

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.

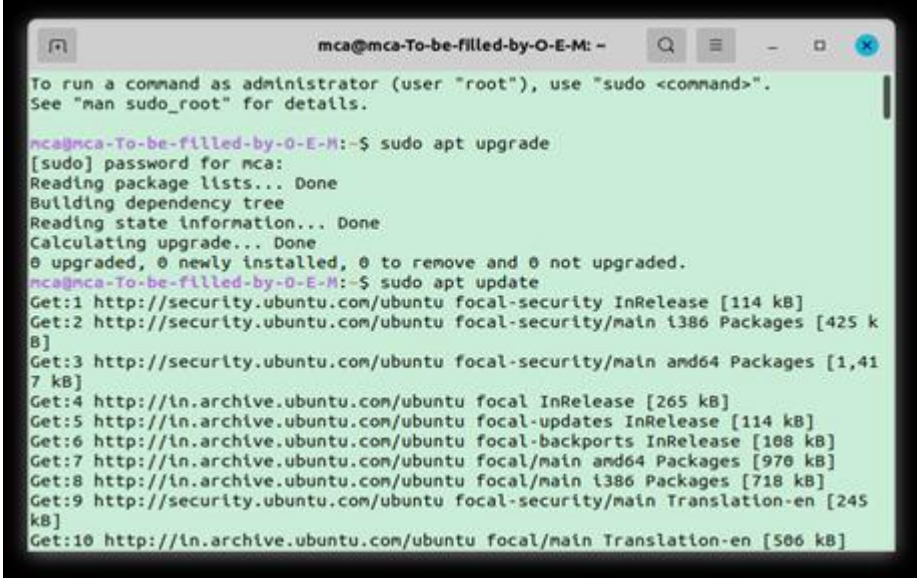
Program: After Installing Ubuntu 20.04 LTS successfully, you can now start with installing of NS3 packages.

List of Packages for Installing ns-3 in Ubuntu Systems

Prerequisite for installing NS3.32

sudo apt upgrade

Sudo apt update



```
mca@mca-To-be-filled-by-O-E-M: ~  
To run a command as administrator (user "root"), use "sudo <command>".  
See "man sudo_root" for details.  
  
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt upgrade  
[sudo] password for mca:  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
Calculating upgrade... Done  
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.  
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt update  
Get:1 http://security.ubuntu.com/ubuntu focal-security InRelease [114 kB]  
Get:2 http://security.ubuntu.com/ubuntu focal-security/main i386 Packages [425 kB]  
Get:3 http://security.ubuntu.com/ubuntu focal-security/main amd64 Packages [1,417 kB]  
Get:4 http://in.archive.ubuntu.com/ubuntu focal InRelease [265 kB]  
Get:5 http://in.archive.ubuntu.com/ubuntu focal-updates InRelease [114 kB]  
Get:6 http://in.archive.ubuntu.com/ubuntu focal-backports InRelease [108 kB]  
Get:7 http://in.archive.ubuntu.com/ubuntu focal/main amd64 Packages [970 kB]  
Get:8 http://in.archive.ubuntu.com/ubuntu focal/main i386 Packages [718 kB]  
Get:9 http://security.ubuntu.com/ubuntu focal-security/main Translation-en [245 kB]  
Get:10 http://in.archive.ubuntu.com/ubuntu focal/main Translation-en [506 kB]
```

Minimal requirements for C++ users

apt-get install g++ python3

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Roll No: 14

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```
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-config sqlite3

```
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).
python3 is already the newest version (3.8.2-0ubuntu2).
The following additional packages will be installed:
  libexpat1 libexpat1-dev libpython3.8-dev libpython3.8 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 libpython3.8-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://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8 amd64 3.8.10-0ubuntu1-20.04.4 [387 kB]
Get:2 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8 amd64 3.8.10-0ubuntu1-20.04.4 [1,625 kB]
Get:3 http://ln.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://ln.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://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8-minimal amd64 3.8.10-0ubuntu1-20.04.4 [717 kB]
Get:6 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 libexpat1 amd64 2.2.9-1ubuntu0.4 [74.4 kB]
Get:7 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g amd64 1:1.2.11.dfsg-2ubuntu1.3 [53.8 kB]
Get:8 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 libexpat1-dev amd64 2.2.9-1ubuntu0.4 [117 kB]
Get:9 http://ln.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://ln.archive.ubuntu.com/ubuntu focal/main amd64 libpython3.8-dev amd64 3.8.2-0ubuntu2 [7,236 B]
Get:11 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g-dev amd64 1:1.2.11.dfsg-2ubuntu1.3 [155 kB]
Get:12 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8-dev amd64 3.8.10-0ubuntu1-20.04.4 [514 kB]
Get:13 http://ln.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3-distutils all 3.8.10-0ubuntu1-20.04 [141 kB]
Get:14 http://ln.archive.ubuntu.com/ubuntu focal/main amd64 python3-dev amd64 3.8.2-0ubuntu2 [1,212 B]
Get:15 http://ln.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

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```
mca@mca-To-be-filled-by-0-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 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 libegl1 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-0-E-M:~$ sudo apt-get install gir1.2-goocanvas-2.0 python-gi python-gi-cairo python3-gi python3-gi-cairo python3-pygr
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-0-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

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```
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 the texlive 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

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```
mca@mca-To-be-filled-by-O-E-M:-$ sudo apt-get install cmake libnc-dev libnc-dev-1386 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).
libnc-dev is already the newest version (2.31-0ubuntu9.7).
libnc-dev-1386 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.
```

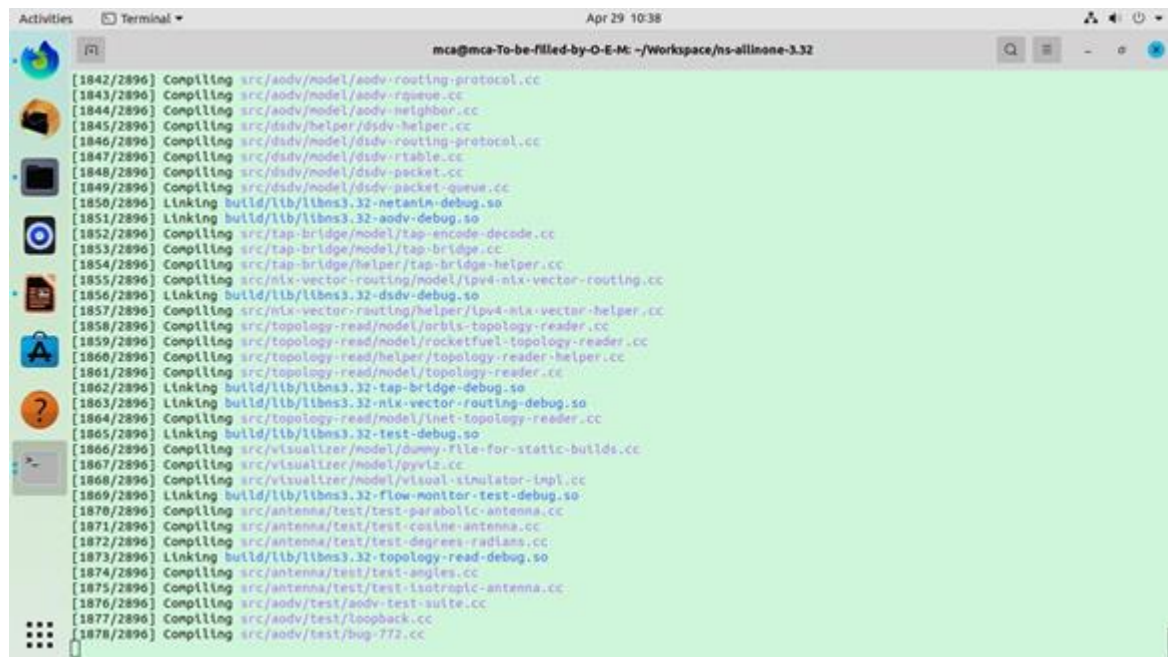
After installing the required packages,
create a folder named workspace in the home directory and then put the NS3 tar
package into the workspace.
Go to terminal and input these commands consecutively after each command finishes
executing:

```
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:

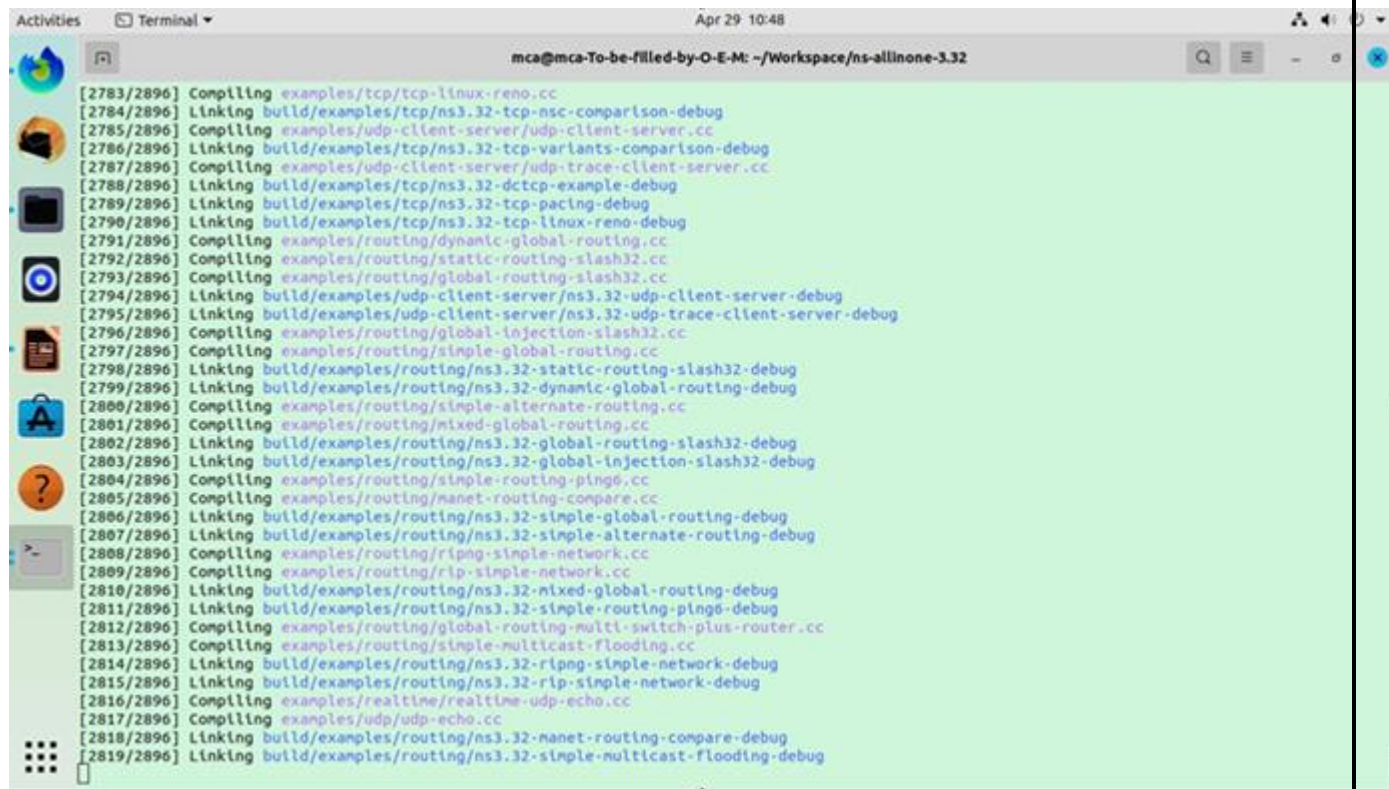
```
cd ns-<version number>
./test.py
```



```
Activities Terminal Apr 29 10:38
mca@mca-To-be-filled-by-O-E-M: ~/Workspace/ns-allinone-3.32

[1842/2896] Compiling src/aodv/model/aodv-routing-protocol.cc
[1843/2896] Compiling src/aodv/model/aodv-queue.cc
[1844/2896] Compiling src/aodv/model/aodv-neighbor.cc
[1845/2896] Compiling src/dsdv/helper/dsdv-helper.cc
[1846/2896] Compiling src/dsdv/model/dsdv-routing-protocol.cc
[1847/2896] Compiling src/dsdv/model/dsdv-rtable.cc
[1848/2896] Compiling src/dsdv/model/dsdv-packet.cc
[1849/2896] Compiling src/dsdv/model/dsdv-packet-queue.cc
[1850/2896] Linking build/lib/libns3.32-netanim-debug.so
[1851/2896] Linking build/lib/libns3.32-aodv-debug.so
[1852/2896] Compiling src/tap-bridge/model/tap-encode-decode.cc
[1853/2896] Compiling src/tap-bridge/model/tap-bridge.cc
[1854/2896] Compiling src/tap-bridge/helper/tap-bridge-helper.cc
[1855/2896] Compiling src/nix-vector-routing/model/ipv4-nix-vector-routing.cc
[1856/2896] Linking build/lib/libns3.32-dsdv-debug.so
[1857/2896] Compiling src/nix-vector-routing/helper/ipv4-nix-vector-helper.cc
[1858/2896] Compiling src/topology-read/model/orbit-topology-reader.cc
[1859/2896] Compiling src/topology-read/model/rocketfuel-topology-reader.cc
[1860/2896] Compiling src/topology-read/helper/topology-reader-helper.cc
[1861/2896] Compiling src/topology-read/model/topology-reader.cc
[1862/2896] Linking build/lib/libns3.32-tap-bridge-debug.so
[1863/2896] Linking build/lib/libns3.32-nix-vector-routing-debug.so
[1864/2896] Compiling src/topology-read/model/inet-topology-reader.cc
[1865/2896] Linking build/lib/libns3.32-test-debug.so
[1866/2896] Compiling src/visualizer/model/dummy-file-for-static-builds.cc
[1867/2896] Compiling src/visualizer/model/pvpl2.cc
[1868/2896] Compiling src/visualizer/model/visual-simulator-impl.cc
[1869/2896] Linking build/lib/libns3.32-flow-monitor-test-debug.so
[1870/2896] Compiling src/antenna/test/test-parabolic-antenna.cc
[1871/2896] Compiling src/antenna/test/test-cosine-antenna.cc
[1872/2896] Compiling src/antenna/test/test-degrees-radians.cc
[1873/2896] Linking build/lib/libns3.32-topology-read-debug.so
[1874/2896] Compiling src/antenna/test/test-angles.cc
[1875/2896] Compiling src/antenna/test/test-isotropic-antenna.cc
[1876/2896] Compiling src/aodv/test/aodv-test-suite.cc
[1877/2896] Compiling src/aodv/test/loopback.cc
[1878/2896] Compiling src/aodv/test/bug-772.cc
```

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The screenshot shows a terminal window titled "mca@mca-To-be-filled-by-O-E-M: ~/Workspace/ns-allinone-3.32". The terminal displays a list of commands for compiling and linking various ns3.32 examples. The commands are organized into pairs of [line number]/[line number] and the corresponding command. The examples include TCP, UDP, and routing-related programs.

```
[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.

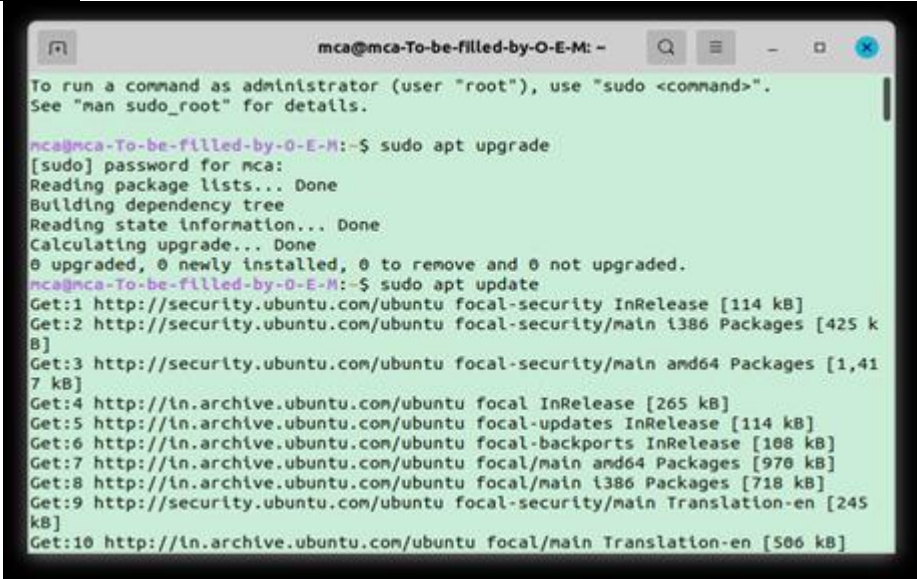
Installation: After Installing Ubuntu 20.04 LTS successfully, you can now start with installing of Net anim packages.

List of Packages for Installing ns-3 in Ubuntu Systems

Prerequisite for installing NS3.32

sudo apt upgrade

Sudo apt update



```
mca@mca-To-be-filled-by-O-E-M: ~  
To run a command as administrator (user "root"), use "sudo <command>".  
See "man sudo_root" for details.  
  
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt upgrade  
[sudo] password for mca:  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
Calculating upgrade... Done  
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.  
mca@mca-To-be-filled-by-O-E-M:~$ sudo apt update  
Get:1 http://security.ubuntu.com/ubuntu focal-security InRelease [114 kB]  
Get:2 http://security.ubuntu.com/ubuntu focal-security/main i386 Packages [425 kB]  
Get:3 http://security.ubuntu.com/ubuntu focal-security/main amd64 Packages [1,417 kB]  
Get:4 http://ln.archive.ubuntu.com/ubuntu focal InRelease [265 kB]  
Get:5 http://ln.archive.ubuntu.com/ubuntu focal-updates InRelease [114 kB]  
Get:6 http://ln.archive.ubuntu.com/ubuntu focal-backports InRelease [108 kB]  
Get:7 http://ln.archive.ubuntu.com/ubuntu focal/main amd64 Packages [970 kB]  
Get:8 http://ln.archive.ubuntu.com/ubuntu focal/main i386 Packages [718 kB]  
Get:9 http://security.ubuntu.com/ubuntu focal-security/main Translation-en [245 kB]  
Get:10 http://ln.archive.ubuntu.com/ubuntu focal/main Translation-en [506 kB]
```

Minimal requirements for C++ users

apt-get install g++ python3

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```
mca@mca-To-be-filled-by-0-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-config sqlite3

```
mca@mca-To-be-filled-by-0-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).
python3 is already the newest version (3.8.2-0ubuntu2).
The following additional packages will be installed:
  libexpat1 libexpat1-dev libpython3.8-dev libpython3.8 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 libpython3.8-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://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8 amd64 3.8.10-0ubuntu1-20.04.4 [387 kB]
Get:2 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8 amd64 3.8.10-0ubuntu1-20.04.4 [1,625 kB]
Get:3 http://ft.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://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8-minimal amd64 3.8.10-0ubuntu1-20.04.4 [1,099 kB]
Get:5 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3.8-minimal amd64 3.8.10-0ubuntu1-20.04.4 [717 kB]
Get:6 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libexpat1 amd64 2.2.9-1ubuntu0.4 [74.4 kB]
Get:7 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g amd64 1:1.2.11.dfsg-2ubuntu1.3 [53.8 kB]
Get:8 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libexpat1-dev amd64 2.2.9-1ubuntu0.4 [117 kB]
Get:9 http://ft.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://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libpython3-dev amd64 3.8.2-0ubuntu2 [7,236 B]
Get:11 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g-dev amd64 1:1.2.11.dfsg-2ubuntu1.3 [155 kB]
Get:12 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3.8-dev amd64 3.8.10-0ubuntu1-20.04.4 [514 kB]
Get:13 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3-distutils all 3.8.10-0ubuntu1-20.04.4 [141 kB]
Get:14 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3-dev amd64 3.8.2-0ubuntu2 [1,212 B]
Get:15 http://ft.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 ... 150039 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-0-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 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 libqt5qml5 libqt5qml5-qt5 libqt5qml5-qt5 libqt5svg5 libqt5test5 libqt5widgets5
  libqt5xml5 libvulkan-dev libx11-dev libxau-dev libxcb-xinerama0 libxcb-xinput0 libxcb1-dev libxdmcp-dev libxext-dev libxft-dev libxft-common
  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 | ngdiff 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 libqt5qml5 libqt5qml5-qt5 libqt5qml5-qt5 libqt5svg5 libqt5test5 libqt5widgets5 libqt5xml5
  libvulkan-dev libx11-dev libxcb-xinerama0 libxcb-xinput0 libxcb1-dev libxdmcp-dev libxext-dev libxft-dev libxft-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:
  libgl1 libgl1 libgl2 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://ft.archive.ubuntu.com/ubuntu focal/universe amd64 libdouble-conversion3 amd64 3.1.5-4ubuntu1 [37.9 kB]
Get:2 http://ft.archive.ubuntu.com/ubuntu focal/main amd64 libpcre2-16-0 amd64 10.34-7 [181 kB]
Get:3 http://ft.archive.ubuntu.com/ubuntu focal/universe amd64 libqt5core5a amd64 5.12.8+dfsg-0ubuntu2.1 [2,006 kB]
Get:4 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libgl1 amd64 1.3.2-1-ubuntu0.20.04.2 [85.0 kB]
Get:5 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libglx0 amd64 1.3.2-1-ubuntu0.20.04.2 [32.5 kB]
Get:6 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libgles2 amd64 1.3.2-1-ubuntu0.20.04.2 [15.6 kB]
Get:7 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libgl1 amd64 1.3.2-1-ubuntu0.20.04.2 [31.9 kB]
Get:8 http://ft.archive.ubuntu.com/ubuntu focal-updates/main amd64 libglvnd0 amd64 1.3.2-1-ubuntu0.20.04.2 [40.1 kB]
Get:9 http://ft.archive.ubuntu.com/ubuntu focal-updates/universe amd64 libqt5dbus5 amd64 5.12.8+dfsg-0ubuntu2.1 [208 kB]
```

ns-3-pyviz visualizer

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apt-get install gir1.2-gocanvas-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-gocanvas-2.0 python-gi python-gi-cairo python3-gi python3-gi-cairo python3-pygraphviz 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-gocanvas-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 (2019.20200218-1).
texlive-font-utils is already the newest version (2019.20200218-1).
texlive-latex-extra is already the newest version (2019.20200218-1).
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.
```

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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 the texlive packages above):

apt-get install python3-sphinx dia

```
mca@mca-To-be-filled-by-0-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-0-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-0-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 (1:1.16.1-4ubuntu0).
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

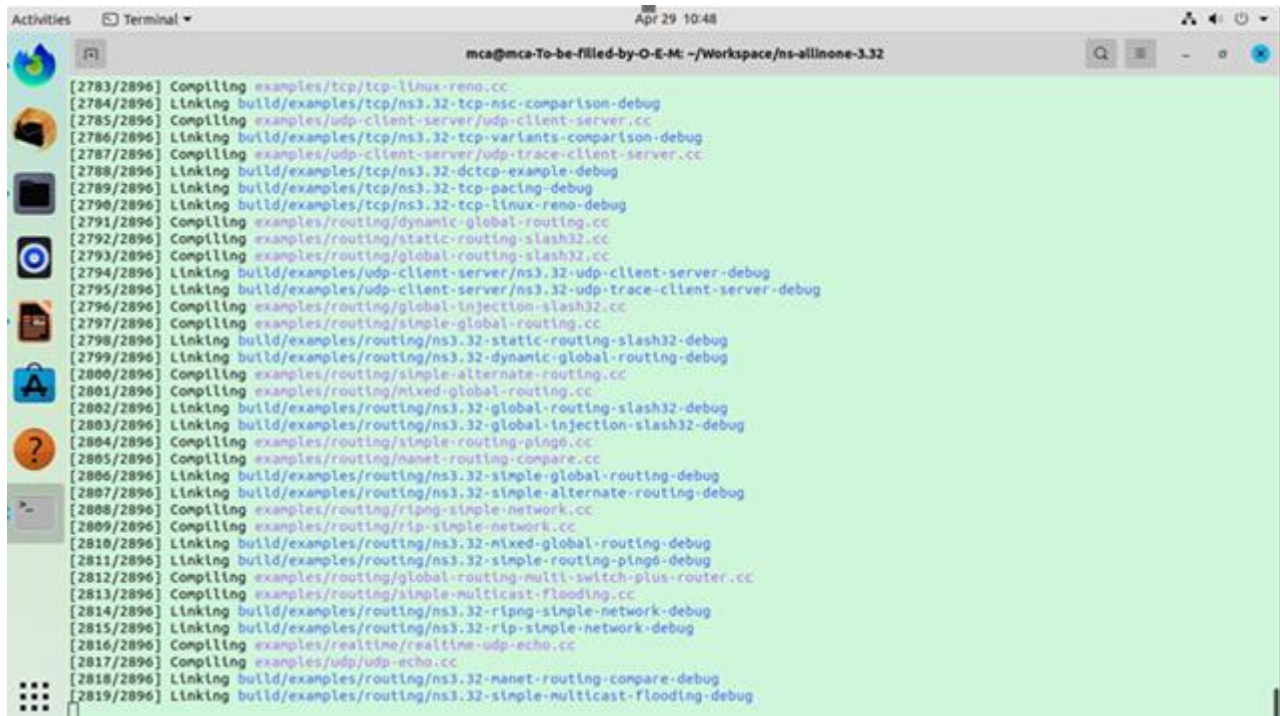
It takes time be patient !!

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

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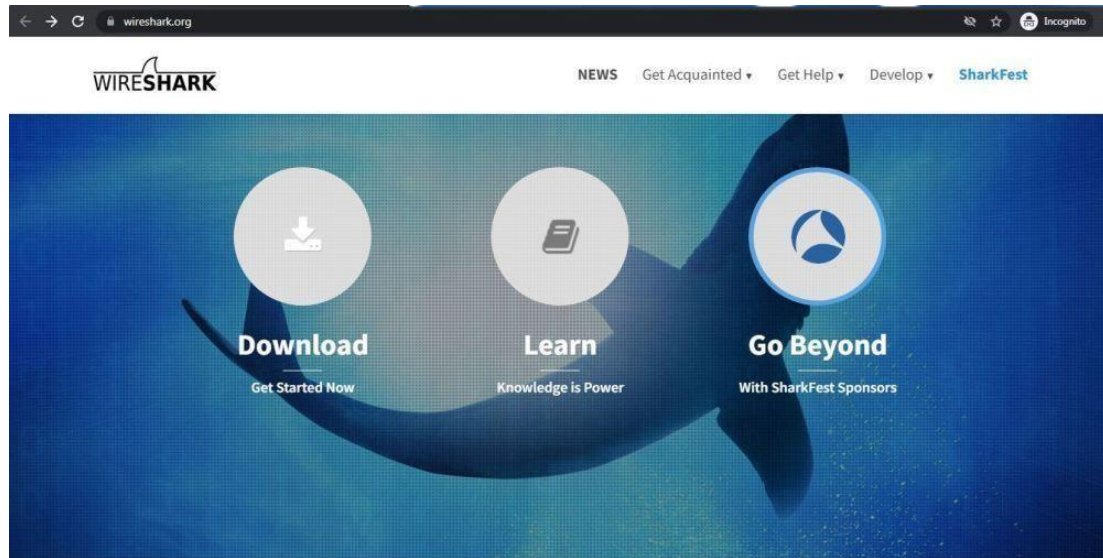


```
Activities Terminal Apr 29 10:48 mca@mca-To-be-filled-by-O-E-M: ~/Workspace/ns-allinone-3.32

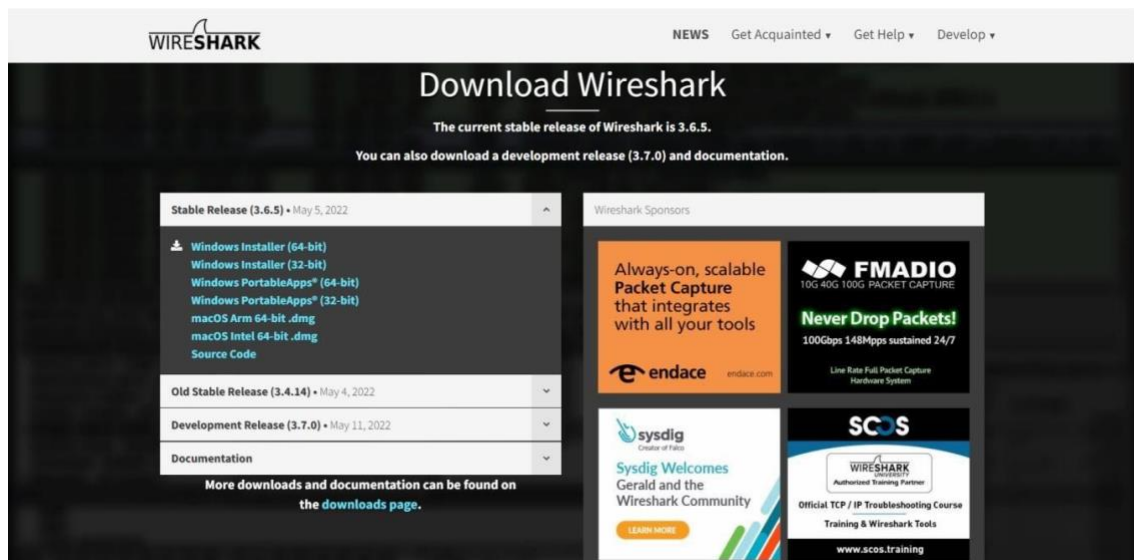
[2783/2896] Compiling examples/tcp/tcp-linux-reno.cc
[2784/2896] Linking build/examples/tcp/ns3.32-tcp-nsc-comparison-debug
[2785/2896] Compiling examples/udp-client-server/udp-client-server.cc
[2786/2896] Linking build/examples/tcp/ns3.32-tcp-variants-comparison-debug
[2787/2896] Compiling examples/udp-client-server/udp-trace-client-server.cc
[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/nanet-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-nanet-routing-compare-debug
[2819/2896] Linking build/examples/routing/ns3.32-simple-multicast-flooding-debug
```


Practical - 3

AIM:	Installation of Wire Shark
Objective:	To learn to Install Wire Shark in Ubuntu Linux
Step to Install:	<u>1] Visit the official Wireshark website using any web browser.</u>

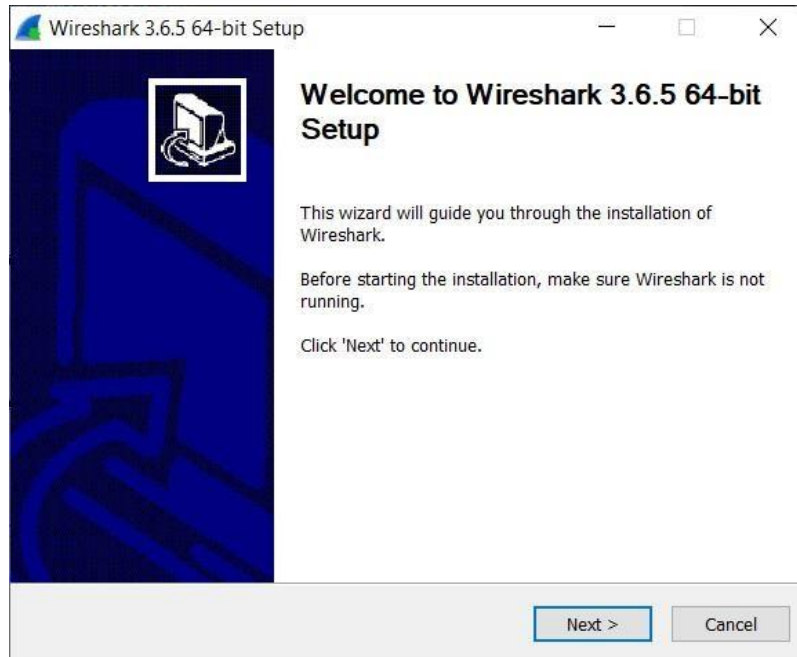


2] Click on Download, a new webpage will open with different installers of Wireshark.

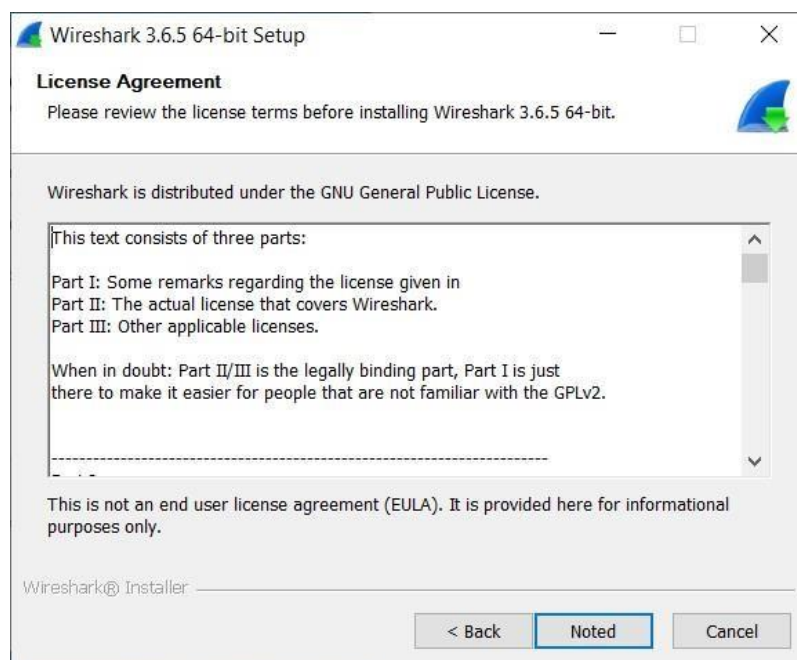


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- | | |
|--|--|
| | 3] <u>Downloading of the executable file will start shortly. It is a small 73.69 MB file that will take some time</u> |
| | 4] <u>Now check for the executable file in downloads in your system and run it.</u> |
| | 5] <u>It will prompt confirmation to make changes to your system. Click on Yes.</u> |
| | 6] <u>Setup screen will appear, click on Next.</u> |

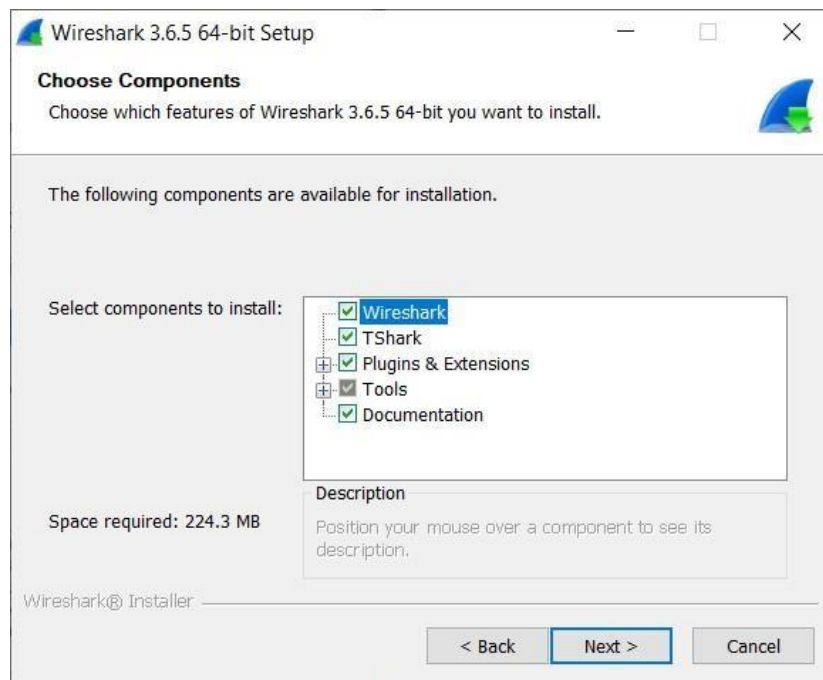


- | | |
|--|--|
| | 7] <u>The next screen will be of License Agreement, click on Noted.</u> |
|--|--|

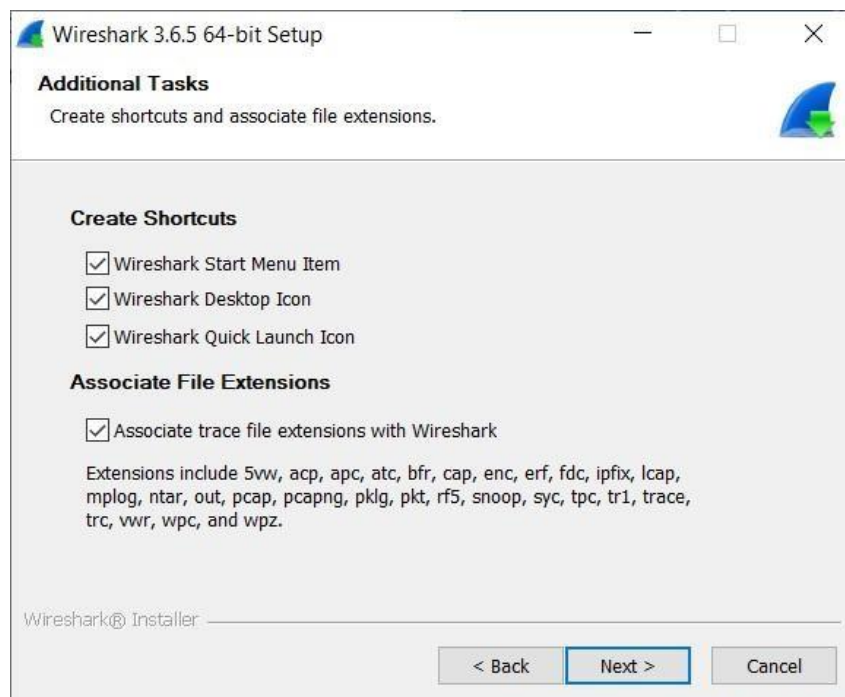


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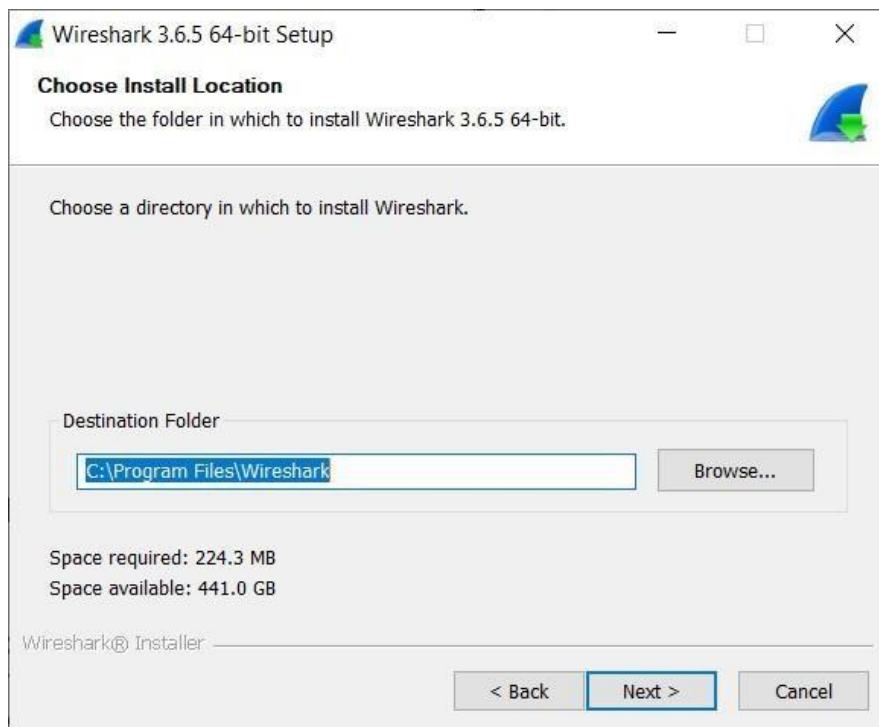
8] This screen is for choosing components, all components are already marked so don't change anything just click on the Next button.



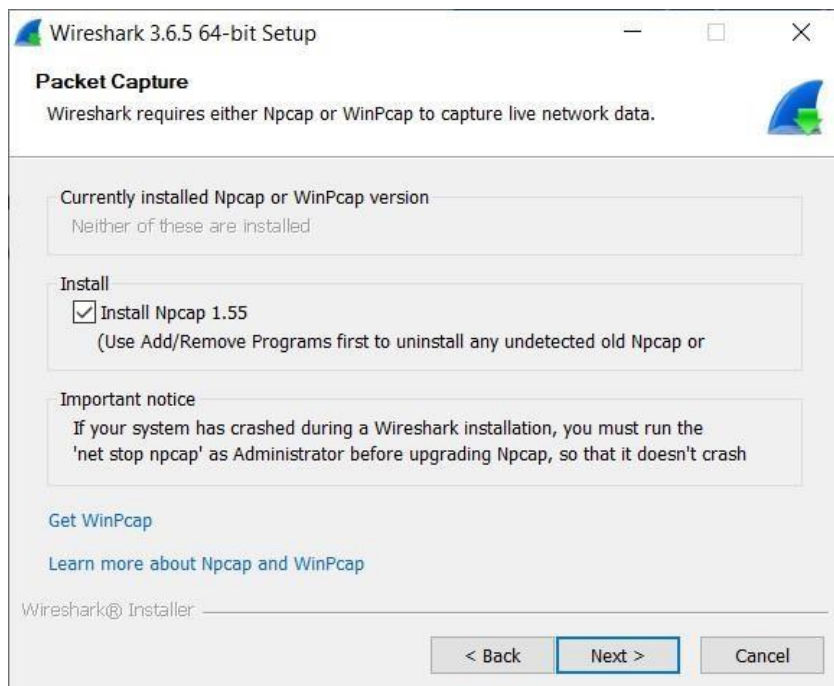
9] This screen is of choosing shortcuts like start menu or desktop icon along with file extensions which can be intercepted by Wireshark, tick all boxes and click on Next button.



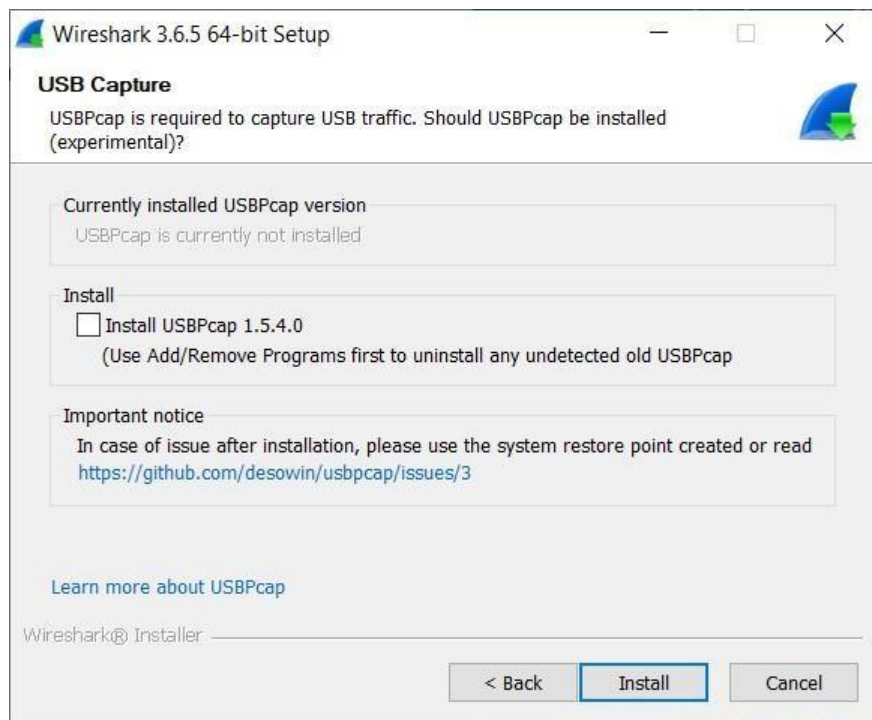
10] The next screen will be of installing location so choose the drive which will have sufficient memory space for installation. It needed only a memory space of 224.3 MB



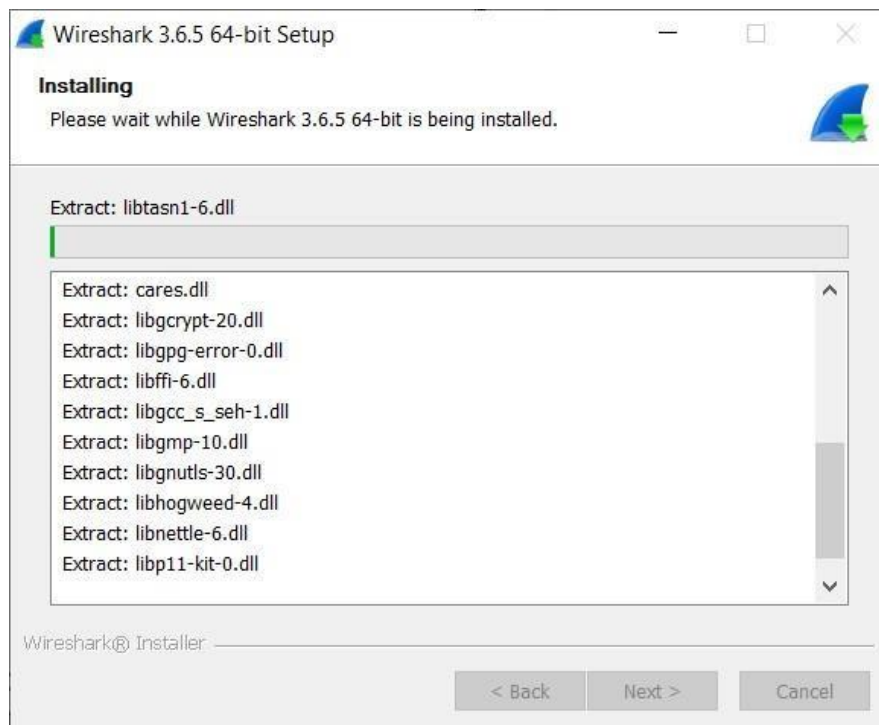
11] Next screen has an option to install Npcap which is used with Wireshark to capture packets *pcap* means packet capture so the install option is already checked don't change anything and click the next button.



12] Next screen is about USB network capturing so it is one's choice to use it or not, click on Install.

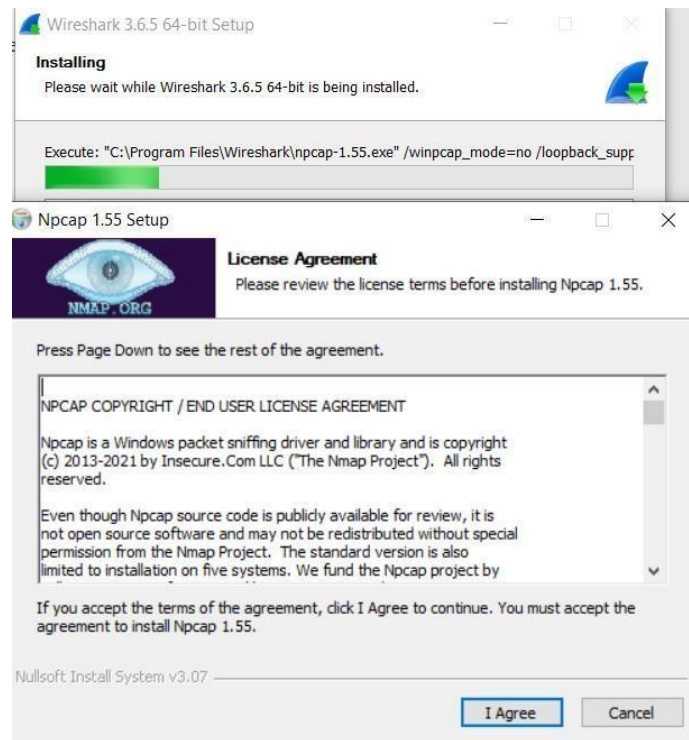


13] After this installation process will start.

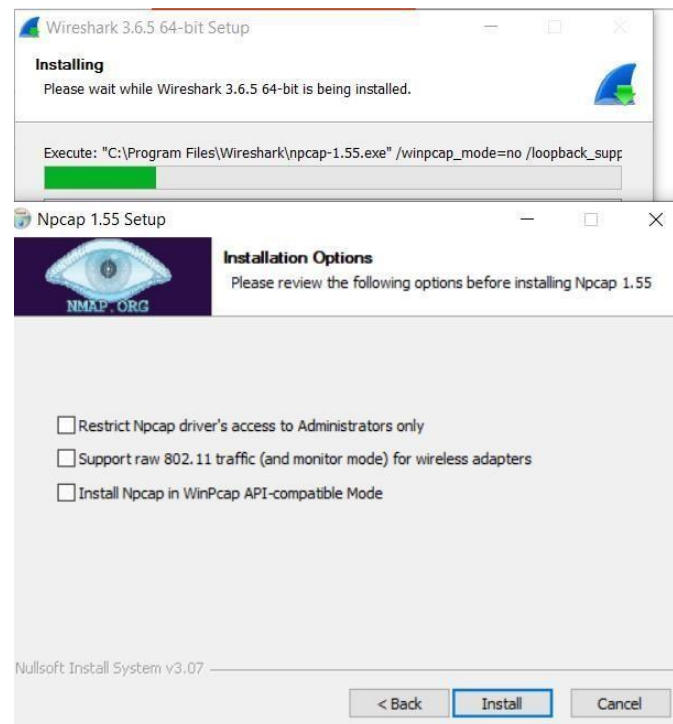


MCAL26- NETWORKING WITH LINUX LAB

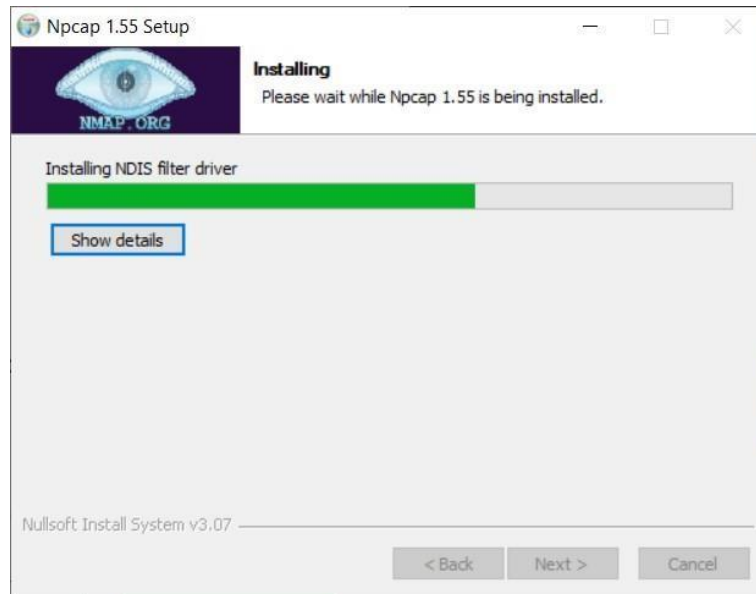
14] This installation will prompt for Npcap installation as already checked so the license agreement of Npcap will appear to click on the *I Agree* button.



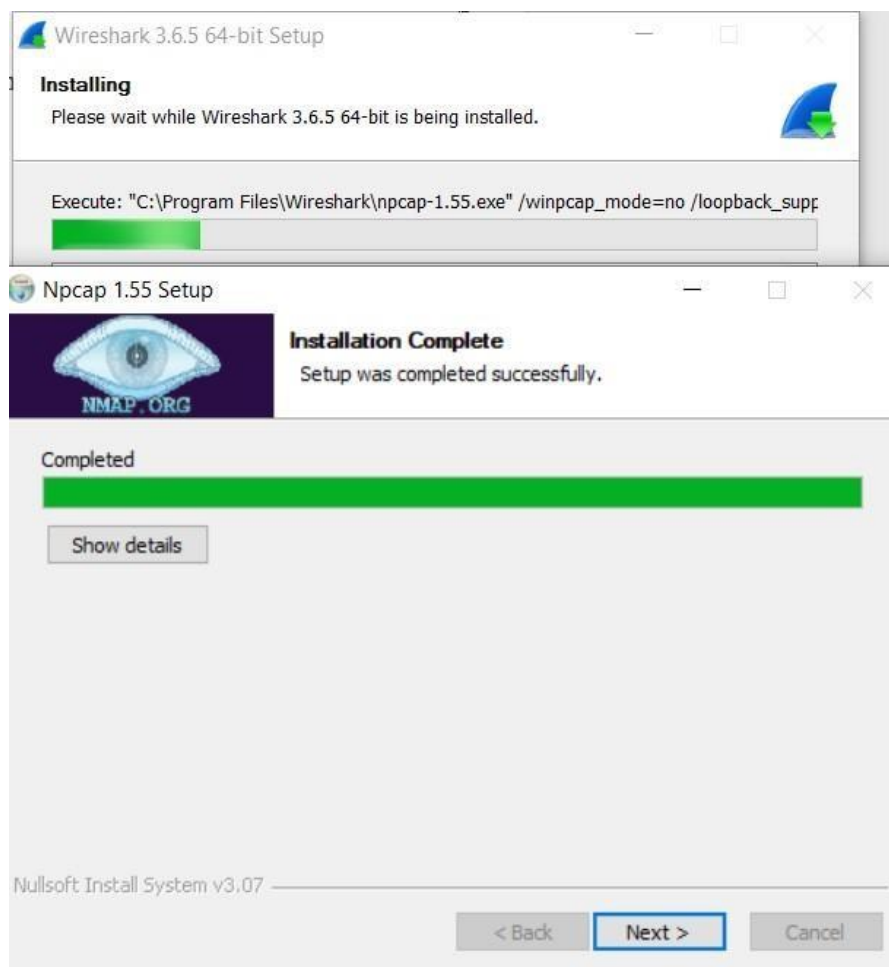
15] Next screen is about different installing options of *npcap*, don't do anything click on Install.



16 After this installation process will start which will take only a minute.

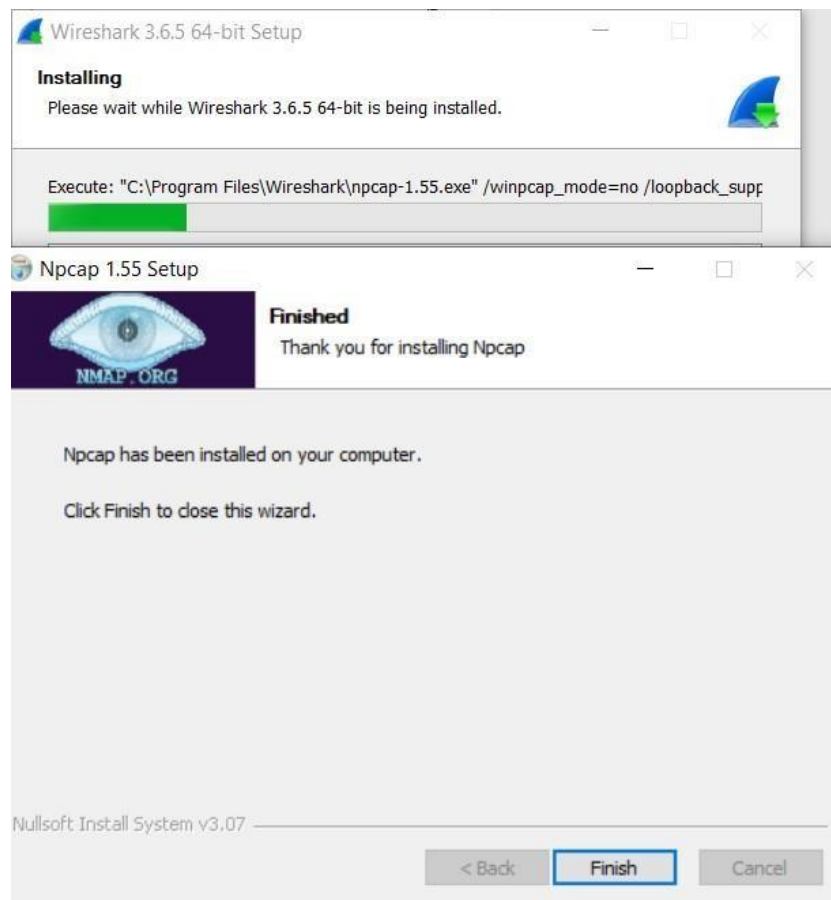


17 After this installation process will start which will take only a minute.

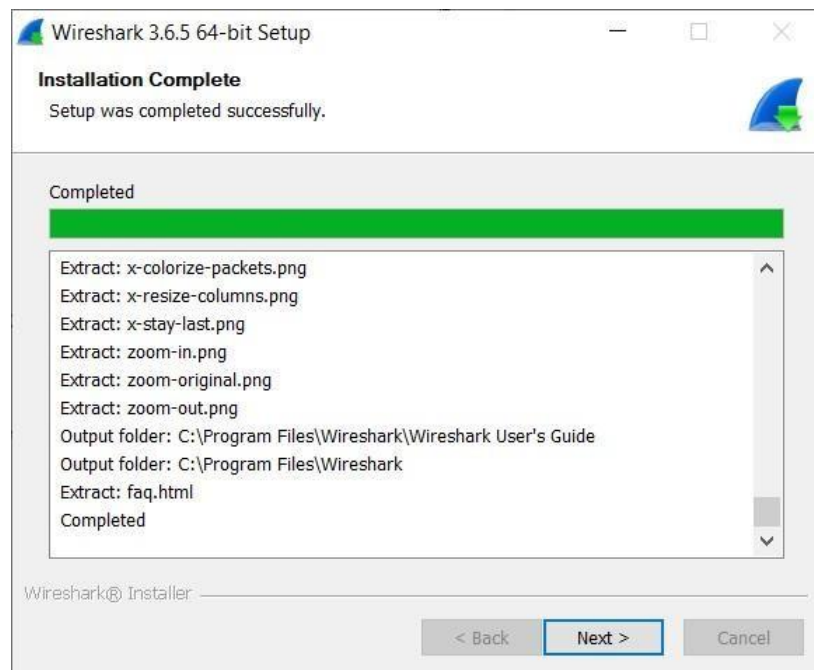


MCAL26- NETWORKING WITH LINUX LAB

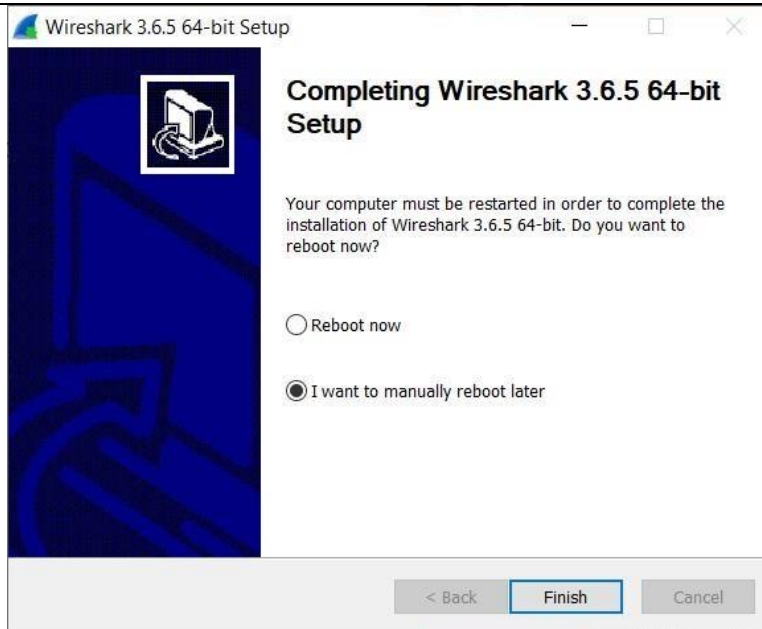
18] Click on Finish after the installation process is complete..



19] After this installation process of Wireshark will complete click on the Next button



201 Click on Finish after the installation process of Wireshark is complete.



Wireshark is successfully installed on the system and an icon is created on the desktop

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

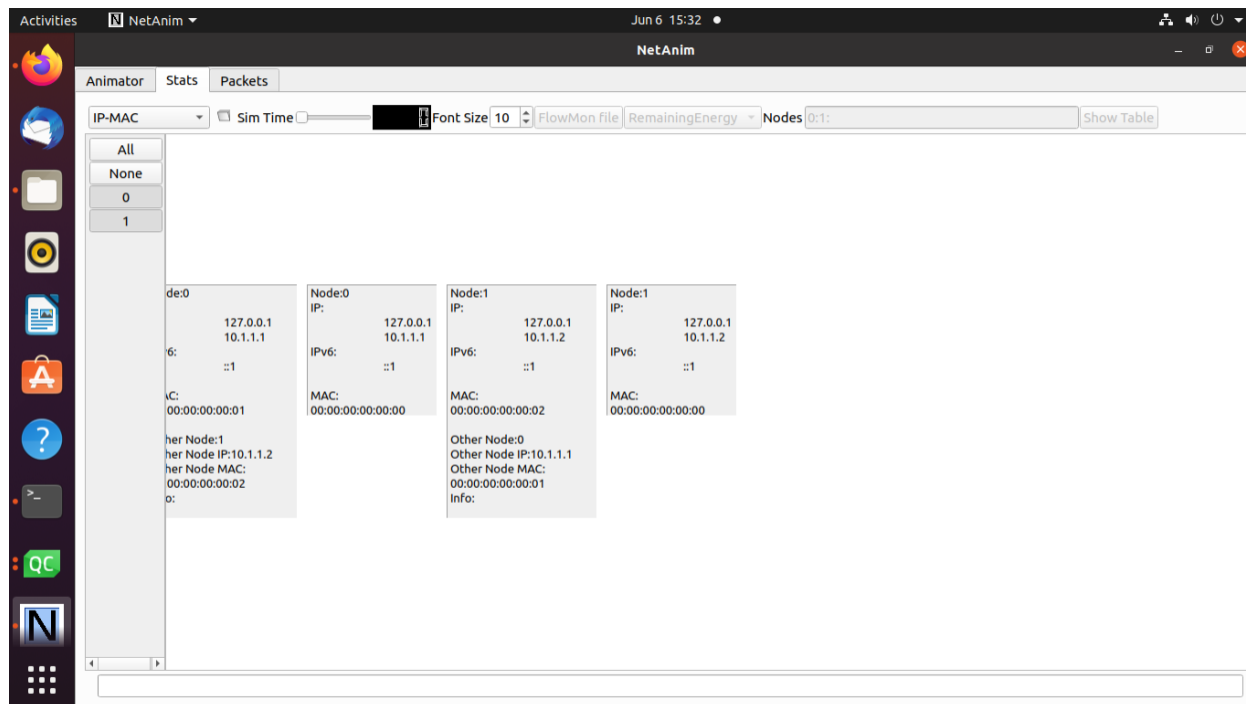
```
#include "ns3/core-module.h" #include "ns3/network-module.h" #include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h" #include "ns3/applications-module.h"
// Default Network Topology
//
//      10.1.1.0
// n0   n1
//      point-to-point
//
using namespace ns3;
NS_LOG_COMPONENT_DEFINE ("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));
```

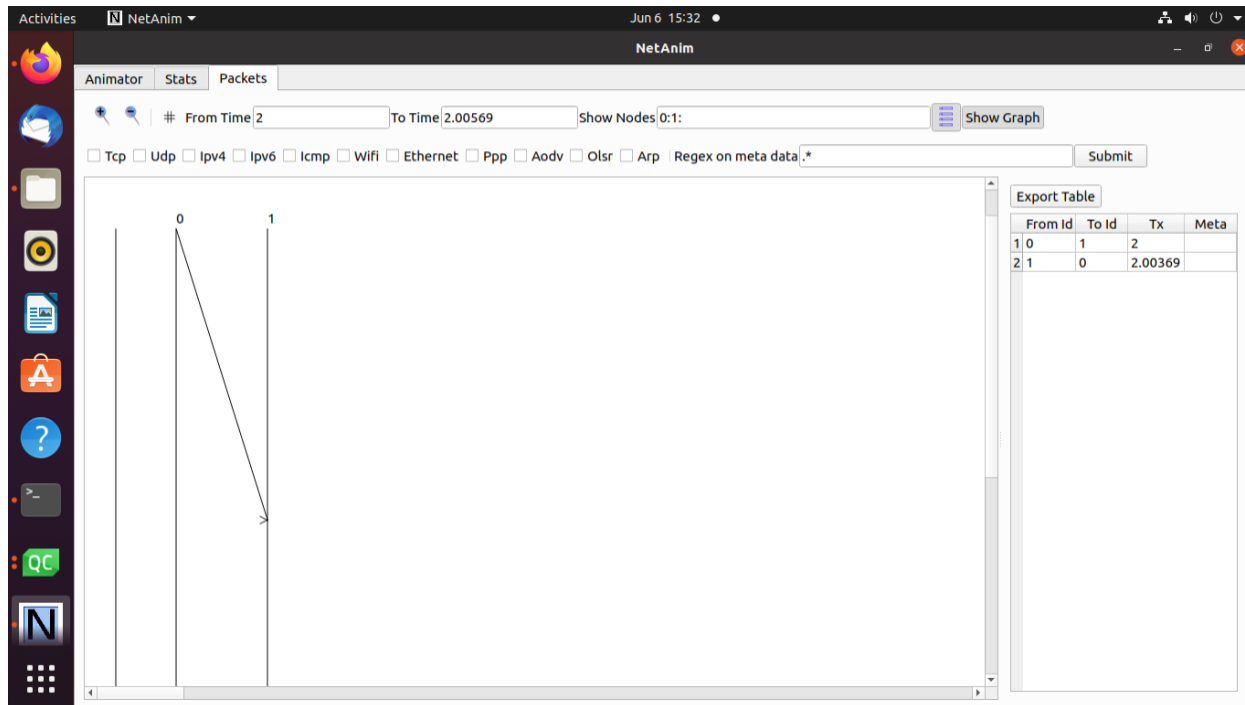
```
clientApps.Stop (Seconds (10.0));
```

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

Terminal and Output Screen:

```
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ cd ..
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34$ cd ns-3.34
mca@mca-To-be-filled-by-0-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-0-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```





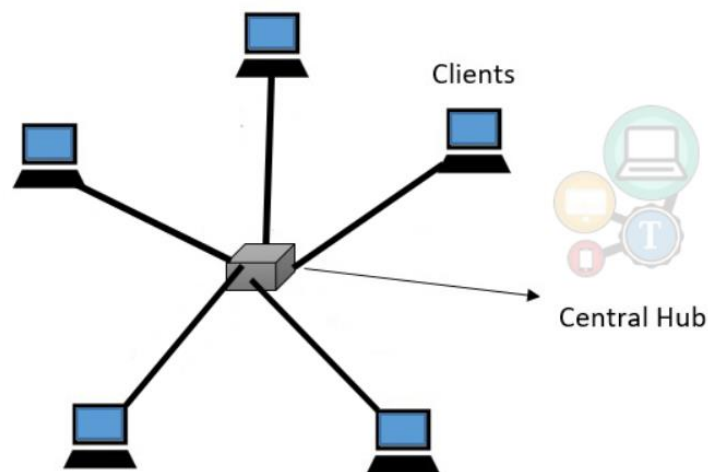
Practical No: 5

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.

Star Topology Diagram



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:

star.cc

```
#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 (__FILE__);
    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.");
AnimationInterface anim("StarT.xml");

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

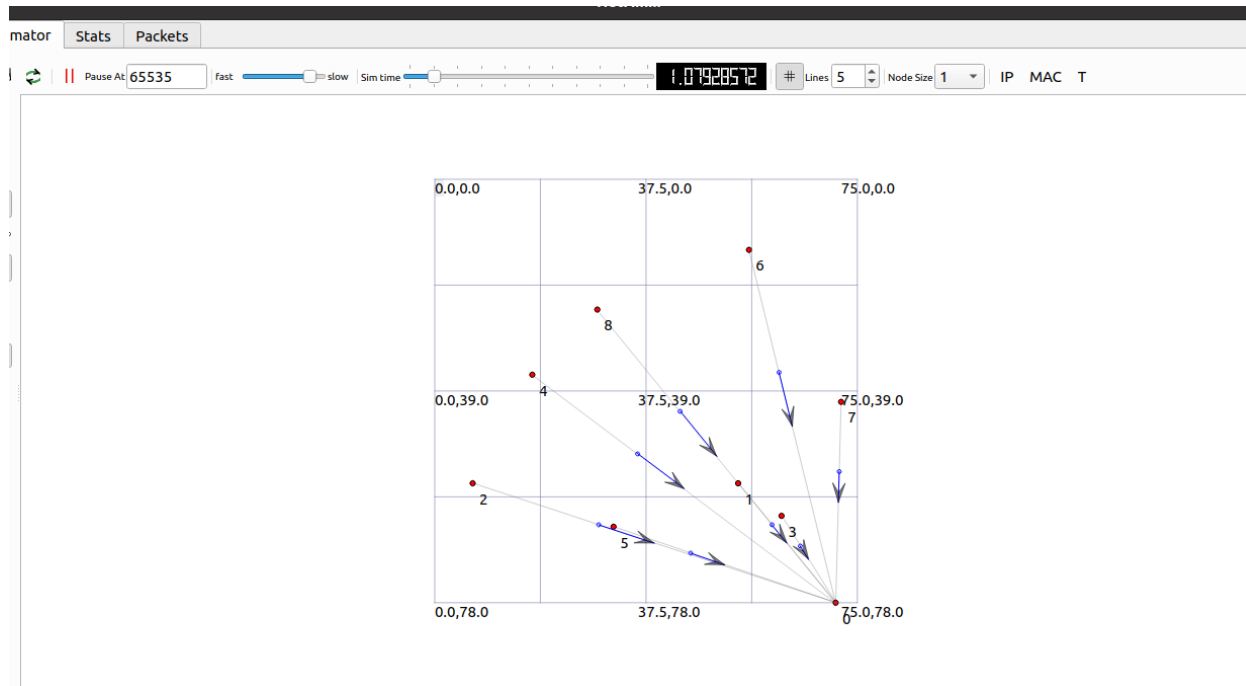
```

Terminal and Output NetAnim Screen:

```

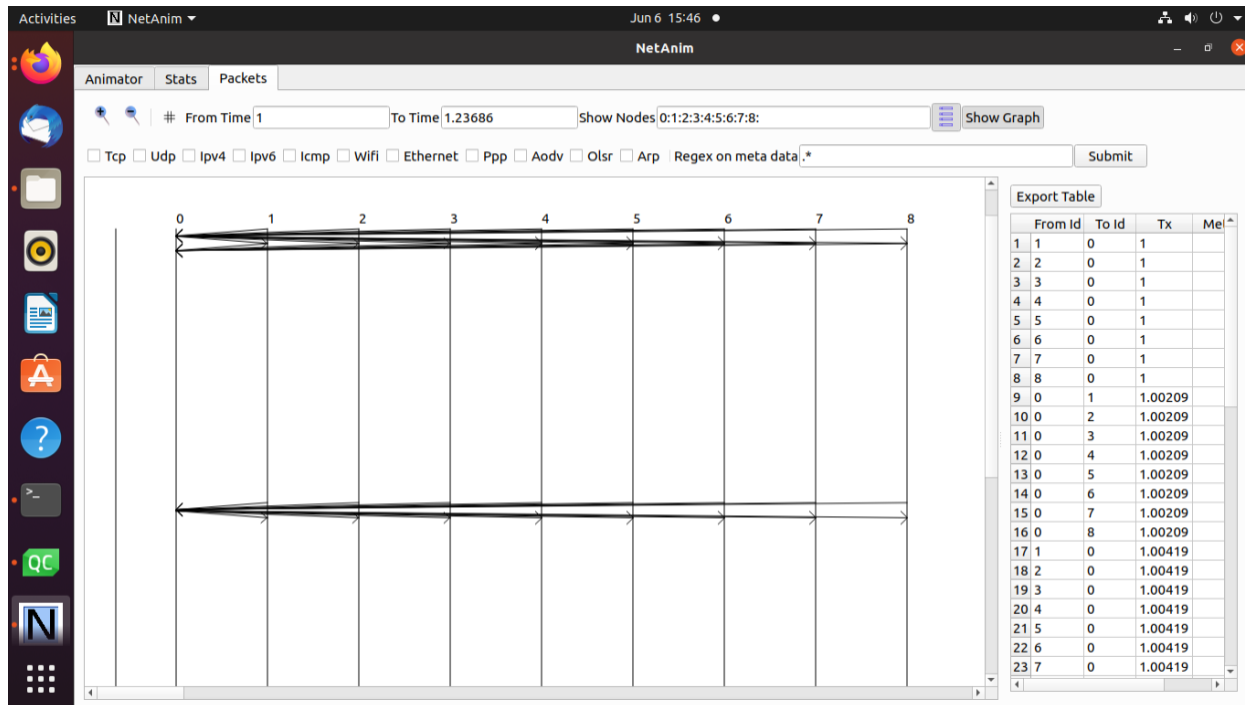
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ cd ..
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34$ cd ns-3.34
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34/ns-3.34$ ./waf --run star.cc
Waf: Entering directory '/home/mca/repos/ns-allinone-3.34/ns-3.34/build'
[1959/2017] Compiling scratch/star.cc
[1960/2017] Compiling scratch/first.cc
[1961/2017] Compiling scratch/scratch-simulator.cc
[1962/2017] Compiling scratch/subdir/scratch-simulator-subdir.cc
[1971/2017] Compiling scratch/first123.cc
[1972/2017] Linking build/scratch/scratch-simulator
[1973/2017] Linking build/scratch/subdir/subdir
[1974/2017] Compiling scratch/tcpfile.cc
[1975/2017] Linking build/scratch/first
[1976/2017] Linking build/scratch/star
[1977/2017] Linking build/scratch/first123
[1978/2017] 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 (8.147s)
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:5 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:6 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:7 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:8 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
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:5 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:6 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:7 Does not have a mobility model. Use SetConstantPosition if it is stationary
AnimationInterface WARNING:Node:8 Does not have a mobility model. Use SetConstantPosition if it is stationary
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34/ns-3.34$ █

```

The NetAnim interface displays a table of node information. The table has columns for 'All', 'None', '0', '1', '2', '3', '4', '5', '6', '7', and '8'. The table contains information for each node, including IP, MAC, and other details. The table is titled 'Nodes: 0:1:2:3:4:5:6:7:8' and has a 'Show Table' button. The table is organized into two main sections: 'Node:0' and 'Node:1'. Each section contains a table of node information. The 'Node:0' section contains a table with columns for 'IP', 'MAC', and 'Info'. The 'Node:1' section contains a table with columns for 'IP', 'MAC', and 'Info'. The table is organized into two main sections: 'Node:0' and 'Node:1'. Each section contains a table of node information. The 'Node:0' section contains a table with columns for 'IP', 'MAC', and 'Info'. The 'Node:1' section contains a table with columns for 'IP', 'MAC', and 'Info'.

All	None	0	1	2	3	4	5	6	7	8
10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1	10.1.2.1
10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1	10.1.6.1
10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1	10.1.4.1
10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1	10.1.3.1
10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1	10.1.7.1
127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1	127.0.0.1
10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1	10.1.1.1
10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1	10.1.5.1
10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1	10.1.8.1
IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1	IP: 10.1.2.1
MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03	MAC: 00:00:00:00:00:03
Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02	Info: 00:00:00:00:00:02
Other Node:1	Other Node:2	Other Node:3	Other Node:4	Other Node:5	Other Node:6	Other Node:7	Other Node:8	Other Node:9	Other Node:10	Other Node:11
Other Node IP: 10.1.1.2	Other Node IP: 10.1.2.2	Other Node IP: 10.1.3.2	Other Node IP: 10.1.4.2	Other Node IP: 10.1.5.2	Other Node IP: 10.1.6.2	Other Node IP: 10.1.7.2	Other Node IP: 10.1.8.2	Other Node IP: 10.1.9.2	Other Node IP: 10.1.10.2	Other Node IP: 10.1.11.2
Other Node MAC: 00:00:00:00:00:02	Other Node MAC: 00:00:00:00:00:04	Other Node MAC: 00:00:00:00:00:06	Other Node MAC: 00:00:00:00:00:08	Other Node MAC: 00:00:00:00:00:0a	Other Node MAC: 00:00:00:00:00:0c	Other Node MAC: 00:00:00:00:00:0e	Other Node MAC: 00:00:00:00:00:0f	Other Node MAC: 00:00:00:00:00:11	Other Node MAC: 00:00:00:00:00:13	Other Node MAC: 00:00:00:00:00:15
Other Node Info: 00:00:00:00:00:02	Other Node Info: 00:00:00:00:00:04	Other Node Info: 00:00:00:00:00:06	Other Node Info: 00:00:00:00:00:08	Other Node Info: 00:00:00:00:00:0a	Other Node Info: 00:00:00:00:00:0c	Other Node Info: 00:00:00:00:00:0e	Other Node Info: 00:00:00:00:00:0f	Other Node Info: 00:00:00:00:00:11	Other Node Info: 00:00:00:00:00:13	Other Node Info: 00:00:00:00:00:15

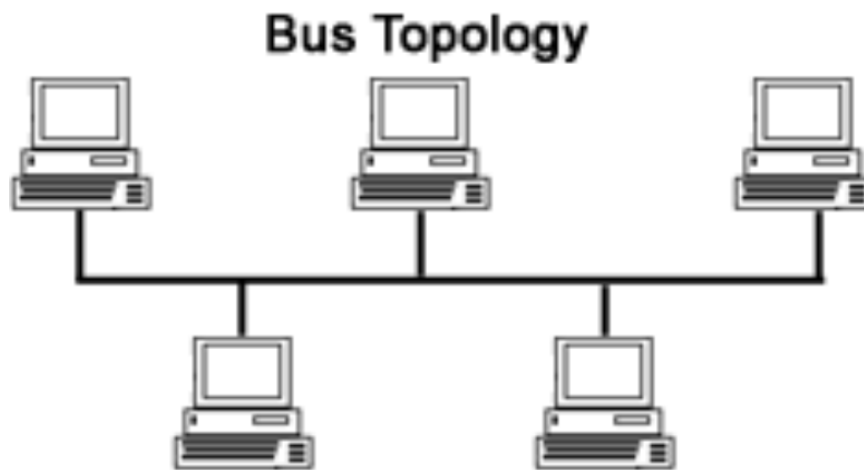


Practical No: 6

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 nCsmas = 3;

    CommandLine cmd (__FILE__);
    cmd.AddValue ("nCsmas", "Number of \"extra\" CSMA nodes/devices", nCsmas);
    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);
    }

    nCsmas = nCsmas == 0 ? 1 : nCsmas;

    NodeContainer p2pNodes;
    p2pNodes.Create (2);

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

    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;
}
```

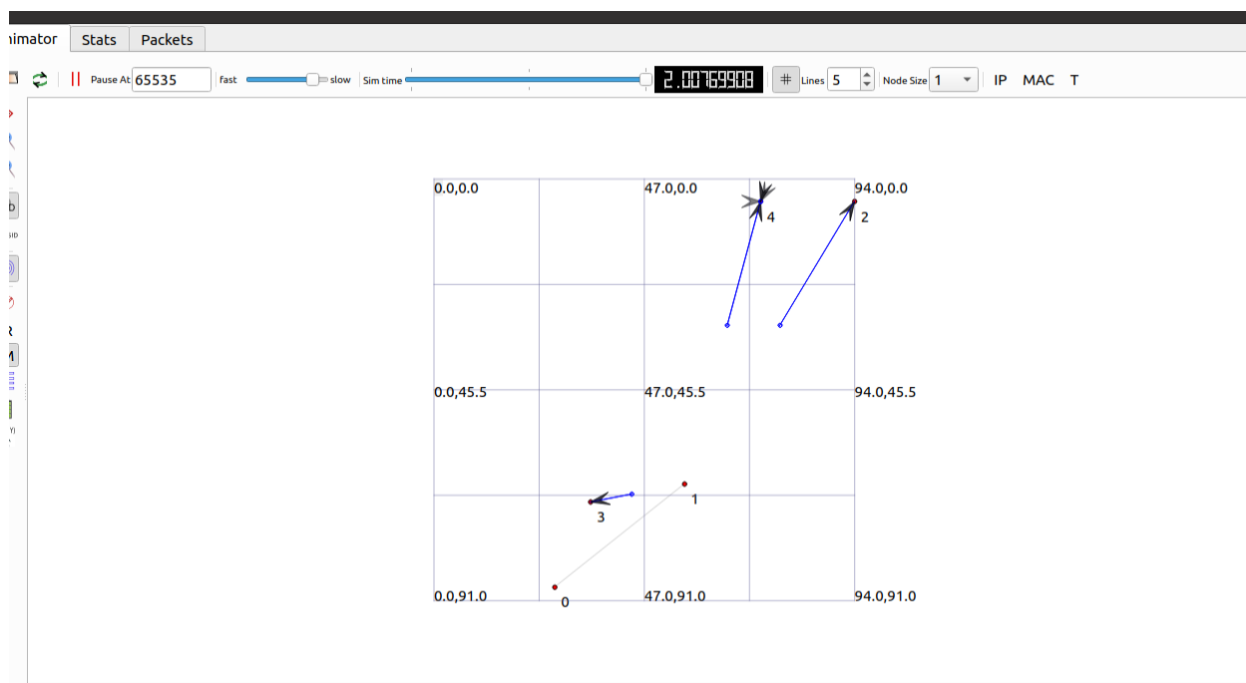
Program:

```

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: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: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: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: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 +2.0176s 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

IP-MAC Sim Time Font Size 10 FlowMon file RemainingEnergy Nodes 0:1:2:3:4: Show Table

All
None
0
1
2
3
4

Node:0
IP: 127.0.0.1
10.1.1.1
IPv6: ::1
MAC: 00:00:00:00:01
Other Node:1
Other Node IP:10.1.1.2
Other Node MAC:
00:00:00:00:02
Info:

Node:0
IP: 127.0.0.1
10.1.1.1
IPv6: ::1
MAC: 00:00:00:00:00

Node:1
IP: 10.1.2.1
127.0.0.1
10.1.1.2
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: 10.1.2.1
127.0.0.1
10.1.1.2
IPv6: ::1
MAC: 00:00:00:00:00:03

Node:2
IP: 10.1.2.2
127.0.0.1
IPv6: ::1
MAC: 00:00:00:00:00:04

Node:3
IP: 127.0.0.1
10.1.2.3
IPv6: ::1
MAC: 00:00:00:00:00:05

Node:4
IP: 10.1.2.4
127.0.0.1
IPv6: ::1
MAC: 00:00:00:00:00:06

Animator Stats Packets

From Time 2 To Time 2.01392 Show Nodes 0:1:2:3:4: Show Graph

☐ Tcp ☐ Udp ☐ Ipv4 ☐ Ipv6 ☐ Icmp ☐ Wifi ☐ Ethernet ☐ Ppp ☐ Aodv ☐ Olsr ☐ Arp ☐ Regex on meta data.* Submit

0 1 2 3 4

Export Table

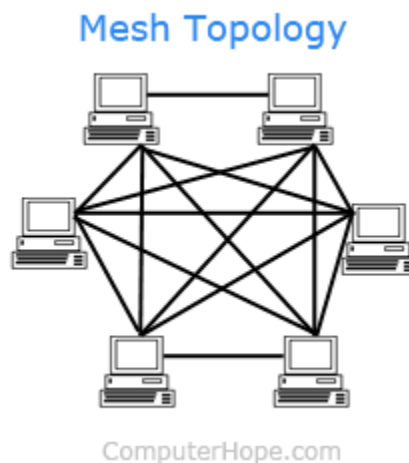
	From Id	To Id	Tx	Me
1	0	1	2	
2	1	2	2.00769	
3	1	2	2.00769	
4	1	3	2.00769	
5	1	3	2.00769	
6	1	4	2.00769	
7	1	4	2.00769	
8	4	1	2.0077	
9	4	1	2.0077	
10	4	2	2.0077	
11	4	3	2.0077	
12	1	2	2.00771	
13	1	3	2.00771	
14	1	4	2.00771	
15	1	4	2.00771	
16	4	1	2.0138	
17	4	1	2.0138	
18	4	2	2.0138	
19	4	2	2.0138	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

Practical No: 7

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"
```

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Roll No: 004

```
#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-0-E-M:~/repos/ns-allinone-3.34/ns-3.34$ ./waf --run mesh.cc
```

```
laf: 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
```

```
laf: 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-0-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
```

```
mca@mca-To-be-filled-by-0-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-0-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
```

```
mca@mca-To-be-filled-by-0-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim
```

Output Screen:

Animator Stats Packets

IP-MAC Sim Time Font Size 10 FlowMon file RemainingEnergy Nodes 0:1:2:3:4:5:6:7:8 Show Table

All None 0 1 2 3 4 5 6 7 8

de:0 127.0.0.1 10.1.1.1 IPv6: ::1 MAC: 00:00:00:00:01	Node:1 IP: 127.0.0.1 10.1.1.2 IPv6: ::1 MAC: 00:00:00:00:02	Node:2 IP: 127.0.0.1 10.1.1.3 IPv6: ::1 MAC: 00:00:00:00:03	Node:3 IP: 127.0.0.1 10.1.1.4 IPv6: ::1 MAC: 00:00:00:00:04	Node:4 IP: 127.0.0.1 10.1.1.5 IPv6: ::1 MAC: 00:00:00:00:05	Node:5 IP: 127.0.0.1 10.1.1.6 IPv6: ::1 MAC: 00:00:00:00:06	Node:6 IP: 127.0.0.1 10.1.1.7 IPv6: ::1 MAC: 00:00:00:00:07
de:7 127.0.0.1 10.1.1.8 IPv6: ::1 MAC: 00:00:00:00:08	Node:8 IP: 127.0.0.1 10.1.1.9 IPv6: ::1 MAC: 00:00:00:00:09					

Playing

Animator Stats Packets

From Time 0.0129744 To Time 0.0152376 Show Nodes 0:1:2:3:4:5:6:7:8 Show Graph

☐ Tcp ☐ Udp ☐ Ipv4 ☐ Ipv6 ☐ Icmp ☐ Wifi ☐ Ethernet ☐ Ppp ☐ Aodv ☐ Olsr ☐ Arp | Regex on meta data.* Submit

Export Table

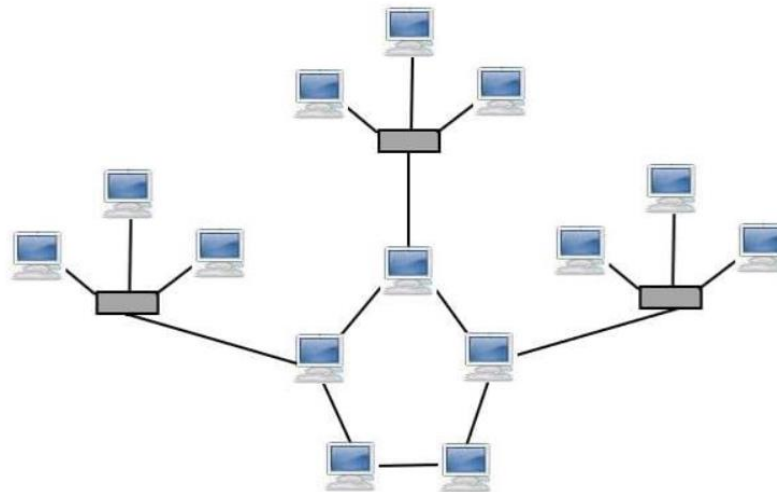
	From Id	To Id	Tx
1	1	0	0.0129744
2	1	2	0.0129744
3	1	4	0.0129744
4	4	7	0.0131126
5	4	1	0.0133086
6	4	3	0.0133086
7	4	5	0.0133086
8	4	7	0.0133086
9	4	1	0.0135046
10	4	3	0.0135046
11	4	5	0.0135046
12	4	7	0.0135046
13	4	1	0.0136916
14	4	3	0.0136916
15	4	5	0.0136916
16	4	7	0.0136916
17	2	5	0.0137996
18	4	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
```

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Roll No: 004

```

* 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;
}

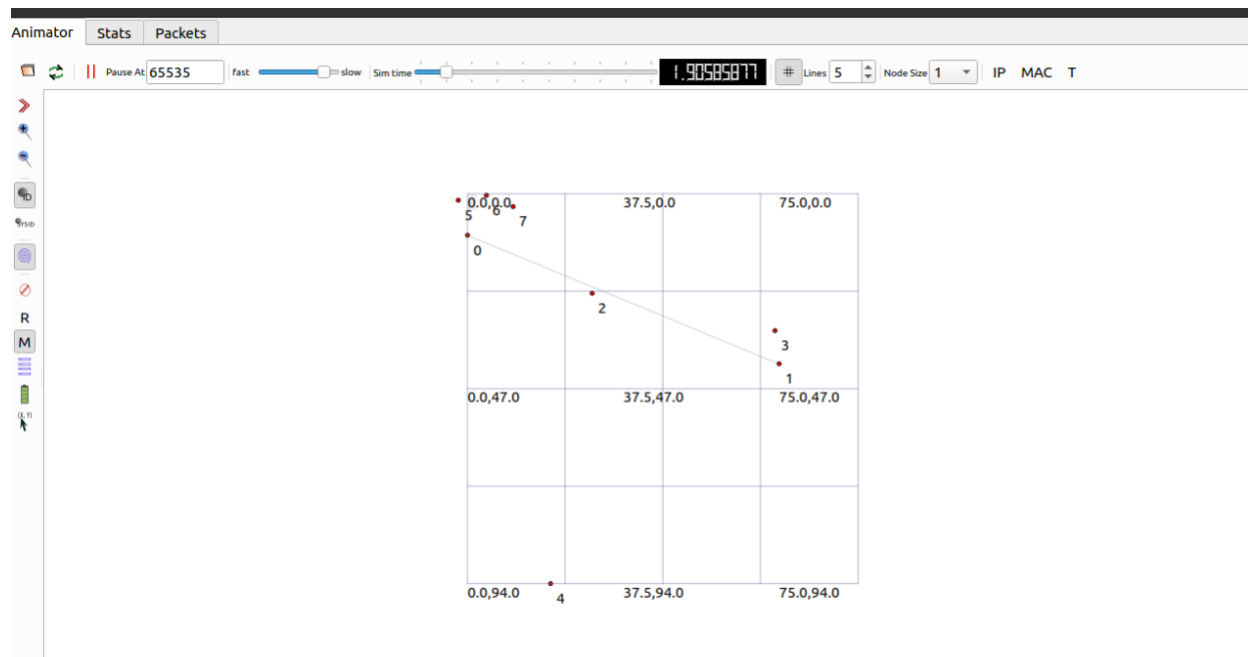
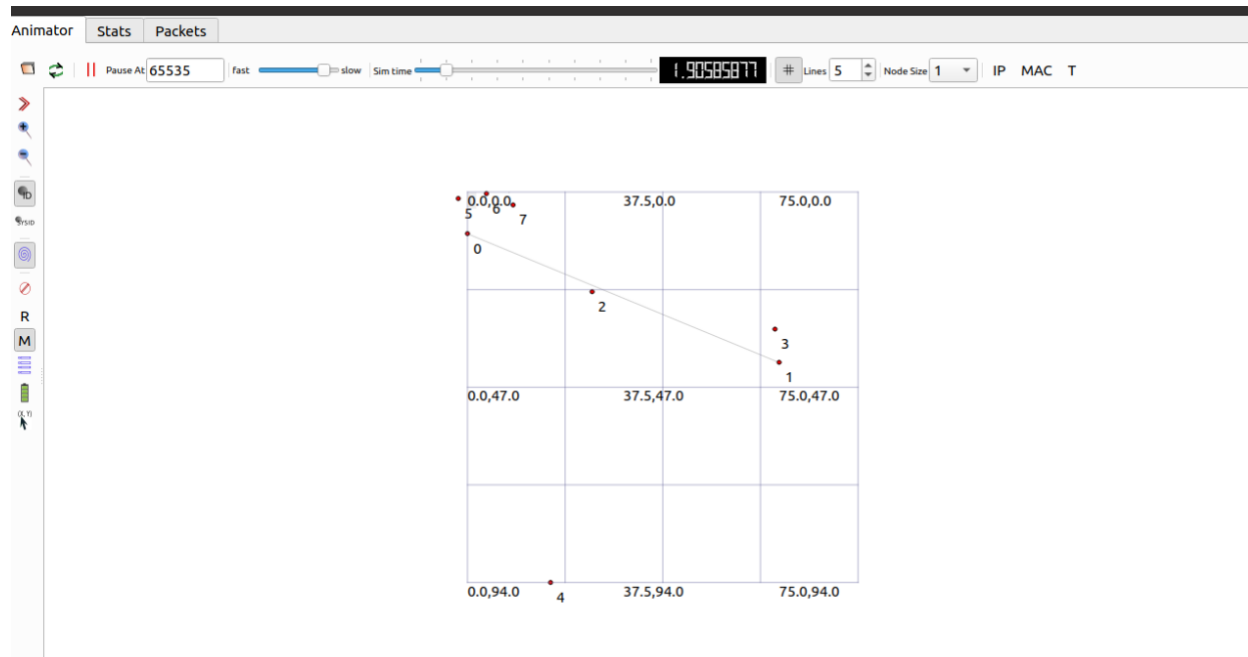
```

```

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
sca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/ns-3.34$ cd ..
sca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34$ cd netanim-3.108
sca@mca-To-be-filled-by-O-E-M:~/repos/ns-allinone-3.34/netanim-3.108$ ./NetAnim

```

Output Screen:



NetAnim

Animator Stats Packets

IP-MAC Sim Time Font Size 10 FlowMon file RemainingEnergy Nodes 0:1:2:3:4:5:6:7 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: 00:00:00:00:00:01

Node:1
IP: 127.0.0.1
10.1.1.2
10.1.2.1
IPv6: ::1
MAC: 00:00:00:00:00:02

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:5
IP: 127.0.0.1
10.1.3.1
IPv6: ::1
MAC: 00:00:00:00:00:07

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

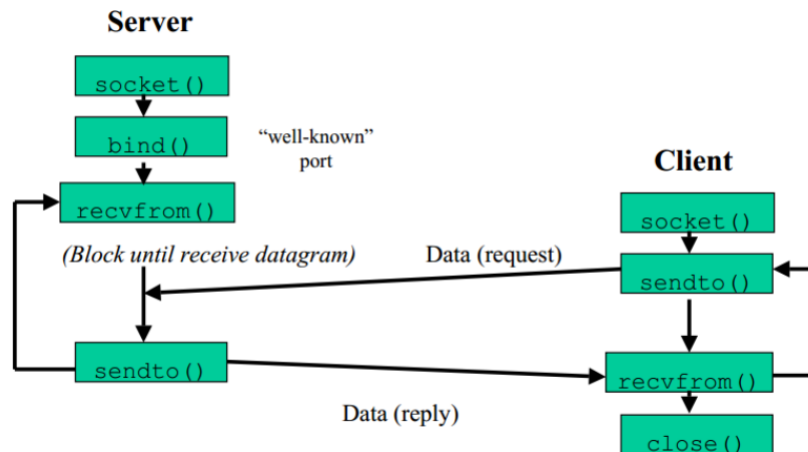
Practical No: 9

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");

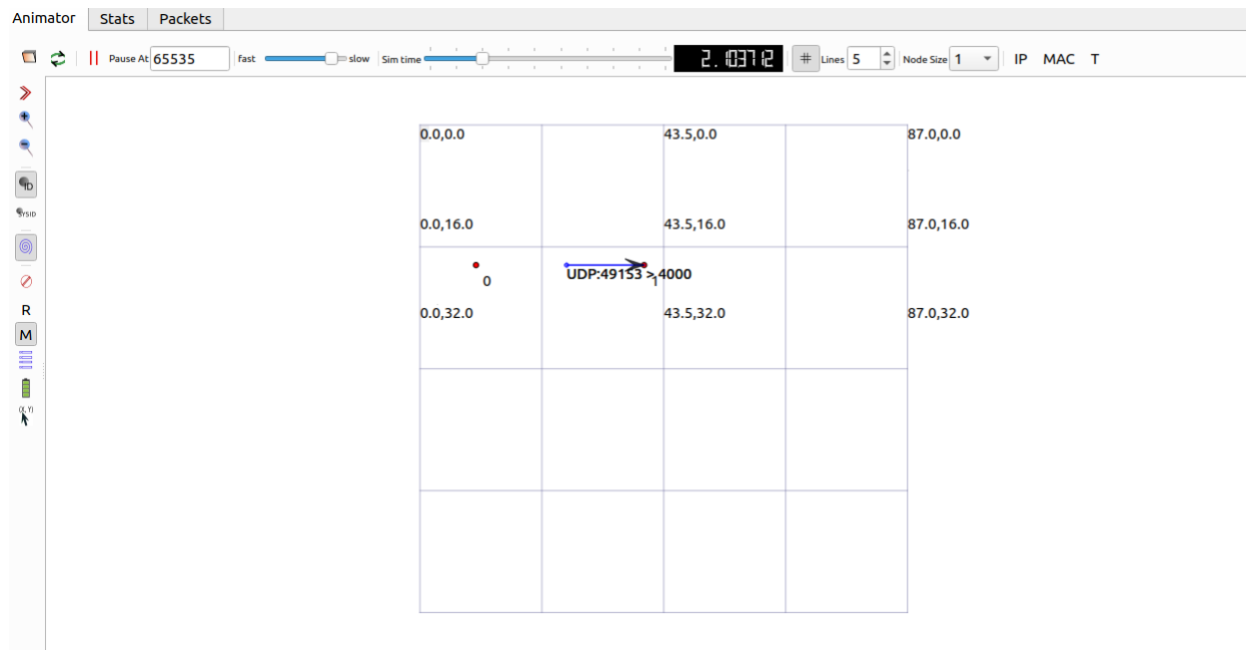
//
// Now, do the actual simulation.
//
NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
}
```

```

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 Uld: 437 Time: +9.15s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 143 Uld: 437 TXtime: +9.15e+09ns RXtime: +9.15371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 440 Time: +9.2s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 144 Uld: 440 TXtime: +9.2e+09ns RXtime: +9.20371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 443 Time: +9.25s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 145 Uld: 443 TXtime: +9.25e+09ns RXtime: +9.25371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 446 Time: +9.3s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 146 Uld: 446 TXtime: +9.3e+09ns RXtime: +9.30371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 449 Time: +9.35s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 147 Uld: 449 TXtime: +9.35e+09ns RXtime: +9.35371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 452 Time: +9.4s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 148 Uld: 452 TXtime: +9.4e+09ns RXtime: +9.40371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 455 Time: +9.45s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 149 Uld: 455 TXtime: +9.45e+09ns RXtime: +9.45371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 458 Time: +9.5s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 150 Uld: 458 TXtime: +9.5e+09ns RXtime: +9.50371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 461 Time: +9.55s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 151 Uld: 461 TXtime: +9.55e+09ns RXtime: +9.55371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 464 Time: +9.6s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 152 Uld: 464 TXtime: +9.6e+09ns RXtime: +9.60371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 467 Time: +9.65s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 153 Uld: 467 TXtime: +9.65e+09ns RXtime: +9.65371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 470 Time: +9.7s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 154 Uld: 470 TXtime: +9.7e+09ns RXtime: +9.70371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 473 Time: +9.75s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 155 Uld: 473 TXtime: +9.75e+09ns RXtime: +9.75371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 476 Time: +9.8s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 156 Uld: 476 TXtime: +9.8e+09ns RXtime: +9.80371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 479 Time: +9.85s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 157 Uld: 479 TXtime: +9.85e+09ns RXtime: +9.85371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 482 Time: +9.9s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 158 Uld: 482 TXtime: +9.9e+09ns RXtime: +9.90371e+09ns Delay: +3.712e+06ns
TraceDelay TX 1024 bytes to 10.1.1.2 Uld: 485 Time: +9.95s
TraceDelay: RX 1024 bytes from 10.1.1.1 Sequence Number: 159 Uld: 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
IC: 00:00:00:00:00:00

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 Regexp on meta data.* Submit

0 1

UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000
UDP 49153 > 4000

Export Table

	From Id	To Id	Tx	
19	0	1	2.35	UDF
20	0	1	2.35	UDF
21	0	1	2.4	UDF
22	0	1	2.4	UDF
23	0	1	2.45	UDF
24	0	1	2.45	UDF
25	0	1	2.5	UDF
26	0	1	2.5	UDF
27	0	1	2.55	UDF
28	0	1	2.55	UDF
29	0	1	2.6	UDF
30	0	1	2.6	UDF
31	0	1	2.65	UDF
32	0	1	2.65	UDF

Output: WireShark:

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	00:00:00_00:00:01	Broadcast	ARP	64	Who has 10.1.1.2? Tel
2	0.000000	00:00:00_00:00:02	00:00:00_00:00:01	ARP	64	10.1.1.2 is at 00:00:
3	0.005816	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024
4	0.043610	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024
5	0.093610	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024
6	0.143610	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024
7	0.193610	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024
8	0.243610	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024
9	0.293610	10.1.1.1	10.1.1.2	UDP	1070	49153 → 4000 Len=1024

▶ Frame 1: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
 ▶ Ethernet II, Src: 00:00:00_00:00:01 (00:00:00:00:00:01), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
 ▶ Address Resolution Protocol (request)

```

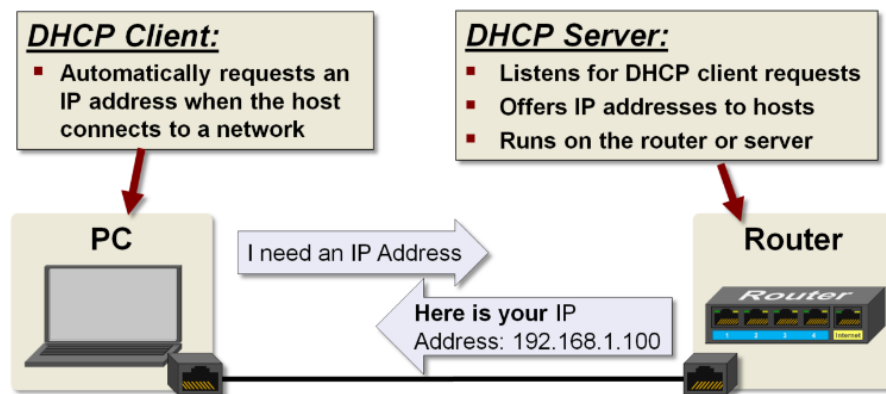
0000  ff ff ff ff ff ff 00 00 00 00 01 08 06 00 01  .....
0010  08 00 06 04 00 01 00 00 00 00 01 0a 01 01 01  .....
0020  ff ff ff ff ff ff 0a 01 01 02 00 00 00 00 00  .....
0030  00 00 00 00 00 00 00 00 00 00 00 00 00 00  .....
  
```


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.



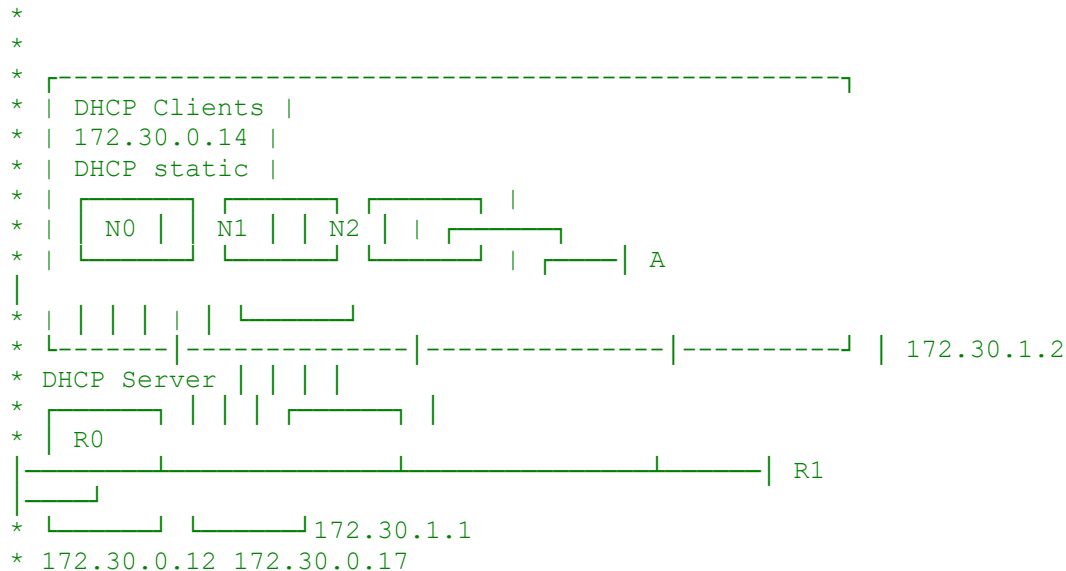
Program:

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.



* Things to notice:

- * 1) The routes in A are manually set to have R1 as the default router, just because using a dynamic routing 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:

