Practical No: 1

Aim:- Installation of NS-3 in Linux

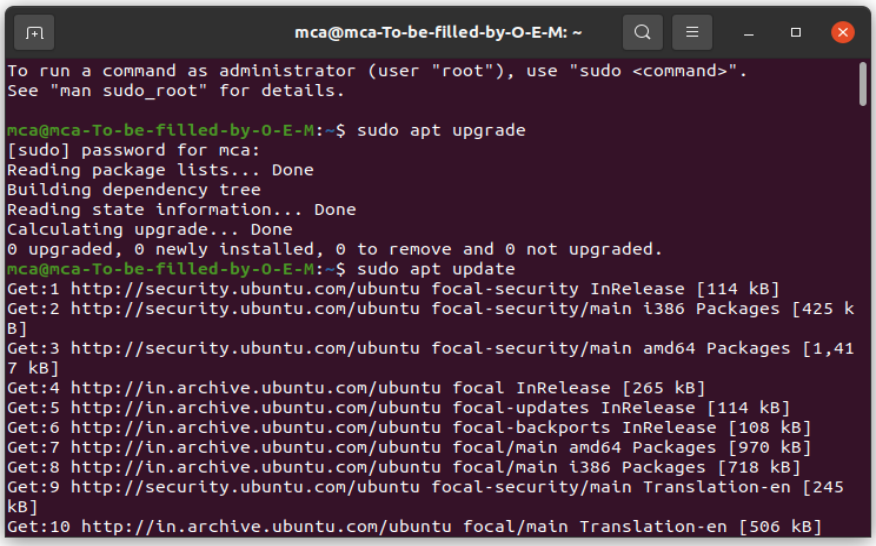
Objective: To learn to Install NS3 in Ubuntu Linux.

Theory: NS-3 has been developed to provide an open, extensible network simulation platform, for networking research and education. In brief, ns-3 provides models of how packet data networks work and perform and provides a simulation engine for users to conduct simulation experiments. NS-3 is primarily developed on GNU/Linux and macOS platforms, and the minimal requirements to run basic simulations are a C++ compiler; either g++ or clang++ compiler, and Python (version 3) interpreter.

Program: After Installing Ubuntu 20.04 LTS successfully, you can now start withinstalling of NS3 packages.

List of Packages for Installing ns-3 in Ubuntu Systems

Prequisite for installing NS3.32
sudo apt upgrade
Sudo apt update



Minimal requirements for C++ users
apt-get install g++ python3

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install g++ python3
Reading package lists... Done
Building dependency tree
Reading state information... Done
python3 is already the newest version (3.8.2-0ubuntu2).
python3 set to manually installed.
The following additional packages will be installed:
  binutils binutils-common binutils-x86-64-linux-gnu cpp-9 g++-9 gcc gcc-9
  gcc-9-base libasan5 libatomic1 libbinutils libc-dev-bin libc6 libc6-dbg
  libc6-dev libcrypt-dev libctf-nobfd0 libctf0 libgcc-9-dev libitm1 liblsan0
  libquadmath0 libstdc++-9-dev libtsan0 libubsan1 linux-libc-dev manpages-dev
Suggested packages:
  binutils-doc gcc-9-locales g++-multilib g++-9-multilib gcc-9-doc
  gcc-multilib make autoconf automake libtool flex bison gcc-doc
  gcc-9-multilib glibc-doc libstdc++-9-doc
The following NEW packages will be installed:
  binutils binutils-common binutils-x86-64-linux-gnu g++ g++-9 gcc gcc-9
  libasan5 libatomic1 libbinutils libc-dev-bin libc6-dev libcrypt-dev
  libctf-nobfd0 libctf0 libgcc-9-dev libitm1 liblsan0 libquadmath0
  libstdc++-9-dev libtsan0 libubsan1 linux-libc-dev manpages-dev
```

Minimal requirements for Python API users
apt-get install g++ python3 python3-dev pkg-configsqlite3

```
mca@mca-To-be-filled-by-O-E-M: ~
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install g++ python3 python3-dev pkg-config sqlite3
Reading package lists... Done
Building dependency tree
Reading state information... Done
g++ is already the newest version (4:9.3.0-1ubuntu2).
pkg-config is already the newest version (0.29.1-0ubuntu4).
pkg-config set to manually installed.
python3 is already the newest version (3.8.2-0ubuntu2).
The following additional packages will be installed:
  libexpat1 libexpat1-dev libpython3-dev libpython3.8 libpython3.8-dev libpython3.8-minimal libpython3.8-stdlib python3-distutils python3.8
  python3.8-dev python3.8-minimal zlib1g zlib1g-dev
Suggested packages:
  python3.8-venv python3.8-doc binfmt-support sqlite3-doc
The following NEW packages will be installed:
  libexpat1-dev libpython3-dev libpython3.8-dev python3-dev python3-distutils python3.8-dev sqlite3 zlib1g-dev
The following packages will be upgraded:
  libexpat1 libpython3.8 libpython3.8-minimal libpython3.8-stdlib python3.8 python3.8-minimal zlib1g
7 upgraded, 8 newly installed, 0 to remove and 266 not upgraded.
Need to get 12.2 MB of archives.
After this operation, 26.3 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8 amd64 3.8.10-0ubuntu1~20.04.4 [387 kB]
Get:2 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8 amd64 3.8.10-0ubuntu1~20.04.4 [1,625 kB]
Get:3 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8-stdlib amd64 3.8.10-0ubuntu1~20.04.4 [1,675 kB]
Get:4 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8-minimal amd64 3.8.10-0ubuntu1~20.04.4 [1,899 kB]
Get:5 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8-minimal amd64 3.8.10-0ubuntu1~20.04.4 [717 kB]
Get:6 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libexpat1 amd64 2.2.9-1ubuntu0.4 [74.4 kB]
Get:7 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g amd64 1:1.2.11.dfsg-2ubuntu1.3 [53.8 kB]
Get:8 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libexpat1-dev amd64 2.2.9-1ubuntu0.4 [117 kB]
Get:9 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8-dev amd64 3.8.10-0ubuntu1~20.04.4 [3,952 kB]
Get:10 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libpython3-dev amd64 3.8.2-0ubuntu2 [7,236 B]
Get:11 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g-dev amd64 1:1.2.11.dfsg-2ubuntu1.3 [155 kB]
Get:12 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8-dev amd64 3.8.10-0ubuntu1~20.04.4 [514 kB]
Get:13 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3-distutils all 3.8.10-0ubuntu1~20.04 [141 kB]
Get:14 http://in.archive.ubuntu.com/ubuntu focal/main amd64 python3-dev amd64 3.8.2-0ubuntu2 [1,212 B]
Get:15 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 sqlite3 amd64 3.31.1-4ubuntu0.2 [860 kB]
Fetched 12.2 MB in 4s (3,005 kB/s)
(Reading database ... 150639 files and directories currently installed.)
```

Netanim animator:
qt5 development tools are needed for Netanim animator; apt-get install qt5-default mercurial

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install qt5-default mercurial
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libdouble-conversion3 libegl-dev libegl1 libgl-dev libgl1 libgles2 libglu1-mesa-dev libglvnd0 libglx-dev libglx0 libpcre2-16-0
  libpthread-stubs0-dev libpython2-stdlib libpython2.7-minimal libpython2.7-stdlib libqt5concurrent5 libqt5core5a libqt5dbus5 libqt5gui5
  libqt5network5 libqt5opengl5 libqt5opengl5-dev libqt5printsupport5 libqt5sql5 libqt5sql5-sqlite libqt5svg5 libqt5test5 libqt5widgets5
  libqt5xml5 libvulkan-dev libx11-dev libxau-dev libxcb-xinerama0 libxcb-xinput0 libxcb1-dev libxdmcp-dev libxext-dev mercurial-common
  python2 python2-minimal python2.7 python2.7-minimal qt5-gtk-platformtheme qt5-qmake qt5-qmake-bin qtbase5-dev qtbase5-dev-tools qtchooser
  qttranslations5-l10n x11proto-core-dev x11proto-dev x11proto-xext-dev xorg-sgml-doctools xtrans-dev
Suggested packages:
  qt5-image-formats-plugins qtwayland5 libx11-doc libxcb-doc libxext-doc kdiff3 | kdiff3-qt | kompare | meld | tkcvs | mgdiff qct
  python-mysqldb python-openssl python-pygments wish python2-doc python-tk python2.7-doc binfmt-support default-libmysqlclient-dev
  firebird-dev libpq-dev libsqlite3-dev unixodbc-dev
The following NEW packages will be installed:
  libdouble-conversion3 libegl-dev libgl-dev libglu1-mesa-dev libglx-dev libpcre2-16-0 libpthread-stubs0-dev libpython2-stdlib
  libpython2.7-minimal libpython2.7-stdlib libqt5concurrent5 libqt5core5a libqt5dbus5 libqt5gui5 libqt5network5 libqt5opengl5
  libqt5opengl5-dev libqt5printsupport5 libqt5sql5 libqt5sql5-sqlite libqt5svg5 libqt5test5 libqt5widgets5 libqt5xml5 libvulkan-dev
  libx11-dev libxau-dev libxcb-xinerama0 libxcb-xinput0 libxcb1-dev libxdmcp-dev libxext-dev mercurial mercurial-common python2
  python2-minimal python2.7 python2.7-minimal qt5-default qt5-gtk-platformtheme qt5-qmake qt5-qmake-bin qtbase5-dev qtbase5-dev-tools
  qtchooser qttranslations5-l10n x11proto-core-dev x11proto-dev x11proto-xext-dev xorg-sgml-doctools xtrans-dev
The following packages will be upgraded:
  libegl1 libgl1 libgles2 libglvnd0 libglx0
5 upgraded, 51 newly installed, 0 to remove and 261 not upgraded.
Need to get 23.2 MB of archives.
After this operation, 117 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://in.archive.ubuntu.com/ubuntu focal/universe amd64 libdouble-conversion3 amd64 3.1.5-4ubuntu1 [37.9 kB]
Get:2 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libpcre2-16-0 amd64 10.34-7 [181 kB]
Get:3 http://in.archive.ubuntu.com/ubuntu focal-updates/universe amd64 libqt5core5a amd64 5.12.8+dfsg-0ubuntu2.1 [2,006 kB]
Get:4 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libgl1 amd64 1.3.2-1~ubuntu0.20.04.2 [85.8 kB]
Get:5 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libglx0 amd64 1.3.2-1~ubuntu0.20.04.2 [32.5 kB]
Get:6 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libgles2 amd64 1.3.2-1~ubuntu0.20.04.2 [15.6 kB]
Get:7 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libegl1 amd64 1.3.2-1~ubuntu0.20.04.2 [31.9 kB]
Get:8 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 libglvnd0 amd64 1.3.2-1~ubuntu0.20.04.2 [48.1 kB]
Get:9 http://in.archive.ubuntu.com/ubuntu focal-updates/universe amd64 libqt5dbus5 amd64 5.12.8+dfsg-0ubuntu2.1 [208 kB]
```

ns-3-pyviz visualizer

apt-get install gir1.2-goocanvas-2.0 python-gi python-gi-cairo python-pygraphviz python3-gi python3-gi-cairo python3-pygraphviz gir1.2-gtk-3.0 ipython ipython3

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install gir1.2-goocanvas-2.0 python-gi python-gi-cairo python3-gi python3-gi-cairo python3-pygra
phviz gir1.2-gtk-3.0
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-goocanvas-2.0 is already the newest version (2.0.4-1).
python-gi is already the newest version (3.36.0-1).
python-gi-cairo is already the newest version (3.36.0-1).
python3-pygraphviz is already the newest version (1.5-4build1).
gir1.2-gtk-3.0 is already the newest version (3.24.20-0ubuntu1.1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Debugging:

apt-get install gdb valgrind

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install gdb valgrind
Reading package lists... Done
Building dependency tree
Reading state information... Done
gdb is already the newest version (9.2-0ubuntu1~20.04.1).
valgrind is already the newest version (1:3.15.0-1ubuntu9.1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Doxygen and related inline documentation:
sudo apt-get install doxygen graphviz imagemagick

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install doxygen graphviz imagemagick
Reading package lists... Done
Building dependency tree
Reading state information... Done
doxygen is already the newest version (1.8.17-0ubuntu2).
graphviz is already the newest version (2.42.2-3build2).
imagemagick is already the newest version (8:6.9.10.23+dfsg-2.1ubuntu11.4).
```

Sudo apt-get install texlive texlive-extra-utils texlive-latex-extra texlive-font-utils dvipng latexmk

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install texlive texlive-extra-utils texlive-latex-extra texlive-font-utils dvipng latexmk
Reading package lists... Done
Building dependency tree
Reading state information... Done
dvipng is already the newest version (1.15-1.1).
latexmk is already the newest version (1:4.67-0.1).
texlive is already the newest version (2019.20200218-1).
texlive-extra-utils is already the newest version (2019.202000218-1).
texlive-font-utils is already the newest version (2019.202000218-1).
texlive-latex-extra is already the newest version (2019.202000218-1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

The ns-3 manual and tutorial are written in reStructuredText for Sphinx (doc/tutorial, doc/manual,doc/models), and figures typically in dia (also needs thetexlive packages above):
apt-get install python3-sphinx dia

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install python3-sphinx dia
Reading package lists... Done
Building dependency tree
Reading state information... Done
python3-sphinx is already the newest version (1.8.5-7ubuntu3).
dia is already the newest version (0.97.3+git20160930-9).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

To read pcap packet traces
apt-get install tcpdump

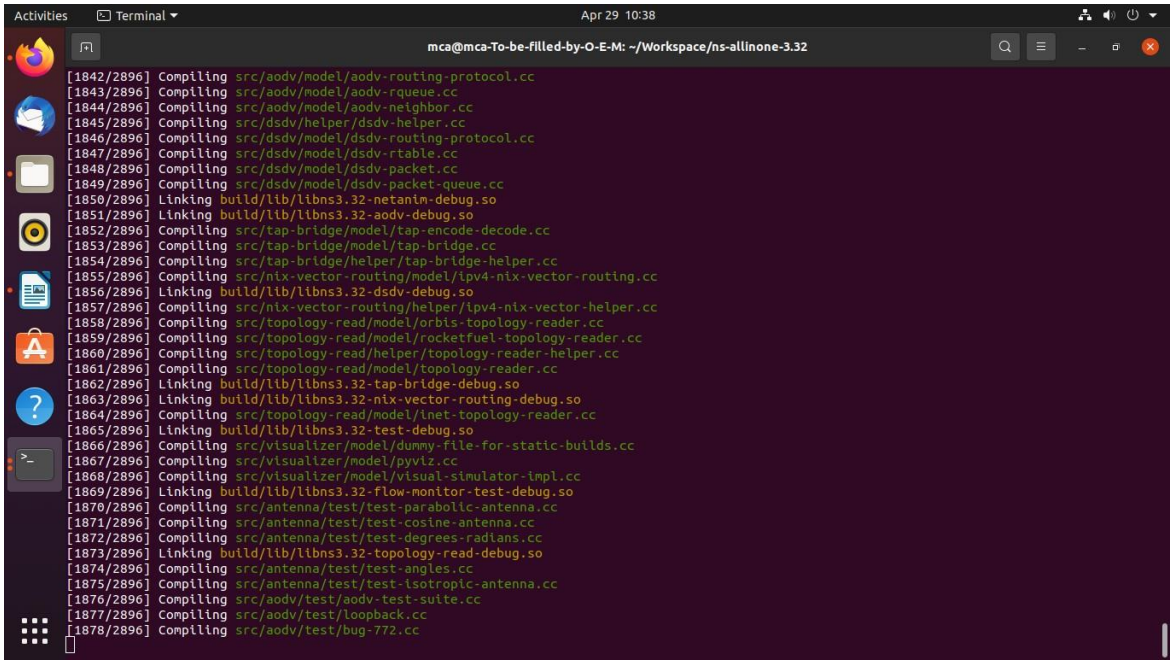
```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install tcpdump
Reading package lists... Done
Building dependency tree
Reading state information... Done
tcpdump is already the newest version (4.9.3-4ubuntu0.1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

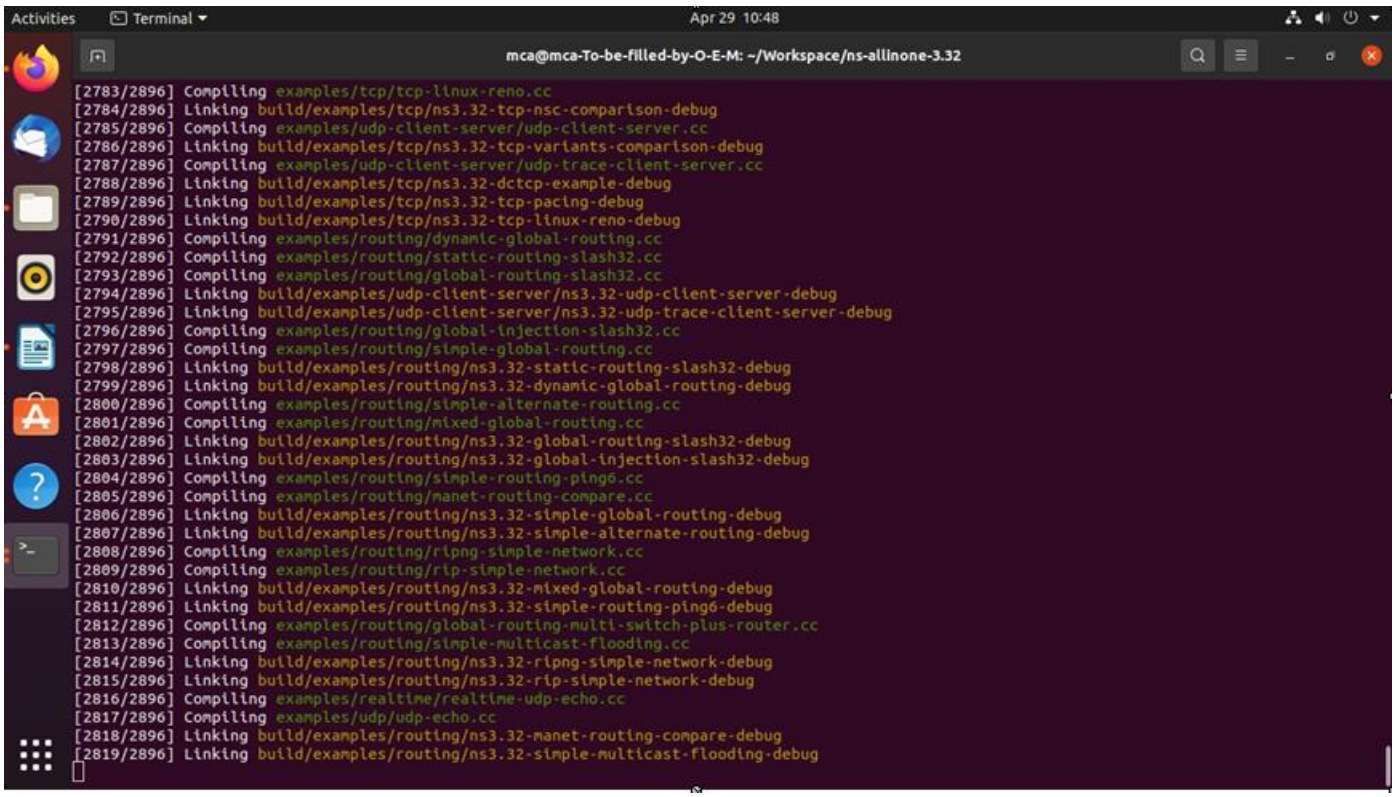
Support for generating modified python bindings

apt-get install cmake libc6-dev libc6-dev-i386 libclang-6.0-dev llvm-6.0-dev automake python3-pip

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install cmake libc6-dev libc6-dev-i386 libclang-6.0-dev llvm-6.0-dev   automake python3-pip
Reading package lists... Done
Building dependency tree
Reading state information... Done
automake is already the newest version (1:1.16.1-4ubuntu6).
cmake is already the newest version (3.16.3-1ubuntu1).
libclang-6.0-dev is already the newest version (1:6.0.1-14).
llvm-6.0-dev is already the newest version (1:6.0.1-14).
libc6-dev is already the newest version (2.31-0ubuntu9.7).
libc6-dev-i386 is already the newest version (2.31-0ubuntu9.7).
python3-pip is already the newest version (20.0.2-5ubuntu1.6).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

After installing the required packages,
create a folder named workspace in the home directory and then put the NS3 tar package into the workspace.
Go to terminal and input these commands consecutively after each command finishes executing:
cd
cd workspace tar xjf <name of NS3 downloaded filename>
cd <name of extracted NS3>
./build.py --enable-examples --enable-tests
It takes time be patient !!
Test the NS3 build and installation success by running test.py in the ns directory using the following commands:
cd ns-<version number>
./test.py




Activities
Terminal
Apr 29 10:48
mca@mca-To-be-filled-by-O-E-M: ~/Workspace/ns-allinone-3.32
[2783/2896] Compiling examples/tcp/tcp-linux-reno.cc
[2784/2896] Linking build/examples/tcp/ns3.32-tcp-nsc-comparison-debug
[2785/2896] Compiling examples/udp-client-server/udp-client-server.cc
[2786/2896] Linking build/examples/tcp/ns3.32-tcp-variants-comparison-debug
[2787/2896] Compiling examples/udp-client-server/udp-trace-client-server.cc
[2788/2896] Linking build/examples/tcp/ns3.32-dctcp-example-debug
[2789/2896] Linking build/examples/tcp/ns3.32-tcp-pacing-debug
[2790/2896] Linking build/examples/tcp/ns3.32-tcp-linux-reno-debug
[2791/2896] Compiling examples/routing/dynamic-global-routing.cc
[2792/2896] Compiling examples/routing/static-routing-slash32.cc
[2793/2896] Compiling examples/routing/global-routing-slash32.cc
[2794/2896] Linking build/examples/udp-client-server/ns3.32-udp-client-server-debug
[2795/2896] Linking build/examples/udp-client-server/ns3.32-udp-trace-client-server-debug
[2796/2896] Compiling examples/routing/global-injection-slash32.cc
[2797/2896] Compiling examples/routing/simple-global-routing.cc
[2798/2896] Linking build/examples/routing/ns3.32-static-routing-slash32-debug
[2799/2896] Linking build/examples/routing/ns3.32-dynamic-global-routing-debug
[2800/2896] Compiling examples/routing/simple-alternate-routing.cc
[2801/2896] Compiling examples/routing/mixed-global-routing.cc
[2802/2896] Linking build/examples/routing/ns3.32-global-routing-slash32-debug
[2803/2896] Linking build/examples/routing/ns3.32-global-injection-slash32-debug
[2804/2896] Compiling examples/routing/simple-routing-ping6.cc
[2805/2896] Compiling examples/routing/manet-routing-compare.cc
[2806/2896] Linking build/examples/routing/ns3.32-simple-global-routing-debug
[2807/2896] Linking build/examples/routing/ns3.32-simple-alternate-routing-debug
[2808/2896] Compiling examples/routing/ripng-simple-network.cc
[2809/2896] Compiling examples/routing/rip-simple-network.cc
[2810/2896] Linking build/examples/routing/ns3.32-mixed-global-routing-debug
[2811/2896] Linking build/examples/routing/ns3.32-simple-routing-ping6-debug
[2812/2896] Compiling examples/routing/global-routing-multi-switch-plus-router.cc
[2813/2896] Compiling examples/routing/simple-multicast-flooding.cc
[2814/2896] Linking build/examples/routing/ns3.32-ripng-simple-network-debug
[2815/2896] Linking build/examples/routing/ns3.32-rip-simple-network-debug
[2816/2896] Compiling examples/realtime/realtime-udp-echo.cc
[2817/2896] Compiling examples/udp/udp-echo.cc
[2818/2896] Linking build/examples/routing/ns3.32-manet-routing-compare-debug
[2819/2896] Linking build/examples/routing/ns3.32-simple-multicast-flooding-debug

Practical No: 2

Aim:- Installation of NetAnim

Objective: To learn to Install Net anim in Ubuntu Linux

Theory: NetAnim is **an offline animator based on the Qt toolkit**. It currently animates the simulation using an XML trace file collected during simulation. The NetAnim application requires a **custom trace file for animation**. This trace file is created by AnimationInterface in ns-3.

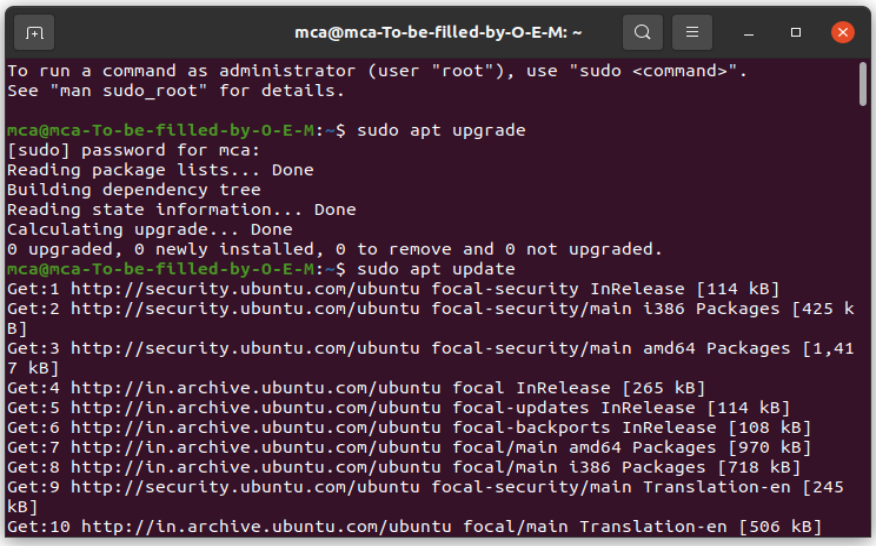
Installation: After Installing Ubuntu 20.04 LTS successfully, you can now start withinstalling of Net anim packages.

List of Packages for Installing ns-3 in Ubantu Systems

Prequisite for installing NS3.32

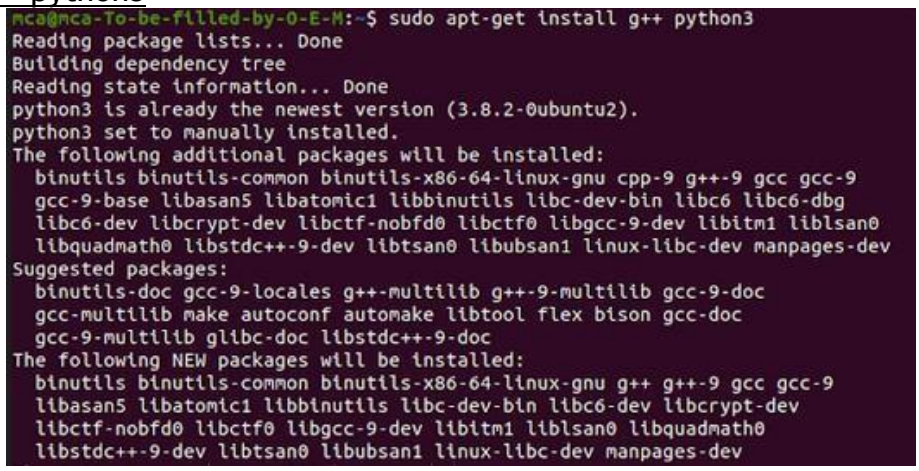
sudo apt upgrade

Sudo apt update



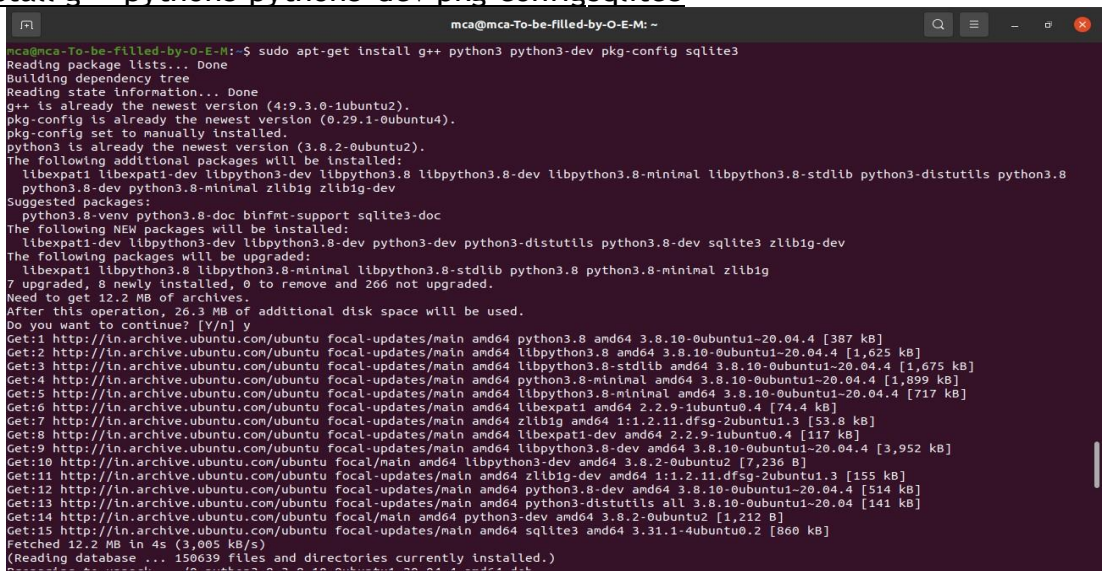
Minimal requirements for C++ users

apt-get install g++ python3



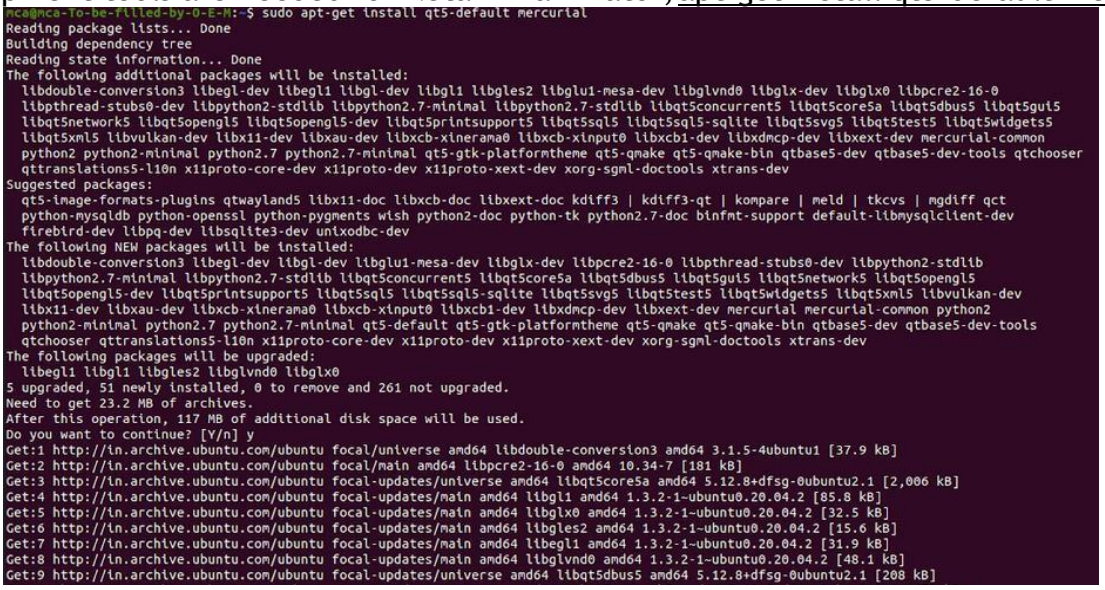
Minimal requirements for Python API users

apt-get install g++ python3 python3-dev pkg-configsqlite3



Netanim animator:

qt5 development tools are needed for Netanim animator; apt-get install qt5-default mercurial



ns-3-pyviz visualizer

apt-get install gir1.2-goocanvas-2.0 python-gi python-gi-cairo python-pygraphviz python3-gi python3-gi-cairo python3-pygraphviz gir1.2-gtk-3.0 ipython ipython3

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install gir1.2-goocanvas-2.0 python-gi python-gi-cairo python3-gi python3-gi-cairo python3-pygra
phviz gir1.2-gtk-3.0
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-goocanvas-2.0 is already the newest version (2.0.4-1).
python-gi is already the newest version (3.36.0-1).
python-gi-cairo is already the newest version (3.36.0-1).
python3-pygraphviz is already the newest version (1.5-4build1).
gir1.2-gtk-3.0 is already the newest version (3.24.20-0ubuntu1.1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Debugging:

apt-get install gdb valgrind

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install gdb valgrind
Reading package lists... Done
Building dependency tree
Reading state information... Done
gdb is already the newest version (9.2-0ubuntu1~20.04.1).
valgrind is already the newest version (1:3.15.0-1ubuntu9.1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Doxygen and related inline documentation:

apt-get install doxygen graphviz imagemagick

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install doxygen graphviz imagemagick
Reading package lists... Done
Building dependency tree
Reading state information... Done
doxygen is already the newest version (1.8.17-0ubuntu2).
graphviz is already the newest version (2.42.2-3build2).
imagemagick is already the newest version (8:6.9.10.23+dfsg-2.1ubuntu11.4).
```

apt-get install texlive texlive-extra-utils texlive-latex-extra texlive-font-utils dvipng latexmk

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install texlive texlive-extra-utils texlive-latex-extra texlive-font-utils dvipng latexmk
Reading package lists... Done
Building dependency tree
Reading state information... Done
dvipng is already the newest version (1.15-1.1).
latexmk is already the newest version (1:4.67-0.1).
texlive is already the newest version (2019.20200218-1).
texlive-extra-utils is already the newest version (2019.202000218-1).
texlive-font-utils is already the newest version (2019.202000218-1).
texlive-latex-extra is already the newest version (2019.202000218-1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

The ns-3 manual and tutorial are written in reStructuredText for Sphinx (doc/tutorial, doc/manual,doc/models), and figures typically in dia (also needs thetexlive packages above):
apt-get install python3-sphinx dia

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install python3-sphinx dia
Reading package lists... Done
Building dependency tree
Reading state information... Done
python3-sphinx is already the newest version (1.8.5-7ubuntu3).
dia is already the newest version (0.97.3+git20160930-9).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

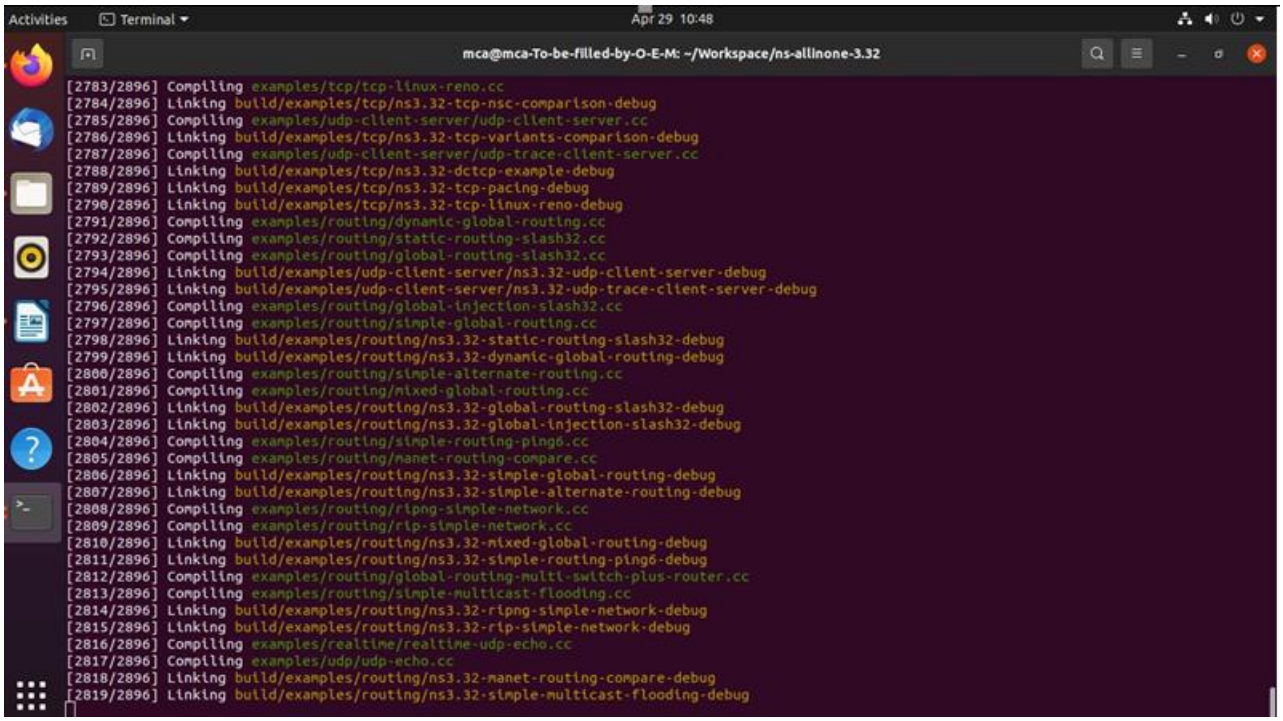
To read pcap packet traces
apt-get install tcpdump

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install tcpdump
Reading package lists... Done
Building dependency tree
Reading state information... Done
tcpdump is already the newest version (4.9.3-4ubuntu0.1).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Support for generating modified python bindings
apt-get install cmake libc6-dev libc6-dev-i386 libclang-6.0-dev llvm-6.0-dev automake python3-pip

```
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt-get install cmake libc6-dev libc6-dev-i386 libclang-6.0-dev llvm-6.0-dev   automake python3-pip
Reading package lists... Done
Building dependency tree
Reading state information... Done
automake is already the newest version (1:1.16.1-4ubuntu6).
cmake is already the newest version (3.16.3-1ubuntu1).
libclang-6.0-dev is already the newest version (1:6.0.1-14).
llvm-6.0-dev is already the newest version (1:6.0.1-14).
libc6-dev is already the newest version (2.31-0ubuntu9.7).
libc6-dev-i386 is already the newest version (2.31-0ubuntu9.7).
python3-pip is already the newest version (20.0.2-5ubuntu1.6).
The following package was automatically installed and is no longer required:
  libfwupdplugin1
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

After installing the required packages,
create a folder named workspace in the home directory and then putthe NS3 tar package into the workspace.
Go to terminal and input these commands consecutively after eachcommand finishes executing:
cd
cd workspace tar xjf <name of NS3 downloaded filename>
cd <name of extracted NS3>
./build.py --enable-examples --enable-tests
It takes time be patient !!
Test the NS3 build and installation success by running test.py in thens directory using the following commands:
cd ns-<version number>
./test.py


Activities
Terminal
Apr 29 10:48
mca@mca-To-be-filled-by-O-E-M: ~/Workspace/ns-allinone-3.32
[2783/2896] Compiling examples/tcp/tcp-linux-reno.cc
[2784/2896] Linking build/examples/tcp/ns3.32-tcp-nsc-comparison-debug
[2785/2896] Compiling examples/udp-client-server/udp-client-server.cc
[2786/2896] Linking build/examples/tcp/ns3.32-tcp-variants-comparison-debug
[2787/2896] Compiling examples/udp-client-server/udp-trace-client-server.cc
[2788/2896] Linking build/examples/tcp/ns3.32-dctcp-example-debug
[2789/2896] Linking build/examples/tcp/ns3.32-tcp-pacing-debug
[2790/2896] Linking build/examples/tcp/ns3.32-tcp-linux-reno-debug
[2791/2896] Compiling examples/routing/dynamic-global-routing.cc
[2792/2896] Compiling examples/routing/static-routing-slash32.cc
[2793/2896] Compiling examples/routing/global-routing-slash32.cc
[2794/2896] Linking build/examples/udp-client-server/ns3.32-udp-client-server-debug
[2795/2896] Linking build/examples/udp-client-server/ns3.32-udp-trace-client-server-debug
[2796/2896] Compiling examples/routing/global-injection-slash32.cc
[2797/2896] Compiling examples/routing/simple-global-routing.cc
[2798/2896] Linking build/examples/routing/ns3.32-static-routing-slash32-debug
[2799/2896] Linking build/examples/routing/ns3.32-dynamic-global-routing-debug
[2800/2896] Compiling examples/routing/simple-alternate-routing.cc
[2801/2896] Compiling examples/routing/mixed-global-routing.cc
[2802/2896] Linking build/examples/routing/ns3.32-global-routing-slash32-debug
[2803/2896] Linking build/examples/routing/ns3.32-global-injection-slash32-debug
[2804/2896] Compiling examples/routing/simple-routing-ping6.cc
[2805/2896] Compiling examples/routing/manet-routing-compare.cc
[2806/2896] Linking build/examples/routing/ns3.32-simple-global-routing-debug
[2807/2896] Linking build/examples/routing/ns3.32-simple-alternate-routing-debug
[2808/2896] Compiling examples/routing/ripng-simple-network.cc
[2809/2896] Compiling examples/routing/rip-simple-network.cc
[2810/2896] Linking build/examples/routing/ns3.32-mixed-global-routing-debug
[2811/2896] Linking build/examples/routing/ns3.32-simple-routing-ping6-debug
[2812/2896] Compiling examples/routing/global-routing-multi-switch-plus-router.cc
[2813/2896] Compiling examples/routing/simple-multicast-flooding.cc
[2814/2896] Linking build/examples/routing/ns3.32-ripng-simple-network-debug
[2815/2896] Linking build/examples/routing/ns3.32-rip-simple-network-debug
[2816/2896] Compiling examples/realtime/realtime-udp-echo.cc
[2817/2896] Compiling examples/udp/udp-echo.cc
[2818/2896] Linking build/examples/routing/ns3.32-manet-routing-compare-debug
[2819/2896] Linking build/examples/routing/ns3.32-simple-multicast-flooding-debug

Practical No: 3

Aim:- Installation of WireShark

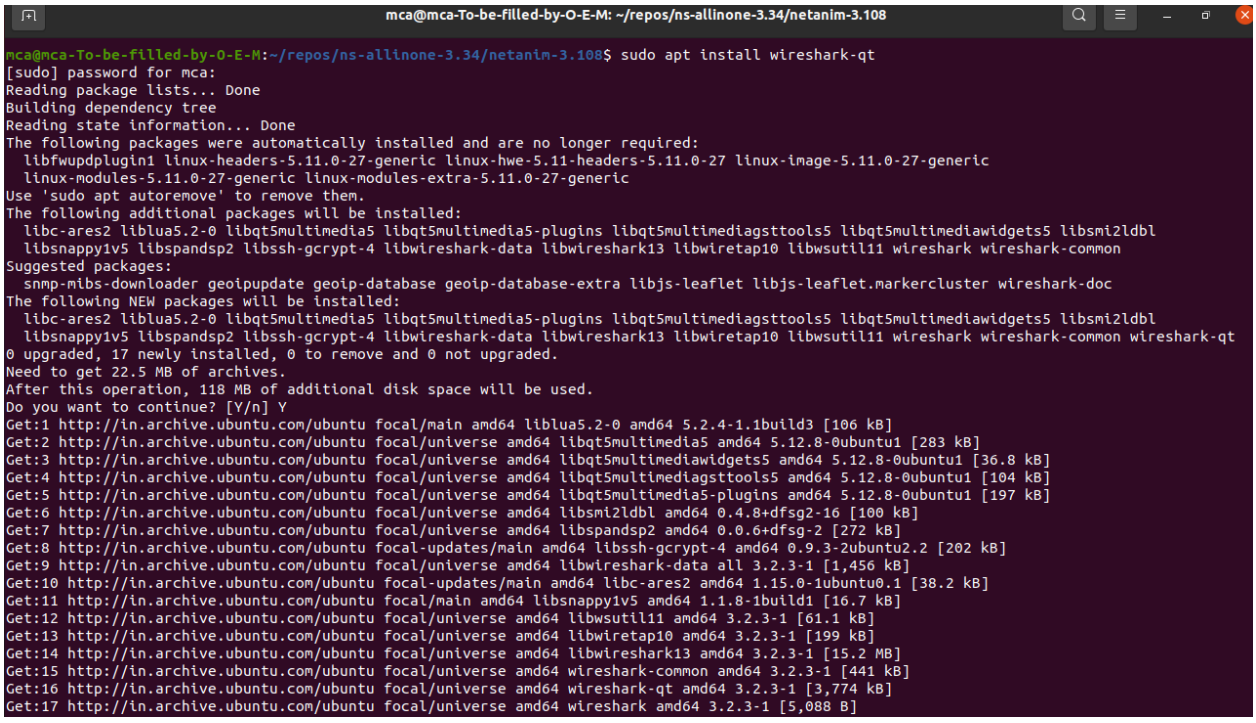
Objective: To learn to Install Wireshark in Ubuntu Linux

Theory: Wireshark is **a network protocol analyzer, or an application that captures packets from a network connection**, such as from your computer to your home office or the internet. Packet is the name given to a discrete unit of data in a typical Ethernet network. Wireshark is the most often-used packet sniffer in the world.

Here are some reasons people use Wireshark:

- Network administrators use it to troubleshoot network problems.
- Network security engineers use it to examine security problems.
- QA engineers use it to verify network applications.
- Developers use it to debug protocol implementations.

Installation Process:



Practical No: 4

Aim:- Program to simulate traffic between two nodes

Objective: To learn simulate traffic between two nodes and print String **.**

Theory: The Simulation Generate node provides an easy way to generate simulated data, either without historical data using user specified statistical distributions, or automatically using the distributions obtained from running a Simulation Fitting node on existing historical data.

Program:

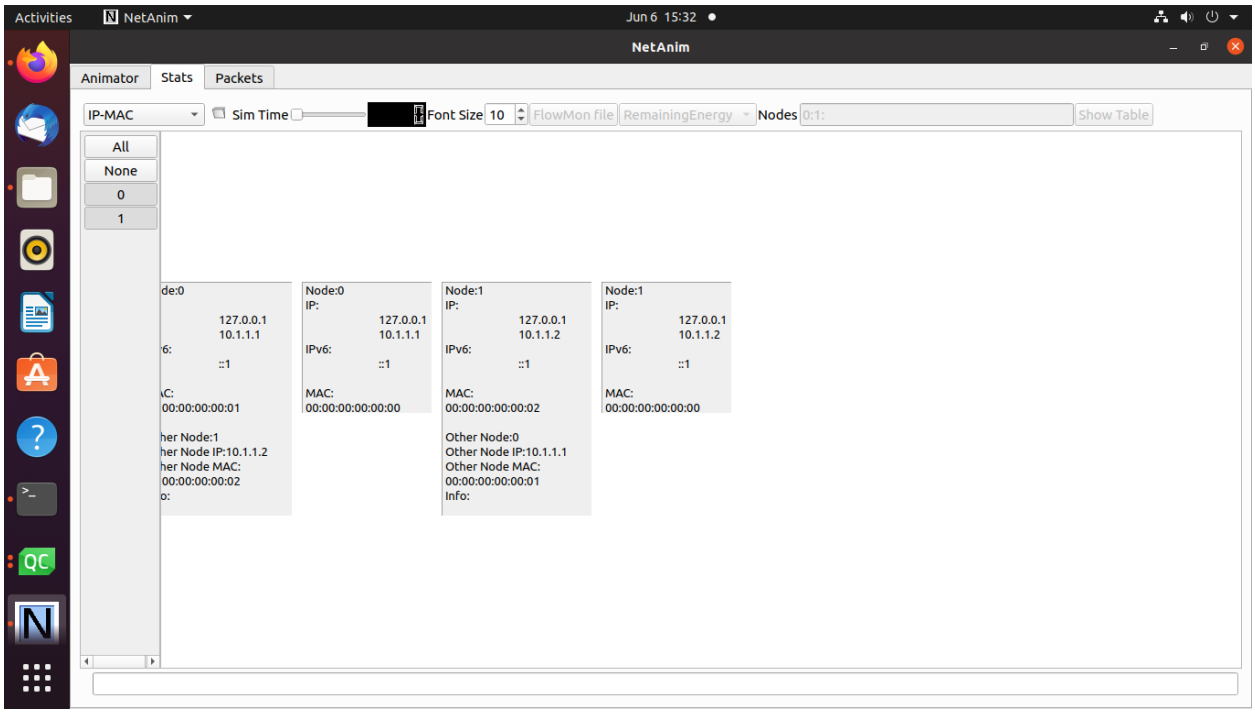
First.cc

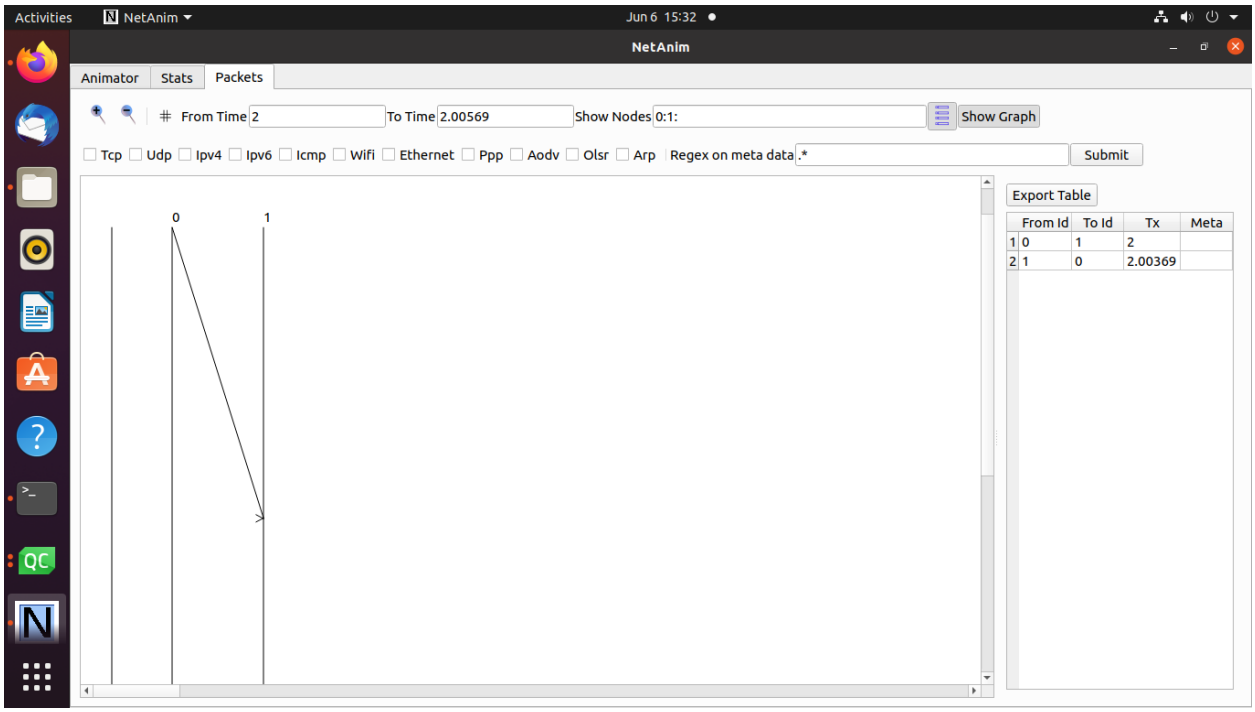
```
#include "ns3/core-module.h" #include "ns3/network-module.h" #include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"#include "ns3/applications-module.h"
// Default Network Topology
//
//       10.1.1.0
// n0   n1
//       point-to-point
//
using namespace ns3;
NS_LOG_COMPONENT_DEFINE ("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);
//server
UdpEchoServerHelper echoServer (9);
ApplicationContainer serverApps = echoServer.Install(nodes.Get (1));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));
//client
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;
}
```

Terminal and Output Screen:

```
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ cd ..
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd ns-3.34
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ ./waf --run first.cc
Waf: Entering directory `/home/mca/repos/ns-allinone-3.34/ns-3.34/build'
^[[A[1953/2007] Compiling scratch/first.cc
[1968/2007] Linking build/scratch/first
Waf: Leaving directory `/home/mca/repos/ns-allinone-3.34/ns-3.34/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (4.659s)
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: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
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
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```



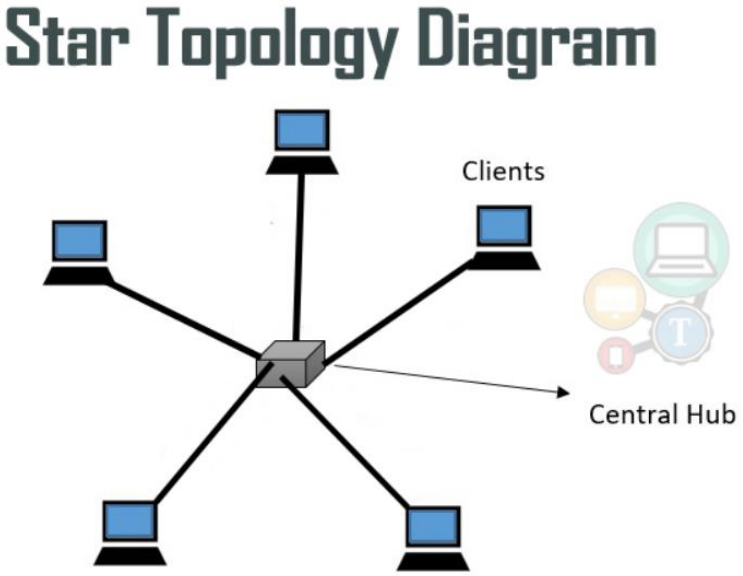

Activities
NetAnim
Jun 6 15:32
NetAnim
Animator
Stats
Packets
From Time 2
To Time 2.00569
Show Nodes 0:1:
Show Graph
Tcp Udp Ipv4 Ipv6 Icmp Wifi Ethernet Ppp Aodv Olsr Arp
Regex on meta data .*
Submit
Export Table
From Id To Id Tx Meta
1 0 1 2
2 1 0 2.00369
0
1

Practical No: 5

Aim:- Program to simulate star topology

Objective: To learn simulate star topology.

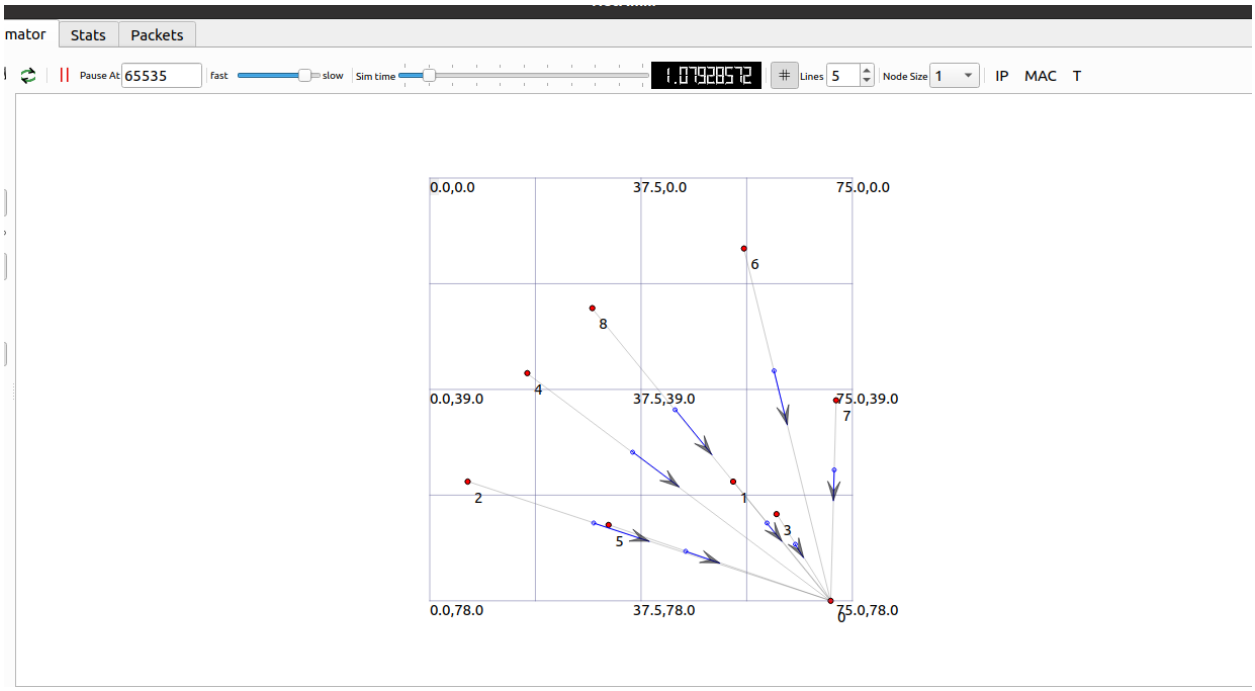
Theory: Star topology is **a network topology in which each network component is physically connected to a central node such as a router, hub or switch**. In a star topology, the central hub acts like a server and the connecting nodes act like clients.

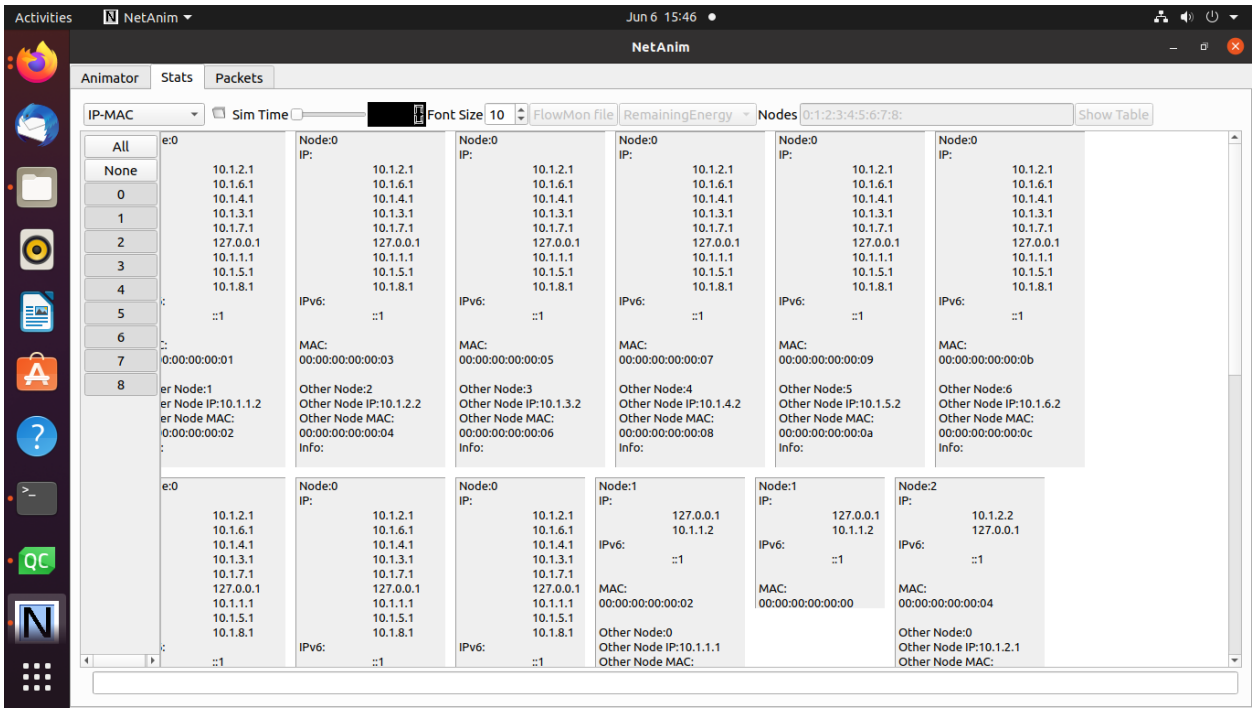


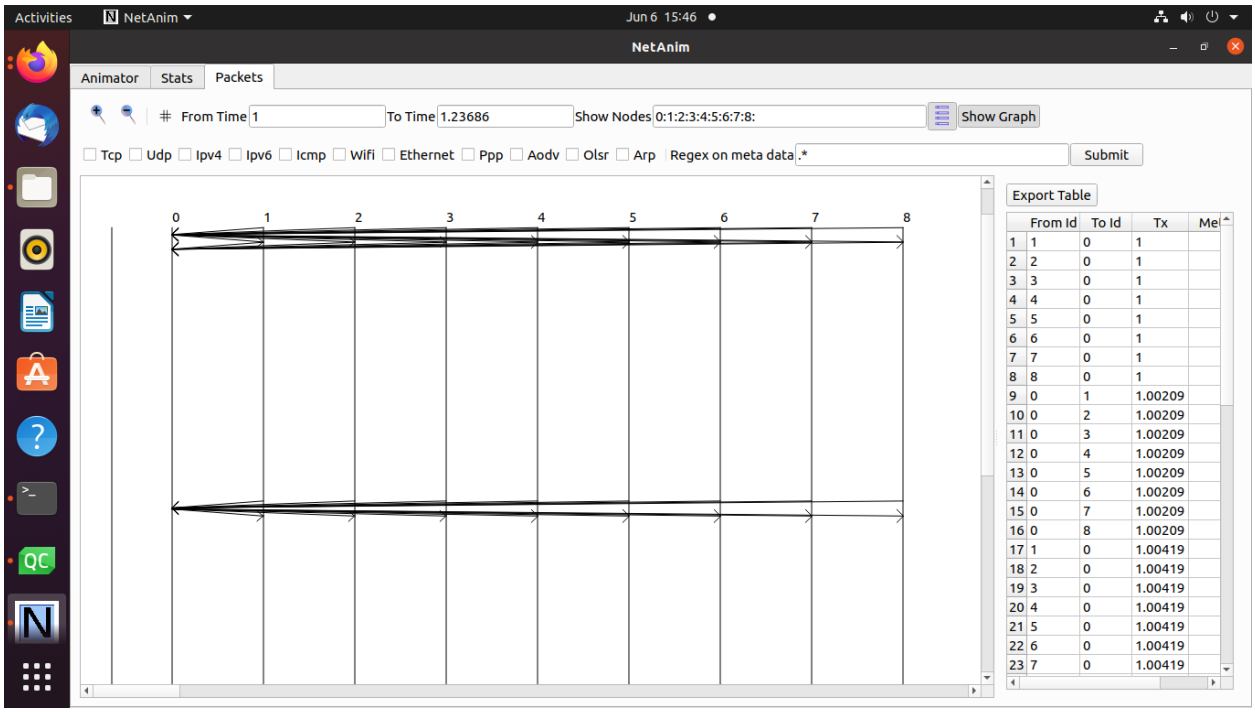
When a computer sends data to other computers on the network, it is sent along the cable to a central hub or switch, which then determines which port it needs to send the data through for it to reach the proper destination.

Program:

Terminal and Output NetAnim Screen:


mator
Stats
Packets
Pause At 65535
fast
slow
Sim time
Lines 5
Node Size 1
IP
MAC
T
0.0,0.0
37.5,0.0
75.0,0.0
0.0,39.0
37.5,39.0
75.0,39.0
0.0,78.0
37.5,78.0
75.0,78.0
0
1
2
3
4
5
6
7
8


Activities
NetAnim
Jun 6 15:46
NetAnim
Animator
Stats
Packets
IP-MAC
Sim Time
Font Size 10
FlowMon file
RemainingEnergy
Nodes
Show Table
All
None
0
1
2
3
4
5
6
7
8



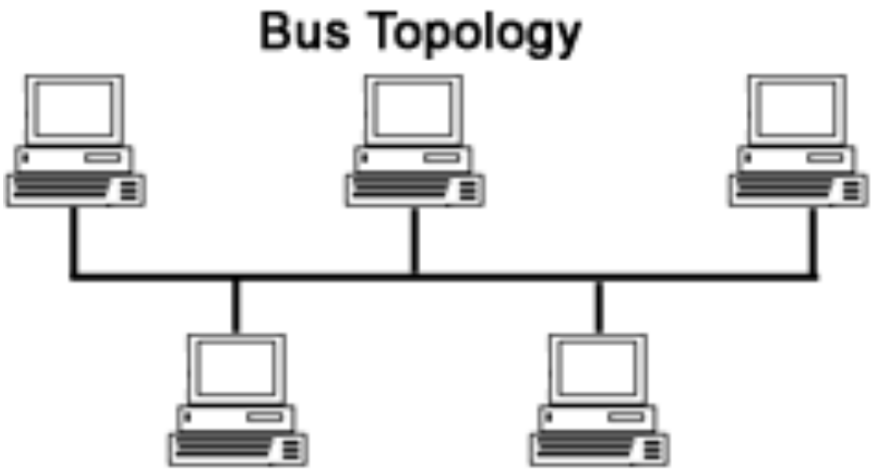
	From Id	To Id	Tx	Me
1	1	0	1	
2	2	0	1	
3	3	0	1	
4	4	0	1	
5	5	0	1	
6	6	0	1	
7	7	0	1	
8	8	0	1	
9	0	1	1.00209	
10	0	2	1.00209	
11	0	3	1.00209	
12	0	4	1.00209	
13	0	5	1.00209	
14	0	6	1.00209	
15	0	7	1.00209	
16	0	8	1.00209	
17	1	0	1.00419	
18	2	0	1.00419	
19	3	0	1.00419	
20	4	0	1.00419	
21	5	0	1.00419	
22	6	0	1.00419	
23	7	0	1.00419	

Practical No: 6

Aim:- Program to simulate bus topology

Objective: To learn simulate Program to simulate bus topology.

Theory: Bus topology, also known as line topology, is **a type of network topology in which all devices in the network are connected by one central RJ-45 network cable or coaxial cable**. The single cable, where all data is transmitted between devices, is referred to as the bus, backbone, or trunk. A bus topology **connects computers along a single or more cable to connect linearly**. A network that uses a bus topology is referred to as a "bus network" which was the original form of Ethernet networks.



Line of Code:

Bus.cc

```
#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"
#include "ns3/netanim-module.h"
// Default Network Topology
//
//       10.1.1.0
// n0 -------------- n1   n2   n3   n4
//    point-to-point  |    |    |    |
//                    ================
//                      LAN 10.1.2.0

using namespace ns3;
```

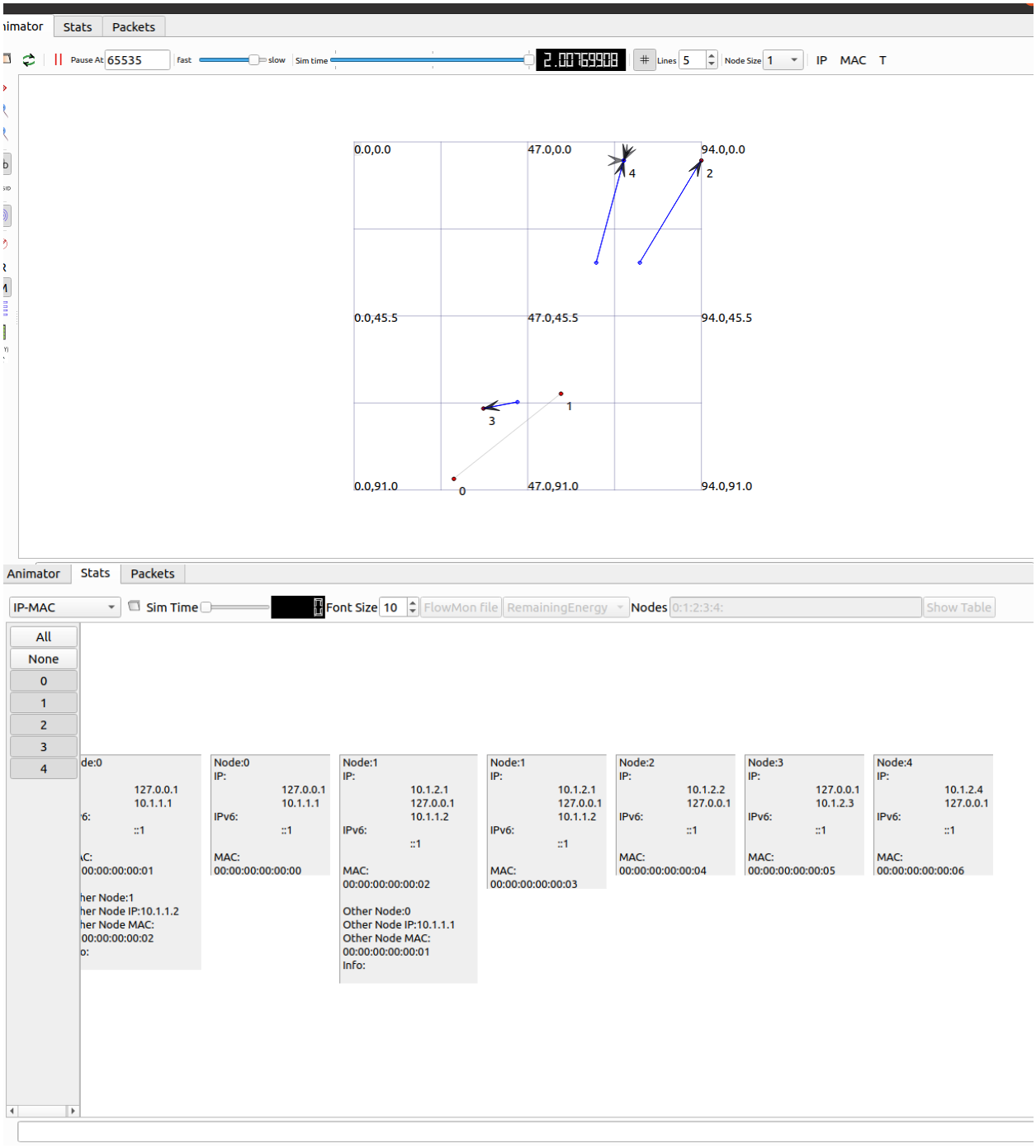
```
NS_LOG_COMPONENT_DEFINE ("SecondScriptExample");

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);
```

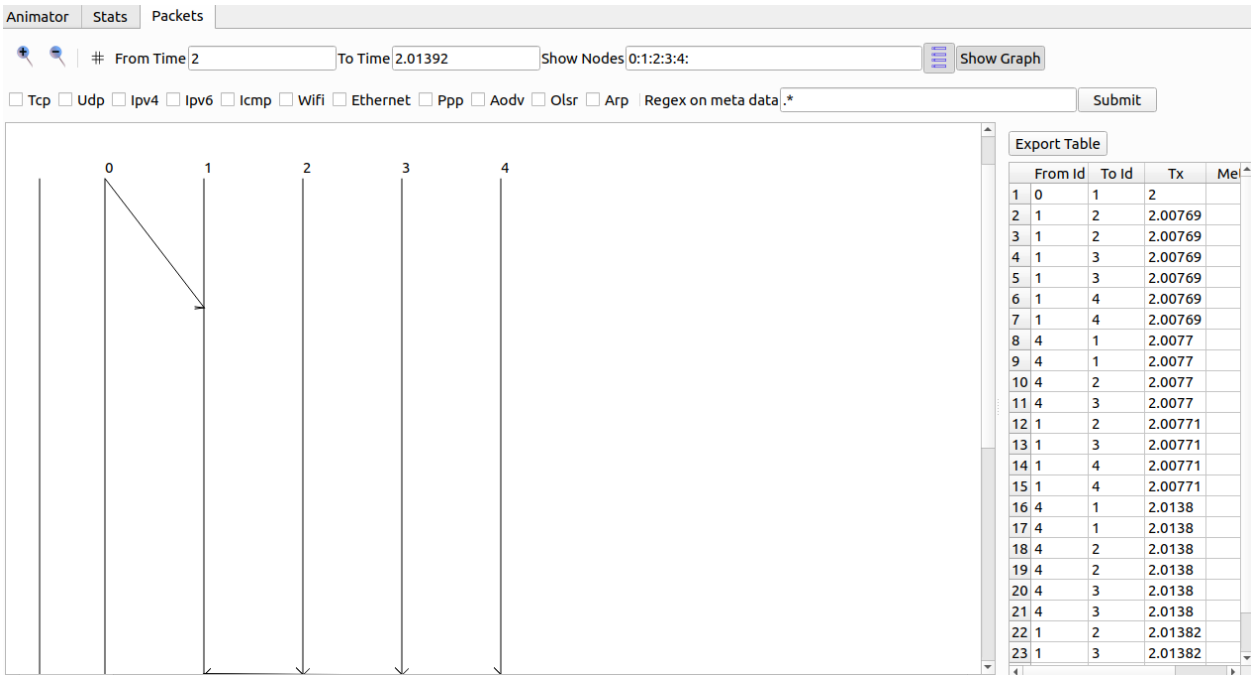
```
  UdpEchoServerHelper echoServer (9);

  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);
  AnimationInterface anim("bus.xml");
  Simulator::Run ();
  Simulator::Destroy ();
  return 0;
}
```

Program:

```
mca@mca-To-be-filled-by-O-E-M: ~/repos/ns-allinone-3.34/netanim-3.108
AnimationInterface WARNING:Node:4 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:4 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: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:1 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: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
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
AnimationInterface WARNING:Node:4 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:4 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:1 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: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:4 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:4 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
At time +2.01761s client received 1024 bytes from 10.1.2.4 port 9
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```

Output Screen:





	From Id	To Id	Tx	Me
1	0	1	2	
2	1	2	2.00769	
3	1	2	2.00769	
4	1	3	2.00769	
5	1	3	2.00769	
6	1	4	2.00769	
7	1	4	2.00769	
8	4	1	2.0077	
9	4	1	2.0077	
10	4	2	2.0077	
11	4	3	2.0077	
12	1	2	2.00771	
13	1	3	2.00771	
14	1	4	2.00771	
15	1	4	2.00771	
16	4	1	2.0138	
17	4	1	2.0138	
18	4	2	2.0138	
19	4	2	2.0138	
20	4	3	2.0138	
21	4	3	2.0138	
22	1	2	2.01382	
23	1	3	2.01382	

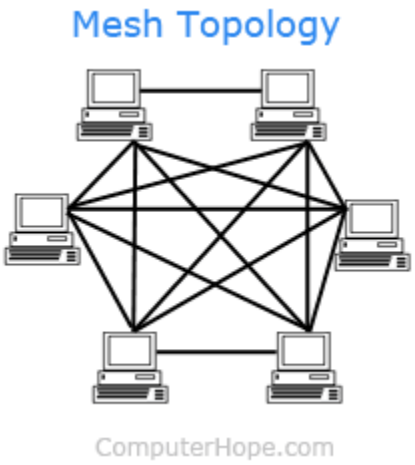
Practical No: 7

Name: Patel Arun Ramjanak Roll No. 26

Aim:- Program to simulate mesh topology

Objective: To learn simulate mesh topology

Theory: In a mesh topology there is no central connection point. Instead, each node is connected to at least one other node and usually to more than one. Each node is capable of sending messages to and receiving messages from other nodes. The nodes act as relays, passing on a message towards its final destination.



Line of Code:

Mesh.cc

```
/* -*- 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 <iostream>
#include <sstream>
#include <fstream>
#include "ns3/core-module.h"
#include "ns3/internet-module.h"
#include "ns3/network-module.h"
#include "ns3/applications-module.h"
#include "ns3/mesh-module.h"
```

```
#include "ns3/mobility-module.h"
#include "ns3/mesh-helper.h"
#include "ns3/yans-wifi-helper.h"
#include "ns3/netanim-module.h"

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("MeshExample");

// Declaring these variables outside of main() for use in trace sinks
uint32_t g_udpTxCount = 0;
uint32_t g_udpRxCount = 0;

void
TxTrace (Ptr<const Packet> p)
{
  NS_LOG_DEBUG ("Sent " << p->GetSize () << " bytes");
  g_udpTxCount++;
}

void
RxTrace (Ptr<const Packet> p)
{
  NS_LOG_DEBUG ("Received " << p->GetSize () << " bytes");
  g_udpRxCount++;
}

/**
 * \ingroup mesh
 * \brief MeshTest class
 */
class MeshTest
{
public:
  /// Init test
  MeshTest ();
  /**
   * Configure test from command line arguments
   *
   * \param argc command line argument count
   * \param argv command line arguments
   */
  void Configure (int argc, char ** argv);
  /**
   * Run test
   * \returns the test status
   */
  int Run ();
private:
  int       m_xSize; ///< X size
  int       m_ySize; ///< Y size
  double    m_step; ///< step
  double    m_randomStart; ///< random start
  double    m_totalTime; ///< total time
  double    m_packetInterval; ///< packet interval
  uint16_t  m_packetSize; ///< packet size
  uint32_t  m_nIfaces; ///< number interfaces
```

```
  bool      m_chan; ///< channel
  bool      m_pcap; ///< PCAP
  bool      m_ascii; ///< ASCII
  std::string m_stack; ///< stack
  std::string m_root; ///< root
  /// List of network nodes
  NodeContainer nodes;
  /// List of all mesh point devices
  NetDeviceContainer meshDevices;
  /// Addresses of interfaces:
  Ipv4InterfaceContainer interfaces;
  /// MeshHelper. Report is not static methods
  MeshHelper mesh;
private:
  /// Create nodes and setup their mobility
  void CreateNodes ();
  /// Install internet m_stack on nodes
  void InstallInternetStack ();
  /// Install applications
  void InstallApplication ();
  /// Print mesh devices diagnostics
  void Report ();
};
MeshTest::MeshTest () :
  m_xSize (3),
  m_ySize (3),
  m_step (50.0),
  m_randomStart (0.1),
  m_totalTime (100.0),
  m_packetInterval (1),
  m_packetSize (1024),
  m_nIfaces (1),
  m_chan (true),
  m_pcap (false),
  m_ascii (false),
  m_stack ("ns3::Dot11sStack"),
  m_root ("ff:ff:ff:ff:ff:ff")
{
}
void
MeshTest::Configure (int argc, char *argv[])
{
  CommandLine cmd (__FILE__);
  cmd.AddValue ("x-size", "Number of nodes in a row grid", m_xSize);
  cmd.AddValue ("y-size", "Number of rows in a grid", m_ySize);
  cmd.AddValue ("step",   "Size of edge in our grid (meters)", m_step);
  // Avoid starting all mesh nodes at the same time (beacons may collide)
  cmd.AddValue ("start",  "Maximum random start delay for beacon jitter (sec)",
m_randomStart);
  cmd.AddValue ("time",  "Simulation time (sec)", m_totalTime);
  cmd.AddValue ("packet-interval",  "Interval between packets in UDP ping (sec)",
m_packetInterval);
  cmd.AddValue ("packet-size",  "Size of packets in UDP ping (bytes)", m_packetSize);
  cmd.AddValue ("interfaces", "Number of radio interfaces used by each mesh point",
m_nIfaces);
  cmd.AddValue ("channels",   "Use different frequency channels for different
interfaces", m_chan);
  cmd.AddValue ("pcap",   "Enable PCAP traces on interfaces", m_pcap);
  cmd.AddValue ("ascii",   "Enable Ascii traces on interfaces", m_ascii);
```

```
  cmd.AddValue ("stack",  "Type of protocol stack. ns3::Dot11sStack by default",
m_stack);
  cmd.AddValue ("root", "Mac address of root mesh point in HWMP", m_root);

  cmd.Parse (argc, argv);
  NS_LOG_DEBUG ("Grid:" << m_xSize << "*" << m_ySize);
  NS_LOG_DEBUG ("Simulation time: " << m_totalTime << " s");
  if (m_ascii)
    {
      PacketMetadata::Enable ();
    }
}
void
MeshTest::CreateNodes ()
{
  /*
   * Create m_ySize*m_xSize stations to form a grid topology
   */
  nodes.Create (m_ySize*m_xSize);
  // Configure YansWifiChannel
  YansWifiPhyHelper wifiPhy;
  YansWifiChannelHelper wifiChannel = YansWifiChannelHelper::Default ();
  wifiPhy.SetChannel (wifiChannel.Create ());
  /*
   * Create mesh helper and set stack installer to it
   * Stack installer creates all needed protocols and install them to
   * mesh point device
   */
  mesh = MeshHelper::Default ();
  if (!Mac48Address (m_root.c_str ()).IsBroadcast ())
    {
      mesh.SetStackInstaller (m_stack, "Root", Mac48AddressValue (Mac48Address
(m_root.c_str ())));
    }
  else
    {
      //If root is not set, we do not use "Root" attribute, because it
      //is specified only for 11s
      mesh.SetStackInstaller (m_stack);
    }
  if (m_chan)
    {
      mesh.SetSpreadInterfaceChannels (MeshHelper::SPREAD_CHANNELS);
    }
  else
    {
      mesh.SetSpreadInterfaceChannels (MeshHelper::ZERO_CHANNEL);
    }
  mesh.SetMacType ("RandomStart", TimeValue (Seconds (m_randomStart)));
  // Set number of interfaces - default is single-interface mesh point
  mesh.SetNumberOfInterfaces (m_nIfaces);
  // Install protocols and return container if MeshPointDevices
  meshDevices = mesh.Install (wifiPhy, nodes);
  // AssignStreams can optionally be used to control random variable streams
  mesh.AssignStreams (meshDevices, 0);
  // Setup mobility - static grid topology
  MobilityHelper mobility;
  mobility.SetPositionAllocator ("ns3::GridPositionAllocator",
                                 "MinX", DoubleValue (0.0),
```

```
                                "MinY", DoubleValue (0.0),
                                "DeltaX", DoubleValue (m_step),
                                "DeltaY", DoubleValue (m_step),
                                "GridWidth", UintegerValue (m_xSize),
                                "LayoutType", StringValue ("RowFirst"));
  mobility.SetMobilityModel ("ns3::ConstantPositionMobilityModel");
  mobility.Install (nodes);
  if (m_pcap)
    wifiPhy.EnablePcapAll (std::string ("mp"));
  if (m_ascii)
    {
      AsciiTraceHelper ascii;
      wifiPhy.EnableAsciiAll (ascii.CreateFileStream ("mesh.tr"));
    }
}
void
MeshTest::InstallInternetStack ()
{
  InternetStackHelper internetStack;
  internetStack.Install (nodes);
  Ipv4AddressHelper address;
  address.SetBase ("10.1.1.0", "255.255.255.0");
  interfaces = address.Assign (meshDevices);
}
void
MeshTest::InstallApplication ()
{
  uint16_t portNumber = 9;
  UdpEchoServerHelper echoServer (portNumber);
  uint16_t sinkNodeId = m_xSize * m_ySize - 1;
  ApplicationContainer serverApps = echoServer.Install (nodes.Get (sinkNodeId));
  serverApps.Start (Seconds (1.0));
  serverApps.Stop (Seconds (m_totalTime + 1));
  UdpEchoClientHelper echoClient (interfaces.GetAddress (sinkNodeId), portNumber);
  echoClient.SetAttribute ("MaxPackets", UintegerValue
((uint32_t)(m_totalTime*(1/m_packetInterval))));
  echoClient.SetAttribute ("Interval", TimeValue (Seconds (m_packetInterval)));
  echoClient.SetAttribute ("PacketSize", UintegerValue (m_packetSize));
  ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
  Ptr<UdpEchoClient> app = clientApps.Get (0)->GetObject<UdpEchoClient> ();
  app->TraceConnectWithoutContext ("Tx", MakeCallback (&TxTrace));
  app->TraceConnectWithoutContext ("Rx", MakeCallback (&RxTrace));
  clientApps.Start (Seconds (1.0));
  clientApps.Stop (Seconds (m_totalTime + 1.5));
}
int
MeshTest::Run ()
{
  CreateNodes ();
  InstallInternetStack ();
  InstallApplication ();
  Simulator::Schedule (Seconds (m_totalTime), &MeshTest::Report, this);
  Simulator::Stop (Seconds (m_totalTime + 2));
         AnimationInterface anim("Mesh.xml");
  Simulator::Run ();
  Simulator::Destroy ();
  std::cout << "UDP echo packets sent: " << g_udpTxCount << " received: " <<
g_udpRxCount << std::endl;
  return 0;
```

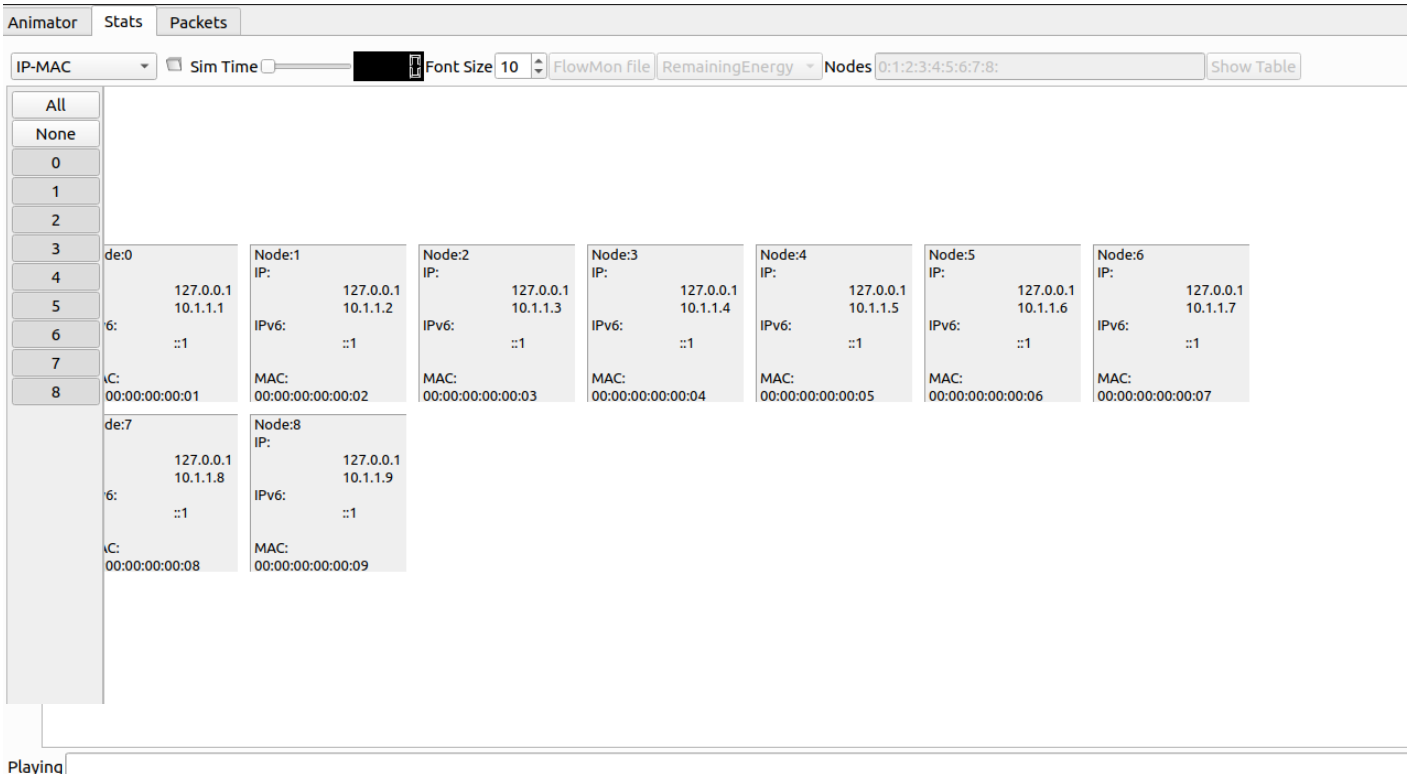
```
}
void
MeshTest::Report ()
{
  unsigned n (0);
  for (NetDeviceContainer::Iterator i = meshDevices.Begin (); i != meshDevices.End ();
++i, ++n)
    {
      std::ostringstream os;
      os << "mp-report-" << n << ".xml";
      std::cerr << "Printing mesh point device #" << n << " diagnostics to " << os.str
() << "\n";
      std::ofstream of;
      of.open (os.str ().c_str ());
      if (!of.is_open ())
        {
          std::cerr << "Error: Can't open file " << os.str () << "\n";
          return;
        }
      mesh.Report (*i, of);
      of.close ();
    }
}
int
main (int argc, char *argv[])
{
  MeshTest t;
  t.Configure (argc, argv);
  return t.Run ();
}
```

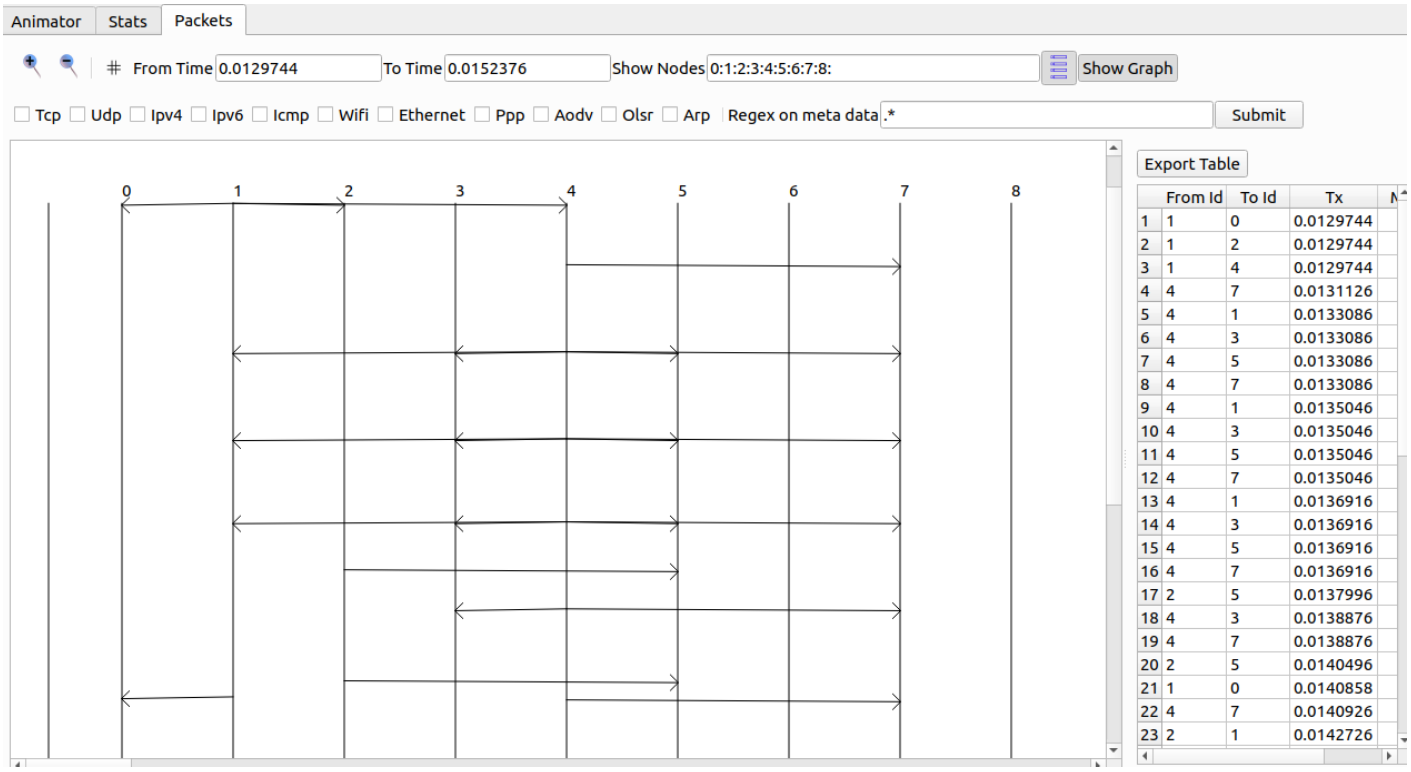
Program:

```
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ ./waf --run mesh.cc
Waf: Entering directory `/home/mca/repos/ns-allinone-3.34/ns-3.34/build'
[1951/2015] Compiling scratch/mesh.cc
[1952/2015] Compiling scratch/fifth.cc
[1953/2015] Compiling scratch/threeway.cc
[1954/2015] Compiling scratch/hybrid.cc
[1963/2015] Compiling scratch/first.cc
[1964/2015] Linking build/scratch/fifth
[1965/2015] Linking build/scratch/hybrid
[1966/2015] Linking build/scratch/threeway
[1967/2015] Linking build/scratch/mesh
[1968/2015] Compiling scratch/scratch-simulator.cc
[1969/2015] Linking build/scratch/first
[1970/2015] Compiling scratch/subdir/scratch-simulator-subdir.cc
[1971/2015] Compiling scratch/first123.cc
[1972/2015] Compiling scratch/tcpfile.cc
[1973/2015] Linking build/scratch/scratch-simulator
[1974/2015] Linking build/scratch/subdir/subdir
[1975/2015] Linking build/scratch/first123
[1976/2015] Linking build/scratch/tcpfile
Waf: Leaving directory `/home/mca/repos/ns-allinone-3.34/ns-3.34/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (12.252s)
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 #7 diagnostics to mp-report-7.xml
Printing mesh point device #8 diagnostics to mp-report-8.xml
UDP echo packets sent: 100 received: 0
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd ns-3.108
bash: cd: ns-3.108: No such file or directory
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```

Output Screen:





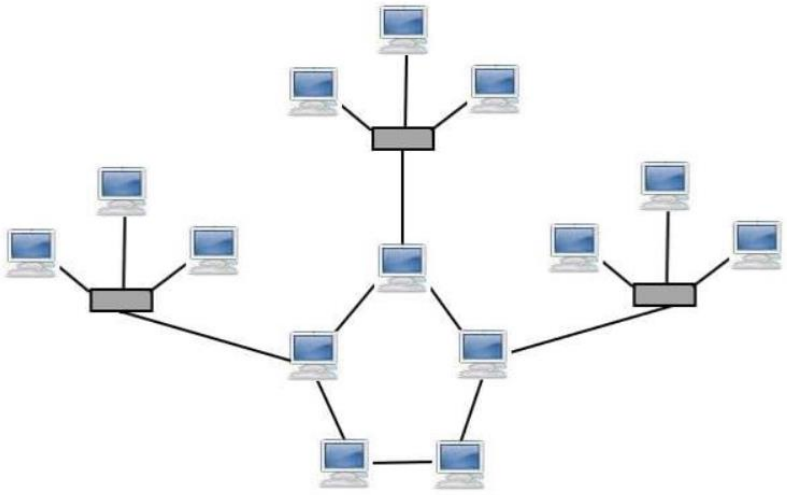
	From Id	To Id	Tx
1	1	0	0.0129744
2	1	2	0.0129744
3	1	4	0.0129744
4	4	7	0.0131126
5	4	1	0.0133086
6	4	3	0.0133086
7	4	5	0.0133086
8	4	7	0.0133086
9	4	1	0.0135046
10	4	3	0.0135046
11	4	5	0.0135046
12	4	7	0.0135046
13	4	1	0.0136916
14	4	3	0.0136916
15	4	5	0.0136916
16	4	7	0.0136916
17	2	5	0.0137996
18	4	3	0.0138876
19	4	7	0.0138876
20	2	5	0.0140496
21	1	0	0.0140858
22	4	7	0.0140926
23	2	1	0.0142726

Practical No: 8

Aim:- Program to simulate hybrid topology

Objective: To learn simulate hybrid topology

Theory: A hybrid topology is **a type of network topology that uses two or more differing network topologies**. These topologies can include a mix of bus topology, mesh topology, ring topology, star topology, and tree 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. The below figure is describing the structure of hybrid topology that contains more than one topology.



Program:

Line of Code:
Hybrid.cc

```
/* -*- 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/point-to-point-module.h"
#include "ns3/network-module.h"
#include "ns3/applications-module.h"
#include "ns3/mobility-module.h"
#include "ns3/csma-module.h"
#include "ns3/internet-module.h"
#include "ns3/yans-wifi-helper.h"
#include "ns3/ssid.h"
# include "ns3/netanim-module.h"
// Default Network Topology
//
//   Wifi 10.1.3.0
//                 AP
//  *    *    *    *
//  |    |    |    |    10.1.1.0
// n5   n6   n7   n0 -------------- n1   n2   n3   n4
//                   point-to-point  |    |    |    |
//                                   ================
```

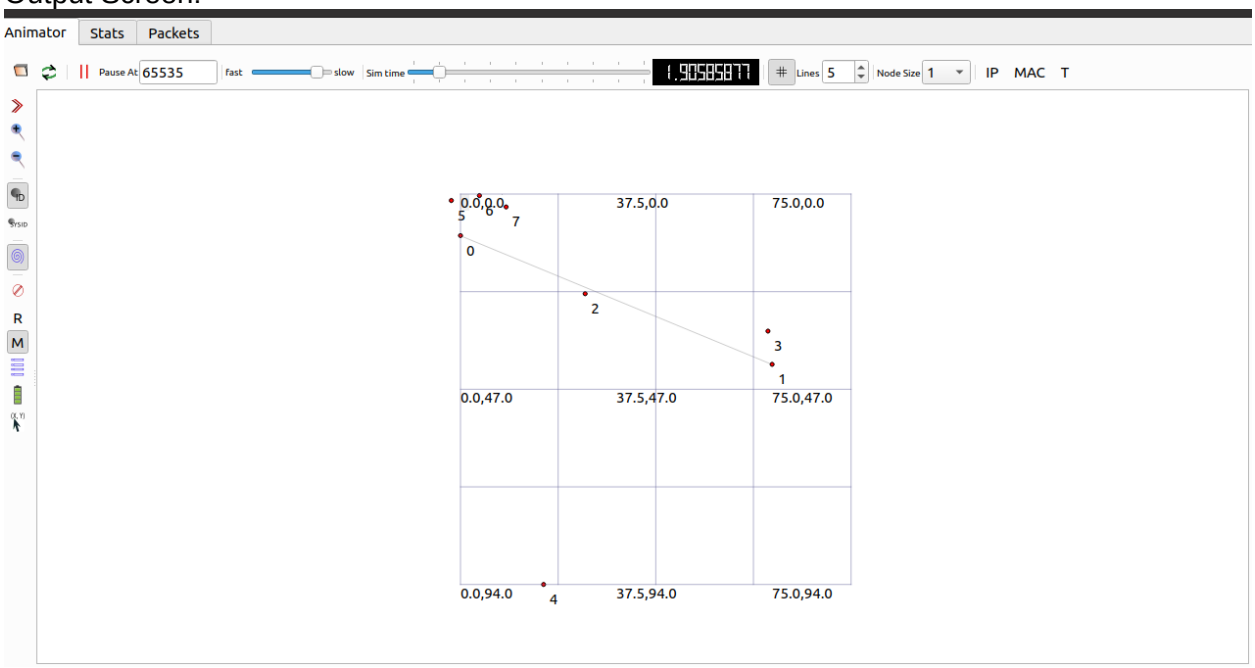
```
//                                    LAN 10.1.2.0

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("ThirdScriptExample");

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

  CommandLine cmd (__FILE__);
  cmd.AddValue ("nCsma", "Number of \"extra\" CSMA nodes/devices", nCsma);
  cmd.AddValue ("nWifi", "Number of wifi STA devices", nWifi);
  cmd.AddValue ("verbose", "Tell echo applications to log if true", verbose);
  cmd.AddValue ("tracing", "Enable pcap tracing", tracing);

  cmd.Parse (argc,argv);

  // The underlying restriction of 18 is due to the grid position
  // allocator's configuration; the grid layout will exceed the
  // bounding box if more than 18 nodes are provided.
  if (nWifi > 18)
    {
      std::cout << "nWifi should be 18 or less; otherwise grid layout exceeds the
bounding box" << std::endl;
      return 1;
    }

  if (verbose)
    {
      LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
      LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
    }

  NodeContainer p2pNodes;
  p2pNodes.Create (2);

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

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

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

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

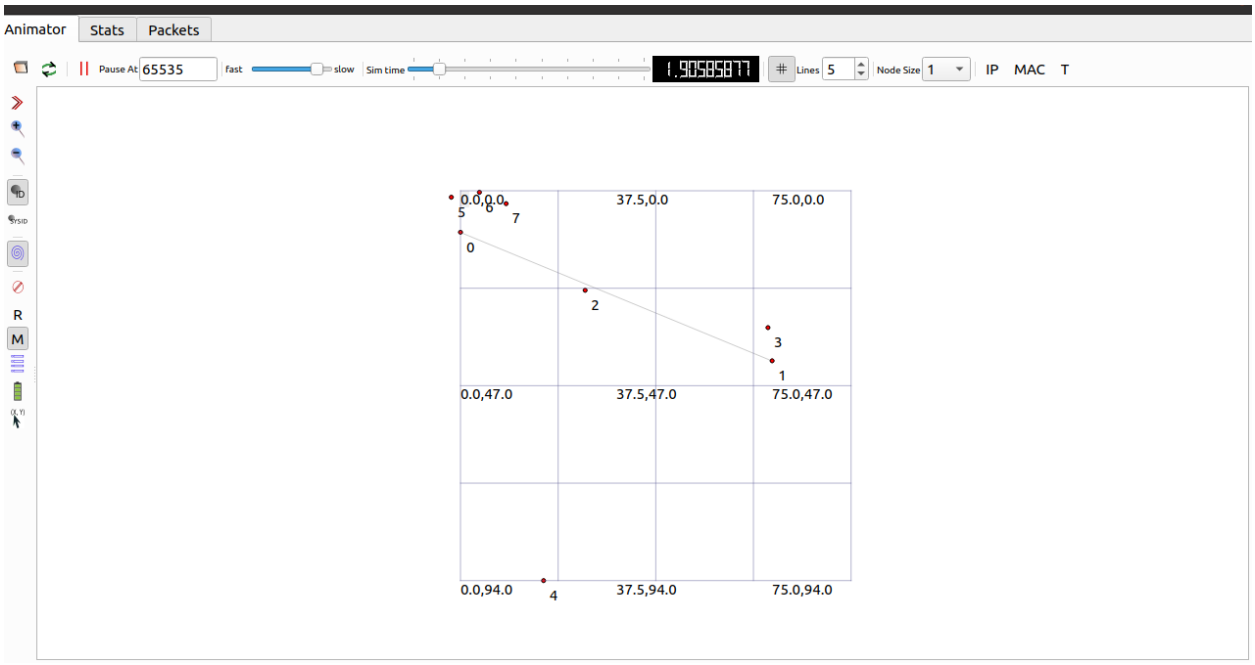
```
NetDeviceContainer csmaDevices;
csmaDevices = csma.Install (csmaNodes);

NodeContainer wifiStaNodes;
wifiStaNodes.Create (nWifi);
NodeContainer wifiApNode = p2pNodes.Get (0);

YansWifiChannelHelper channel = YansWifiChannelHelper::Default ();
YansWifiPhyHelper phy;
phy.SetChannel (channel.Create ());

WifiHelper wifi;
wifi.SetRemoteStationManager ("ns3::AarfWifiManager");

WifiMacHelper mac;
Ssid ssid = Ssid ("ns-3-ssid");
mac.SetType ("ns3::StaWifiMac",
             "Ssid", SsidValue (ssid),
             "ActiveProbing", BooleanValue (false));

NetDeviceContainer staDevices;
staDevices = wifi.Install (phy, mac, wifiStaNodes);

mac.SetType ("ns3::ApWifiMac",
             "Ssid", SsidValue (ssid));

NetDeviceContainer apDevices;
apDevices = wifi.Install (phy, mac, wifiApNode);

MobilityHelper mobility;

mobility.SetPositionAllocator ("ns3::GridPositionAllocator",
                               "MinX", DoubleValue (0.0),
                               "MinY", DoubleValue (0.0),
                               "DeltaX", DoubleValue (5.0),
                               "DeltaY", DoubleValue (10.0),
                               "GridWidth", UintegerValue (3),
                               "LayoutType", StringValue ("RowFirst"));

mobility.SetMobilityModel ("ns3::RandomWalk2dMobilityModel",
                           "Bounds", RectangleValue (Rectangle (-50, 50, -50, 50)));
mobility.Install (wifiStaNodes);

mobility.SetMobilityModel ("ns3::ConstantPositionMobilityModel");
mobility.Install (wifiApNode);

InternetStackHelper stack;
stack.Install (csmaNodes);
stack.Install (wifiApNode);
stack.Install (wifiStaNodes);

Ipv4AddressHelper address;

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

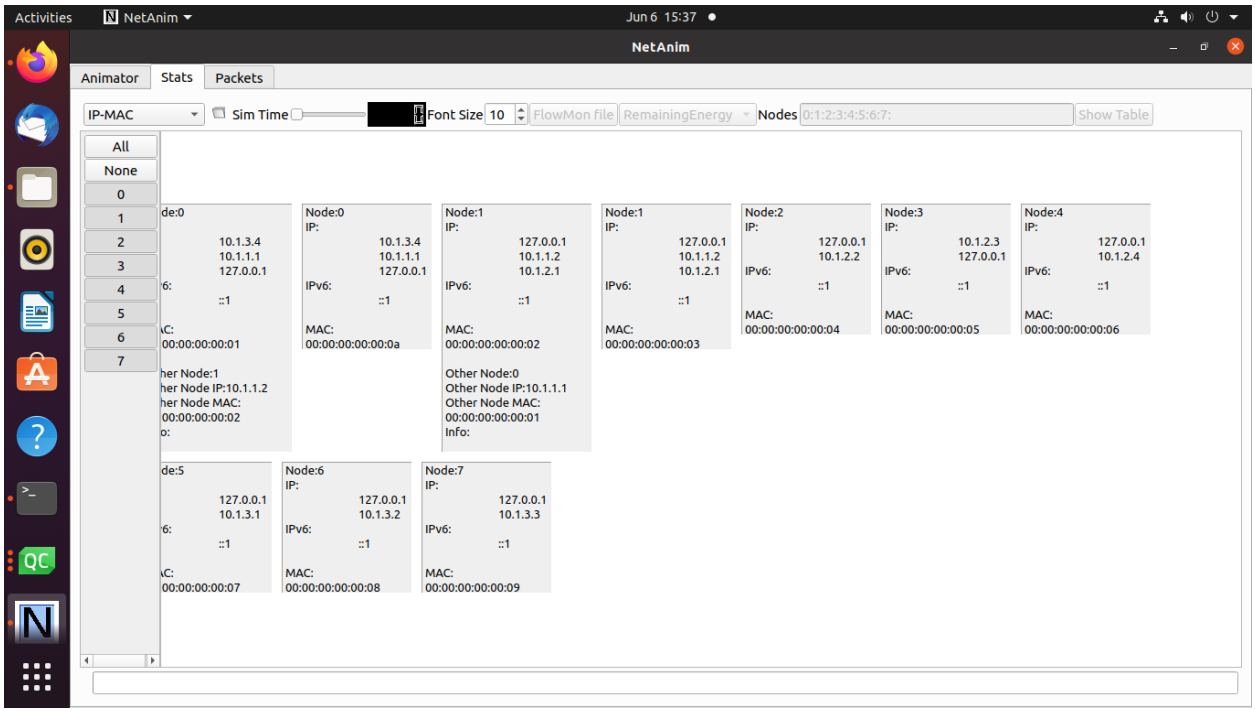
```
  p2pInterfaces = address.Assign (p2pDevices);

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

  address.SetBase ("10.1.3.0", "255.255.255.0");
  address.Assign (staDevices);
  address.Assign (apDevices);

  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 (wifiStaNodes.Get (nWifi - 1));
  clientApps.Start (Seconds (2.0));
  clientApps.Stop (Seconds (10.0));

  Ipv4GlobalRoutingHelper::PopulateRoutingTables ();

  Simulator::Stop (Seconds (10.0));

  if (tracing == true)
    {
      pointToPoint.EnablePcapAll ("third");
      phy.EnablePcap ("third", apDevices.Get (0));
      csma.EnablePcap ("third", csmaDevices.Get (0), true);
    }

AnimationInterface anim("hybrid.xml");
  Simulator::Run ();
  Simulator::Destroy ();
  return 0;
}
```

```
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
AnimationInterface WARNING:Node:4 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:4 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:1 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: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:4 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:4 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
At time +2.03371s client received 1024 bytes from 10.1.2.4 port 9
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```

Output Screen:




Animator
Stats
Packets
Pause At 65535
fast
slow
Sim time
Lines 5
Node Size 1
IP
MAC
T
0.0,0.0
37.5,0.0
75.0,0.0
0.0,47.0
37.5,47.0
75.0,47.0
0.0,94.0
37.5,94.0
75.0,94.0
0
1
2
3
4
5
6
7


Activities
NetAnim
Jun 6 15:37
NetAnim
Animator
Stats
Packets
IP-MAC
Sim Time
Font Size 10
FlowMon file
RemainingEnergy
Nodes
Show Table
All
None
0
1
2
3
4
5
6
7
Node:0
IP:
10.1.3.4
10.1.1.1
127.0.0.1
IPv6:
::1
MAC:
00:00:00:00:00:0a
Node:1
IP:
127.0.0.1
10.1.1.2
10.1.2.1
IPv6:
::1
MAC:
00:00:00:00:00:02
Other Node:0
Other Node IP:10.1.1.1
Other Node MAC:
00:00:00:00:00:01
Info:
Node:1
IP:
127.0.0.1
10.1.1.2
10.1.2.1
IPv6:
::1
MAC:
00:00:00:00:00:03
Node:2
IP:
127.0.0.1
10.1.2.2
IPv6:
::1
MAC:
00:00:00:00:00:04
Node:3
IP:
10.1.2.3
127.0.0.1
IPv6:
::1
MAC:
00:00:00:00:00:05
Node:4
IP:
127.0.0.1
10.1.2.4
IPv6:
::1
MAC:
00:00:00:00:00:06
Node:6
IP:
127.0.0.1
10.1.3.2
IPv6:
::1
MAC:
00:00:00:00:00:08
Node:7
IP:
127.0.0.1
10.1.3.3
IPv6:
::1
MAC:
00:00:00:00:00:09

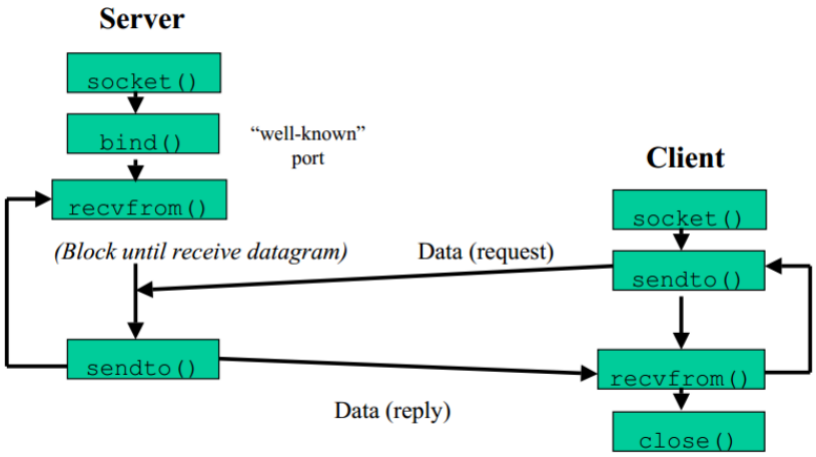
Practical No: 9

Aim:- Program to simulate UDP server client

Objective: To learn simulate UDP server client

Theory: In UDP, **the client does not form a connection with the server like in TCP and instead just sends a datagram**. Similarly, the server need not accept a connection and just waits for datagrams to arrive. Datagrams upon arrival contain the address of the sender which the server uses to send data to the correct client.

UDP Client-Server



Program:

Line of Code:

UDP.cc

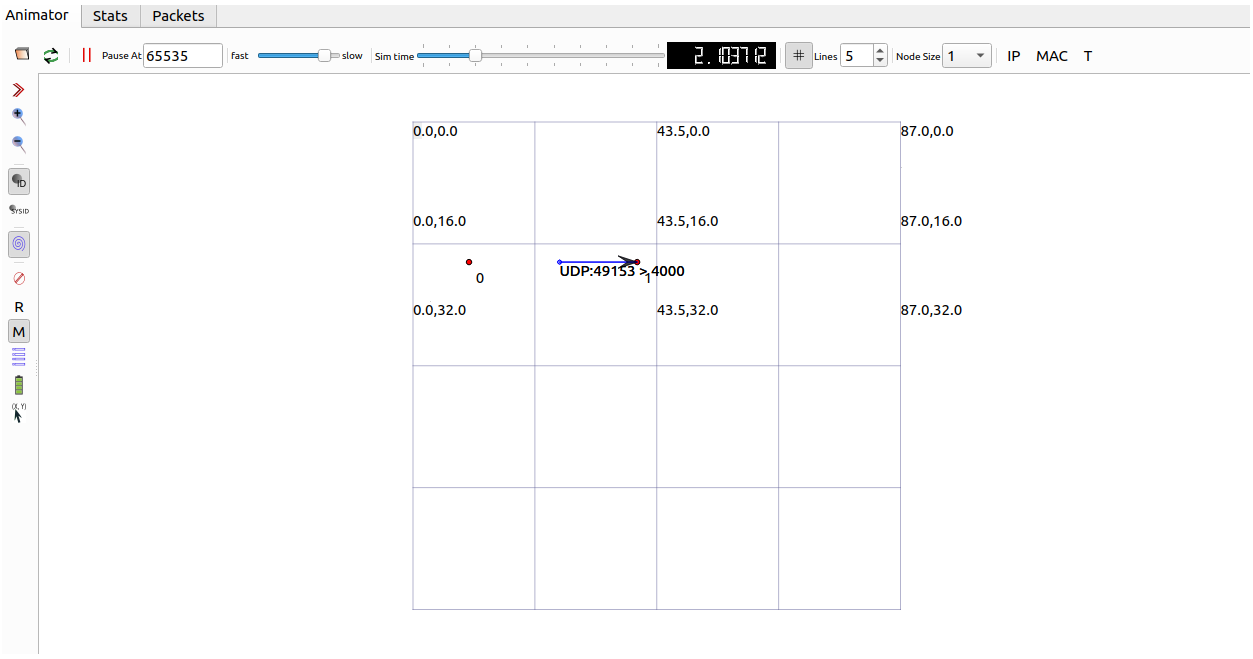
```
/* -*- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -*- */
/*
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License version 2 as
 * published by the Free Software Foundation;
 *
 * This program is distributed in the 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
 */
```

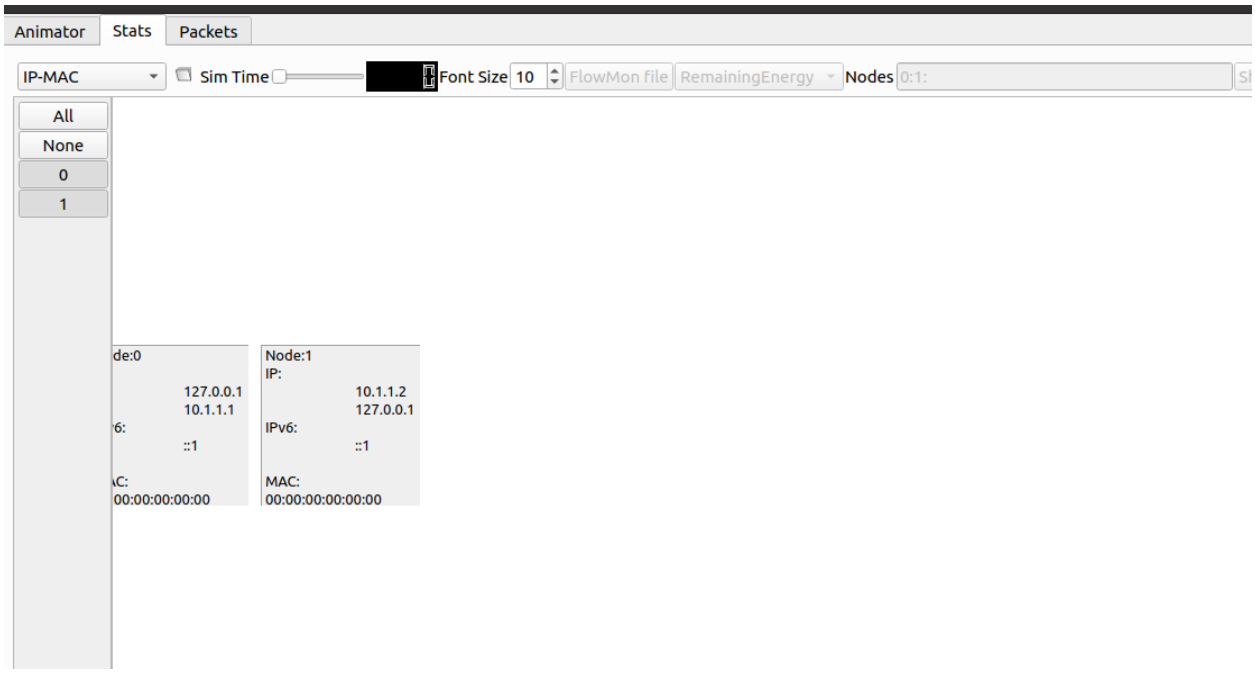
```
#include <fstream>
#include "ns3/core-module.h"
#include "ns3/csma-module.h"
#include "ns3/applications-module.h"
#include "ns3/internet-module.h"
//netAnimation
#include "ns3/netanim-module.h"
#include "ns3/mobility-module.h"
using namespace ns3;
NS_LOG_COMPONENT_DEFINE ("UdpClientServerExample");
int
main (int argc, char *argv[])
{
//
// Enable logging for UdpClient and
//
LogComponentEnable ("UdpClient", LOG_LEVEL_INFO);
LogComponentEnable ("UdpServer", LOG_LEVEL_INFO);
bool useV6 = false;
Address serverAddress;
CommandLine cmd (__FILE__);
cmd.AddValue ("useIpv6", "Use Ipv6", useV6);
cmd.Parse (argc, argv);
//
// Explicitly create the nodes required by the topology (shown above).
//
NS_LOG_INFO ("Create nodes.");
NodeContainer n;
n.Create (2);
InternetStackHelper internet;
internet.Install (n);
NS_LOG_INFO ("Create channels.");
//
// Explicitly create the channels required by the topology (shown above).
//
CsmaHelper csma;
csma.SetChannelAttribute ("DataRate", DataRateValue (DataRate (5000000)));
csma.SetChannelAttribute ("Delay", TimeValue (MilliSeconds (2)));
csma.SetDeviceAttribute ("Mtu", UintegerValue (1400));
NetDeviceContainer d = csma.Install (n);
//
// We've got the "hardware" in place. Now we need to add IP addresses.
//
NS_LOG_INFO ("Assign IP Addresses.");
if (useV6 == false)
{
Ipv4AddressHelper ipv4;
ipv4.SetBase ("10.1.1.0", "255.255.255.0");
Ipv4InterfaceContainer i = ipv4.Assign (d);
serverAddress = Address (i.GetAddress (1));
}
else
{
Ipv6AddressHelper ipv6;
ipv6.SetBase ("2001:0000:f00d:cafe::", Ipv6Prefix (64));
Ipv6InterfaceContainer i6 = ipv6.Assign (d);
serverAddress = Address(i6.GetAddress (1,1));
}
NS_LOG_INFO ("Create Applications.");
```

```
//
// Create one udpServer applications on node one.
//
uint16_t port = 4000;
UdpServerHelper server (port);
ApplicationContainer apps = server.Install (n.Get (1));
apps.Start (Seconds (1.0));
apps.Stop (Seconds (10.0));
//
// Create one UdpClient application to send UDP datagrams from node zero to
// node one.
//
uint32_t MaxPacketSize = 1024;
Time interPacketInterval = Seconds (0.05);
uint32_t maxPacketCount = 320;
UdpClientHelper client (serverAddress, port);
client.SetAttribute ("MaxPackets", UintegerValue (maxPacketCount));
client.SetAttribute ("Interval", TimeValue (interPacketInterval));
client.SetAttribute ("PacketSize", UintegerValue (MaxPacketSize));
apps = client.Install (n.Get (0));
apps.Start (Seconds (2.0));
apps.Stop (Seconds (10.0));
AnimationInterface anim("udp-cs.xml");
AnimationInterface::SetConstantPosition (n.Get(0), 10, 25);
AnimationInterface ::SetConstantPosition(n.Get(1), 40,25);
anim.EnablePacketMetadata(true);
csma.EnablePcapAll("udp-cs");

//
// Now, do the actual simulation.
//
NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
}
```

```
mca@mca-To-be-filled-by-O-E-M: ~/repos/ns-allinone-3.34/netanim-3.108
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 437 Time: +9.15s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 143 Uid: 437 TXtime: +9.15e+09ns RXtime: +9.15371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 440 Time: +9.2s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 144 Uid: 440 TXtime: +9.2e+09ns RXtime: +9.20371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 443 Time: +9.25s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 145 Uid: 443 TXtime: +9.25e+09ns RXtime: +9.25371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 446 Time: +9.3s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 146 Uid: 446 TXtime: +9.3e+09ns RXtime: +9.30371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 449 Time: +9.35s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 147 Uid: 449 TXtime: +9.35e+09ns RXtime: +9.35371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 452 Time: +9.4s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 148 Uid: 452 TXtime: +9.4e+09ns RXtime: +9.40371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 455 Time: +9.45s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 149 Uid: 455 TXtime: +9.45e+09ns RXtime: +9.45371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 458 Time: +9.5s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 150 Uid: 458 TXtime: +9.5e+09ns RXtime: +9.50371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 461 Time: +9.55s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 151 Uid: 461 TXtime: +9.55e+09ns RXtime: +9.55371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 464 Time: +9.6s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 152 Uid: 464 TXtime: +9.6e+09ns RXtime: +9.60371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 467 Time: +9.65s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 153 Uid: 467 TXtime: +9.65e+09ns RXtime: +9.65371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 470 Time: +9.7s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 154 Uid: 470 TXtime: +9.7e+09ns RXtime: +9.70371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 473 Time: +9.75s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 155 Uid: 473 TXtime: +9.75e+09ns RXtime: +9.75371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 476 Time: +9.8s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 156 Uid: 476 TXtime: +9.8e+09ns RXtime: +9.80371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 479 Time: +9.85s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 157 Uid: 479 TXtime: +9.85e+09ns RXtime: +9.85371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 482 Time: +9.9s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 158 Uid: 482 TXtime: +9.9e+09ns RXtime: +9.90371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uid: 485 Time: +9.95s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 159 Uid: 485 TXtime: +9.95e+09ns RXtime: +9.95371e+09ns Delay: +3.712e+06ns
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
mca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```

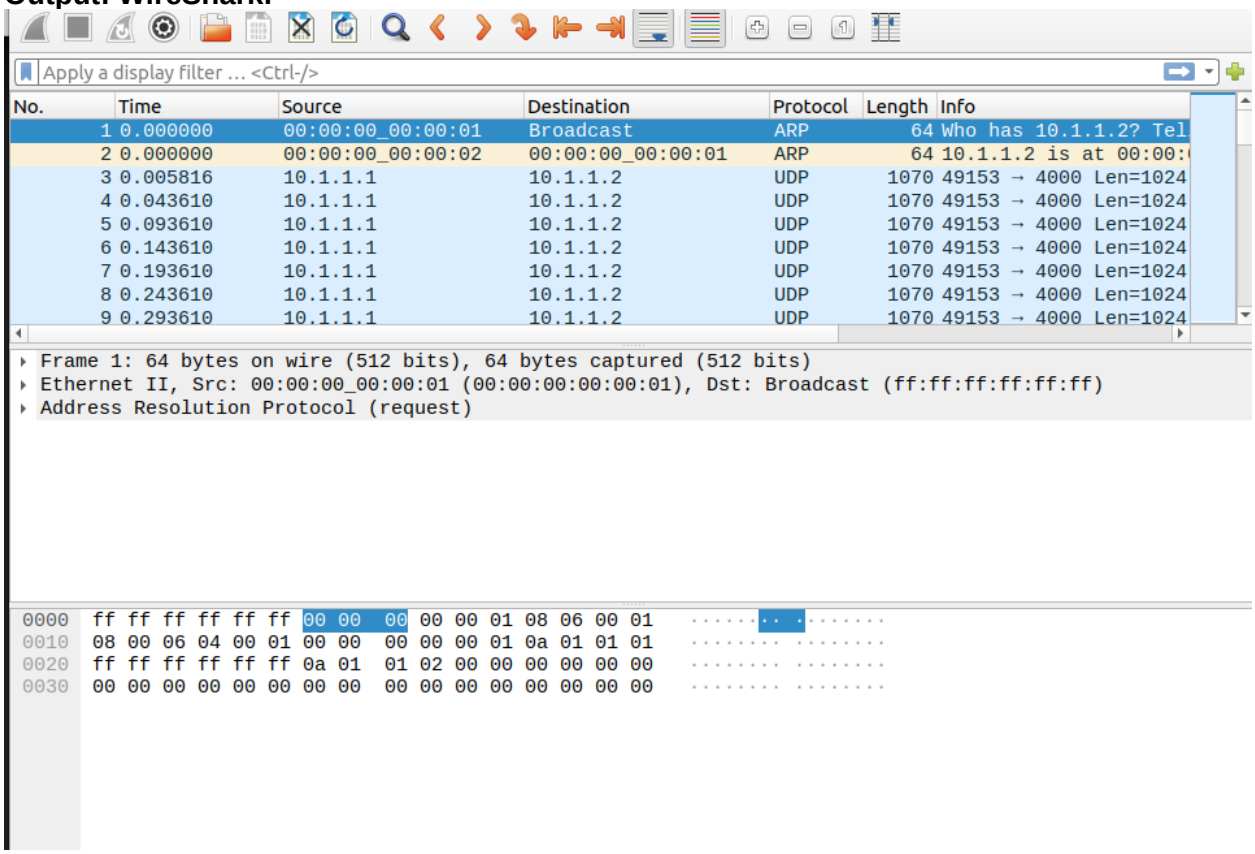
Output: Netanim Screen:




Animator
Stats
Packets
IP-MAC
Sim Time
Font Size
10
FlowMon file
RemainingEnergy
Nodes
0:1:
All
None
0
1
de:0
127.0.0.1
10.1.1.1
6:
::1
C:
00:00:00:00:00
Node:1
IP:
10.1.1.2
127.0.0.1
IPv6:
::1
MAC:
00:00:00:00:00:00


Animator
Stats
Packets
From Time
2.008
To Time
3.10371
Show Nodes
0:1:
Show Graph
Tcp
Udp
Ipv4
Ipv6
Icmp
Wifi
Ethernet
Ppp
Aodv
Olsr
Arp
Regex on meta data
.*
Submit
0
1
SrcIp : 10.1.1.2 DstIp : 10.1.1.1
SrcIp : 10.1.1.1 DstIp : 10.1.1.2
UDP 49153 > 4000
Export Table
From Id
To Id
Tx
19 0 1 2.35 UDP
20 0 1 2.35 UDP
21 0 1 2.4 UDP
22 0 1 2.4 UDP
23 0 1 2.45 UDP
24 0 1 2.45 UDP
25 0 1 2.5 UDP
26 0 1 2.5 UDP
27 0 1 2.55 UDP
28 0 1 2.55 UDP
29 0 1 2.6 UDP
30 0 1 2.6 UDP
31 0 1 2.65 UDP
32 0 1 2.65 UDP

Output: WireShark:

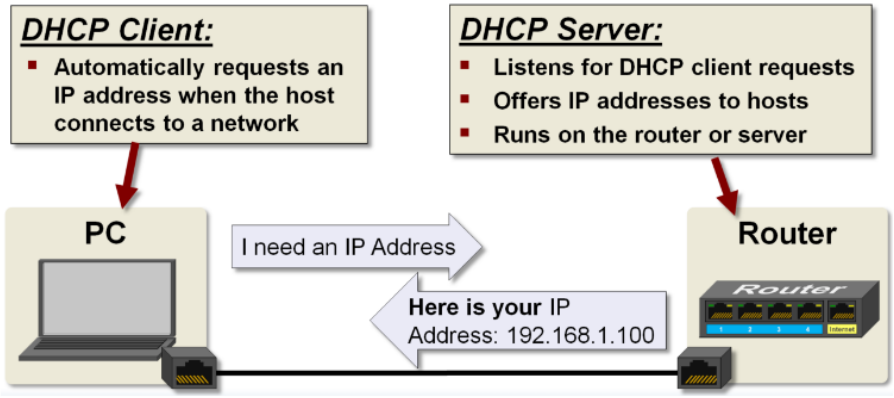


Practical No: 10

Aim:- Program to simulate DHCP server and n clients

Objective: To learn simulate DHCP server and n clients

Theory: A DHCP Server is **a network server that automatically provides and assigns IP addresses, default gateways and other network parameters to client devices**. It relies on the standard protocol known as Dynamic Host Configuration Protocol or DHCP to respond to broadcast queries by clients.



Program:

Line of Code:

DHCP.cc

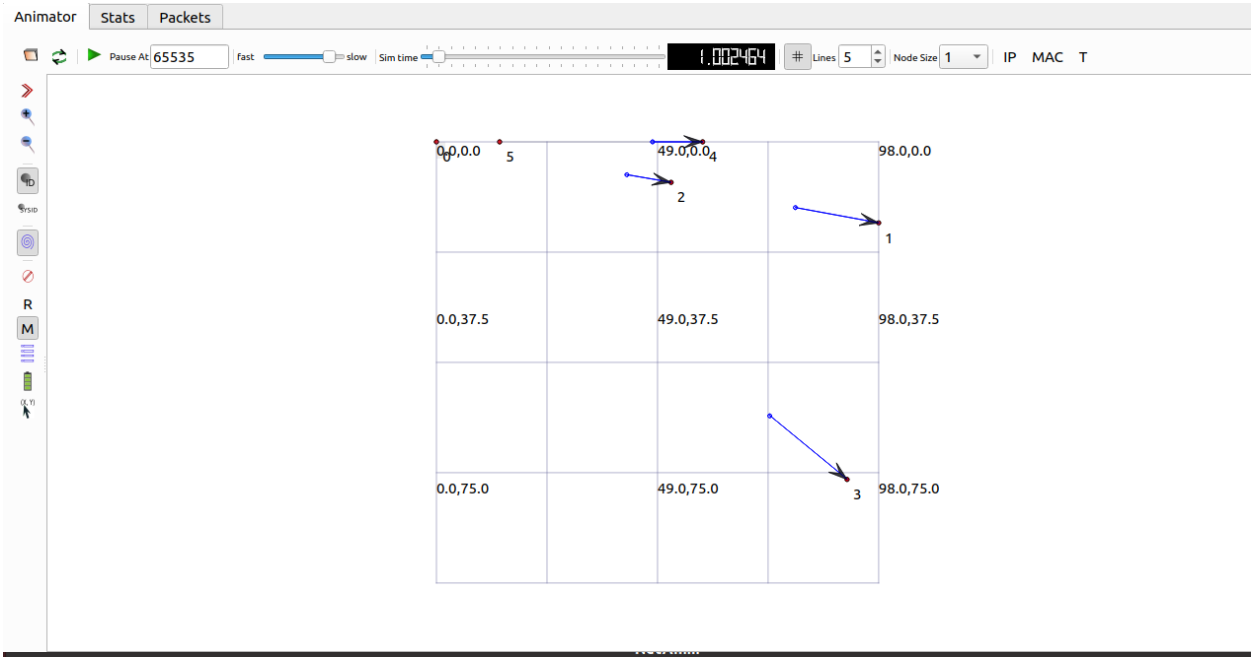
```
/* -*- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -*- */

/*
* 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
*
/
//
* Network layout:
*
* R0 is a DHCP server. The DHCP server announced R1 as the default router.
```

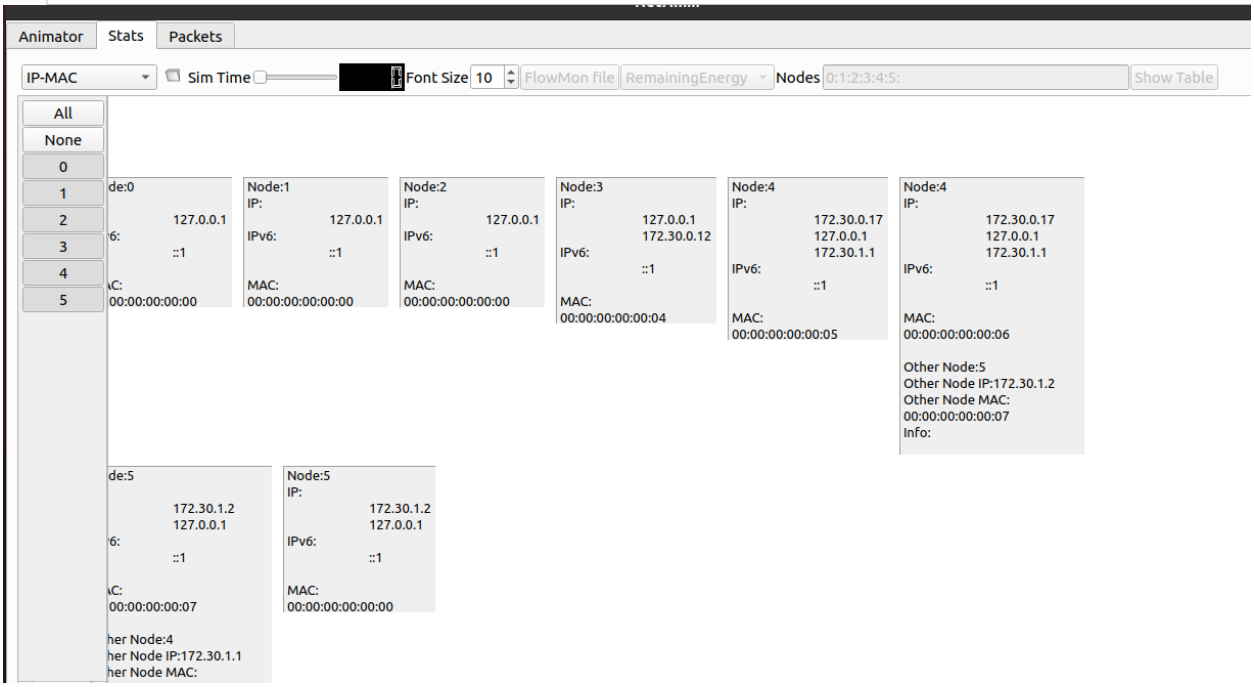
```
* Nodes N1 will send UDP Echo packets to node A.
*
*
*  ┌-----------------------------------------------┐
*  | DHCP Clients |
*  | 172.30.0.14 |
*  | DHCP static |
*  |  ┌─────┐  ┌─────┐  ┌─────┐  |
*  |  │ N0  │  │ N1  │  │ N2  │  |  ┌─────┐
*  |  └─────┘  └─────┘  └─────┘  |  ┌──| A
|
*  |  |  |  |  |  |  └─────┘
*  └-------|--------------|---------------|----------┘  | 172.30.1.2
*  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"
#include "ns3/netanim-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;
std::string animFile = "dhcp-server-client-animation.xml";
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);
```

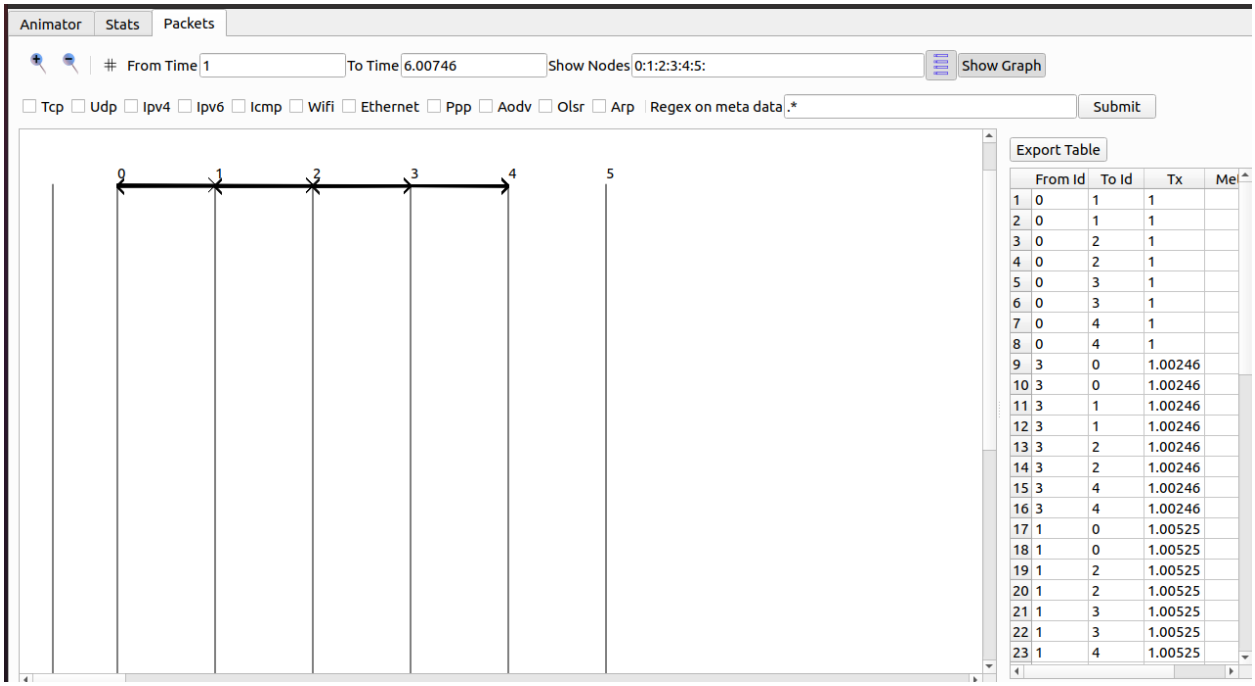
```
NS_LOG_INFO ("Create nodes.");
NodeContainer nodes;
NodeContainer router;
nodes.Create (3);
router.Create (2);
NodeContainer net (nodes, router);
NS_LOG_INFO ("Create channels.");
CsmaHelper csma;
csma.SetChannelAttribute ("DataRate", StringValue ("5Mbps"));
csma.SetChannelAttribute ("Delay", StringValue ("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"),
Ipv4Address ("172.30.0.0"), Ipv4Mask ("/24"),
Ipv4Address ("172.30.0.10"), Ipv4Address ("172.30.0.15"),
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);
Simulator::Stop (stopTime + Seconds (10.0));
// Create the animation object and configure for specified output
AnimationInterface anim ("dhcp.xml");
if (tracing)
{
csma.EnablePcapAll ("dhcp-csma");
pointToPoint.EnablePcapAll ("dhcp-p2p");
}
NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
}
```

Output: NetAnim Screen:


Animator
Stats
Packets
Pause At 65535
fast
slow
Sim time
Lines 5
Node Size 1
IP
MAC
T
0.0,0.0
49.0,0.0
98.0,0.0
0.0,37.5
49.0,37.5
98.0,37.5
0.0,75.0
49.0,75.0
98.0,75.0
0
1
2
3
4
5


Animator
Stats
Packets
IP-MAC
Sim Time
Font Size 10
FlowMon file
RemainingEnergy
Nodes 0:1:2:3:4:5:
Show Table
All
None
0
1
2
3
4
5
de:0
127.0.0.1
::1
00:00:00:00:00:00
Node:1
IP:
127.0.0.1
IPv6:
::1
MAC:
00:00:00:00:00:00
Node:2
IP:
127.0.0.1
IPv6:
::1
MAC:
00:00:00:00:00:00
Node:3
IP:
127.0.0.1
172.30.0.12
IPv6:
::1
MAC:
00:00:00:00:00:04
Node:4
IP:
172.30.0.17
127.0.0.1
172.30.1.1
IPv6:
::1
MAC:
00:00:00:00:00:05
Node:4
IP:
172.30.0.17
127.0.0.1
172.30.1.1
IPv6:
::1
MAC:
00:00:00:00:00:06
Other Node:5
Other Node IP:172.30.1.2
Other Node MAC:
00:00:00:00:00:07
Info:
de:5
172.30.1.2
127.0.0.1
::1
00:00:00:00:07
her Node:4
her Node IP:172.30.1.1
her Node MAC:
Node:5
IP:
172.30.1.2
127.0.0.1
IPv6:
::1
MAC:
00:00:00:00:00:00



	From Id	To Id	Tx	Me
1	0	1	1	
2	0	1	1	
3	0	2	1	
4	0	2	1	
5	0	3	1	
6	0	3	1	
7	0	4	1	
8	0	4	1	
9	3	0	1.00246	
10	3	0	1.00246	
11	3	1	1.00246	
12	3	1	1.00246	
13	3	2	1.00246	
14	3	2	1.00246	
15	3	4	1.00246	
16	3	4	1.00246	
17	1	0	1.00525	
18	1	0	1.00525	
19	1	2	1.00525	
20	1	2	1.00525	
21	1	3	1.00525	
22	1	3	1.00525	
23	1	4	1.00525	