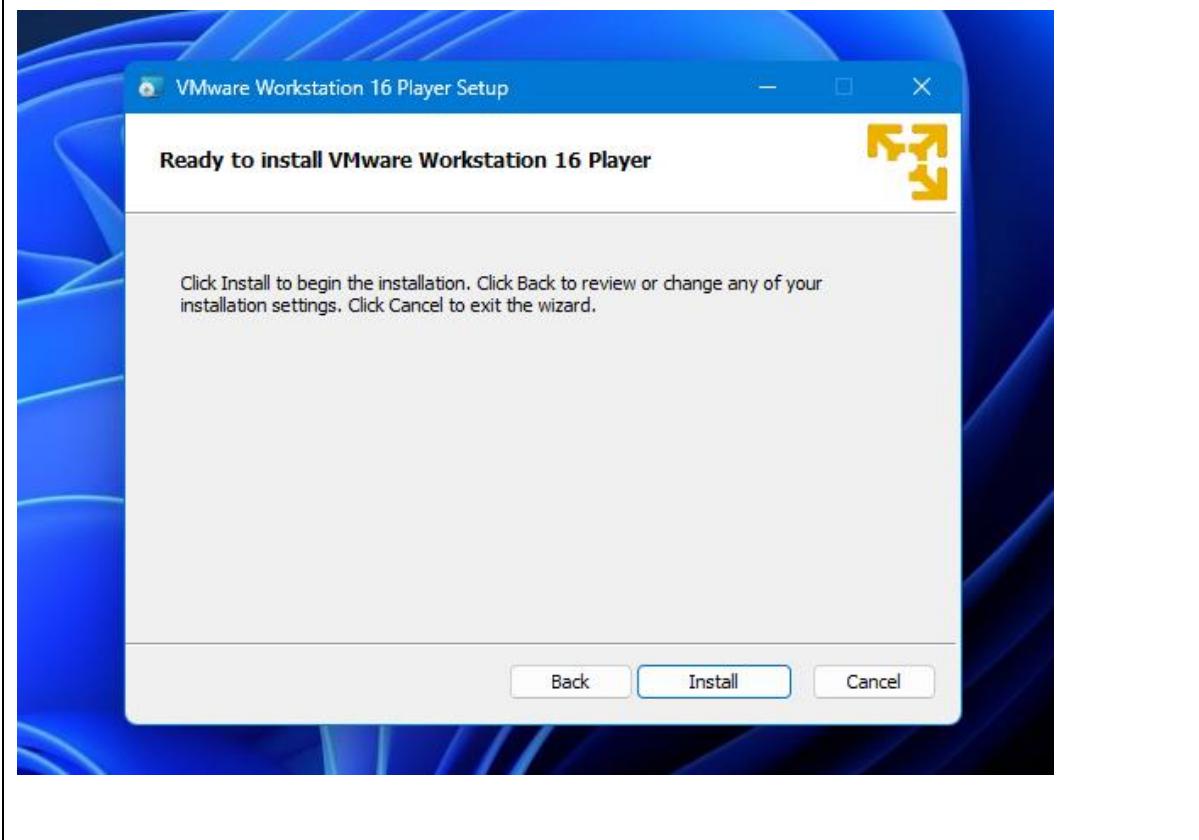
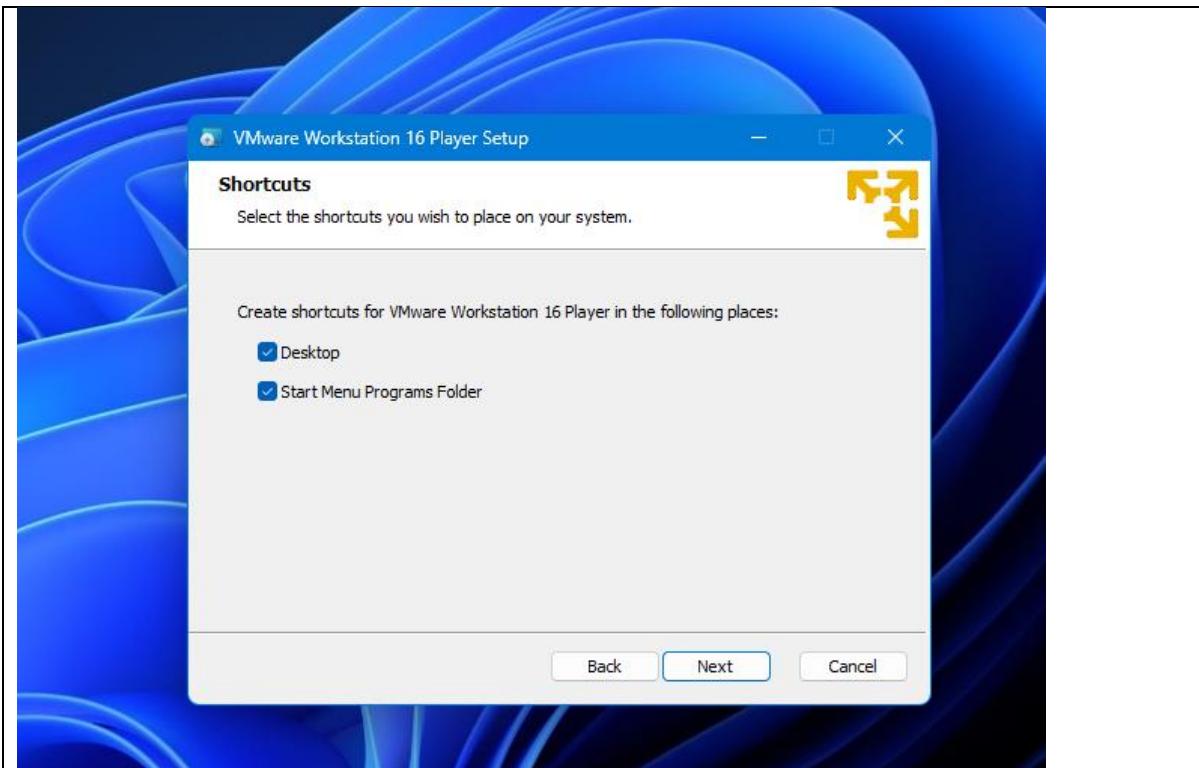
Using NS3 we can create PointToPoint, Wireless, CSMA, etc connections between nodes. PointToPoint connection is same as a LAN connected between two computers. Wireless connection is same as WiFi connection between various computers and routers. CSMA connection is same as bus topology between computers. After building connections we try to install NIC to every node to enable network connectivity.

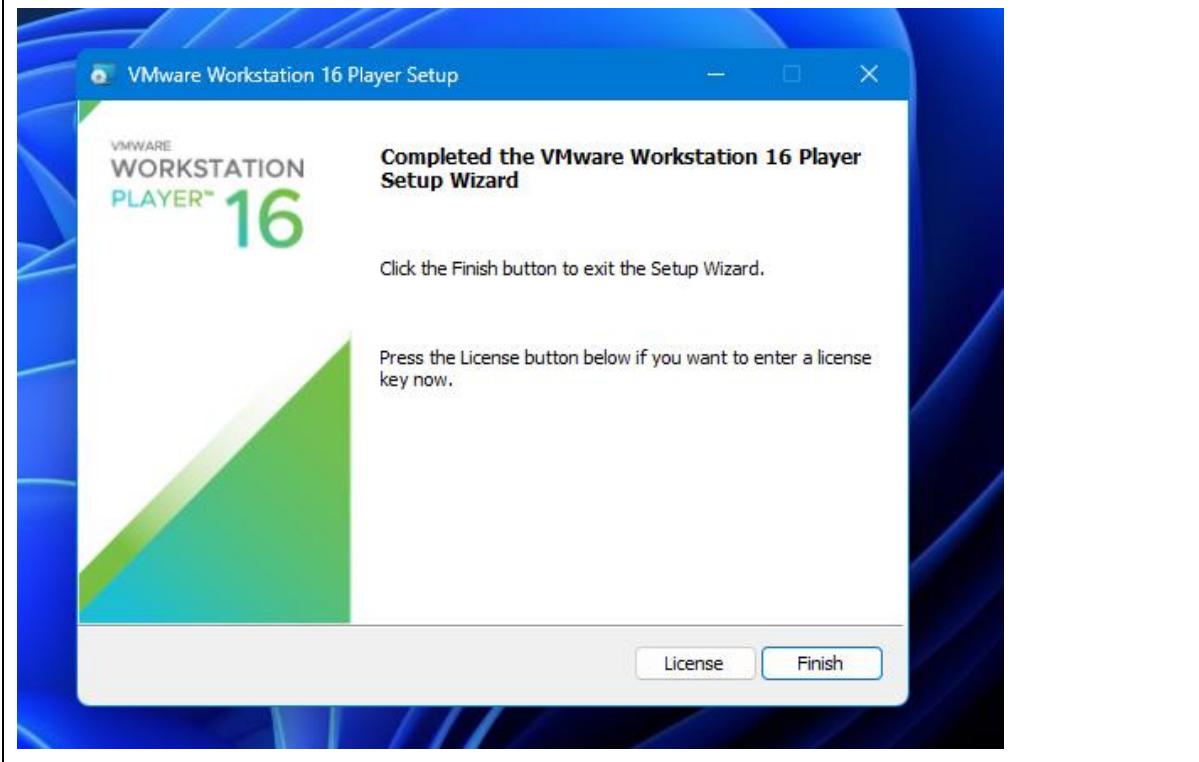
When network cards are enabled in the devices, we add different parameters in the channels (i.e., real world path used to send data) which are data-rate, packet size, etc.

Now we use Application to generate traffic and send the packets using these applications



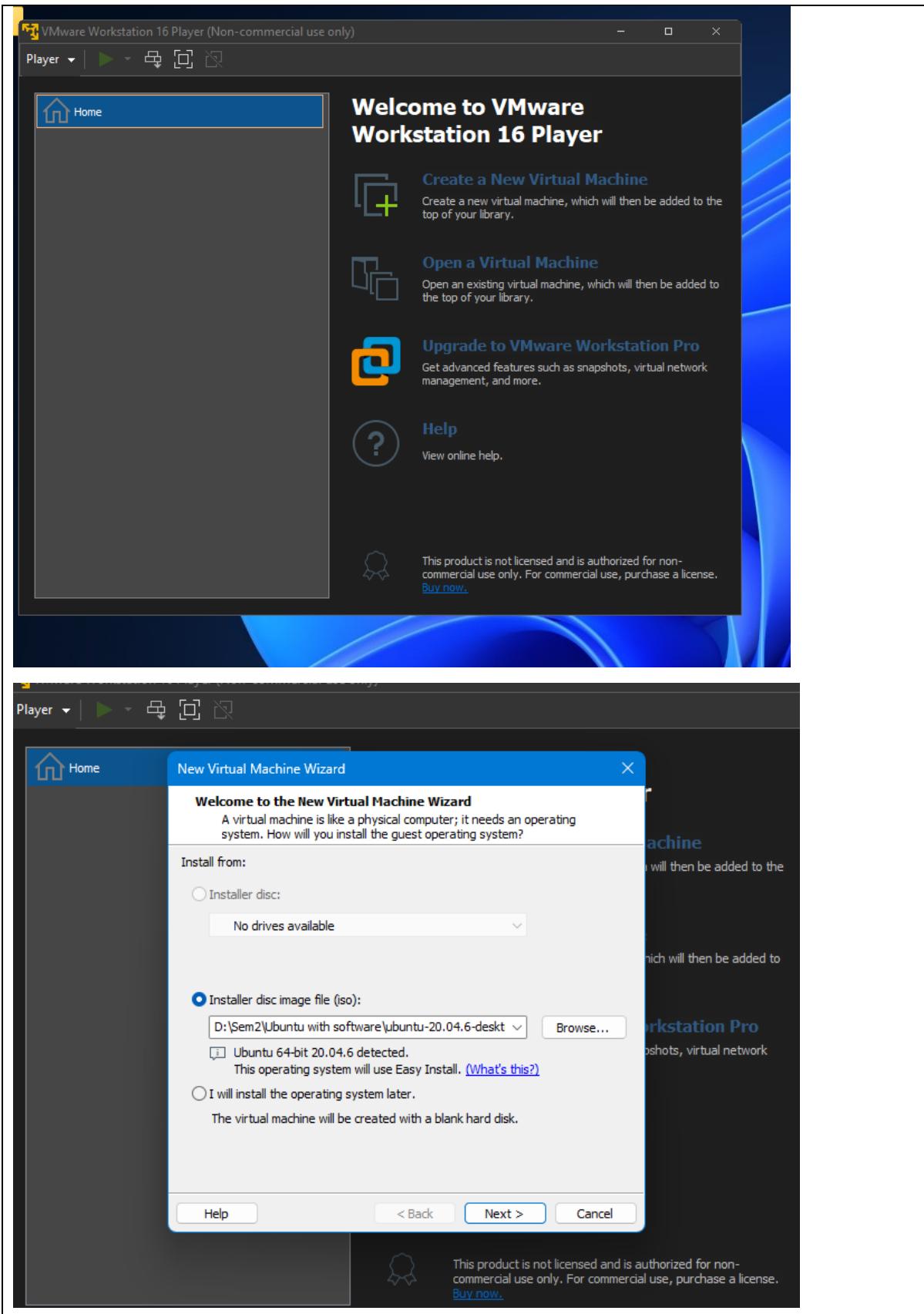


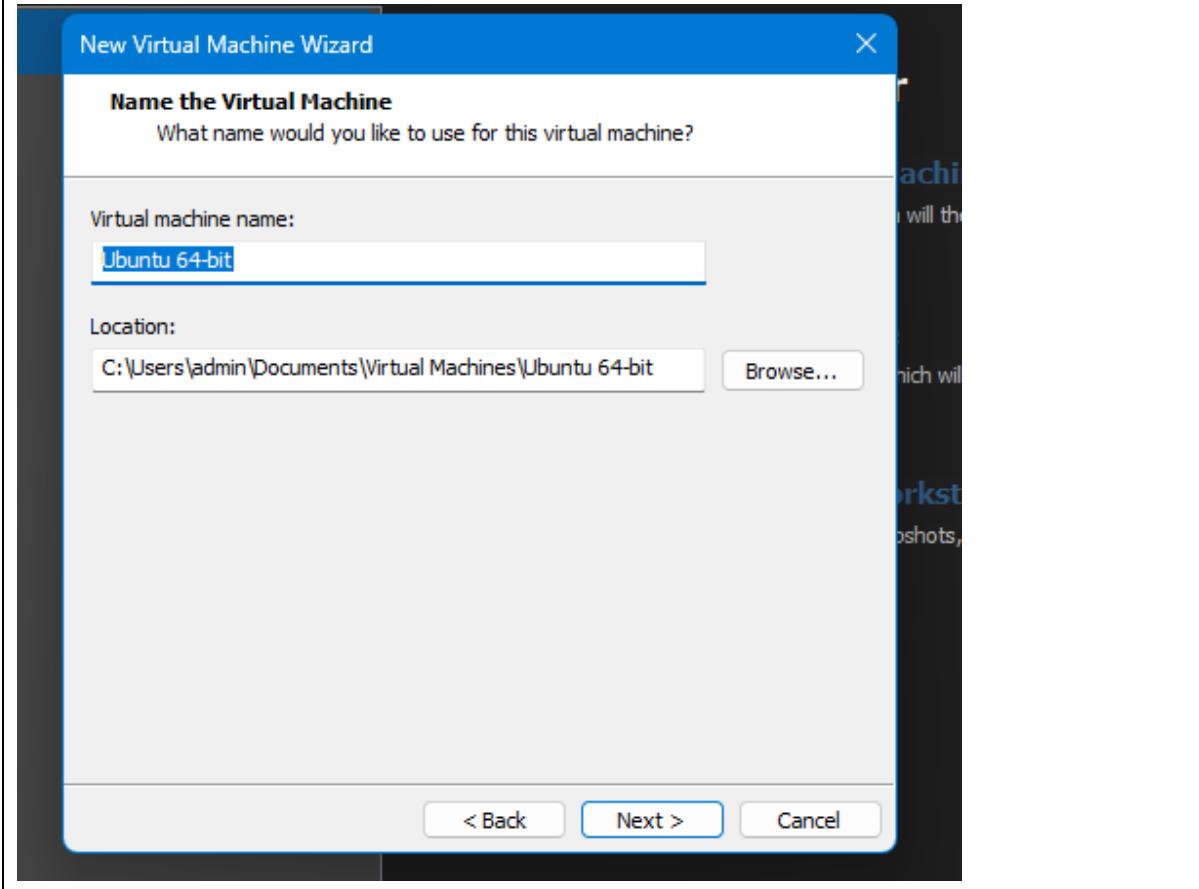
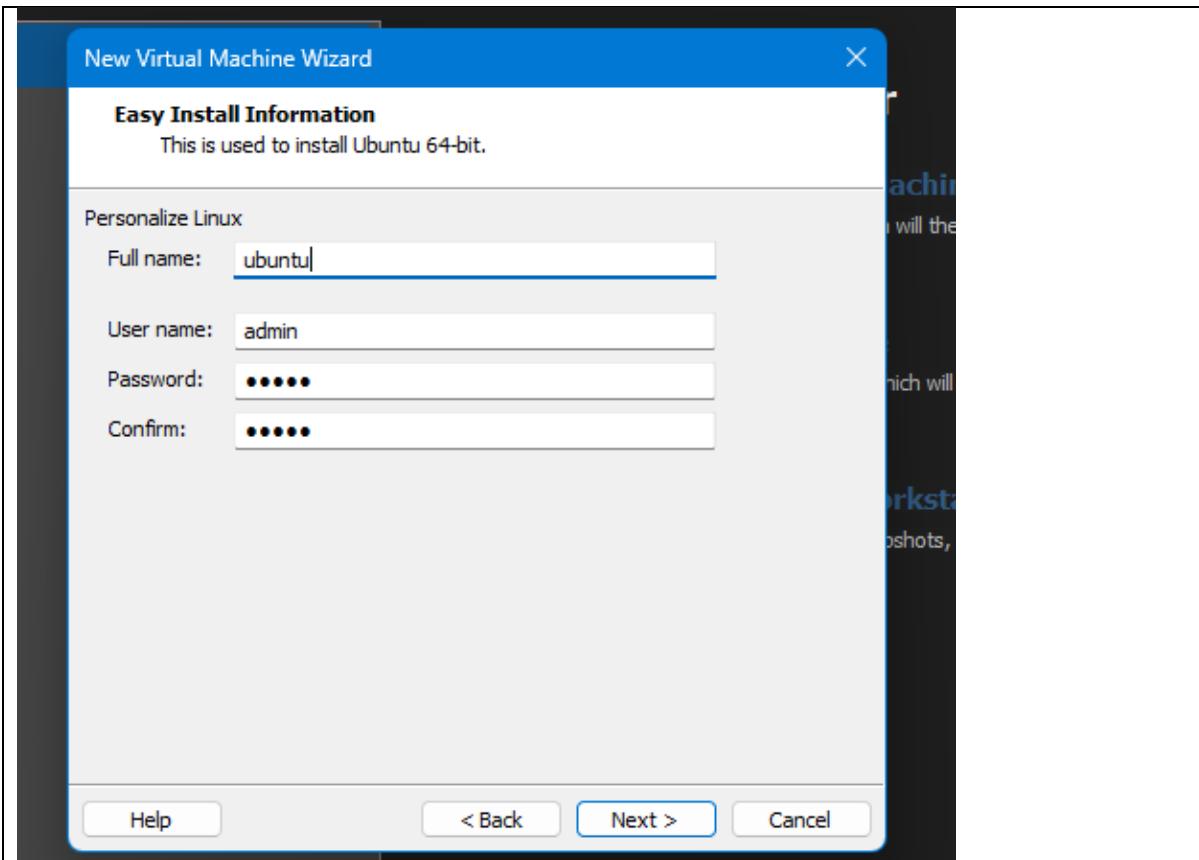


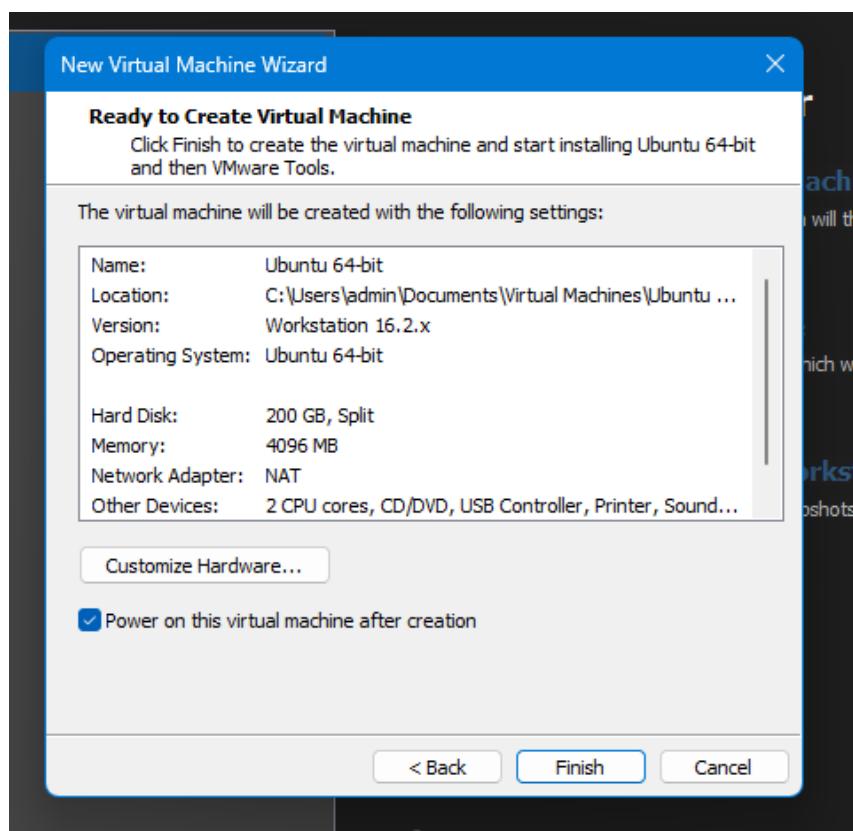
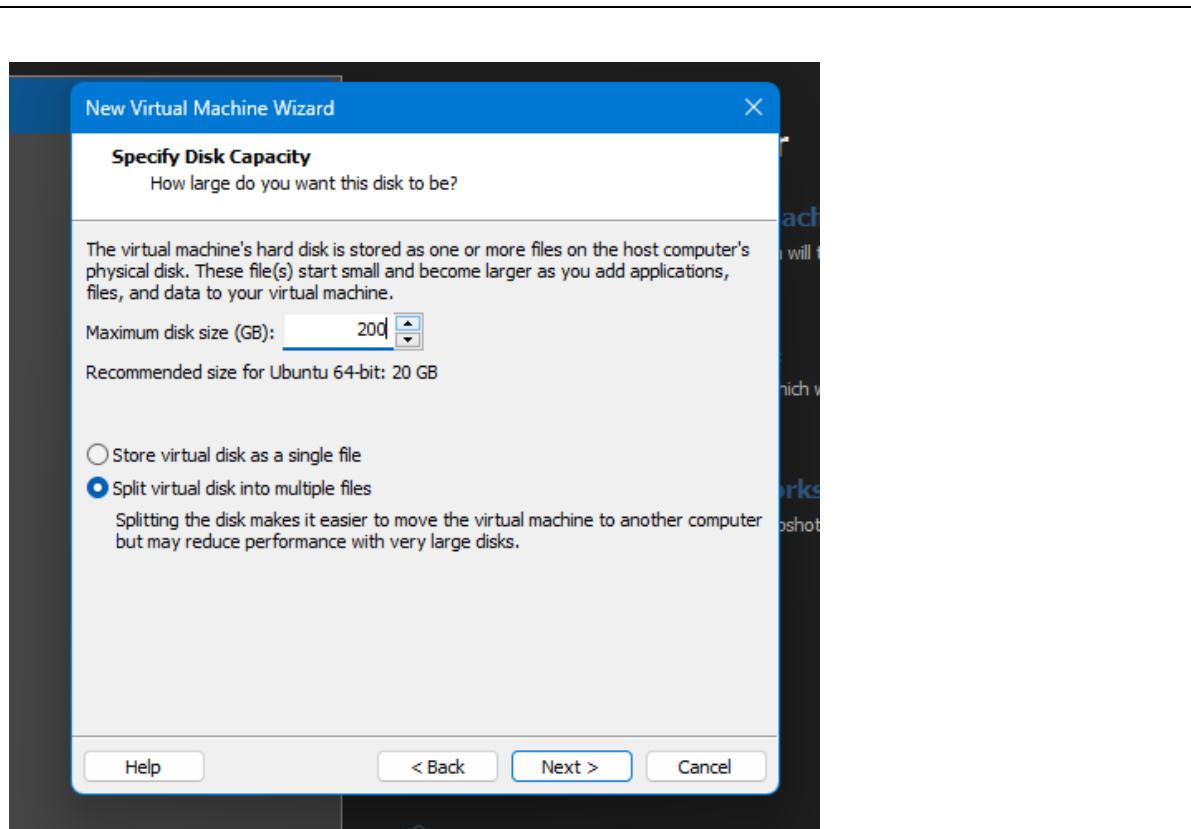


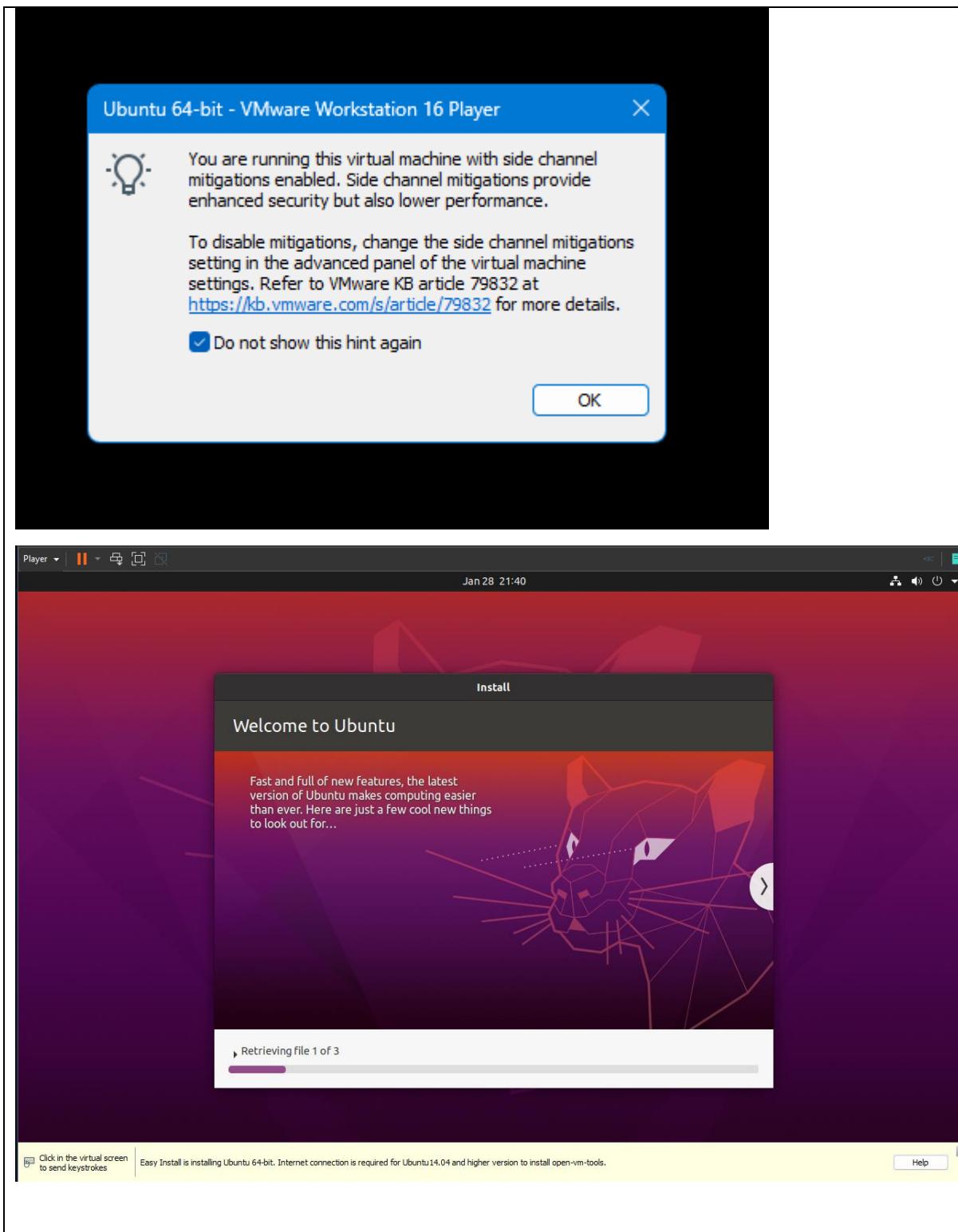


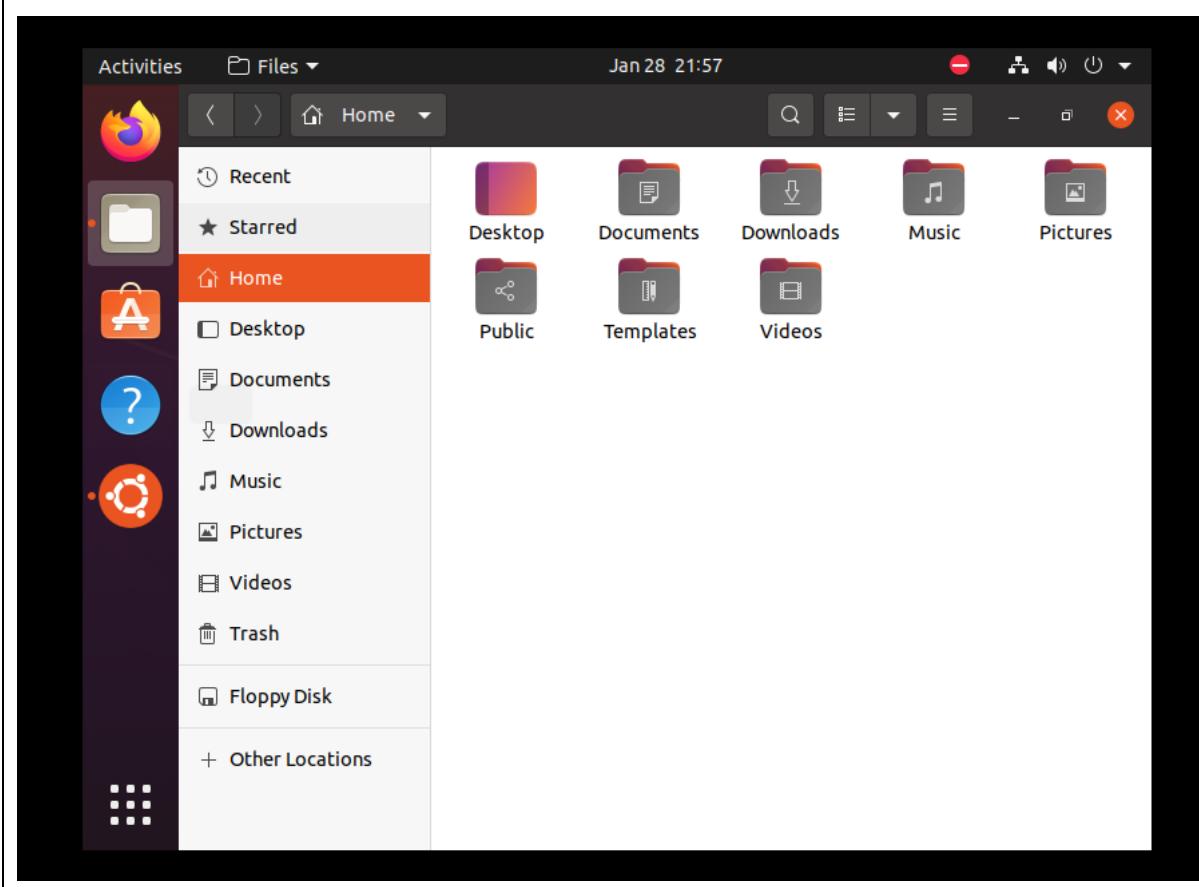
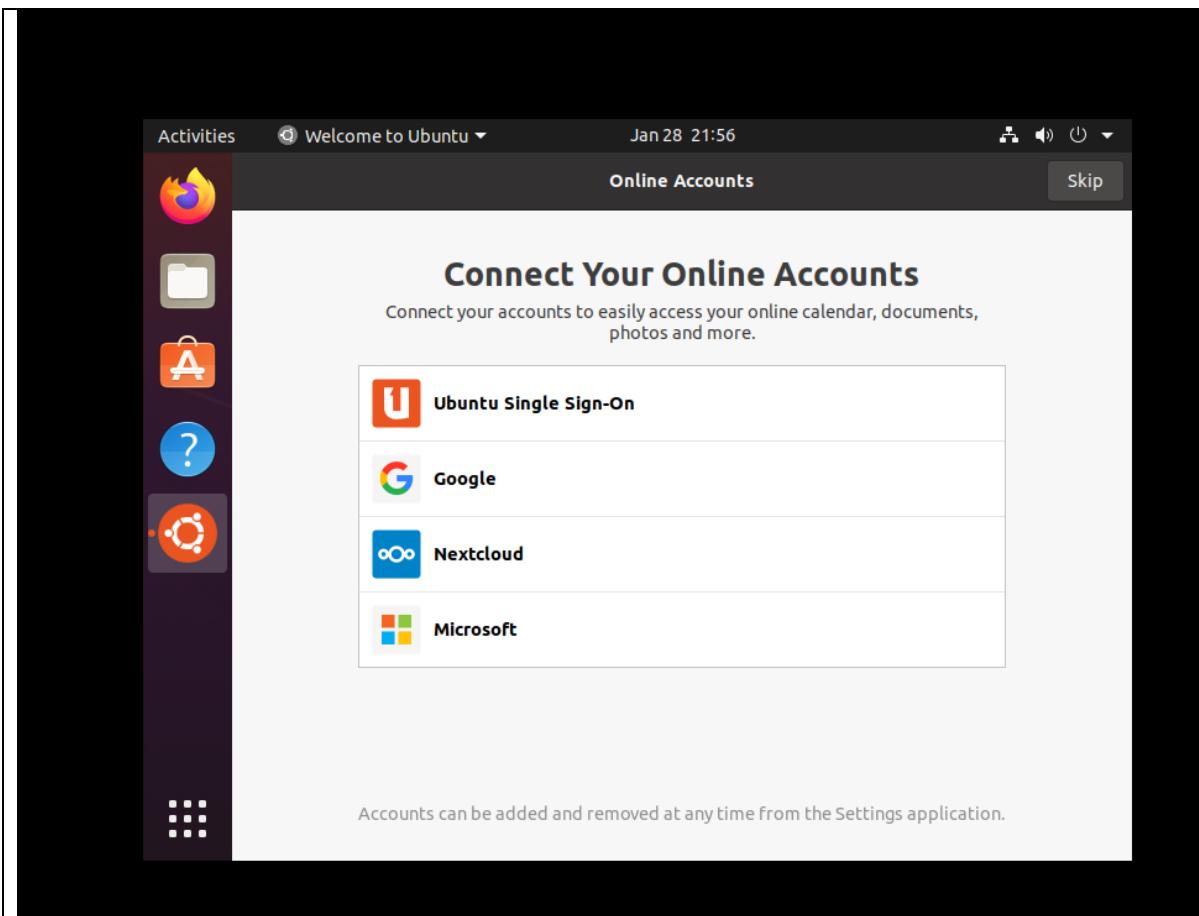
Create a New virtual Machine in VMWare.



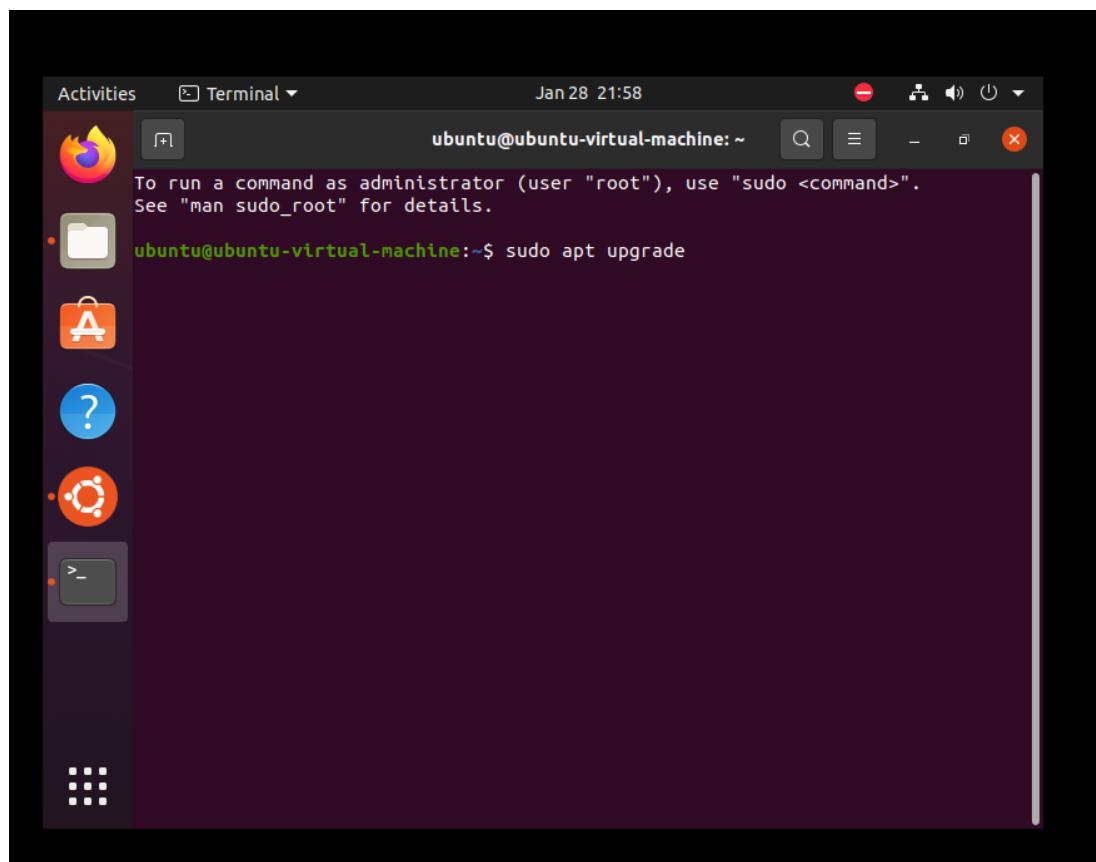






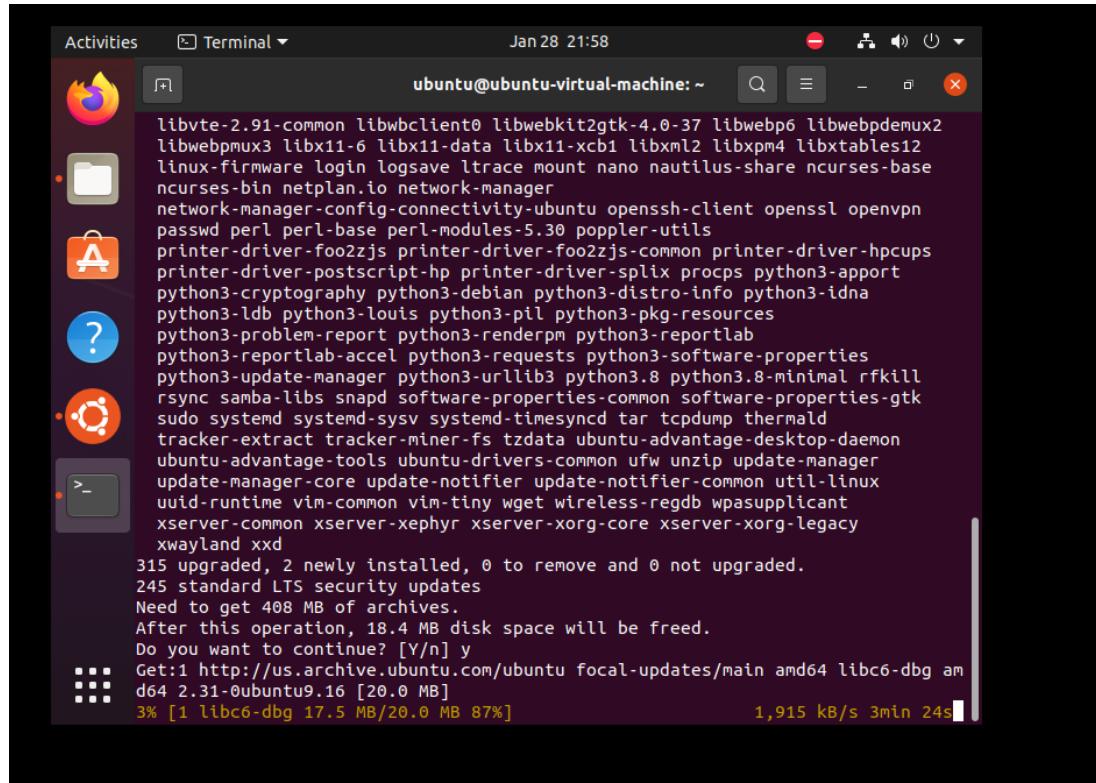


Install the necessary Libraries like NS3, Netanime etc.



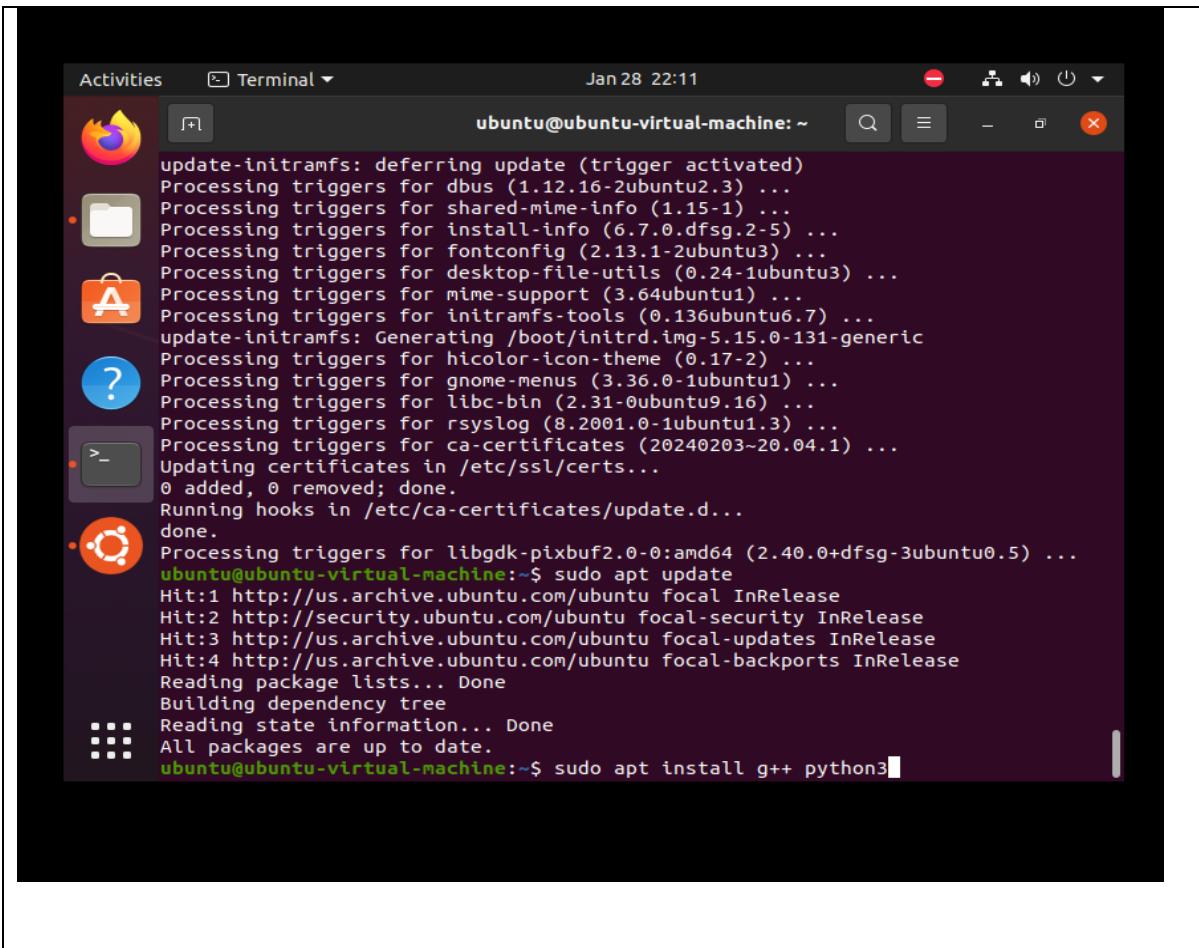
A screenshot of an Ubuntu desktop environment. On the left is the Unity Dash (Activities) bar with icons for the Dash, Home, Applications, Help, and Dash search. The main window is a terminal window titled "Terminal" with the command "sudo apt upgrade" entered. The terminal output shows a warning about running commands as root and then lists packages being upgraded.

```
To run a command as administrator (user "root"), use "sudo <command>".  
See "man sudo_root" for details.  
ubuntu@ubuntu-virtual-machine:~$ sudo apt upgrade
```



A screenshot of an Ubuntu desktop environment, similar to the one above. The terminal window shows the output of the "sudo apt upgrade" command. It lists numerous packages being upgraded, including libvte-2.91-common, libwbclient0, libwebkit2gtk-4.0-37, libwebp6, libwebpdemux2, libwebpmux3, libx11-6, libx11-data, libx11-xcb1, libxml2, libxpm4, libxtables12, linux-firmware, login, logsave, ltrace, mount, nano, nautilus-share, ncurses-base, ncurses-bin, netplan.io, network-manager, network-manager-config-connectivity-ubuntu, openssh-client, openssl, openvpn, passwd, perl, perl-base, perl-modules-5.30, poppler-utils, printer-driver-foo2zjs, printer-driver-foo2zjs-common, printer-driver-hpcups, printer-driver-postscript-hp, printer-driver-splix, procps, python3-apport, python3-cryptography, python3-debian, python3-distro-info, python3-idna, python3-lldb, python3-louis, python3-pil, python3-pkg-resources, python3-problem-report, python3-renderpm, python3-reportlab, python3-reportlab-accel, python3-requests, python3-software-properties, python3-update-manager, python3-urllib3, python3.8, python3.8-minimal, rfkill, rsync, samba-libs, snapd, software-properties-common, software-properties-gtk, sudo, systemd, systemd-sysv, systemd-timesyncd, tar, tcpdump, thermald, tracker-extract, tracker-miner-fs, tzdata, ubuntu-adantage-desktop-daemon, ubuntu-adantage-tools, ubuntu-drivers-common, ufw, unzip, update-manager, update-manager-core, update-notifier, update-notifier-common, util-linux, uuid-runtime, vim-common, vim-tiny, wget, wireless-regdb, wpasupplicant, xserver-common, xserver-xephyr, xserver-xorg-core, xserver-xorg-legacy, xwayland, xxd. The terminal also shows the number of upgrades, the amount of disk space freed, and a prompt asking if the user wants to continue.

```
libvte-2.91-common libwbclient0 libwebkit2gtk-4.0-37 libwebp6 libwebpdemux2  
libwebpdux3 libx11-6 libx11-data libx11-xcb1 libxml2 libxpm4 libxtables12  
linux-firmware login logsave ltrace mount nano nautilus-share ncurses-base  
ncurses-bin netplan.io network-manager  
network-manager-config-connectivity-ubuntu openssh-client openssl openvpn  
passwd perl perl-base perl-modules-5.30 poppler-utils  
printer-driver-foo2zjs printer-driver-foo2zjs-common printer-driver-hpcups  
printer-driver-postscript-hp printer-driver-splix procps python3-apport  
python3-cryptography python3-debian python3-distro-info python3-idna  
python3-lldb python3-louis python3-pil python3-pkg-resources  
python3-problem-report python3-renderpm python3-reportlab  
python3-reportlab-accel python3-requests python3-software-properties  
python3-update-manager python3-urllib3 python3.8 python3.8-minimal rfkill  
rsync samba-libs snapd software-properties-common software-properties-gtk  
sudo systemd systemd-sysv systemd-timesyncd tar tcpdump thermald  
tracker-extract tracker-miner-fs tzdata ubuntu-adantage-desktop-daemon  
ubuntu-adantage-tools ubuntu-drivers-common ufw unzip update-manager  
update-manager-core update-notifier update-notifier-common util-linux  
uuid-runtime vim-common vim-tiny wget wireless-regdb wpasupplicant  
xserver-common xserver-xephyr xserver-xorg-core xserver-xorg-legacy  
xwayland xxd  
315 upgraded, 2 newly installed, 0 to remove and 0 not upgraded.  
245 standard LTS security updates  
Need to get 408 MB of archives.  
After this operation, 18.4 MB disk space will be freed.  
Do you want to continue? [Y/n] y  
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc6-dbg am  
d64 2.31-0ubuntu9.16 [20.0 MB]  
3% [1 libc6-dbg 17.5 MB/20.0 MB 87%] 1,915 kB/s 3min 24s
```



A screenshot of an Ubuntu desktop environment. On the left, there is a dock with icons for the Dash, Home, Applications, and Help. A terminal window is open in the center, titled "Terminal". The terminal shows the following command-line session:

```
Activities Terminal Jan 28 22:11
ubuntu@ubuntu-virtual-machine: ~
update-initramfs: deferring update (trigger activated)
Processing triggers for dbus (1.12.16-2ubuntu2.3) ...
Processing triggers for shared-mime-info (1.15-1) ...
Processing triggers for install-info (6.7.0.dfsg.2-5) ...
Processing triggers for fontconfig (2.13.1-2ubuntu3) ...
Processing triggers for desktop-file-utils (0.24-1ubuntu3) ...
Processing triggers for mime-support (3.64ubuntu1) ...
Processing triggers for initramfs-tools (0.136ubuntu6.7) ...
update-initramfs: Generating /boot/initrd.img-5.15.0-131-generic
Processing triggers for hicolor-icon-theme (0.17-2) ...
Processing triggers for gnome-menus (3.36.0-1ubuntui) ...
Processing triggers for libc-bin (2.31-0ubuntu9.16) ...
Processing triggers for rsyslog (8.2001.0-1ubuntu1.3) ...
Processing triggers for ca-certificates (20240203~20.04.1) ...
Updating certificates in /etc/ssl/certs...
0 added, 0 removed; done.
Running hooks in /etc/ca-certificates/update.d...
done.
Processing triggers for libgdk-pixbuf2.0-0:amd64 (2.40.0+dfsg-3ubuntu0.5) ...
ubuntu@ubuntu-virtual-machine:~$ sudo apt update
Hit:1 http://us.archive.ubuntu.com/ubuntu focal InRelease
Hit:2 http://security.ubuntu.com/ubuntu focal-security InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease
Reading package lists... Done
Building dependency tree
Reading state information... Done
All packages are up to date.
ubuntu@ubuntu-virtual-machine:~$ sudo apt install g++ python3
```

PRACTICAL NO. 2**PROGRAM:****Linux network commands – ifconfig, ip, ping, netstat, traceroute, nslookup, route, hostname.****STEPS:**Ifconfig: used for **configuring and displaying network interfaces**.

```
ubuntu@ubuntu:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
      inet 192.168.126.128 netmask 255.255.255.0 broadcast 192.168.126.255
      inet6 fe80::c7a4:ee0f:a145:a8df prefixlen 64 scopeid 0x20<link>
        ether 00:0c:29:b1:76:1b txqueuelen 1000 (Ethernet)
          RX packets 2485 bytes 1884456 (1.8 MB)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 1862 bytes 298298 (298.2 KB)
          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
      inet6 ::1 prefixlen 128 scopeid 0x10<host>
        loop txqueuelen 1000 (Local Loopback)
          RX packets 551 bytes 58544 (58.5 KB)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 551 bytes 58544 (58.5 KB)
          TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ubuntu@ubuntu:~$
```

ip : Displays and manipulates routing, devices and tunnels.

```
ubuntu@ubuntu:~$ ip
Usage: ip [ OPTIONS ] OBJECT { COMMAND | help }
      ip [ -force ] -batch filename
where OBJECT := { link | address | addrlabel | route | rule | neigh | ntable |
                 tunnel | tuntap | maddress | mroute | mrule | monitor | xfrm
                 |
                 netns | l2tp | fou | macsec | tcp_metrics | token | netconf
                 |
                 vrf | sr | nexthop }
OPTIONS := { -V[ersion] | -s[tatistics] | -d[etails] | -r[esolve] |
             -h[uman-readable] | -iec | -j[son] | -p[retty] |
             -f[amily] { inet | inet6 | mpls | bridge | link } |
             -4 | -6 | -I | -D | -M | -B | -0 |
             -l[oops] { maximum-addr-flush-attempts } | -br[ief] |
             -o[neline] | -t[imestamp] | -ts[hort] | -b[atch] [filename]
             |
             -rc[vbuf] [size] | -n[etns] name | -N[umeric] | -a[ll] |
             -c[olor]}}

ubuntu@ubuntu:~$
```

Ip -v : Shows version and output of ip commands

```
ubuntu@ubuntu:~$ ip -V
ip utility, iproute2-ss200127
ubuntu@ubuntu:~$
```

Ip addr : Shows ip addresses

```
ubuntu@ubuntu:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:29:b1:76:1b brd ff:ff:ff:ff:ff:ff
    altname enp2s1
    inet 192.168.126.128/24 brd 192.168.126.255 scope global dynamic noprefixroute ens33
        valid_lft 1537sec preferred_lft 1537sec
    inet6 fe80::c7a4:ee0f:a145:a8df/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
ubuntu@ubuntu:~$
```

Ip addr show : Displays detailed ip configuration

```
ubuntu@ubuntu:~$ ip addr show lo
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        Show Applications forever preferred_lft forever
ubuntu@ubuntu:~$
```

Ip link : Shows and configures network interfaces

```
ubuntu@ubuntu:~$ ip link
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP mode DEFAULT group default qlen 1000
    link/ether 00:0c:29:b1:76:1b brd ff:ff:ff:ff:ff:ff
    altname enp2s1
```

Ip route show : Displays the current routing table

```
ubuntu@ubuntu:~$ ip route show
default via 192.168.126.2 dev ens33 proto dhcp metric 100
169.254.0.0/16 dev ens33 scope link metric 1000
192.168.126.0/24 dev ens33 proto kernel scope link src 192.168.126.128 metric 100
ubuntu@ubuntu:~$
```

Ifconfig -s : Shows a short summary of network interfaces

```
ubuntu@ubuntu:~$ ifconfig -s
Iface      MTU     RX-OK RX-ERR RX-DRP RX-OVR     TX-OK TX-ERR TX-DRP TX-OVR Flg
ens33      1500    6189     0     0 0    3081     0     0     0 0 BMRU
lo         65536    605      0     0 0    605      0     0     0 0 LRU
ubuntu@ubuntu:~$
```

Dig : Queries DNS Servers for information.

```
ubuntu@ubuntu:~$ dig google.com

; <>> DiG 9.18.30-0ubuntu0.20.04.2-Ubuntu <>> google.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 62423
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1
;; Text Editor
;; OPT PSEUDOSECTION:
;; EDNS: version: 0, flags:; udp: 65494
;; QUESTION SECTION:
;google.com.           IN      A

;; ANSWER SECTION:
google.com.        5       IN      A      142.251.42.110

;; Query time: 3 msec
;; SERVER: 127.0.0.53#53(127.0.0.53) (UDP)
;; WHEN: Mon Feb 17 22:21:22 PST 2025
;; MSG SIZE  rcvd: 55
```

Nslookup : Queries internet name servers interactively for domain name .

```
ubuntu@ubuntu:~$ nslookup google.com
Server:      127.0.0.53
Address:      127.0.0.53#53

Non-authoritative answer:
Name:   google.com
Address: 142.250.183.110
Name:   google.com
Address: 2404:6800:4009:823::200e
```

Netstat -at : Displays all active TCP Connections

```
ubuntu@ubuntu:~$ netstat -at
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address          Foreign Address        State
tcp      0      0 localhost:domain        0.0.0.0:*
tcp      0      0 localhost:ipp          0.0.0.0:*
tcp      0      0 ubuntu:47758           93.243.107.34.bc.:https ESTABLISHED
tcp      0      0 ubuntu:47750           93.243.107.34.bc.:https ESTABLISHED
tcp      0      0 ubuntu:46064            209.100.149.34.bc:https ESTABLISHED
tcp6     0      0 ip6-localhost:ipp       [::]:*
ubuntu@ubuntu:~$
```

Host: performs DNS lookup to find ip addresses

```
ubuntu@ubuntu:~$ host google.com
google.com has address 142.251.42.110
google.com has IPv6 address 2404:6800:4009:832::200e
google.com mail is handled by 10 smtp.google.com.
ubuntu@ubuntu:~$
```

Ping : sends ICMP echo request to test network

```
ubuntu@ubuntu:~$ ping -c 5 google.com
PING google.com (142.250.183.110) 56(84) bytes of data.
64 bytes from bom12s13-in-f14.1e100.net (142.250.183.110): icmp_seq=1 ttl=128 time=2.13 ms
64 bytes from bom12s13-in-f14.1e100.net (142.250.183.110): icmp_seq=2 ttl=128 time=2.02 ms
64 bytes from bom12s13-in-f14.1e100.net (142.250.183.110): icmp_seq=3 ttl=128 time=2.14 ms
64 bytes from bom12s13-in-f14.1e100.net (142.250.183.110): icmp_seq=4 ttl=128 time=2.23 ms
64 bytes from bom12s13-in-f14.1e100.net (142.250.183.110): icmp_seq=5 ttl=128 time=2.11 ms

--- google.com ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4006ms
rtt min/avg/max/mdev = 2.018/2.126/2.231/0.068 ms
ubuntu@ubuntu:~$
```

Traceroute : Traces the route packets take to reach a network host

```
ubuntu@ubuntu:~$ sudo traceroute -T 184.95.56.34
traceroute to 184.95.56.34 (184.95.56.34), 30 hops max, 60 byte packets
 1 _gateway (192.168.126.2)  0.092 ms  0.051 ms  0.081 ms
 2 speedtest.phoenixnap.com (184.95.56.34)  0.523 ms  0.503 ms  0.740 ms
ubuntu@ubuntu:~$ sudo traceroute -T 127.0.0.53
traceroute to 127.0.0.53 (127.0.0.53), 30 hops max, 60 byte packets
 1 localhost (127.0.0.53)  0.020 ms  0.004 ms  0.004 ms
ubuntu@ubuntu:~$
```

Route : Displays or modifies the ip routing table

```
ubuntu@ubuntu:~$ route
Kernel IP routing table
Destination     Gateway         Genmask        Flags Metric Ref    Use Iface
default         _gateway       0.0.0.0       UG    100    0        0 ens33
link-local      0.0.0.0       255.255.0.0   U     1000   0        0 ens33
192.168.126.0  0.0.0.0       255.255.255.0 U     100    0        0 ens33
```

Arp : Displays or modifies the ARP

```
ubuntu@ubuntu:~$ arp
Address          HWtype  HWaddress           Flags Mask  Ifac
e
192.168.126.254 ether    00:50:56:e2:86:ba  C      ens3
3
_gateway         ether    00:50:56:eb:a2:d7  C      ens3
3
ubuntu@ubuntu:~$
```

Iwconfig : Configures wireless network interfaces

```
ubuntu@ubuntu:~$ iwconfig
lo      no wireless extensions.

ens33    no wireless extensions.

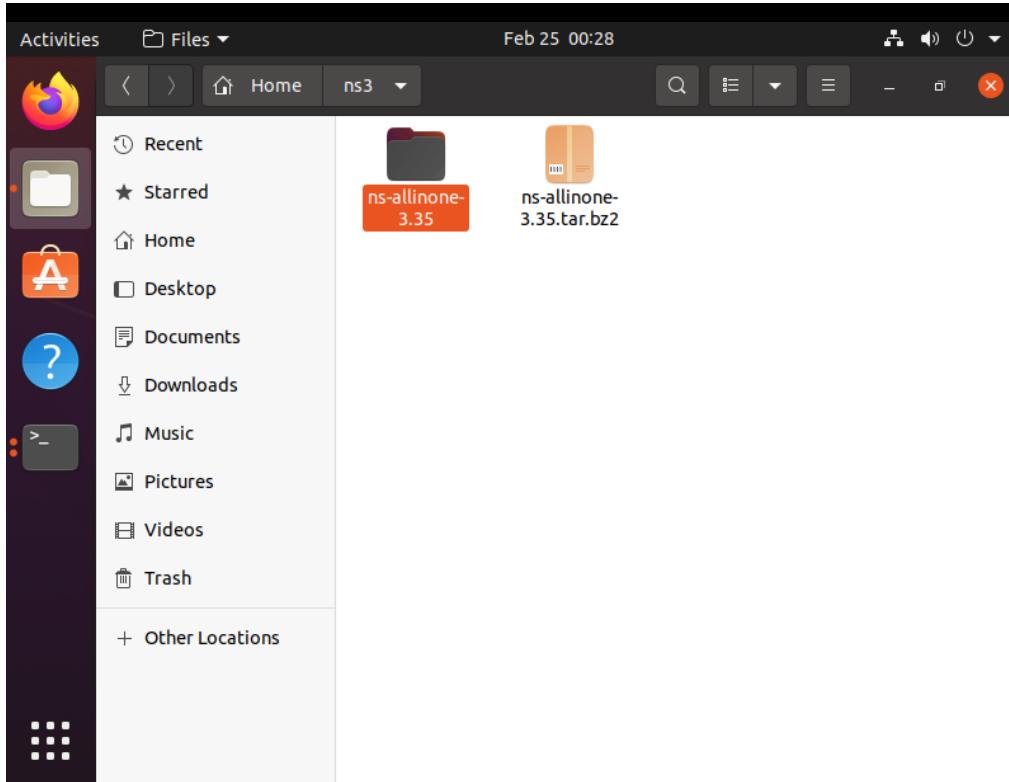
ubuntu@ubuntu:~$
```

Whois : Fetches domain registration information.

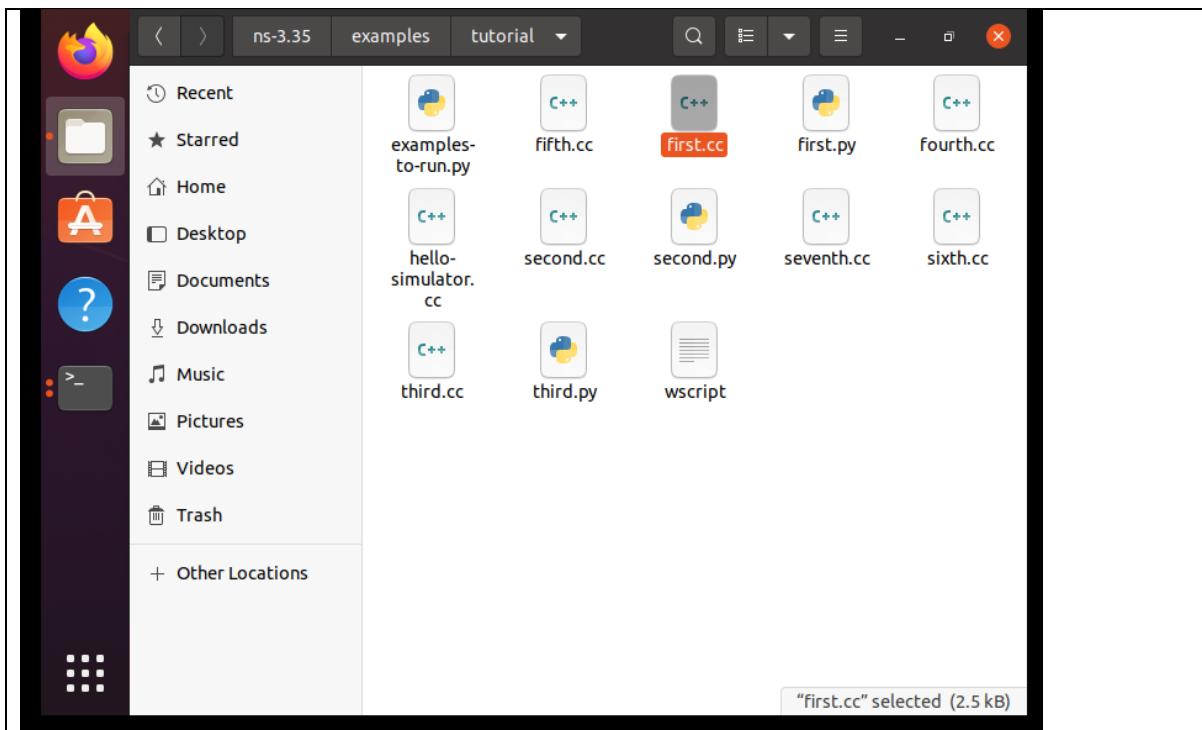
```
ubuntu@ubuntu:~$ whois google.com
Domain Name: GOOGLE.COM
Registry Domain ID: 2138514_DOMAIN_COM-VRSN
Registrar WHOIS Server: whois.markmonitor.com
Registrar URL: http://www.markmonitor.com
Updated Date: 2019-09-09T15:39:04Z
Creation Date: 1997-09-15T04:00:00Z
Registry Expiry Date: 2028-09-14T04:00:00Z
Registrar: MarkMonitor Inc.
Registrar IANA ID: 292
Registrar Abuse Contact Email: abusecomplaints@markmonitor.com
Registrar Abuse Contact Phone: +1.2086851750
Domain Status: clientDeleteProhibited https://icann.org/epp#clientDeleteProhibited
Domain Status: clientTransferProhibited https://icann.org/epp#clientTransferProhibited
Domain Status: clientUpdateProhibited https://icann.org/epp#clientUpdateProhibited
Domain Status: serverDeleteProhibited https://icann.org/epp#serverDeleteProhibited
Domain Status: serverTransferProhibited https://icann.org/epp#serverTransferProhibited
Domain Status: serverUpdateProhibited https://icann.org/epp#serverUpdateProhibited
Name Server: NS1.GOOGLE.COM
Name Server: NS2.GOOGLE.COM
Name Server: NS3.GOOGLE.COM
```

PRACTICAL NO. 3**PROGRAM:****Program to simulate Point to Point Topology.****CODE:**

Start Ubuntu virtual machine , Go to home directory and click on ns3. In ns3 folder open nsallinone folder →open ns 3.35 folder.



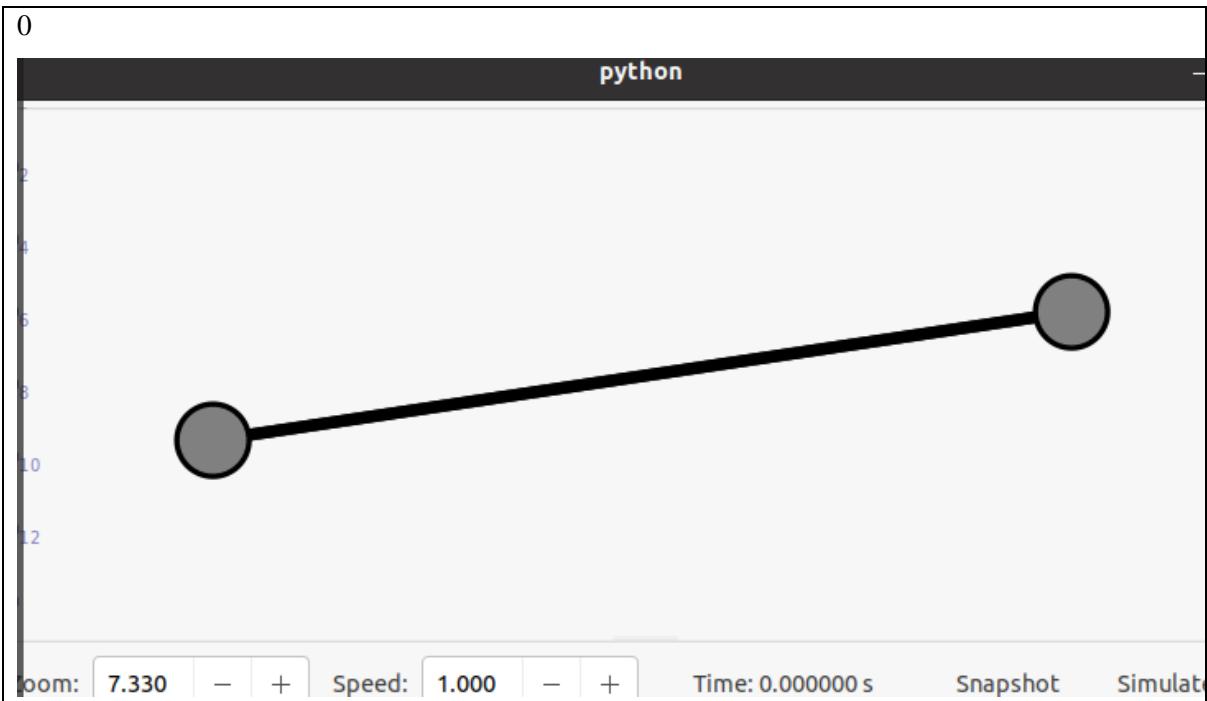
Open examples folder ,go to tutorial and copy the first.cc file into scratch folder of ns3.35.



Go to ns 3.35 and then click on open in terminal.

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run first
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2949/3026] Compiling scratch/first.cc
[2986/3026] Linking build/scratch/first
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (4.808s)
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9

ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run first --vis
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2909/3026] Linking build/examples/tutorial/ns3.35-first-debug
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.984s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python module
scanning topology: 2 nodes...
scanning topology: calling graphviz layout
scanning topology: all done.
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```



CODE:

```
/* -- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -- /
/


- This program is free software; you can redistribute it and/or modify
- it under the terms of the GNU General Public License version 2 as
- published by the Free Software Foundation;
- 
- This program is distributed in the hope that it will be useful,
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- MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
- GNU General Public License for more details.
- 
- You should have received a copy of the GNU General Public License
- along with this program; if not, write to the Free Software
- Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA

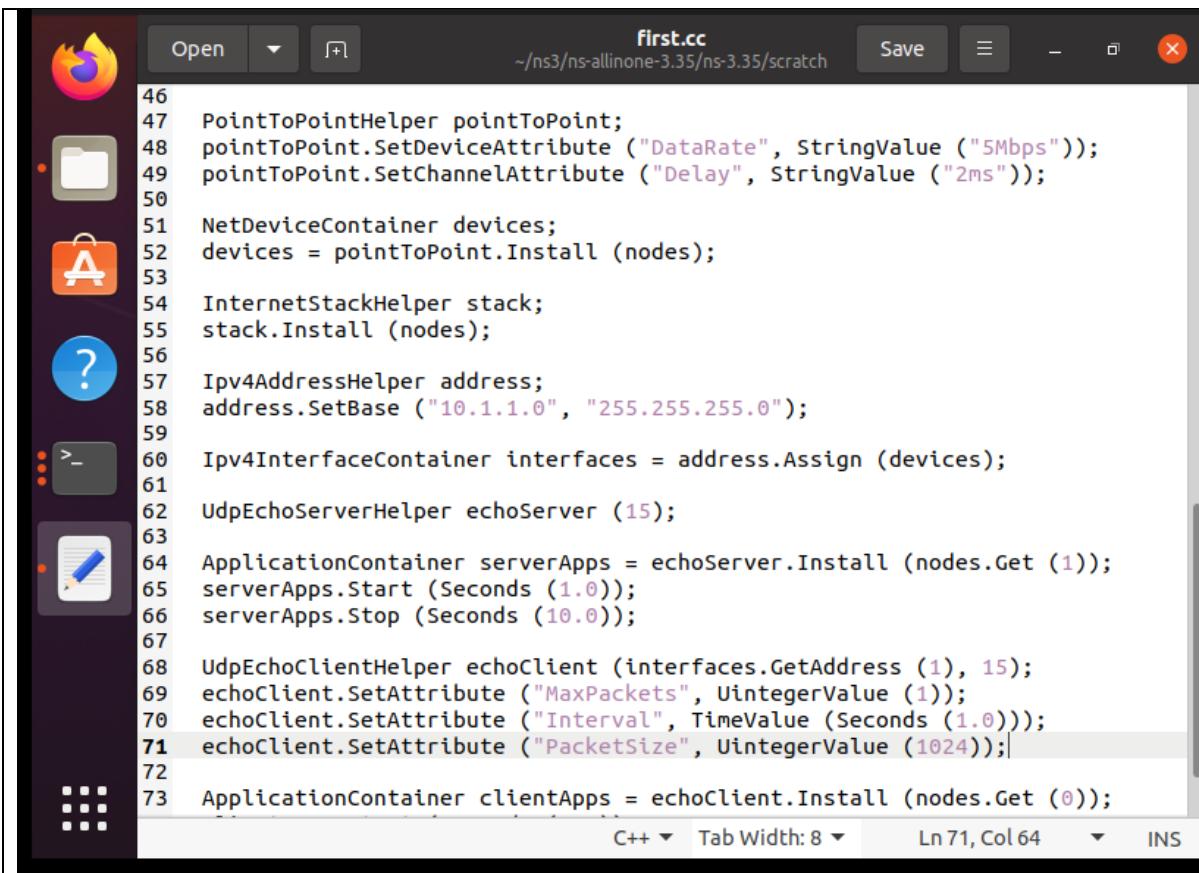

*/
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
```

```
//netanimation
#include "ns3/netanim-module.h"
#include "ns3/mobility-module.h"
// Default Network Topology
//
// 10.1.1.0
// n0 n1
// point-to-point
//
using namespace ns3;
NS_LOG_COMPONENT_DEFINE ("FirstScriptExample");
int
main (int argc, char *argv[])
{
CommandLine cmd ( FILE );
cmd.Parse (argc, argv);
Time::SetResolution (Time::NS);
LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
NodeContainer nodes;
nodes.Create (2);
PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
NetDeviceContainer devices;
devices = pointToPoint.Install (nodes);
InternetStackHelper stack;
stack.Install (nodes);
Ipv4AddressHelper address;
address.SetBase ("10.1.1.0", "255.255.255.0");
Ipv4InterfaceContainer interfaces = address.Assign (devices);
UdpEchoServerHelper echoServer (9);
ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));
```

```
UdpEchoClientHelper echoClient (interfaces.GetAddress (1), 9);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));
ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));
MobilityHelper mobility;
mobility.SetMobilityModel("ns3::ConstantPositionMobilityModel");
mobility.Install(nodes);
AnimationInterface anim("first.xml");
AnimationInterface::SetConstantPosition(nodes.Get(0),10,25);
AnimationInterface::SetConstantPosition(nodes.Get(1),40,25);
anim.EnablePacketMetadata(true);
pointToPoint.EnablePcapAll("first");
Simulator::Run ();
Simulator::Destroy ();
return 0;
}
```

This NS-3 code simulates a simple point-to-point network between two nodes, where one node acts as a UDP echo client and the other as a UDP echo server. The nodes are connected via a link with a data rate of 5 Mbps and 2 ms delay. IP addresses are assigned, and the server listens on port 9 while the client sends one 1024-byte packet after 2 seconds. Mobility models fix the nodes' positions, and the simulation includes NetAnim support for visualization and PCAP tracing for packet capture. The simulation runs for 10 seconds, demonstrating basic end-to-end communication, animation, and tracing.

To edit the given .cc file open the terminal in scratch folder and perform the gedit command.



```
46
47 PointToPointHelper pointToPoint;
48 pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
49 pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
50
51 NetDeviceContainer devices;
52 devices = pointToPoint.Install (nodes);
53
54 InternetStackHelper stack;
55 stack.Install (nodes);
56
57 Ipv4AddressHelper address;
58 address.SetBase ("10.1.1.0", "255.255.255.0");
59
60 Ipv4InterfaceContainer interfaces = address.Assign (devices);
61
62 UdpEchoServerHelper echoServer (15);
63
64 ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));
65 serverApps.Start (Seconds (1.0));
66 serverApps.Stop (Seconds (10.0));
67
68 UdpEchoClientHelper echoClient (interfaces.GetAddress (1), 15);
69 echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
70 echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
71 echoClient.SetAttribute ("PacketSize", UintegerValue (1024));
72
73 ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
```

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/first
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2912/3026] Linking build/examples/tutorial/ns3.35-first-debug
[2956/3026] Compiling scratch/first.cc
[2986/3026] Linking build/scratch/first
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (5.326s)
At time +2s client sent 1024 bytes to 10.1.1.2 port 15
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 15
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```

PRACTICAL NO. 4

PROGRAM:

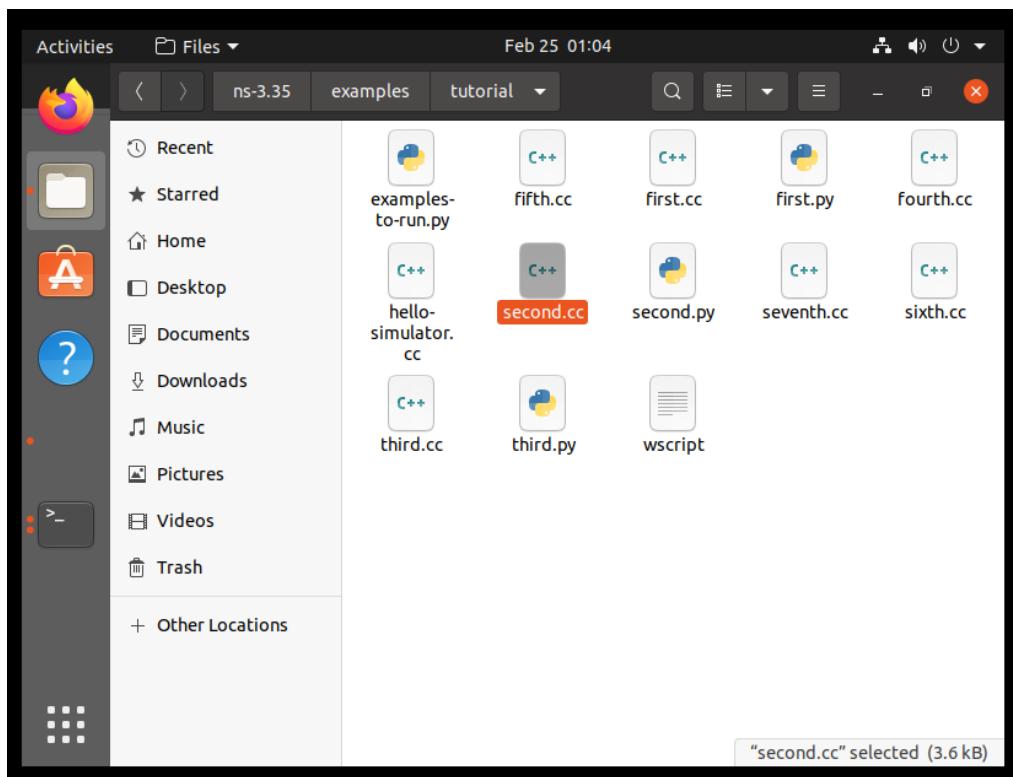
Program to simulate Bus topology.

The bus network topology is also referred to as horizontal topology. This topology is very common among local area networks. In this network, every computer is linked to a single connection line or cable through an interface. Thus each computer can directly communicate with other computer or device in the network.

Each work station or node has a particular address, and to access a specific node, a user just needs to know its address. There is no concentration point in the network, and thus the problem of resolution is severe. Traffic flow among various computers in the network is relatively simple because it grants all stations to get each transmission. So a single station can broadcast to multiple stations.

CODE:

Open the ns3.35 folder and in examples → tutorial → second .cc

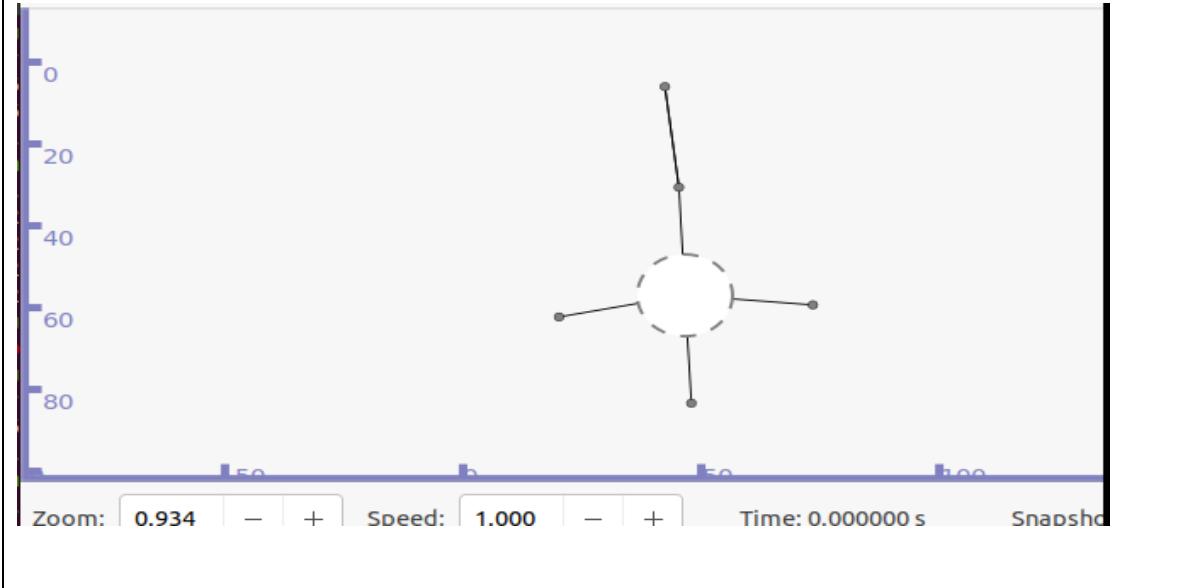


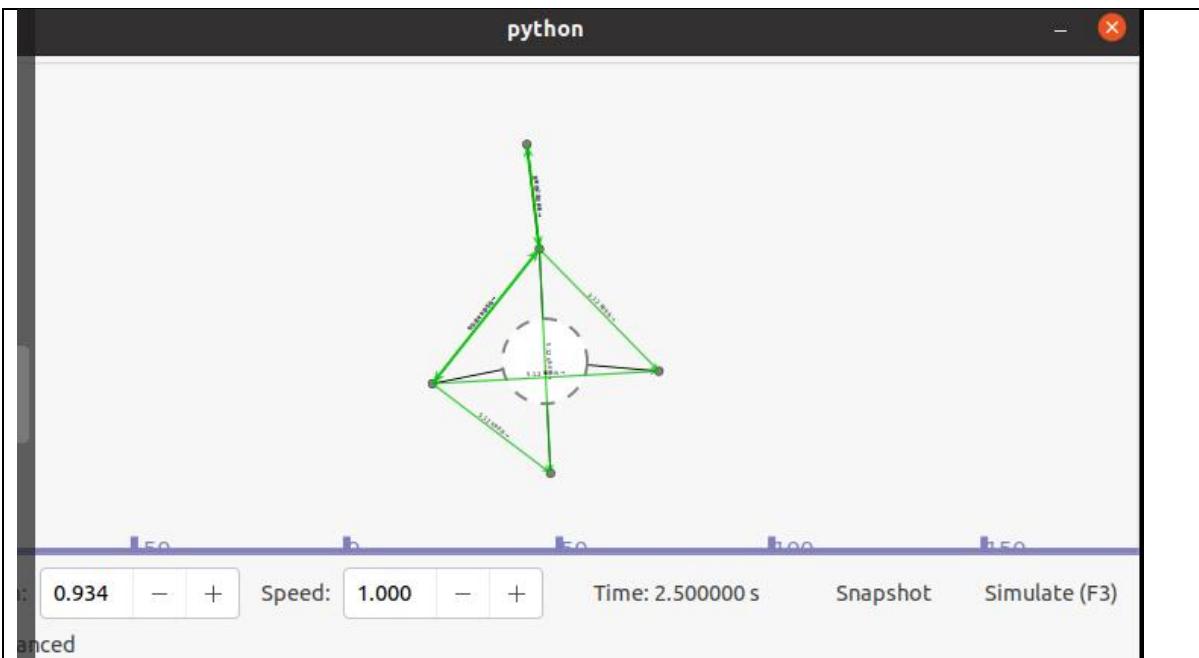
Copy this file and paste it in scratch folder.

Open the terminal in ns3.35 and perform the commands.

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run second
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2907/3026] Linking build/examples/tutorial/ns3.35-second-debug
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.781s)
At time +2s client sent 1024 bytes to 10.1.2.4 port 9
At time +2.0078s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.0078s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.01761s client received 1024 bytes from 10.1.2.4 port 9
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run second --vis
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2905/3026] Linking build/examples/tutorial/ns3.35-second-debug
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.983s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python module
scanning topology: 5 nodes...
scanning topology: calling graphviz layout
scanning topology: all done.
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```



**CODE:**

```
/* -- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -- */
/*
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License version 2 as
 * published by the Free Software Foundation;
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 * GNU General Public License for more details.
 *
 * You should have received a copy of the GNU General Public License
 * along with this program; if not, write to the Free Software
 * Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA
 */

#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/csma-module.h"
```

```
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/ipv4-global-routing-helper.h"

// Default Network Topology
//
//      10.1.1.0
// n0 ----- n1  n2  n3  n4
//   point-to-point |  |  |  |
//                   =====
//                  LAN 10.1.2.0

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("SecondScriptExample");

int
main (int argc, char *argv[])
{
    bool verbose = true;
    uint32_t nCsma = 3;

    CommandLine cmd (_FILE_);
    cmd.AddValue ("nCsma", "Number of \"extra\" CSMA nodes/devices", nCsma);
    cmd.AddValue ("verbose", "Tell echo applications to log if true", verbose);

    cmd.Parse (argc, argv);

    if (verbose)
    {
        LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
```

```
LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
}

nCsma = nCsma == 0 ? 1 : nCsma;

NodeContainer p2pNodes;
p2pNodes.Create (2);

NodeContainer csmaNodes;
csmaNodes.Add (p2pNodes.Get (1));
csmaNodes.Create (nCsma);

PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));

NetDeviceContainer p2pDevices;
p2pDevices = pointToPoint.Install (p2pNodes);

CsmaHelper csma;
csma.SetChannelAttribute ("DataRate", StringValue ("100Mbps"));
csma.SetChannelAttribute ("Delay", TimeValue (NanoSeconds (6560)));

NetDeviceContainer csmaDevices;
csmaDevices = csma.Install (csmaNodes);

InternetStackHelper stack;
stack.Install (p2pNodes.Get (0));
stack.Install (csmaNodes);

Ipv4AddressHelper address;
address.SetBase ("10.1.1.0", "255.255.255.0");
Ipv4InterfaceContainer p2pInterfaces;
```

```
p2pInterfaces = address.Assign (p2pDevices);

address.SetBase ("10.1.2.0", "255.255.255.0");
Ipv4InterfaceContainer csmaInterfaces;
csmaInterfaces = address.Assign (csmaDevices);

UdpEchoServerHelper echoServer (9);

ApplicationContainer serverApps = echoServer.Install (csmaNodes.Get (nCsma));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));

UdpEchoClientHelper echoClient (csmaInterfaces.GetAddress (nCsma), 9);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer clientApps = echoClient.Install (p2pNodes.Get (0));
clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));

Ipv4GlobalRoutingHelper::PopulateRoutingTables ();

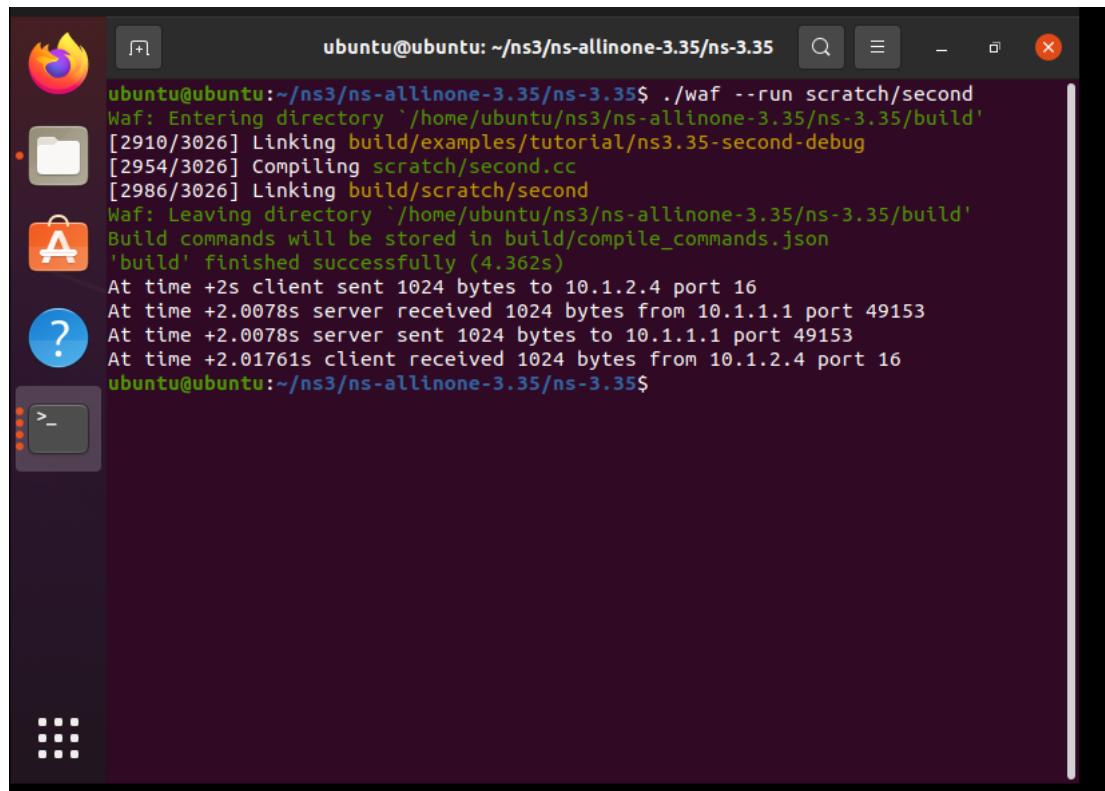
pointToPoint.EnablePcapAll ("second");
csma.EnablePcap ("second", csmaDevices.Get (1), true);

Simulator::Run ();
Simulator::Destroy ();
return 0;
}
```

A P2P link connects two nodes: n0 and n1. Node n1 then connects to a group of CSMA nodes (n2, n3, n4, etc.) via a shared CSMA channel, which simulates a bus-like structure where all nodes are connected to the same medium. The CSMA segment acts as the shared

backbone, similar to a classic bus topology. The server runs on one of the CSMA nodes, and a client runs on the P2P node n0, sending a UDP echo request to the server. This setup demonstrates communication between nodes across a mixed topology with bus-like characteristics.

To make changes in .cc file open the file using gedit command.



```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/second
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2910/3026] Linking build/examples/tutorial/ns3.35-second-debug
[2954/3026] Compiling scratch/second.cc
[2986/3026] Linking build/scratch/second
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (4.362s)
At time +2s client sent 1024 bytes to 10.1.2.4 port 16
At time +2.0078s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.0078s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.01761s client received 1024 bytes from 10.1.2.4 port 16
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```

PRACTICAL NO. 5**PROGRAM:****Program to simulate Star topology**

A star topology, sometimes known as a star network, is a network topology in which each device is connected to a central hub. It is one of the most prevalent computer network configurations, and it's by far the most popular Network Topology. In this network arrangement, all devices linked to a central network device are displayed as a star.

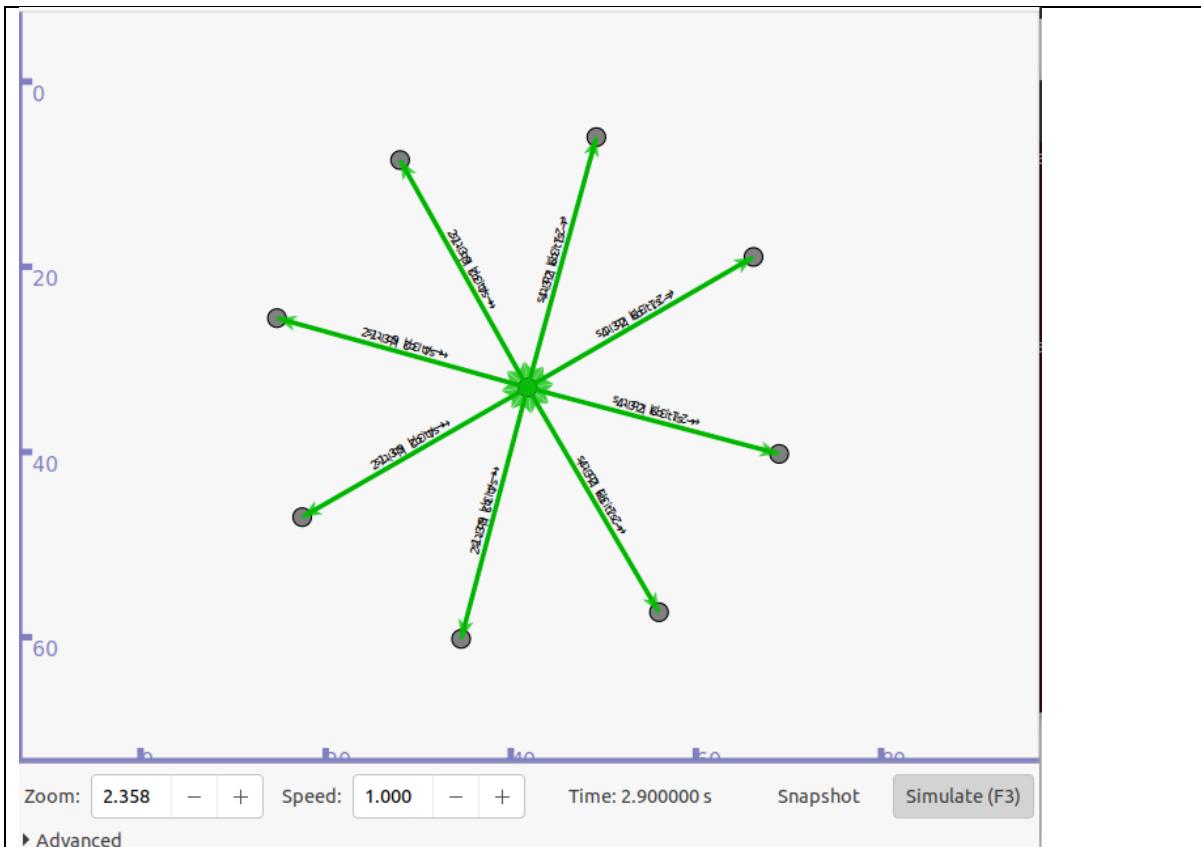
CODE:

Open the ns3.35 folder , go to examples and open tcp folder.

You will find the star.cc there ..Copy the star.cc file to scratch folder

Open the terminal in ns3.35 and compile the star.cc file

```
ubuntu@ubuntu-virtual-machine:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run star
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2895/3028] Linking build/examples/tcp/ns3.35-star-debug
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.687s)
ubuntu@ubuntu-virtual-machine:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run star -v
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2900/3028] Linking build/examples/tcp/ns3.35-star-debug
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.539s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python module
scanning topology: 9 nodes...
scanning topology: calling graphviz layout
scanning topology: all done.
```



```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/netanim-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/point-to-point-layout-module.h"

// Network topology (default)
//
//
//
n2 n3 n4
\|/
.
.
// \| .
// n1--- n0---n5 .
```

```
// /\ .
// /| \.
//
//
n8 n7 n6 .

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("Star");

int

main (int argc, char *argv[])
{

//


// Set up some default values for the simulation.

//


Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (137));

// ??? try and stick 15kb/s into the data rate
Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("14kb/s"));

//


// Default number of nodes in the star. Overridable by command line argument.

//


uint32_t nSpokes = 8;

CommandLine cmd;
cmd.AddValue ("nSpokes", "Number of nodes to place in the star", nSpokes);
cmd.Parse (argc, argv);

NS_LOG_INFO ("Build star topology.");
PointToPointHelper pointToPoint;

pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
PointToPointStarHelper star (nSpokes, pointToPoint);
```

```
NS_LOG_INFO ("Install internet stack on all nodes.");
InternetStackHelper internet;
star.InstallStack (internet);

NS_LOG_INFO ("Assign IP Addresses.");
star.AssignIpv4Addresses (Ipv4AddressHelper ("10.1.1.0", "255.255.255.0"));

NS_LOG_INFO ("Create applications.");
//
// Create a packet sink on the star "hub" to receive packets.
//
uint16_t port = 50000;
Address hubLocalAddress (InetSocketAddress (Ipv4Address::GetAny (), port));
PacketSinkHelper packetSinkHelper ("ns3::TcpSocketFactory", hubLocalAddress);
ApplicationContainer hubApp = packetSinkHelper.Install (star.GetHub ());
hubApp.Start (Seconds (1.0));
hubApp.Stop (Seconds (10.0));

//
// Create OnOff applications to send TCP to the hub, one on each spoke node.
//
OnOffHelper onOffHelper ("ns3::TcpSocketFactory", Address ());
onOffHelper.SetAttribute ("OnTime", StringValue
("ns3::ConstantRandomVariable[Constant=1]"));
onOffHelper.SetAttribute ("OffTime", StringValue
("ns3::ConstantRandomVariable[Constant=0]"));

ApplicationContainer spokeApps;

for (uint32_t i = 0; i < star.SpokeCount (); ++i)
{
    AddressValue remoteAddress (InetSocketAddress (star.GetHubIpv4Address (i),
port));
```

```
onOffHelper.SetAttribute ("Remote", remoteAddress);
spokeApps.Add (onOffHelper.Install (star.GetSpokeNode (i)));
}

spokeApps.Start (Seconds (1.0));
spokeApps.Stop (Seconds (10.0));

NS_LOG_INFO ("Enable static global routing.");
//
// Turn on global static routing so we can actually be routed across the star.
//
Ipv4GlobalRoutingHelper::PopulateRoutingTables ();

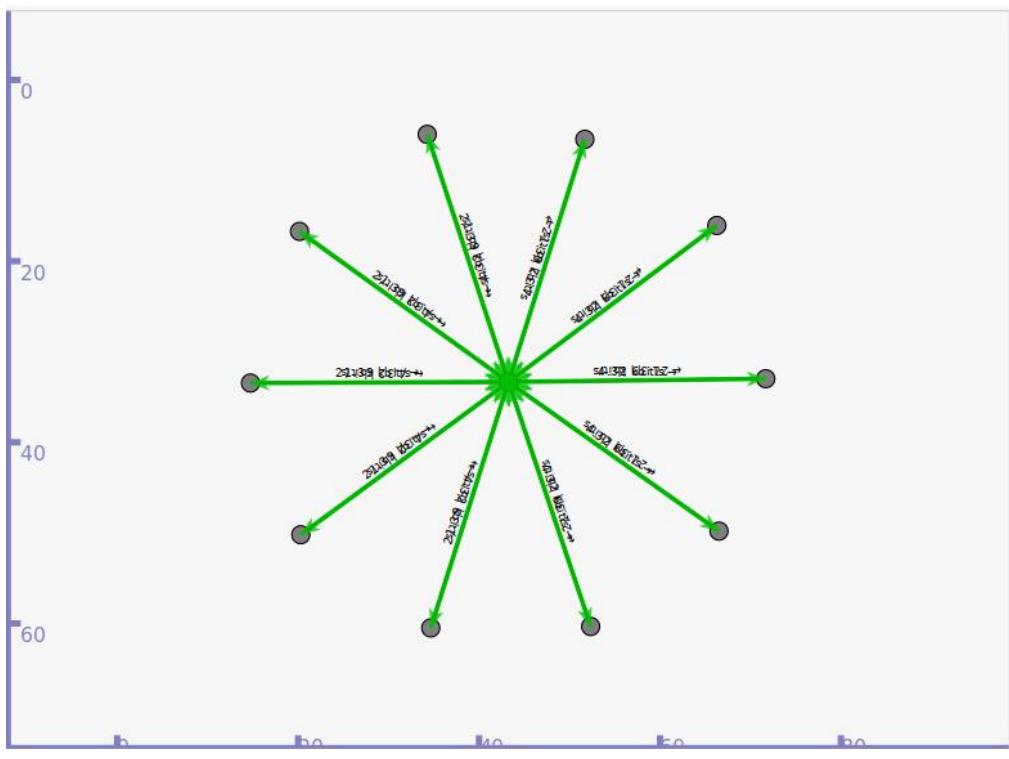
NS_LOG_INFO ("Enable pcap tracing.");
//
// Do pcap tracing on all point-to-point devices on all nodes.
//
pointToPoint.EnablePcapAll ("star");

NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
return 0;
}
```

This NS-3 simulation code creates a star network topology with one central hub node connected to multiple spoke nodes (default 8). Each spoke node runs an OnOff TCP application sending traffic to a packet sink application on the hub node. The point-to-point links have 5 Mbps bandwidth and 2 ms delay. The simulation runs from 1 to 10 seconds, with global static routing enabled to route packets properly. It also enables pcap tracing to capture packet data for analysis. Overall, it demonstrates basic TCP communication in a star topology with traffic flowing from multiple spoke nodes to a single central hub.

To make changes in code use gedit command to open the cc file and make changes in it.

```
ubuntu@ubuntu-virtual-machine:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/star
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2894/3028] Linking build/examples/tcp/ns3.35-star-debug
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.447s)
ubuntu@ubuntu-virtual-machine:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/star --vis
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.849s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python module
scanning topology: 11 nodes...
scanning topology: calling graphviz layout
scanning topology: all done.
ubuntu@ubuntu-virtual-machine:~/ns3/ns-allinone-3.35/ns-3.35$
```



PRACTICAL NO. 6

PROGRAM:

Program to simulate mesh topology.

CODE:

Mesh topology is a type of networking in which all the computers are inter-connected to each other. In Mesh Topology, the connections between devices take place randomly.

The connected nodes can be computers, switches, hubs, or any other devices. In this topology setup, even if one of the connections goes down, it allows other nodes to be distributed. This type of topology is very expensive and does not have any hierarchy, interdependency, and uniform pattern between nodes. The connections of the mesh topology are not easier to establish.

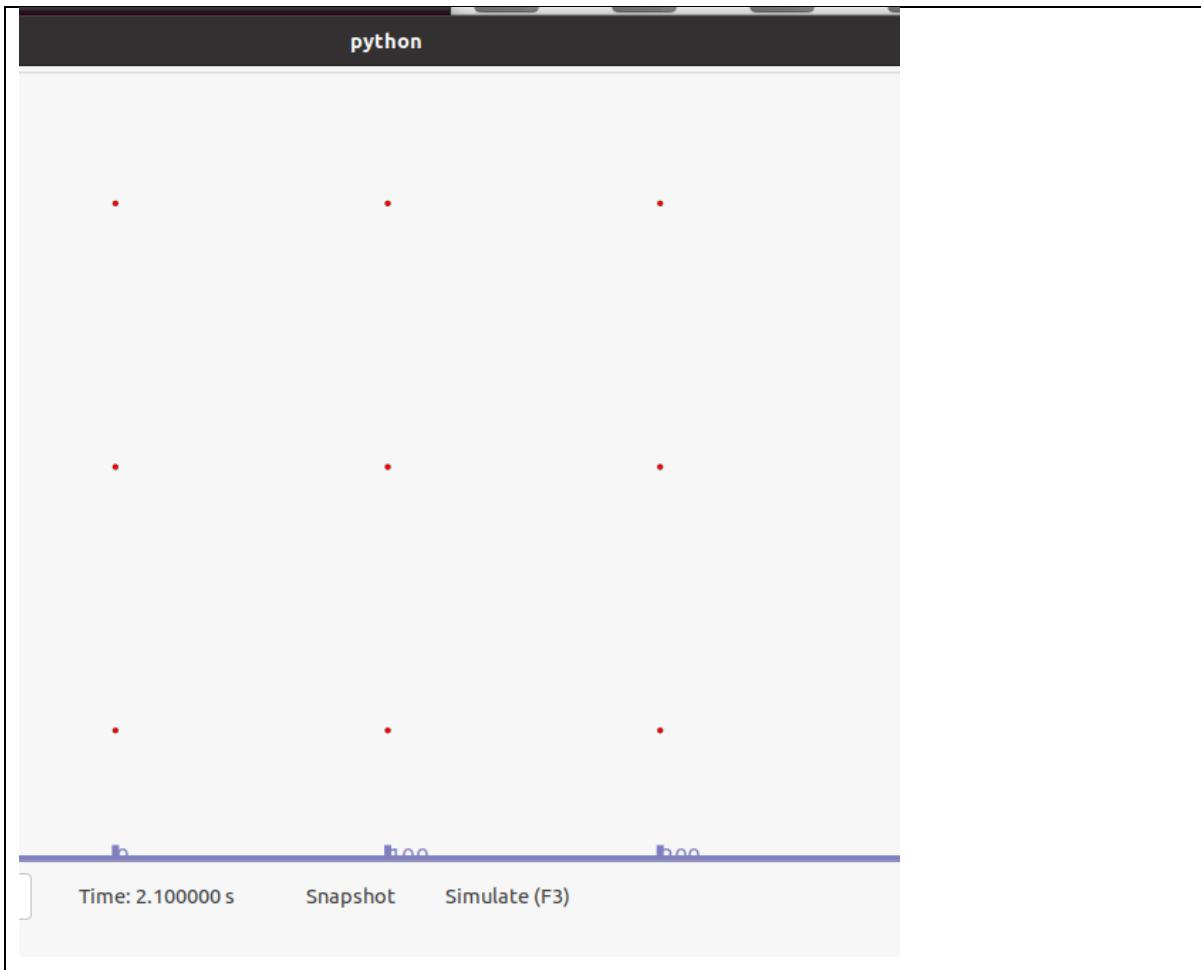
Open ns3.35 → src → mesh → examples → mesh.cc

Copy the mesh.cc file to scratch folder

Open terminal in ns3.35 and compile the mesh.cc file

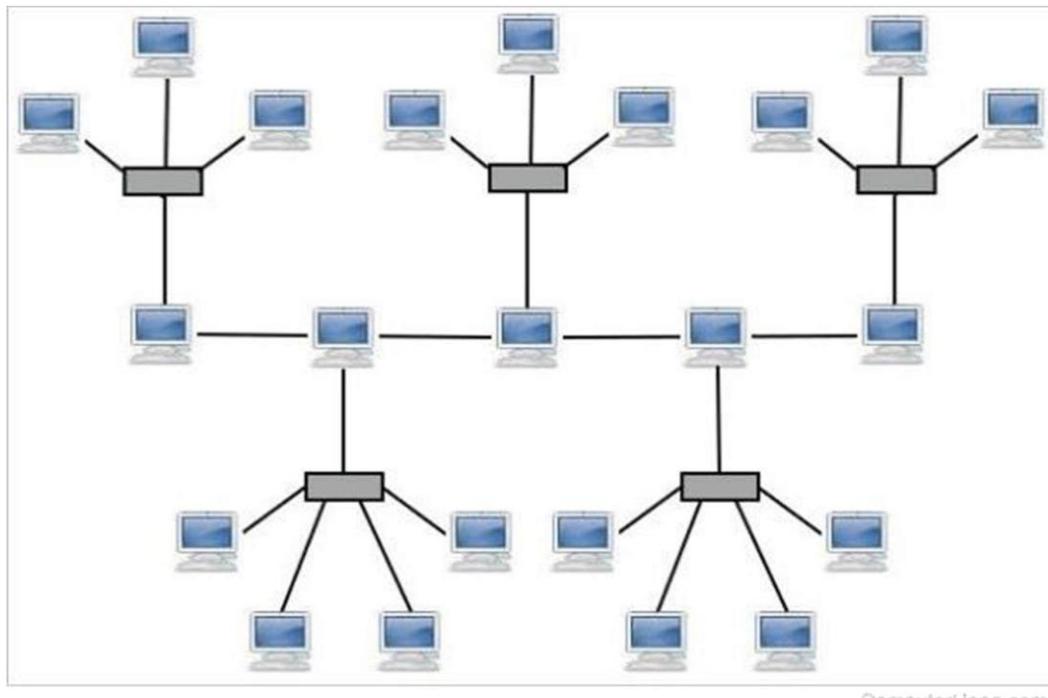
```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run mesh
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2081/2153] Compiling scratch/mesh.cc
[2112/2153] Linking build/scratch/scratch-simulator
[2113/2153] Linking build/scratch/mesh
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (4.885s)
Printing mesh point device #0 diagnostics to mp-report-0.xml
Printing mesh point device #1 diagnostics to mp-report-1.xml
Printing mesh point device #2 diagnostics to mp-report-2.xml
Printing mesh point device #3 diagnostics to mp-report-3.xml
Printing mesh point device #4 diagnostics to mp-report-4.xml
Printing mesh point device #5 diagnostics to mp-report-5.xml
Printing mesh point device #6 diagnostics to mp-report-6.xml
Printing mesh point device #7 diagnostics to mp-report-7.xml
Printing mesh point device #8 diagnostics to mp-report-8.xml
```

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run mesh --vis
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.449s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python mod
```



PRACTICAL NO. 7**PROGRAM:****Program to simulate Hybrid Topology**

A hybrid topology is a kind of network topology that is a combination of two or more network topologies, such as mesh topology, bus topology, and ring topology. Its usage and choice are dependent on its deployments and requirements like the performance of the desired network, and the number of computers, their location.

**CODE:**

Install the necessary libraries for netanim

```
ubuntu@ubuntu:~$ sudo apt update
[sudo] password for ubuntu:
Hit:1 http://security.ubuntu.com/ubuntu focal-security InRelease
Hit:2 http://us.archive.ubuntu.com/ubuntu focal InRelease
Hit:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease
Reading package lists... Done
Building dependency tree
Reading state information... Done
6 packages can be upgraded. Run 'apt list --upgradable' to see them.
ubuntu@ubuntu:~$ sudo apt upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
Get more security updates through Ubuntu Pro with 'esm-apps' enabled:
  ipython3 python2.7-minimal libcgraph6 python2.7 python3-ipython
  liblab-gamut1 libcdt5 libpathplan4 libgvpr2 libpython2.7-minimal libgvc6
  libpython2.7-stdlib traceroute graphviz
Learn more about Ubuntu Pro at https://ubuntu.com/pro
The following NEW packages will be installed:
  ubuntu-pro-client ubuntu-pro-client-l10n
The following packages will be upgraded:
  dns-root-data python3-update-manager snapd ubuntu Advantage-tools

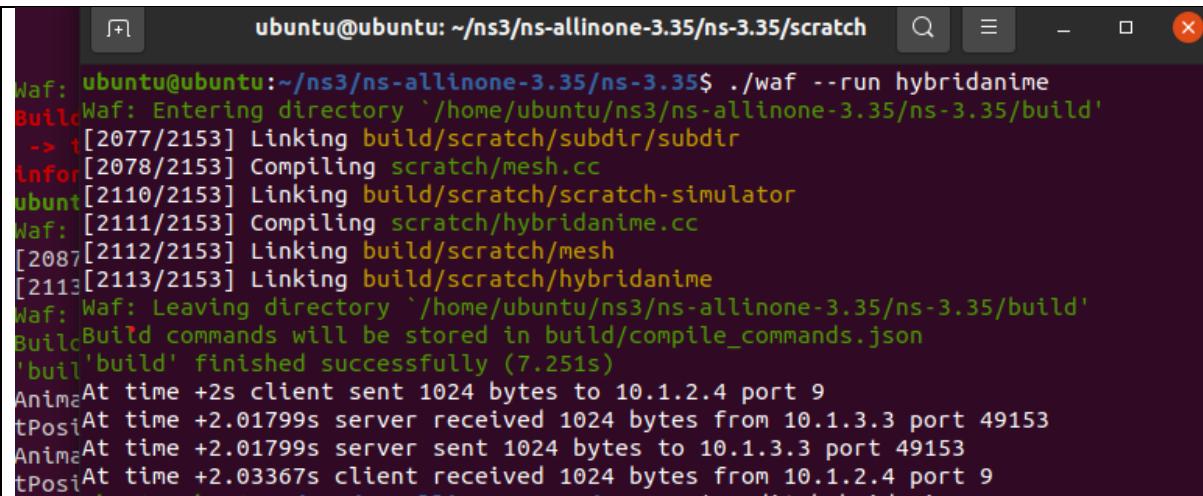
```

```
ubuntu@ubuntu:~$ sudo apt install qt5-default mercurial
Reading package lists... Done
Building dependency tree
Reading state information... Done
mercurial is already the newest version (5.3.1-1ubuntu1).
qt5-default is already the newest version (5.12.8+dfsg-0ubuntu2.1).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
ubuntu@ubuntu:~$
```

```
ubuntu@ubuntu:~$ sudo apt install gir1.2-gocanvas-2.0 python3-gi python3-gi-cairo python3-pygraphviz gir1.2-gtk-3.0 ipython3
Reading package lists... Done
Building dependency tree
Reading state information... Done
python3-gi is already the newest version (3.36.0-1).
python3-gi-cairo is already the newest version (3.36.0-1).
gir1.2-gocanvas-2.0 is already the newest version (2.0.4-1).
ipython3 is already the newest version (7.13.0-1).
python3-pygraphviz is already the newest version (1.5-4build1).
gir1.2-gtk-3.0 is already the newest version (3.24.20-0ubuntu1.2).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
ubuntu@ubuntu:~$
```

Now from examples→tutorial copy paste the third.cc file to scratch

Rename the file name to hybridanim and compile the file.



```

ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run hybridanime
Waf: Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Waf: [2077/2153] Linking build/scratch/subdir/subdir
Waf: [2078/2153] Compiling scratch/mesh.cc
Waf: [2110/2153] Linking build/scratch/scratch-simulator
Waf: [2111/2153] Compiling scratch/hybridanime.cc
Waf: [2087/2153] Linking build/scratch/mesh
Waf: [2113/2153] Linking build/scratch/hybridanime
Waf: Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (7.251s)
At time +2s client sent 1024 bytes to 10.1.2.4 port 9
At time +2.01799s server received 1024 bytes from 10.1.3.3 port 49153
At time +2.01799s server sent 1024 bytes to 10.1.3.3 port 49153
At time +2.03367s client received 1024 bytes from 10.1.2.4 port 9

```

CODE:

```

/* -*- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -*- */
/*
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License version 2 as
 * published by the Free Software Foundation;
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 * GNU General Public License for more details.
 *
 * You should have received a copy of the GNU General Public License
 * along with this program; if not, write to the Free Software
 * Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA
 */

```

```

#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"

```

```
//netanimation
#include "ns3/netanim-module.h"
#include "ns3/mobility-module.h"

// Default Network Topology
//
// 10.1.1.0
// n0 n1
// point-to-point
//
using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("FirstScriptExample");

int
main (int argc, char *argv[])
{
CommandLine cmd ( FILE );
cmd.Parse (argc, argv);

Time::SetResolution (Time::NS);
LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);

NodeContainer nodes;
nodes.Create (2);

PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
NetDeviceContainer devices;
devices = pointToPoint.Install (nodes);
```

```
InternetStackHelper stack;
stack.Install (nodes);

Ipv4AddressHelper address;
address.SetBase ("10.1.1.0", "255.255.255.0");

Ipv4InterfaceContainer interfaces = address.Assign (devices);

UdpEchoServerHelper echoServer (9);

ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));

UdpEchoClientHelper echoClient (interfaces.GetAddress (1), 9);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));

MobilityHelper mobility;
mobility.SetMobilityModel("ns3::ConstantPositionMobilityModel");
mobility.Install(nodes);
AnimationInterface anim("hybridanim.xml");
anim.SetConstantPosition(p2pNodes.Get(0),10.0,10.0);
anim.SetConstantPosition(p2pNodes.Get(0),20.0,20.0);
Simulator::Run ();
Simulator::Destroy ();
return 0;
}
```

Now to make the changes in .cc file open it using gedit and add this lines to create an xml file and save it.

```

    phy.EnablePcap ("third", apDevices.Get (0));
    csma.EnablePcap ("third", csmaDevices.Get (0), true);
}
AnimationInterface anim("hybridanim.xml");
anim.SetConstantPosition(p2pNodes.Get(0),10.0,10.0);
anim.SetConstantPosition(p2pNodes.Get(0),20.0,20.0);
Simulator::Run ();
Simulator::Destroy ();
return 0;
}

```

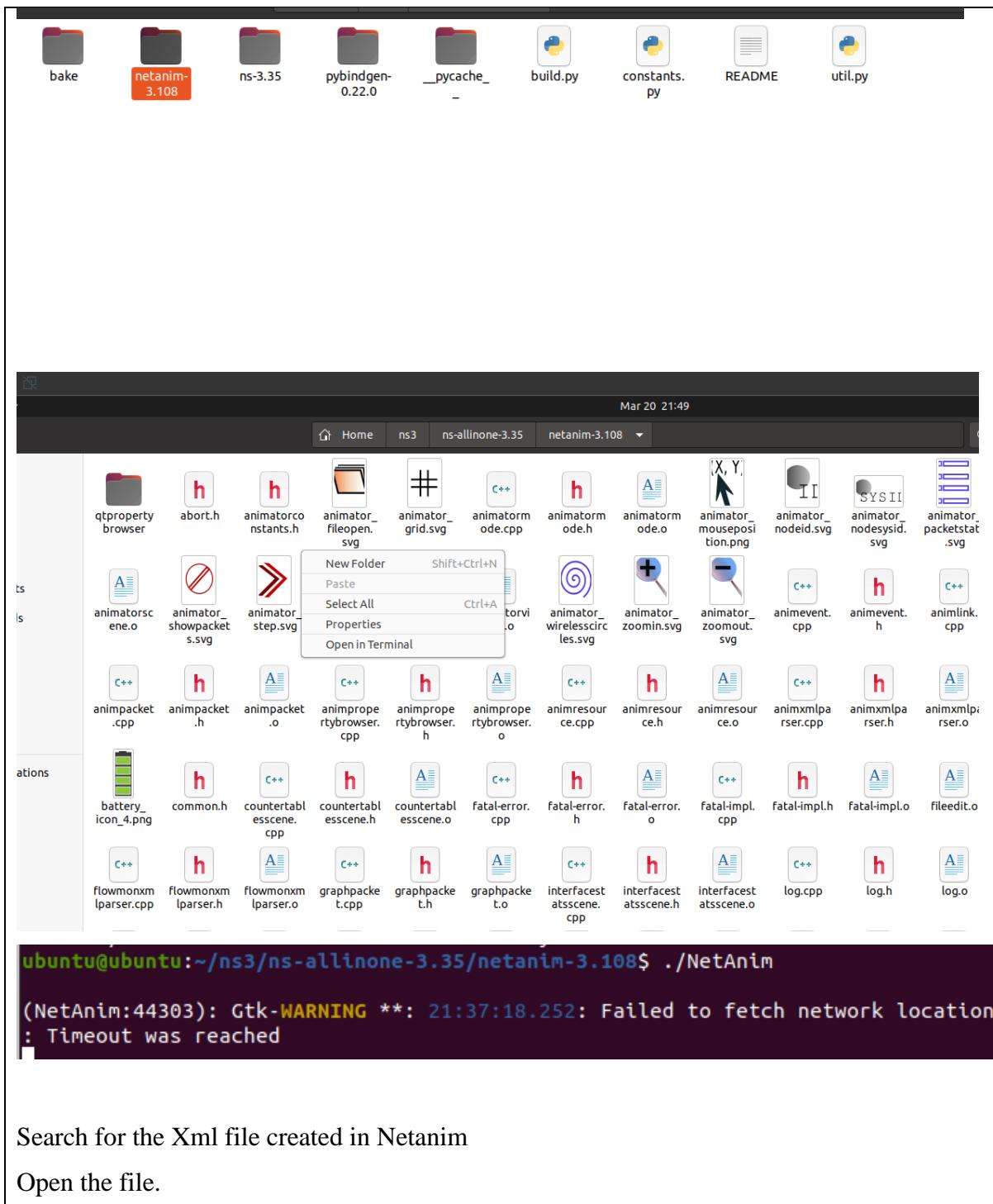
Compile the saved file.

```

ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/hybridanim
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2087/2153] Compiling scratch/hybridanim.cc
[2113/2153] Linking build/scratch/hybridanim
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (4.716s)
AnimationInterface WARNING:Node:1 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:2 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:3 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:4 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:1 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:2 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:3 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:4 Does not have a mobility model. Use SetConstan
tPosition if it is stationary

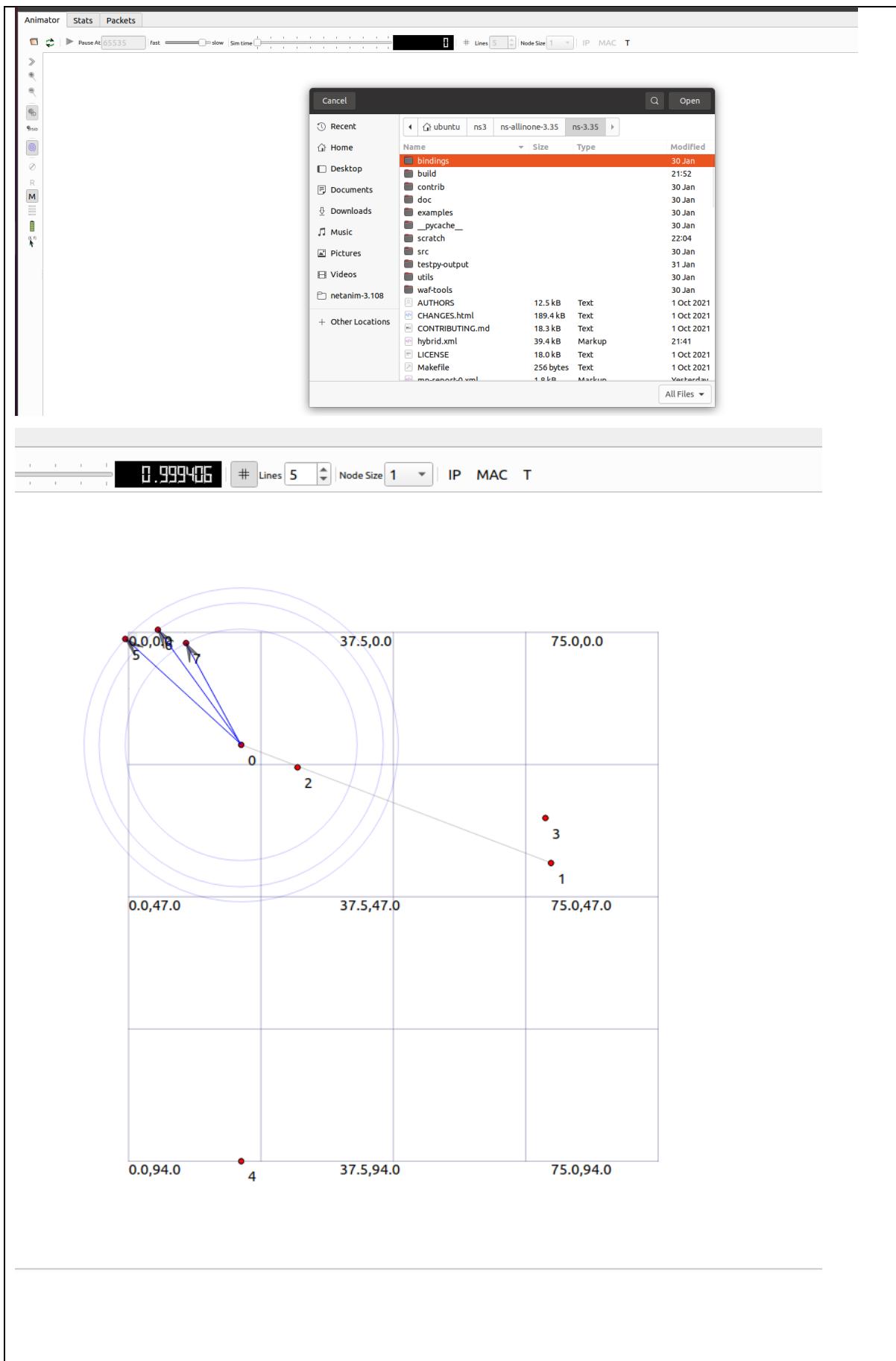
```

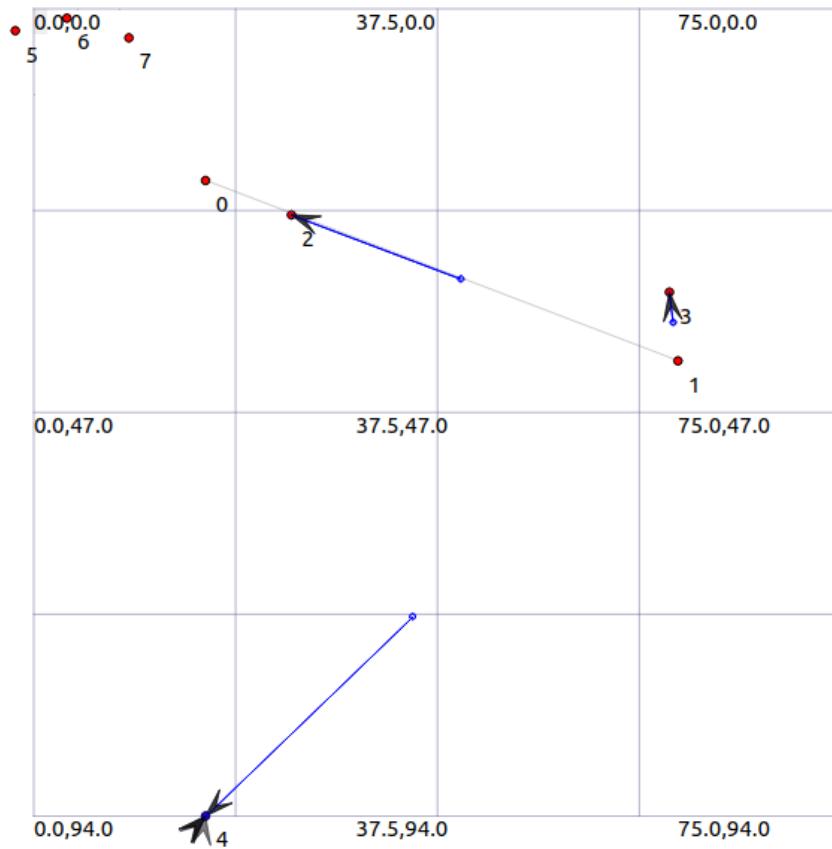
Open Netanim



Search for the Xml file created in Netanim

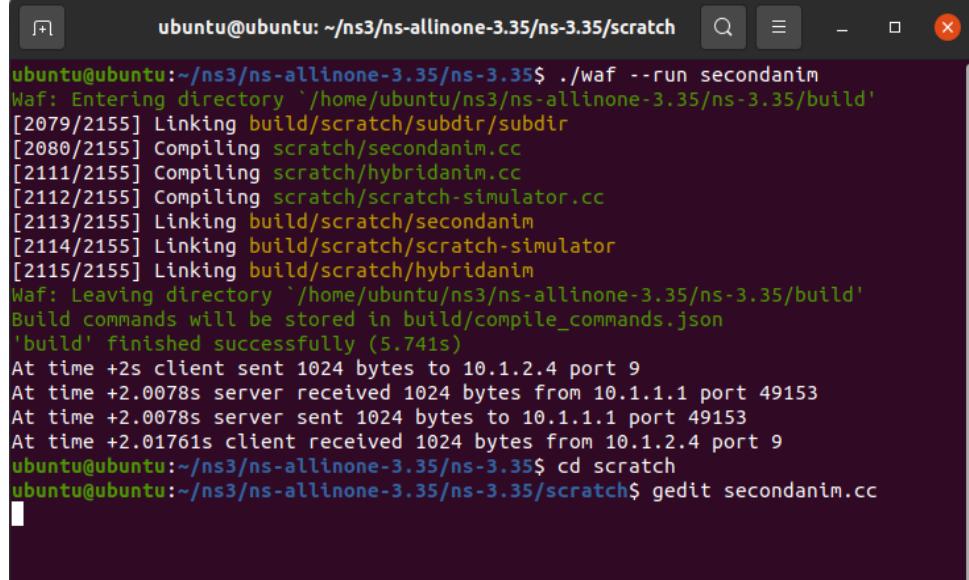
Open the file.



**For bus topology**

Copy paste third.cc to scratch folder from examples folder and rename it.

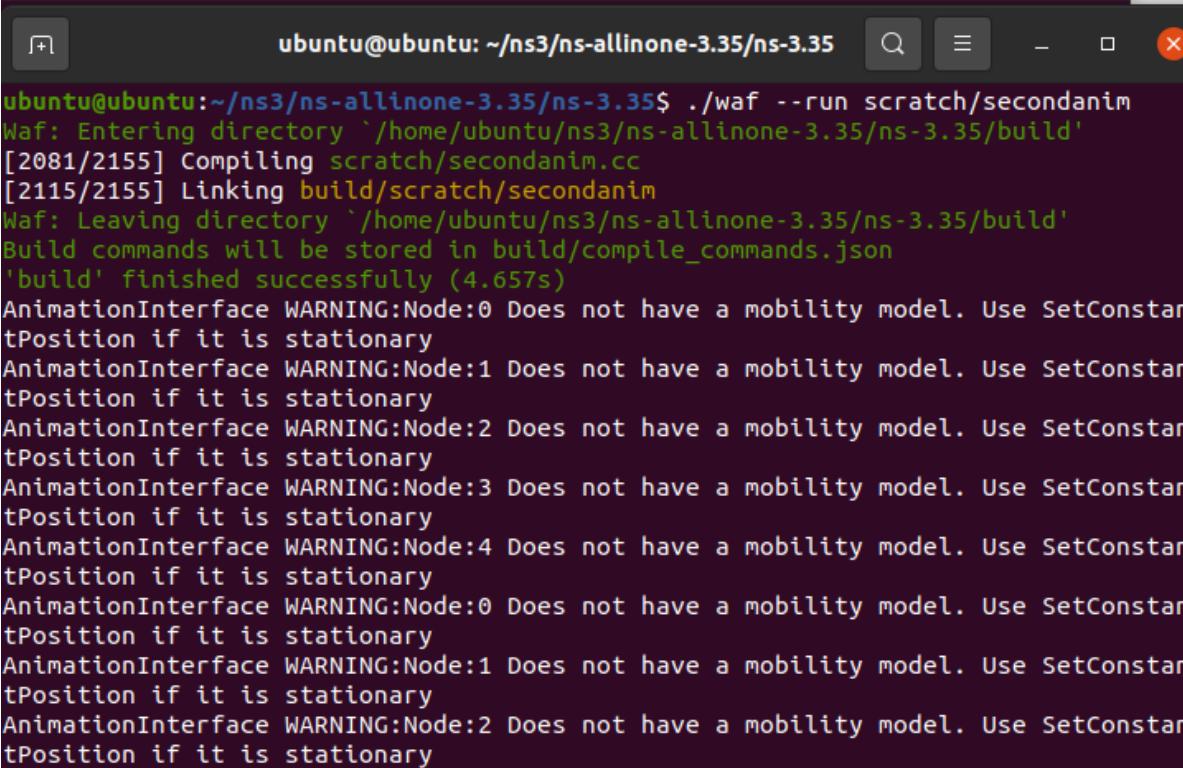
Compile the file.



```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35/scratch$ ./waf --run secondanim
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2079/2155] Linking build/scratch/subdir/subdir
[2080/2155] Compiling scratch/secondanim.cc
[2111/2155] Compiling scratch/hybridanim.cc
[2112/2155] Compiling scratch/scratch-simulator.cc
[2113/2155] Linking build/scratch/secondanim
[2114/2155] Linking build/scratch/scratch-simulator
[2115/2155] Linking build/scratch/hybridanim
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (5.741s)
At time +2s client sent 1024 bytes to 10.1.2.4 port 9
At time +2.0078s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.0078s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.01761s client received 1024 bytes from 10.1.2.4 port 9
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ cd scratch
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35/scratch$ gedit secondanim.cc
```

Make changes in the code and Also write the command to create xml file.

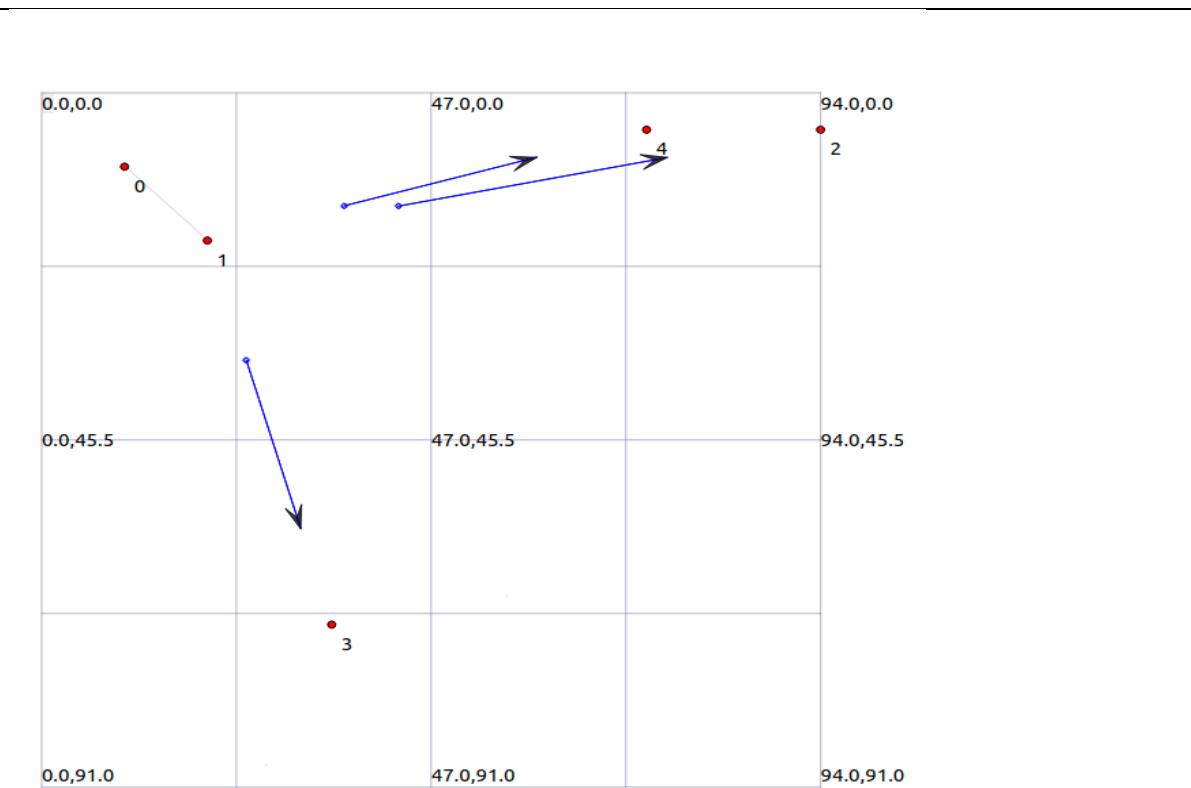
Compile the changed file



```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/secondanim
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2081/2155] Compiling scratch/secondanim.cc
[2115/2155] Linking build/scratch/secondanim
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (4.657s)
AnimationInterface WARNING:Node:0 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:1 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:2 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:3 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:4 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:0 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:1 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:2 Does not have a mobility model. Use SetConstantPosition if it is stationary
```

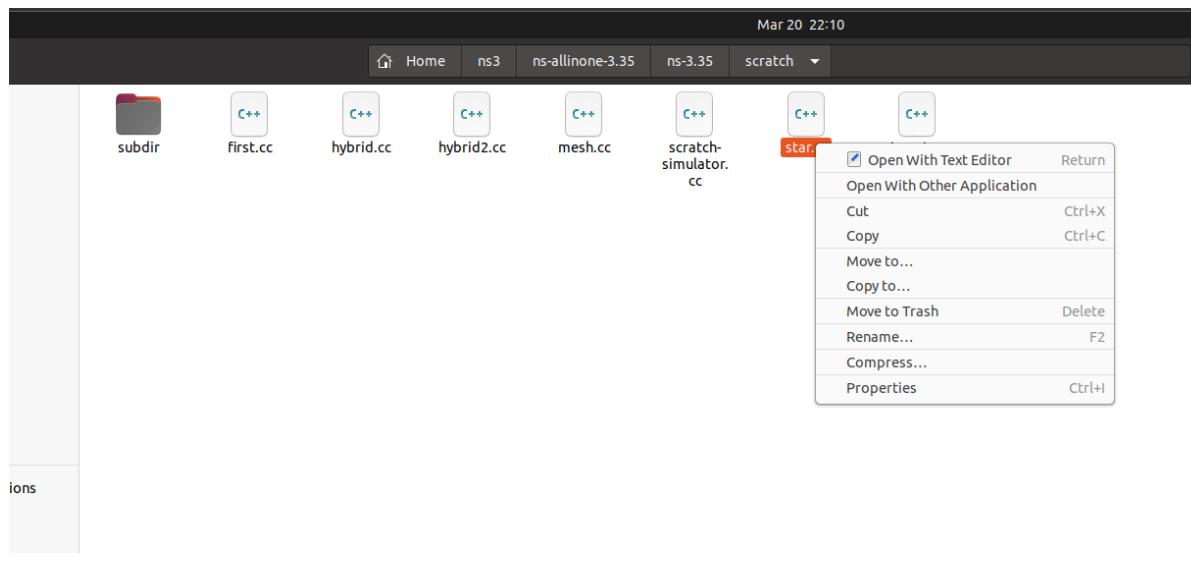
Open Netanim

Search for created xml file and open the xml file.



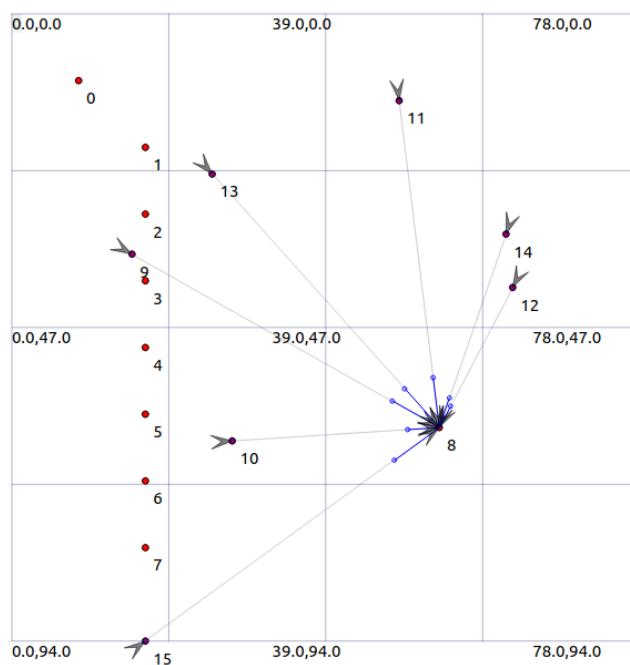
For Netanim Star Topology

Copy paste Star.cc file to scratch folder and rename it.



```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run hybridstar
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[H 2952/3034] Linking build/scratch/scratch-simulator
[2953/3034] Compiling scratch/mesh.cc
[D 2990/3034] Compiling scratch/hybrid.cc
[2991/3034] Compiling scratch/hybridstar.cc
[D 2992/3034] Linking build/scratch/mesh
[2993/3034] Linking build/scratch/hybrid
[D 2994/3034] Linking build/scratch/hybridstar
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (6.709s)
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/netanim-3.108$ ./NetAnim
```



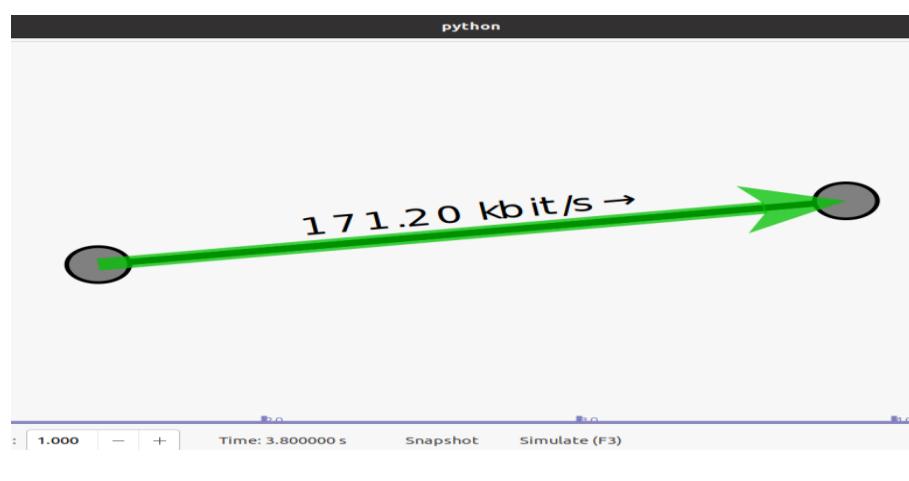
PRACTICAL NO. 8**PROGRAM:****Program to simulate UDP Client server.****CODE:****UDP (User Datagram Protocol)**

Open the ns3.35 folder and copy paste the udp-client-server file to scratch.

Compile the file.

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run udp-client-server
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2076/2161] Compiling scratch/udp-client-server.cc
[2079/2161] Linking build/scratch/subdir/subdir
[2110/2161] Linking build/scratch/mfourth
[2111/2161] Compiling scratch/secondanim.cc
[2112/2161] Compiling scratch/hybridanim.cc
[2113/2161] Compiling scratch/scratch-simulator.cc
[2114/2161] Linking build/scratch/udp-client-server
[2115/2161] Linking build/scratch/secondanim
[2116/2161] Linking build/scratch/hybridanim
[2117/2161] Linking build/scratch/scratch-simulator
[2118/2161] Compiling scratch/staranim.cc
[2119/2161] Compiling scratch/Hybrid.cc
[2120/2161] Linking build/scratch/staranim
[2121/2161] Linking build/scratch/Hybrid

ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run udp-client-server --vis
s
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.462s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python module
scanning topology: 2 nodes...
scanning topology: calling graphviz layout
scanning topology: all done.
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 0 Time: +2s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 0 Uid: 0 TXtime: +2e+09
ns RXtime: +2.01592e+09ns Delay: +1.59188e+07ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 11 Time: +2.05s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 1 Uid: 11 TXtime: +2.05
e+09ns RXtime: +2.05371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 14 Time: +2.1s
```



DES's NMITD

MCA Sem II 2024-25

NETWORKING LAB

ROLL NO: C24090

PRACTICAL NO. 9**PROGRAM:****Program to simulate DHCP Server and clients.**

DHCP stands for Dynamic Host Configuration Protocol. It is the critical feature on which the users of an enterprise network communicate. DHCP helps enterprises to smoothly manage the allocation of IP addresses to the end-user clients' devices such as desktops, laptops, cellphones.

CODE:

DHCP (Dynamic Host Configuration Protocol)

CODE:

```
/* -*- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -*- */
/*
 * Copyright (c) 2011 UPB
 * Copyright (c) 2017 NITK Surathkal
 *
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License version 2 as
 * published by the Free Software Foundation;
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 * GNU General Public License for more details.
 *
 * You should have received a copy of the GNU General Public License
 * along with this program; if not, write to the Free Software
 * Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA
 *
 * Author: Radu Lupu <rlupu@elcom.pub.ro>
 * Ankit Deepak <adadeepak8@gmail.com>
 * Deepti Rajagopal <deoptir96@gmail.com>
 *
 */
```

/*

* Network layout:

*

* R0 is a DHCP server. The DHCP server announced R1 as the default router.

* Nodes N1 will send UDP Echo packets to node A.

*

*

*

* | DHCP Clients |

* | 172.30.0.14 |

* | DHCP static |

* | |

* | | N0 | | N1 | | N2 | |

* | | A

1

*

1

1

1

1

* L | | | ↴ | 172.30.1.

* DHCP Server | | | |

*

* | R0

|————| R1

```
* ┌─────────┐ ┌─────────┐ 172.30.1.1
```

```
* 172.30.0.12 172.30.0.17
```

```
*
```

```
* Things to notice:
```

```
* 1) The routes in A are manually set to have R1 as the default router,
```

```
* just because using a dynamic outing in this example is an overkill.
```

```
* 2) R1's address is set statically though the DHCP server helper interface.
```

```
* This is useful to prevent address conflicts with the dynamic pool.
```

```
* Not necessary if the DHCP pool is not conflicting with static addresses.
```

```
* 3) N2 has a dynamically-assigned, static address (i.e., a fixed address assigned via  
DHCP).
```

```
*
```

```
*/
```

```
#include "ns3/core-module.h"  
#include "ns3/internet-apps-module.h"  
#include "ns3/csma-module.h"  
#include "ns3/internet-module.h"  
#include "ns3/point-to-point-module.h"  
#include "ns3/applications-module.h"
```

```
//netanim code
```

```
#include "ns3/netanim-module.h"  
#include "ns3/mobility-module.h"
```

```
using namespace ns3;
```

```
NS_LOG_COMPONENT_DEFINE ("DhcpExample");
```

```
int
```

```
main (int argc, char *argv[])
```

```
{
```

```
CommandLine cmd ( FILE );
```

```
bool verbose = false;
```

```
bool tracing = false;
cmd.AddValue ("verbose", "turn on the logs", verbose);
cmd.AddValue ("tracing", "turn on the tracing", tracing);

cmd.Parse (argc, argv);
// GlobalValue::Bind ("ChecksumEnabled", BooleanValue (true));
if (verbose)
{
    LogComponentEnable ("DhcpServer", LOG_LEVEL_ALL);
    LogComponentEnable ("DhcpClient", LOG_LEVEL_ALL);
    LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
    LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
}

Time stopTime = Seconds (20);

NS_LOG_INFO ("Create nodes.");
NodeContainer nodes;
NodeContainer router;
nodes.Create (3);
router.Create (2);

NodeContainer net (nodes, router);

NS_LOG_INFO ("Create channels.");
CsmaHelper csma;

csma.SetChannelAttribute ("DataRate", StringValue ("5Mbps"));
csma.SetChannelAttribute ("Delay", StringValue ("2ms"));
csma.SetDeviceAttribute ("Mtu", UIntegerValue (1500));
NetDeviceContainer devNet = csma.Install (net);

NodeContainer p2pNodes;
```

```
p2pNodes.Add (net.Get (4));  
p2pNodes.Create (1);  
  
PointToPointHelper pointToPoint;  
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));  
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));  
  
NetDeviceContainer p2pDevices;  
p2pDevices = pointToPoint.Install (p2pNodes);  
  
InternetStackHelper tcpip;  
tcpip.Install (nodes);  
tcpip.Install (router);  
tcpip.Install (p2pNodes.Get (1));  
  
Ipv4AddressHelper address;  
address.SetBase ("172.30.1.0", "255.255.255.0");  
Ipv4InterfaceContainer p2pInterfaces;  
p2pInterfaces = address.Assign (p2pDevices);  
  
// manually add a routing entry because we don't want to add a dynamic routing  
Ipv4StaticRoutingHelper ipv4RoutingHelper;  
Ptr<Ipv4> ipv4Ptr = p2pNodes.Get (1)->GetObject<Ipv4> ();  
Ptr<Ipv4StaticRouting> staticRoutingA = ipv4RoutingHelper.GetStaticRouting  
(ipv4Ptr);  
staticRoutingA->AddNetworkRouteTo (Ipv4Address ("172.30.0.0"), Ipv4Mask ("/24"),  
Ipv4Address ("172.30.1.1"), 1);  
  
NS_LOG_INFO ("Setup the IP addresses and create DHCP applications.");  
DhcpHelper dhcpHelper;  
  
// The router must have a fixed IP.
```

```
Ipv4InterfaceContainer fixedNodes = dhcpHelper.InstallFixedAddress (devNet.Get (4),
Ipv4Address ("172.30.0.17"), Ipv4Mask ("/24"));
// Not really necessary, IP forwarding is enabled by default in IPv4.
fixedNodes.Get (0).first->SetAttribute ("IpForward", BooleanValue (true));

// DHCP server
ApplicationContainer dhcpServerApp = dhcpHelper.InstallDhcpServer (devNet.Get (3),
Ipv4Address ("172.30.0.12"),
("/24"),
("172.30.0.15"),
Ipv4Address ("172.30.0.0"), Ipv4Mask

Ipv4Address ("172.30.0.10"), Ipv4Address

Ipv4Address ("172.30.0.17"));

// This is just to show how it can be done.
DynamicCast<DhcpServer> (dhcpServerApp.Get (0))->AddStaticDhcpEntry
(devNet.Get (2)->GetAddress (), Ipv4Address ("172.30.0.14"));

dhcpServerApp.Start (Seconds (0.0));
dhcpServerApp.Stop (stopTime);

// DHCP clients
NetDeviceContainer dhcpClientNetDevs;
dhcpClientNetDevs.Add (devNet.Get (0));
dhcpClientNetDevs.Add (devNet.Get (1));
dhcpClientNetDevs.Add (devNet.Get (2));

ApplicationContainer dhcpClients = dhcpHelper.InstallDhcpClient
(dhcpClientNetDevs);
dhcpClients.Start (Seconds (1.0));
```

```
dhcpClients.Stop (stopTime);

UdpEchoServerHelper echoServer (9);

ApplicationContainer serverApps = echoServer.Install (p2pNodes.Get (1));
serverApps.Start (Seconds (0.0));
serverApps.Stop (stopTime);

UdpEchoClientHelper echoClient (p2pInterfaces.GetAddress (1), 9);

echoClient.SetAttribute ("MaxPackets", UintegerValue (100));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

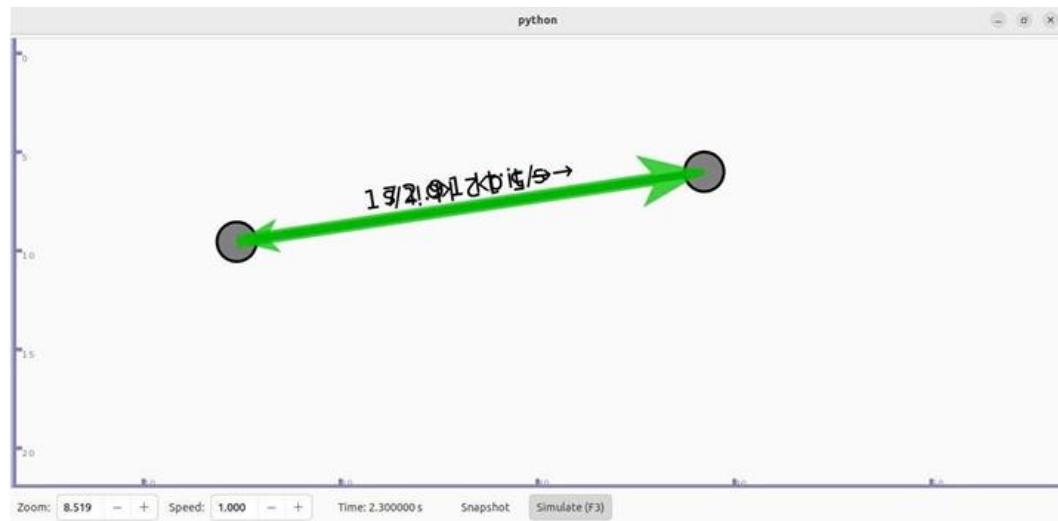
ApplicationContainer clientApps = echoClient.Install (nodes.Get (1));
clientApps.Start (Seconds (10.0));
clientApps.Stop (stopTime);

MobilityHelper mobility;
mobility.SetMobilityModel("ns3::ConstantPositionMobilityModel");
mobility.Install(nodes);

AnimationInterface anim("pranay.xml");
AnimationInterface::SetConstantPosition(nodes.Get(0),10,25);
AnimationInterface::SetConstantPosition(nodes.Get(1),40,25);
anim.EnablePacketMetadata(true);

Simulator::Stop (stopTime + Seconds (10.0));
if (tracing)
{
    csma.EnablePcapAll ("dhcp-csma");
    pointToPoint.EnablePcapAll ("dhcp-p2p");
}
```

```
NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
}
```

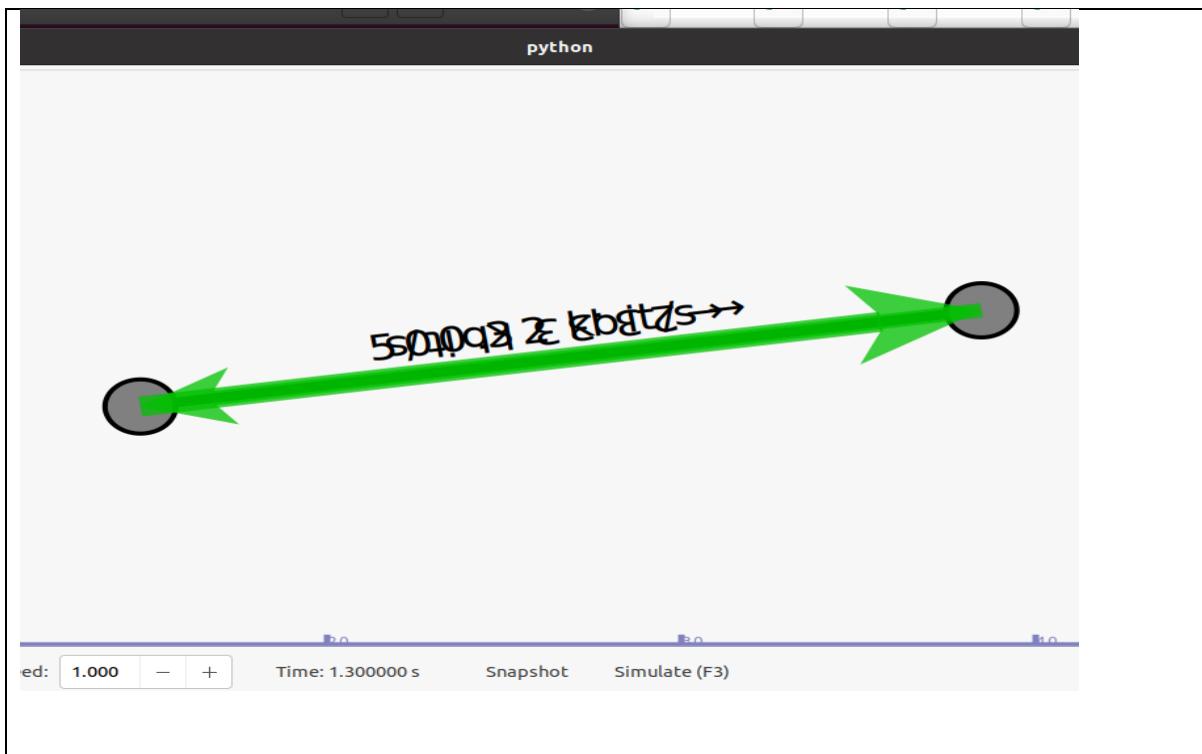


PRACTICAL NO. 10**PROGRAM:****Program to simulate FTP using TCP****CODE:**

FTP (File Transfer Protocol) is a standard network protocol used to transfer files between a client and a server over a TCP/IP network. It allows users to upload, download, rename, delete, and manage files on a remote server. FTP requires authentication (username and password) but can also allow anonymous access. While it is widely used, FTP is not secure by default, so secure versions like FTPS or SFTP (which uses SSH) are preferred for sensitive data.

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run tcp-bulk-send
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2091/2165] Linking build/scratch/scratch-simulator
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.255s)
Total Bytes Received: 553152
```

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run tcp-bulk-send --vis
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.458s)
Could not load plugin 'show_last_packets.py': No module named 'kiwi'
Could not load icon applets-screenshooter due to missing gnomedesktop Python module
scanning topology: 2 nodes...
scanning topology: calling graphviz layout
scanning topology: all done.
/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/src/visualizer/visualizer/core.py:1481
: Warning: Source ID 185 was not found when attempting to remove it
    GLib.source_remove(self._update_timeout_id)
Total Bytes Received: 78256
```



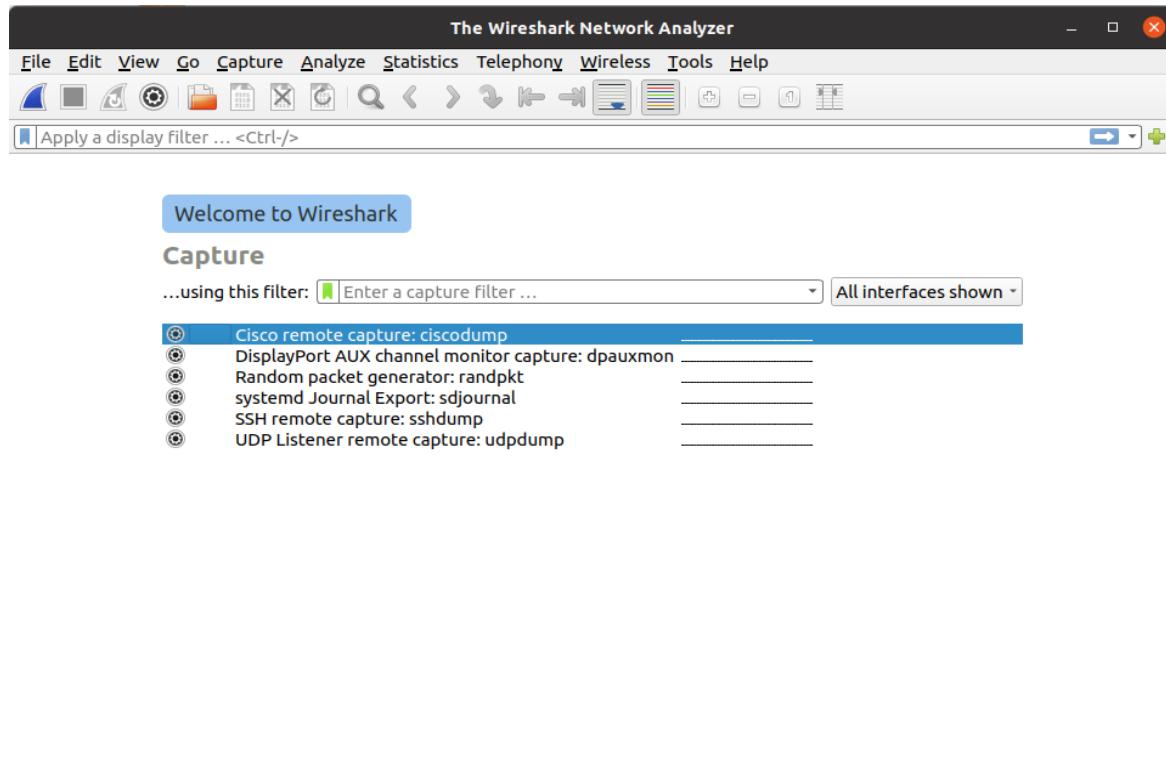
PRACTICAL NO. 11

PROGRAM:

Exercises for analyzing the network protocols using Wireshark.

CODE:

Open Wireshark.



Learn

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You are running Wireshark 3.2.3 (Git v3.2.3 packaged as 3.2.3-1).

Apply filters to analyze various network protocols

No.	Time	Source	Destination	Protocol	Length	Info
31404	234.471637	40.126.17.135	192.168.53.72	TCP	60	443 → 50938 [RST] Seq=15
31405	234.516746	192.168.55.211	224.0.0.251	MDNS	136	Standard query 0x0000 SF
31406	234.558649	192.168.55.60	224.0.0.251	MDNS	737	Standard query 0x0000 SF
31407	234.559098	GrandstreamN_ac:66:...	Broadcast	Ethernet...	500	Ethernet II
31408	234.610058	192.168.53.72	51.89.106.29	TCP	597	50555 → 8080 [PSH, ACK]
31409	234.621082	Cisco_89:f7:db	Spanning-tree-(for-...)	STP	60	Conf. Root = 32768/0/0:
31410	234.675295	fe80::c478:e6ff:fe8... ff02::2		ICMPv6	70	Router Solicitation from
31411	234.711650	LiteON_49:4d:e1	Broadcast	ARP	60	Who has 192.168.52.7? Te
31412	234.728547	GrandstreamN_55:aa:...	Broadcast	Ethernet...	564	Ethernet II
31413	234.737331	51.89.106.29	192.168.53.72	TCP	60	8080 → 50555 [ACK] Seq=2
31414	234.755986	192.168.55.53	224.0.0.251	MDNS	116	Standard query 0x0000 TD
31415	234.761205	GrandstreamN_ac:66:...	Broadcast	Ethernet...	500	Ethernet II
31416	234.776136	Sophos 02:4h:00	Broadcast	ARP	60	Who has 192.168.54.74?

No.	Time	Source	Destination	Protocol	Length	Info
48	1.508750	192.168.54.96	192.168.54.148	TCP	66	50355 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
49	1.508844	192.168.54.148	192.168.54.96	TCP	66	7680 → 50355 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
67	1.868482	192.168.54.96	192.168.54.148	TCP	66	50364 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
68	1.868568	192.168.54.148	192.168.54.96	TCP	66	7680 → 50364 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
102	2.313083	192.168.54.148	192.168.52.102	TCP	66	42649 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
137	3.142404	192.168.54.96	192.168.54.148	TCP	66	50374 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
138	3.142525	192.168.54.148	192.168.54.96	TCP	66	7680 → 50374 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
203	4.221644	192.168.54.96	192.168.54.148	TCP	66	50383 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
204	4.221757	192.168.54.148	192.168.54.96	TCP	66	7680 → 50383 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
226	4.764469	192.168.54.96	192.168.54.148	TCP	66	50392 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
227	4.764552	192.168.54.148	192.168.54.96	TCP	66	7680 → 50392 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
365	8.815837	192.168.54.96	192.168.54.148	TCP	66	50405 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
366	8.815922	192.168.54.148	192.168.54.96	TCP	66	7680 → 50405 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
826	12.444981	192.168.54.96	192.168.54.148	TCP	66	50414 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
829	12.445026	192.168.54.148	192.168.54.96	TCP	66	7680 → 50414 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
3319	27.298148	192.168.54.148	192.168.53.228	TCP	66	42897 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
3328	27.292485	192.168.53.228	192.168.54.148	TCP	66	7680 → 42057 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
3842	39.296808	192.168.53.34	192.168.54.154	TCP	66	57480 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
3906	40.612869	192.168.53.34	192.168.54.148	TCP	66	57488 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
3907	40.612181	192.168.54.148	192.168.53.34	TCP	66	7680 → 57488 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
4052	44.862188	52.172.165.247	192.168.52.10	TCP	74	8086 → 40934 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1440 WS=256 SACK_PERM TSval=1659
4363	50.398263	192.168.54.1	192.168.54.148	TCP	66	52230 → 7680 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
4364	50.398378	192.168.54.148	192.168.54.1	TCP	66	7680 → 52230 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
4365	50.399899	192.168.54.1	192.168.54.148	TCP	66	52231 → 7680 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
4366	50.399154	192.168.54.148	192.168.54.1	TCP	66	7680 → 52231 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
4885	67.304319	192.168.54.148	192.168.53.228	TCP	66	42058 → 7680 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM
4886	67.307459	192.168.53.228	192.168.54.148	TCP	66	7680 → 42058 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 SACK_PERM

Capturing packets while visiting a site.

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Capturing from Ethernet

No. Time Source Destination Protocol Length Info

545 146.75.118.172 192.168.54.154 HTTP 298 HTTP/1.1 384 Not Modified

546 146.75.118.172 23.9.220.6 HTTP 288 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D HTTP/1.1

2182 42.680926 192.168.53.72 OCSP 464 Response

2182 42.677287 23.9.220.6 HTTP 288 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D HTTP/1.1

2182 42.689542 192.168.53.72 OCSP 965 Response

7887 144.282161 192.168.53.72 HTTP 465 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D HTTP/1.1

142.251.42.46 192.168.53.72 HTTP 404 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D HTTP/1.1

16091 166.459565 fe80::e50c:d4ff:1bc671b5c HTTP 248 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-bin) HTTP/1.1

16094 166.466923 fe80::14af:1bc671b5c.. fe80::e50c:d4ff:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10794 166.469511 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10793 166.487786 fe80::e50c:d4ff:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

16786 166.489998 fe80::14af:1bc671b5c.. fe80::e50c:d4ff:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10797 166.503096 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10798 166.517881 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10711 166.518461 fe80::14af:1bc671b5c.. fe80::e50c:d4ff:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10717 166.531248 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10721 166.548419 fe80::e50c:d4ff:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10722 166.548419 fe80::e50c:d4ff:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10723 166.550668 fe80::14af:1bc671b5c.. fe80::e50c:d4ff:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10724 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10725 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10726 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10727 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10728 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10729 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10730 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10731 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

10732 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 241 GET /?Fu7zBmEw5tTAj3grOgIgGua887fqlsJkLEzQ2P1mBzCzdqIqVYmQjsT7QaP4v8cB1jmgggC72hKbMCzALBewkS5g%9o2jBr5NzBTvB83D (application/x-unknown)

10733 166.553790 fe80::14af:1bc671b5c.. fe80::14af:1bc671b5c.. HTTP 404 HTTP/1.1 200 OK (application/x-unknown)

Frame 545: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface **l0DeviceNWP_180CC039F-DEAF-41E3-A209-0782C8660000**

> Ethernet II, Src: Sophos_02:4b:00 (ch14f:86:02:4b:00), Dst: EliteGroupCo_34:61:90 (08:0e:dd:34:61:90)

> Internet Protocol Version 4, Src: 146.75.118.172, Dst: 192.168.54.154

> Transmission Control Protocol, Src Port: 80, Dst Port: 53484, Seq: 1, Ack: 1, Len: 236

> Hypertext Transfer Protocol

Frame 545: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface **l0DeviceNWP_180CC039F-DEAF-41E3-A209-0782C8660000**

0000 88 ee dd 34 4e 98 c8 4f 86 92 4b 98 00 00 45 90 .. :40 - O - K - E

0001 01 14 f9 d4 48 00 40 06 1a 46 92 4b 76 ac c9 a8 .. :d9 @ F - Kv ..

0002 36 9a 60 50 00 00 00 00 00 00 00 00 00 00 00 00 .. :04 N m offile ..

0003 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :D - HT Tr/l1.3

0004 30 34 20 40 67 75 20 4d 67 64 69 66 69 65 64 6d .. :04 Nc m offile ..

0005 0a 44 61 40 65 3d 20 54 75 63 2c 28 32 39 20 41 .. :Date, T ure, 29 A

0006 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0007 20 47 4d 54 00 00 56 69 61 3a 28 31 2e 31 20 76 .. :GHT - Vl a: 1.1 v

0008 61 72 6e 69 73 68 2c 28 48 54 54 59 2f 31 2e 31 .. :anilin .. HTTP/1.1

0009 67 68 3a 2e 31 30 32 32 38 84 58 2d 56 61 72 6e .. :oxy:3128 .. X-Varn

0010 68 73 68 3a 2e 31 30 32 32 31 36 38 36 33 34 8d 1d .. :Cach .. Cache ..

0011 70 75 62 6e 69 63 2c 6d 61 78 28 61 67 65 3d 39 .. :public .. av-age=9

0012 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 Tag : '8dcfc

0013 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0014 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0015 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0016 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0017 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0018 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0019 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0021 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0022 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0023 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0024 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0025 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0026 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0027 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0028 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0029 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .. :00 00 00 00 00 00 00 00 ..

Frame 545: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface **l0DeviceNWP_180CC039F-DEAF-41E3-A209-0782C8660000**

> Ethernet II, Src: Sophos_02:4b:00 (ch14f:86:02:4b:00), Dst: EliteGroupCo_34:61:90 (08:0e:dd:34:61:90)

> Internet Protocol Version 4, Src: 146.75.118.172, Dst: 192.168.54.154

> Transmission Control Protocol, Src Port: 80, Dst Port: 53484, Seq: 1, Ack: 1, Len: 236

> Hypertext Transfer Protocol

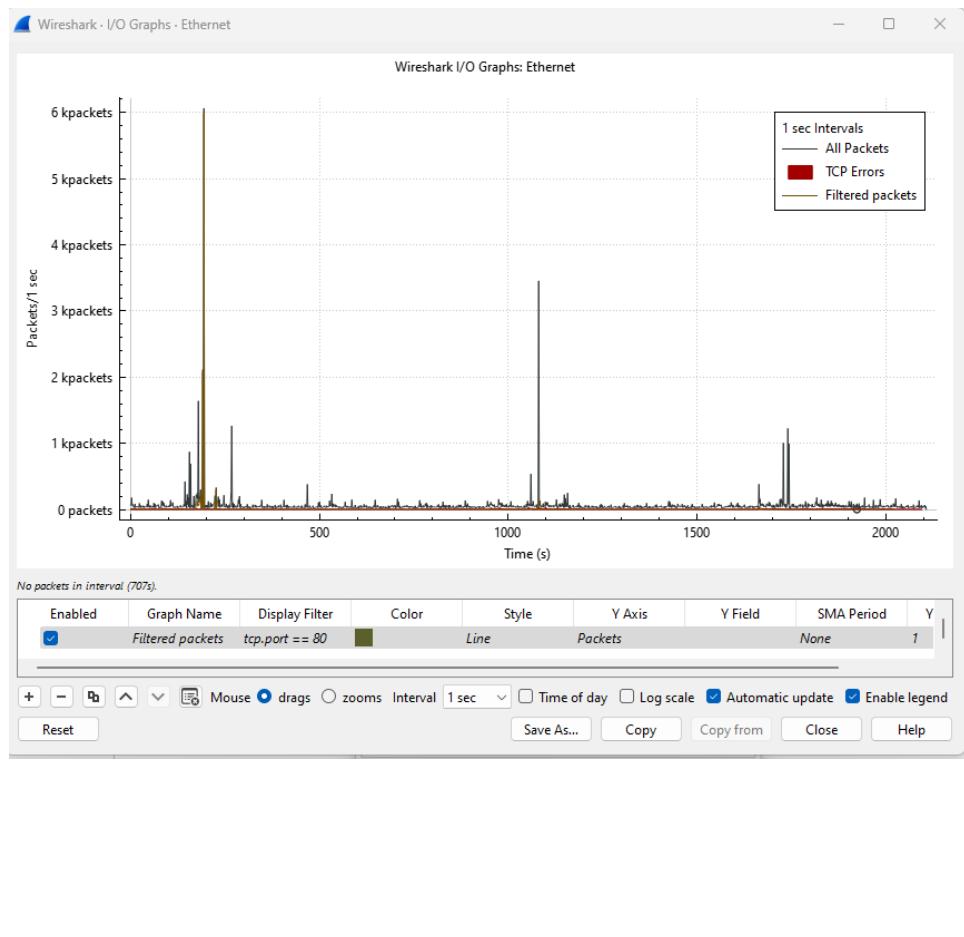
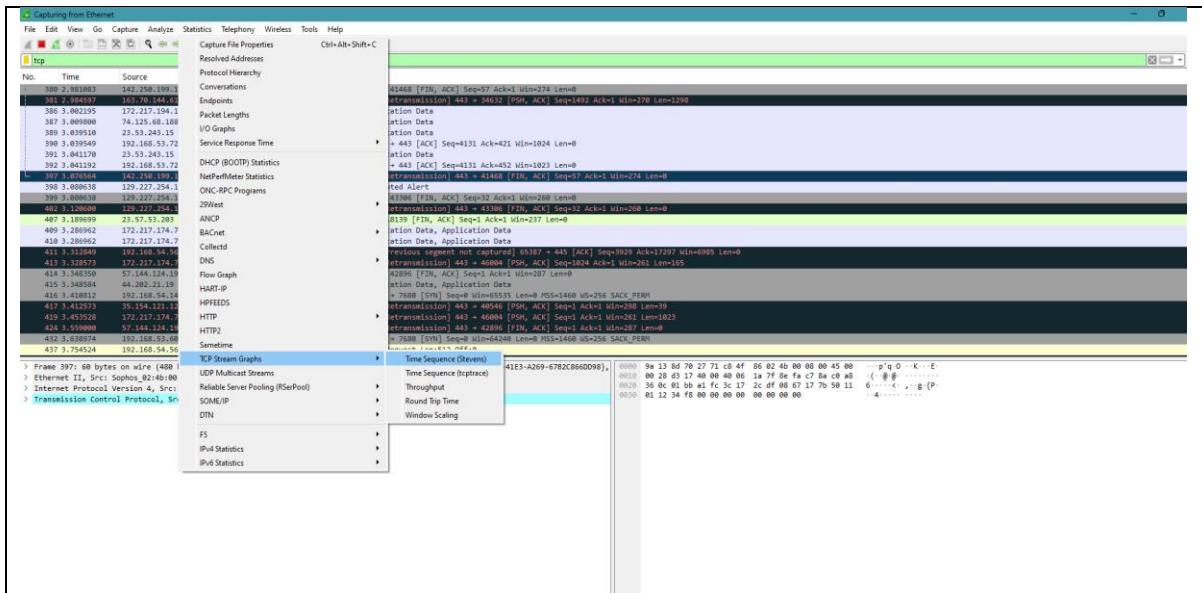
Frame 545: 290 bytes on wire (2320 bits), 290 bytes captured (2320 bits) on interface **l0DeviceNWP_180CC039F-DEAF-41E3-A209-0782C8660000**

0000 ff ff ff ff ff ff 70 1f 53 df fd 39 c0 a8 36 2c p S 9 -

0001 00 00 00 04 00 01 70 1f 53 df fd 39 c0 a8 36 2c p S 9 -

0002 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 4

0003 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00



PRACTICAL NO. 12**PROGRAM:**

Evaluate the performance matrices: throughput, delay, response time, packet loss etc.

CODE:

Open ns 3.35 ,Go to examples→tutorial and copy first.cc file.

Paste this file in scratch folder and rename it.

Make the changes in code using gedit command and then compile the code.

CODE:

```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/flow-monitor.h"
#include "ns3/flow-monitor-helper.h"
#include "ns3/traffic-control-module.h"
#include "ns3/ipv4-flow-classifier.h" // Added missing header
```

```
using namespace ns3;
```

```
NS_LOG_COMPONENT_DEFINE ("demo");
```

```
int main (int argc, char *argv[])
{
    CommandLine cmd (__FILE__);
    cmd.Parse (argc, argv);
```

```
Time::SetResolution (Time::NS);
```

```
NodeContainer nodes;
nodes.Create (2);
```

```
PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));

NetDeviceContainer devices;
devices = pointToPoint.Install (nodes);

InternetStackHelper stack;
stack.Install (nodes);

Ipv4AddressHelper address;
address.SetBase ("10.1.1.0", "255.255.255.0");

Ipv4InterfaceContainer interfaces = address.Assign (devices);

uint16_t port = 9; // Fixed typo
UdpEchoServerHelper echoServer (port);

ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));

UdpEchoClientHelper echoClient (interfaces.GetAddress (1), port);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));

bool tracing = true; // Added tracing variable
FlowMonitorHelper flowHelper;
```

```
Ptr<FlowMonitor> monitor = flowHelper.InstallAll();

Simulator::Stop(Seconds(10.0));

if (tracing) {
    pointToPoint.EnablePcapAll("p2p"); // Fixed missing semicolon
}

Simulator::Run ();
monitor->CheckForLostPackets();

Ptr<Ipv4FlowClassifier> classifier =
DynamicCast<Ipv4FlowClassifier>(flowHelper.GetClassifier());
std::map<FlowId, FlowMonitor::FlowStats> stats = monitor->GetFlowStats();

for (auto iter = stats.begin(); iter != stats.end(); ++iter) {
    Ipv4FlowClassifier::FiveTuple t = classifier->FindFlow(iter->first); // Fixed declaration
of t
    double duration = iter->second.timeLastRxPacket.GetSeconds() - iter-
>second.timeFirstTxPacket.GetSeconds();
    double throughput = (iter->second.rxBytes * 8.0) / duration / 1000000.0; // Mbps
    double avgDelay = (iter->second.rxPackets > 0) ? (iter->second.delaySum.GetSeconds() /
iter->second.rxPackets) : 0;

    std::cout << "Flow " << iter->first << " (" << t.sourceAddress << " -> " <<
t.destinationAddress << ")\n";
    std::cout << " Tx Packets: " << iter->second.txPackets << "\n";
    std::cout << " Rx Packets: " << iter->second.rxPackets << "\n";
    std::cout << " Packet Loss: " << (iter->second.txPackets - iter->second.rxPackets) <<
"\n";
    std::cout << " Delay Sum: " << iter->second.delaySum.GetSeconds() << " s\n";
    std::cout << " Response Time: " << avgDelay << " s\n";
    std::cout << " Dropped Packets: " << iter->second.lostPackets << "\n";
```

```
    std::cout << " Throughput: " << throughput << " Mbps\n";
}

Simulator::Destroy();

return 0;
}
```

```
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$ ./waf --run scratch/Performance-Metrics.cc
Waf: Entering directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
[2086/2169] Linking build/scratch/second
[2087/2169] Linking build/scratch/udp-client-server
[2089/2169] Linking build/scratch/subdir/subdir
[2091/2169] Linking build/scratch/tcp-bulk-send
[2096/2169] Linking build/scratch/mfourth
[2097/2169] Linking build/scratch/secondanim
[2098/2169] Linking build/scratch/hybridanim
[2099/2169] Linking build/scratch/scratch-simulator
[2100/2169] Linking build/scratch/udp-trace-client-server
[2101/2169] Linking build/scratch/staranim
[2102/2169] Linking build/scratch/Hybrid
[2103/2169] Linking build/utils/ns3.35-bench-packets-debug
[2104/2169] Compiling scratch/Performance-Metrics.cc
[2105/2169] Compiling utils/print-introspected-doxygen.cc
[2106/2169] Compiling src/core/bindings/core.py
[2107/2169] Linking build/utils/ns3.35-print-introspected-doxygen-debug
[2108/2169] Compiling build/src/visualizer/visualizer/_/__pycache__/core.cpython-3
8.pyc
[2109/2169] Compiling build/src/visualizer/visualizer/_/__pycache__/base.cpython-3
8.pyc
```

```
Waf: Leaving directory `/home/ubuntu/ns3/ns-allinone-3.35/ns-3.35/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (8.684s)
Flow 1 (10.1.1.1 -> 10.1.1.2)
Tx Packets: 1
Rx Packets: 1
Packet Loss: 0
Delay Sum: 0.0036864 s
Response Time: 0.0036864 s
Dropped Packets: 0
Throughput: 2.28299 Mbps
Flow 2 (10.1.1.2 -> 10.1.1.1)
Tx Packets: 1
Rx Packets: 1
Packet Loss: 0
Delay Sum: 0.0036864 s
Response Time: 0.0036864 s
Dropped Packets: 0
Throughput: 2.28299 Mbps
ubuntu@ubuntu:~/ns3/ns-allinone-3.35/ns-3.35$
```

PRACTICAL NO. 13**Group Project****PROGRAM:****DYNAMIC HOST CONFIGURATION PROTOCOL (DHCP) SIMULATION AND ANALYSIS****CODE:****1. Introduction**

Dynamic Host Configuration Protocol (DHCP) is a network management protocol used to automate the process of configuring devices on IP networks. It assigns IP addresses and other network configuration parameters dynamically, reducing the need for manual intervention by a network administrator.

2. Objectives

- To simulate the working of DHCP in a controlled network environment.
- To analyze the behavior of DHCP under various scenarios such as multiple clients, address exhaustion, and lease expiration.
- To understand the communication flow between DHCP server and clients.

3. Tools Used

- Simulation Software: NS-3
- System Requirements:
- OS: Windows/Linux
- RAM: 4 GB minimum
- Processor: Dual Core or higher
- Recording Tool: Snipping Tool Recording

4. Working Principle

DHCP works on a client-server model and operates using the DORA process:

1. Discover: Client broadcasts a request to find a DHCP server.
2. Offer: DHCP server offers an IP address to the client.
3. Request: Client requests the offered IP address.

4. Acknowledge: Server sends an acknowledgment confirming the lease.

5. Simulation Steps

1. Set up a network with:

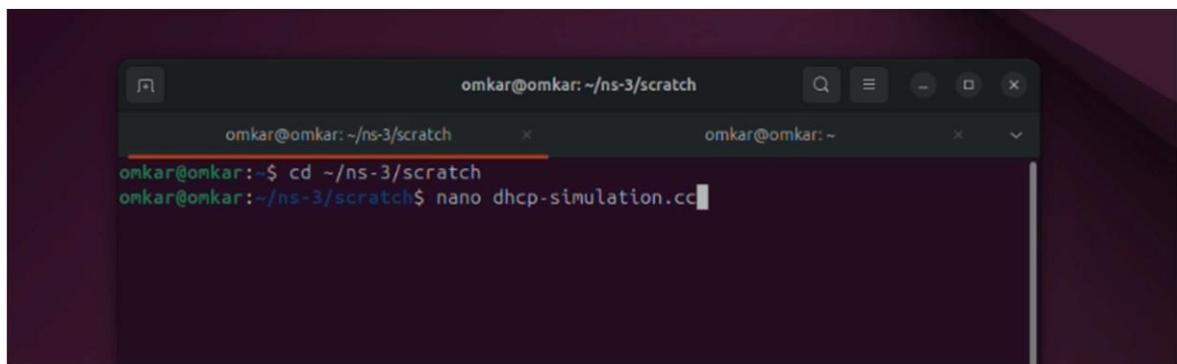
- DHCP Server
- Multiple Client Devices (PCs)
- Switches/Routers (if needed)

Create a New Script

bash

cd ~/ns-3/scratch

nano dhcp-simulation.cc



```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"

using namespace ns3;

NS_LOG_COMPONENT_DEFINE("DhcpSimulation");

int main (int argc, char *argv[])
{
    Time::SetResolution (Time::NS);
    LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
    LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);

    NodeContainer nodes;
```

```
nodes.Create(2); // Client and Server

PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute("DataRate", StringValue("5Mbps"));
pointToPoint.SetChannelAttribute("Delay", StringValue("2ms"));

NetDeviceContainer devices;
devices = pointToPoint.Install(nodes);

InternetStackHelper stack;
stack.Install(nodes);

Ipv4AddressHelper address;
address.SetBase("10.1.1.0", "255.255.255.0");

Ipv4InterfaceContainer interfaces = address.Assign(devices);

UdpEchoServerHelper echoServer(9); // Port 9

ApplicationContainer serverApps = echoServer.Install(nodes.Get(1));
serverApps.Start(Seconds(1.0));
serverApps.Stop(Seconds(10.0));

UdpEchoClientHelper echoClient(interfaces.GetAddress(1), 9);
echoClient.SetAttribute("MaxPackets", UintegerValue(1));
echoClient.SetAttribute("Interval", TimeValue(Seconds(1.0)));
echoClient.SetAttribute("PacketSize", UintegerValue(1024));

ApplicationContainer clientApps = echoClient.Install(nodes.Get(0));
clientApps.Start(Seconds(2.0));
clientApps.Stop(Seconds(10.0));

Simulator::Run ();
Simulator::Destroy ();
return 0;
}
```

Build and Run Script

```
cd ~/ns-3  
./ns3 build  
./ns3 run scratch/dhcp-simulation
```

2. Configure the DHCP Server:

- Define IP address pool

- Set lease duration

- Configure default gateway and DNS

3. On client systems, set IP configuration to “DHCP”.**4. Start the simulation and observe the DHCP DORA process.****5. Capture the packet flow and analyze lease distribution.****6. Analysis**

- IP Assignment Observation: Each client received a unique IP.

- Lease Expiry: IP release and renewal observed during simulation.

- Address Exhaustion: DHCP server denied requests when pool exhausted.

- Network Delay: DORA process took approximately 1 minute 49 seconds to complete.

7. Results

- Successfully simulated DHCP operation with multiple clients.

- Verified efficient IP distribution and lease handling.

- Observed issues when IP pool was exhausted.

- DORA process completed successfully in average time.

```
Position is stationary
AnimationInterface WARNING:Node:0 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:1 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9
omkar@omkar:~/ns-3$ 

omkar@omkar:~/.ns-3
omkar@omkar:~/.ns-3/scratch
omkar@omkar:~/.ns-3/scratch$ nano dhcp-simulation.cc
omkar@omkar:~/.ns-3/scratch$ cd ~/ns-3
omkar@omkar:~/ns-3$ ./ns3 build
[ 0%] Building CXX object scratch/CMakeFiles/scratch_dhcp-simulation.dir/dhcp-s
imulation.cc.o
[ 0%] Linking CXX executable /home/omkar/ns-3/build/scratch/ns3-dev-dhcp-simula
tion-default
Finished executing the following commands:
/usr/bin/cmake --build /home/omkar/ns-3/cmake-cache -j 3
omkar@omkar:~/ns-3$ ./ns3 run scratch/dhcp-simulation
AnimationInterface WARNING:Node:0 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
AnimationInterface WARNING:Node:1 Does not have a mobility model. Use SetConstan
tPosition if it is stationary
```