
Computer Networks

Project #2 Report

DiffServ and TCP Congestion Control

目錄

1.Prepare NS3 installing environment.....	2
2.Install NS3.....	7
3.Build up topology and related parameters	10
4.Programming and run script	11
5. Comparison between DropTail and RED	21
5.1.Queue length for every router vs simulation time	21
5.2.Throughput for every TCP flow vs router buffer size.....	25
5.3.Variations of cwnd for every TCP flow vs simulation time	27
5.4.Packet loss rate in every router	30
5.5.Conclusion.....	31

BY 熊欣

2017.01

1.Prepare NS3 installing environment

1.1. sudo apt-get install mercurial

```
leo@ubuntu:~$ sudo rm /var/cache/apt/archives/lock
leo@ubuntu:~$ sudo rm /var/lib/dpkg/lock
leo@ubuntu:~$ sudo apt-get install mercurial
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  javascript-common libjs-excanvas mercurial-common
Suggested packages:
  apache2 | lighttpd | httpd qct kdiff3 | kdiff3-qt | kompare | meld | tkcvs
  | nedit python-mysqldb python-pygments python-openssl
The following NEW packages will be installed:
  javascript-common libjs-excanvas mercurial-common
0 upgraded, 4 newly installed, 0 to remove and 293 not upgraded.
Need to get 1,931 kB of archives.
After this operation, 10.2 MB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu xenial/main amd64 javascript-common all 11 [6,066 B]
Get:2 http://us.archive.ubuntu.com/ubuntu xenial/universe amd64 libjs-excanvas all 0.3-4 [45.2 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu xenial/universe amd64 mercurial-common all 3.7.3-1ubuntu1 [1,833 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu xenial/universe amd64 mercurial amd64 3.7.3-1ubuntu1 [46.3 kB]
Fetched 1,931 kB in 10s (115 kB/s)
Selecting previously unselected package javascript-common.
(Reading database ... 17236 files and directories currently installed.)
Preparing to unpack .../javascript-common_11_all.deb ...
Unpacking javascript-common (11) ...
Selecting previously unselected package libjs-excanvas.
Preparing to unpack .../libjs-excanvas_0.3-4_all.deb ...
Unpacking libjs-excanvas (0.3-4) ...
Selecting previously unselected package mercurial-common.
Preparing to unpack .../mercurial-common_3.7.3-1ubuntu1_all.deb ...
Unpacking mercurial-common (3.7.3-1ubuntu1) ...
Selecting previously unselected package mercurial.
Preparing to unpack .../mercurial_3.7.3-1ubuntu1_amd64.deb ...
Unpacking mercurial (3.7.3-1ubuntu1) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up javascript-common (11) ...
Setting up libjs-excanvas (0.3-4) ...
Setting up mercurial-common (3.7.3-1ubuntu1) ...
Setting up mercurial (3.7.3-1ubuntu1) ...
Creating config file /etc/mercurial/hgrc.d/hgext.rc with new version
leo@ubuntu:~$ sudo apt-get install bzip2
```

1.2. sudo apt-get install bzip2

```
leo@ubuntu:~$ sudo apt-get install bzip2
Preparing to unpack .../python-simplejson_3.8.1-1ubuntu2_amd64.deb ...
Unpacking python-simplejson (3.8.1-1ubuntu2) ...
Selecting previously unselected package python-wadllib.
Preparing to unpack .../python-wadllib_1.3.2-3_all.deb ...
Unpacking python-wadllib (1.3.2-3) ...
Selecting previously unselected package python-zope.interface.
Preparing to unpack .../python-zope.interface_4.1.3-1build1_amd64.deb ...
Unpacking python-zope.interface (4.1.3-1build1) ...
Selecting previously unselected package python-oauth.
Preparing to unpack .../python-oauth_1.0.1-5_all.deb ...
Unpacking python-oauth (1.0.1-5) ...
Selecting previously unselected package python-lazr.restfulclient.
Preparing to unpack .../python-lazr.restfulclient_0.13.4-5ubuntu1_all.deb ...
Unpacking python-lazr.restfulclient (0.13.4-5ubuntu1) ...
Selecting previously unselected package python-launchpadlib.
Preparing to unpack .../python-launchpadlib_1.10.3-3_all.deb ...
Unpacking python-launchpadlib (1.10.3-3) ...
Selecting previously unselected package python-secretstorage.
Preparing to unpack .../python-secretstorage_2.1.3-1_all.deb ...
Unpacking python-secretstorage (2.1.3-1) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up python-six (1.10.0-3) ...
Setting up python-configobj (5.0.6-2) ...
Setting up python-bzrlib (2.7.0-2ubuntu3) ...
Setting up bzip2 (2.7.0-2ubuntu3) ...
Setting up libjs-jquery (1.11.3+dfsg-4) ...
Setting up python-crypto (2.6.1-0build1) ...
Setting up python-dbus (1.2.0-3) ...
Remove stale byte-compiled files. ...
Setting up python-gi (3.20.0-0ubuntu1) ...
Setting up python-gpgme (0.3-1) ...
Setting up python-httplib2 (0.9.1+dfsg-1) ...
Setting up python-keyring (7.3-1ubuntu1) ...
Setting up python-pkg-resources (20.7.0-1) ...
Setting up python-lazr.uri (1.0.3-2build1) ...
Setting up python-simplejson (3.8.1-1ubuntu2) ...
Setting up python-wadllib (1.3.2-3) ...
Setting up python-zope.interface (4.1.3-1build1) ...
Setting up python-oauth (1.0.1-5) ...
Setting up python-lazr.restfulclient (0.13.4-5ubuntu1) ...
Setting up python-launchpadlib (1.10.3-3) ...
Setting up python-secretstorage (2.1.3-1) ...
```

1.3. sudo apt-get install gdb valgrind

```
leo@ubuntu:~$ sudo apt-get install gcc g++ python
Setting up bzip2 (2.7.0-2ubuntu3) ...
Setting up libjs-jquery (1.11.3+dfsg-4) ...
Setting up python-crypto (2.6.1-0build1) ...
Setting up python-dbus (1.2.0-3) ...
Remove stale byte-compiled files. ...
Setting up python-gi (3.20.0-0ubuntu1) ...
Setting up python-gpgme (0.3.1-1) ...
Setting up python-httplib2 (0.9.1+dfsg-1) ...
Setting up python-keyring (7.3-1ubuntu1) ...
Setting up python-pkg-resources (20.7.0-1) ...
Setting up python-lazr.uri (1.0.3-2build1) ...
Setting up python-simplejson (3.8.1-1ubuntu2) ...
Setting up python-wadllib (1.3.2-3) ...
Setting up python-zope.interface (4.1.3-1build1) ...
Setting up python-south (1.0.1-5) ...
Setting up python-lazr.restfulclient (0.13.4-5ubuntu1) ...
Setting up python-launchpadlib (1.10.3-3) ...
Setting up python-secretstorage (2.1.3-1) ...
leo@ubuntu:~$ sudo apt-get install gdb valgrind
Reading package lists... Done
Building dependency tree
Reading state information... Done
gdb is already the newest version (7.11.1-0ubuntu1-16.04).
gdb set to manually installed.
Suggested packages:
  valgrind-dbg kcachegrind alioyop valkyrie
The following NEW packages will be installed:
  valgrind
0 upgraded, 1 newly installed, 0 to remove and 293 not upgraded.
Need to get 11.0 MB of archives.
After this operation, 66.8 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 valgrind amd64 1:3.11.0-1ubuntu4.1 [11.0 MB]
Fetched 11.0 MB in 1min 13s (149 kB/s)
Selecting previously unselected package valgrind.
(Reading database ... 174145 files and directories currently installed.)
Preparing to unpack .../valgrind_3.11.0-1ubuntu4.1_amd64.deb ...
Unpacking valgrind (1:3.11.0-1ubuntu4.1) ...
Processing triggers for doc-base (0.10.7) ...
Processing 1 added doc-base file...
Processing triggers for man-db (2.7.5-1) ...
Setting up valgrind (1:3.11.0-1ubuntu4.1) ...
leo@ubuntu:~$
```

1.4. sudo apt-get install gcc g++ python

```
leo@ubuntu:~$ sudo apt-get install gcc g++ python
Setting up python-simplejson (3.8.1-1ubuntu2) ...
Setting up python-wadllib (1.3.2-3) ...
Setting up python-zope.interface (4.1.3-1build1) ...
Setting up python-south (1.0.1-5) ...
Setting up python-lazr.restfulclient (0.13.4-5ubuntu1) ...
Setting up python-launchpadlib (1.10.3-3) ...
Setting up python-secretstorage (2.1.3-1) ...
leo@ubuntu:~$ sudo apt-get install gcc g++ python
Reading package lists... Done
Building dependency tree
Reading state information... Done
gcc is already the newest version (4:5.3.1-1ubuntu1).
g++ is already the newest version (4:5.3.1-1ubuntu1).
g++ set to manually installed.
python is already the newest version (2.7.11-1).
python set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 293 not upgraded.
leo@ubuntu:~$
```

1.5.sudo apt-get install gsl-bin libgsl0-dev libgsl0ldbl

```
leo@ubuntu:~$ sudo apt-get install gsl-bin libgsl0-dev libgsl0ldbl
Setting up thunderbird-gnome-support (1:45.5.1+build1-0ubuntu0.16.04.1) ...
Setting up thunderbird-locale-en-us (1:45.5.1+build1-0ubuntu0.16.04.1) ...
Setting up ubuntu-rtwork (1:14.04-16.04.20161024-0ubuntu1) ...
Setting up unattended-upgrades (0.90ubuntu0.2) ...
Replacing config file /etc/apt/apt.conf.d/50unattended-upgrades with new version
update-rc.d: warning: start and stop actions are no longer supported; falling back to defaults
Setting up xdg-utils (1:1.1.2-1) ...
Setting up xserver-xorg-video-intel (2:2.99.917+git20160325-1ubuntu1.2) ...
Setting up p11-kit (0.23.2-5-ubuntu16.04.1) ...
Processing triggers for gconf2 (3.2.6-3ubuntu6) ...
Setting up libnetcdf-private32:amd64 (1:1.3.1-7-0ubuntu0.2) ...
Setting up compiz-gnome (1:0.9.12.2+16.04.20160823-0ubuntu1) ...
Setting up compiz (1:0.9.12.2+16.04.20160823-0ubuntu1) ...
Setting up ubuntu-session (3.18.1-2-ubuntu16.04.2) ...
Setting up unity (7.4.0-16.04.20160909-0ubuntu1) ...
Setting up nautius (1:3.18.4+ts.3.14.3-0ubuntu5) ...
Setting up python3-distupgrade (1:16.04.19) ...
Setting up python3-update-manager (1:16.04.4) ...
Setting up ubuntu-release-upgrader-core (1:16.04.19) ...
Setting up update-manager-core (1:16.04.4) ...
Setting up update-manager (1:16.04.4) ...
Setting up update-notifier (3.168.2) ...
Processing triggers for cups (2.1.3-4) ...
Updating PPD files for cups-filters ...
Updating PPD files for fontastic-db-compressed-ppds ...
Updating PPD files for openprinting-ppds ...
Updating PPD files for brlaser ...
Updating PPD files for c2esp ...
Updating PPD files for fo2zjs-common ...
Updating PPD files for gutenprint ...
Updating PPD files for hpcups ...
Updating PPD files for postscript-hp ...
Updating PPD files for ptouch ...
Updating PPD files for pxljr ...
Updating PPD files for sag-gdi ...
Updating PPD files for splix ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
Processing triggers for intransf-tools (0.122ubuntu8.7) ...
update-intransf: Generating /boot/initrd.img-4.4.0-31-generic
Processing triggers for systemd (225-4ubuntu1) ...
Processing triggers for ureadahead (0.100.0-19) ...
leo@ubuntu:~$
```

1.6.sudo apt-get install flex bison

```
leo@ubuntu:~$ sudo apt-get install libbison-dev
Need to get 1,108 kB of archives.
After this operation, 3,101 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu xential/main amd64 libbison-dev amd64 2.10-4 [14.1 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu xential/main amd64 m4 amd64 1.4.17-5 [195 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu xential/main amd64 libfl-dev amd64 2.6.0-11 [12.5 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu xential/main amd64 flex amd64 2.6.0-11 [290 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu xential/main amd64 libbison-dev amd64 2:3.0.4.dfsg-1 [338 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu xential/main amd64 bison amd64 2:3.0.4.dfsg-1 [259 kB]
Fetched 1,108 kB in 14s (73.9 kB/s)
Selecting previously unselected package libbison-dev:amd64.
(Reading database ... 174667 files and directories currently installed.)
Preparing to unpack .../libbison-dev_2.10-4_amd64.deb ...
Unpacking libbison-dev:amd64 (2.10-4) ...
Selecting previously unselected package m4.
Preparing to unpack .../archives/m4_1.4.17-5_amd64.deb ...
Unpacking m4 (1.4.17-5) ...
Selecting previously unselected package libfl-dev:amd64.
Preparing to unpack .../libfl-dev_2.6.0-11_amd64.deb ...
Unpacking libfl-dev:amd64 (2.6.0-11) ...
Selecting previously unselected package flex.
Preparing to unpack .../flex_2.6.0-11_amd64.deb ...
Unpacking flex (2.6.0-11) ...
Selecting previously unselected package libbison-dev:amd64.
Preparing to unpack .../libbison-dev_2:3.0.4.dfsg-1_amd64.deb ...
Unpacking libbison-dev:amd64 (2:3.0.4.dfsg-1) ...
Selecting previously unselected package bison.
Preparing to unpack .../bison_2:3.0.4.dfsg-1_amd64.deb ...
Unpacking bison (2:3.0.4.dfsg-1) ...
Processing triggers for install-info (6.1.0.dfsg.1-5) ...
Processing triggers for man-db (2.7.5-1) ...
Processing triggers for libc-bin (2.23-0ubuntu2) ...
Setting up libbison-dev:amd64 (2.10-4) ...
Setting up m4 (1.4.17-5) ...
Setting up libfl-dev:amd64 (2.6.0-11) ...
Setting up flex (2.6.0-11) ...
Setting up libbison-dev:amd64 (2:3.0.4.dfsg-1) ...
Setting up bison (2:3.0.4.dfsg-1) ...
update-alternatives: using /usr/bin/libbison.yacc to provide /usr/bin/yacc (yacc) in auto mode
Processing triggers for libc-bin (2.23-0ubuntu2) ...
leo@ubuntu:~$
```

1.7.sudo apt-get install g++-3.4 gcc-3.4

```
leo@ubuntu:~$ sudo apt-get install g++-3.4 gcc-3.4
Setting up libxtdmcp-dev:amd64 (1:1.1.2-1.1) ...
Setting up x11proto-input-dev (2.3.1-1) ...
Setting up x11proto-kb-dev (1.0.7-0ubuntu1) ...
Setting up xtrans-dev (1.3.5-1) ...
Setting up libpthread-stubs0-dev:amd64 (0.3-4) ...
Setting up libxcb1-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libx11-dev:amd64 (2:1.6.3-1ubuntu2) ...
Setting up libdrm-dev:amd64 (2.4.67-1ubuntu0.16.04.2) ...
Setting up mesa-common-dev:amd64 (11.2.0-1ubuntu2.2) ...
Setting up libx11-xcb-dev:amd64 (2:1.6.3-1ubuntu2) ...
Setting up libxcb-dri3-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-render0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-randr0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-shape0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-xfixes0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-sync-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-present-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-shm-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-dri2-0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-glx0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up x11proto-xext-dev (7.3.0-1) ...
Setting up x11proto-fixes-dev (1:5.0-2ubuntu2) ...
Setting up libxfixes-dev:amd64 (1:5.0.1-2) ...
Setting up x11proto-damage-dev (1:1.2.1-2) ...
Setting up libxdamage-dev:amd64 (1:1.1.4-2) ...
Setting up libxext-dev:amd64 (2:1.3.3-1) ...
Setting up x11proto-damage-dev (1:1.2.1-2) ...
Setting up libxfixes-dev:amd64 (1:5.0.1-2) ...
Setting up x11proto-dri2-dev (2.8-2) ...
Setting up x11proto-glx-dev (1.4.17-1) ...
Setting up libgl1-mesa-dev:amd64 (11.2.0-1ubuntu2.2) ...
Setting up libgl1-mesa-dev:amd64 (9.0.0-2.1) ...
Setting up libxgk-medial3-0-dev (3.0.2+dfsg-1.3) ...
update-alternatives: using /usr/lib/x86_64-linux-gnu/wx/config/gtk2-unicode-3.0 to provide /usr/bin/wx-config (wx-config) in auto mode
Setting up libxgk-medial3-0-dev:amd64 (3.0.2+dfsg-1.3) ...
Setting up libmodule-pluggable-perl (5.2-1) ...
Setting up libalien-wxwidgets-perl (0.07+dfsg-3) ...
Setting up libparams-classify-perl (0.013-5build1) ...
Setting up libmodule-runtime-perl (0.014-2) ...
Setting up libx11-doc (2:1.6.3-1ubuntu2) ...
Processing triggers for libc-bin (2.23-0ubuntu2) ...
leo@ubuntu:~$
```

1.8.sudo apt-get install tcpdump

```
leo@ubuntu:~$ sudo apt-get install tcpdump
Setting up libdrm-dev:amd64 (2.4.67-1ubuntu0.16.04.2) ...
Setting up mesa-common-dev:amd64 (11.2.0-1ubuntu2.2) ...
Setting up libx11-xcb-dev:amd64 (2:1.6.3-1ubuntu2) ...
Setting up libxcb-dri3-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-render0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-randr0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-shape0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-xfixes0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-sync-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-present-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-shm-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-dri2-0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libxcb-glx0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up x11proto-xext-dev (7.3.0-1) ...
Setting up x11proto-fixes-dev (1:5.0-2ubuntu2) ...
Setting up libxfixes-dev:amd64 (1:5.0.1-2) ...
Setting up x11proto-damage-dev (1:1.2.1-2) ...
Setting up libxdamage-dev:amd64 (1:1.1.4-2) ...
Setting up libxext-dev:amd64 (2:1.3.3-1) ...
Setting up x11proto-damage-dev (1:1.2.1-2) ...
Setting up libxfixes-dev:amd64 (1:5.0.1-2) ...
Setting up x11proto-dri2-dev (2.8-2) ...
Setting up x11proto-glx-dev (1.4.17-1) ...
Setting up libgl1-mesa-dev:amd64 (11.2.0-1ubuntu2.2) ...
Setting up libgl1-mesa-dev:amd64 (9.0.0-2.1) ...
Setting up libxgk-medial3-0-dev (3.0.2+dfsg-1.3) ...
update-alternatives: using /usr/lib/x86_64-linux-gnu/wx/config/gtk2-unicode-3.0 to provide /usr/bin/wx-config (wx-config) in auto mode
Setting up libxgk-medial3-0-dev:amd64 (3.0.2+dfsg-1.3) ...
Setting up libmodule-pluggable-perl (5.2-1) ...
Setting up libalien-wxwidgets-perl (0.07+dfsg-3) ...
Setting up libparams-classify-perl (0.013-5build1) ...
Setting up libmodule-runtime-perl (0.014-2) ...
Setting up libx11-doc (2:1.6.3-1ubuntu2) ...
Processing triggers for libc-bin (2.23-0ubuntu2) ...
leo@ubuntu:~$ sudo apt-get install tcpdump
Reading package lists... Done
Building dependency tree
Reading state information... Done
tcpdump is already the newest version (4.7.4-1ubuntu1).
tcpdump set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
leo@ubuntu:~$
```

1.9.sudo apt-get install sqlite sqlite3 libsqlite3-dev


```
leo@ubuntu:~$ sudo apt-get install sqlite3 libsqlite3-dev
Reading state information... Done
tcpdump is already the newest version (4.7.4-1ubuntu1).
tcpdump set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
leo@ubuntu:~$ sudo apt-get install sqlite3 libsqlite3-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libsqlite0
Suggested packages:
  sqlite3-doc sqlite-doc
The following NEW packages will be installed:
  libsqlite0 libsqlite3-dev sqlite3
0 upgraded, 4 newly installed, 0 to remove and 12 not upgraded.
Need to get 1,177 kB of archives.
After this operation, 4,231 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu xenial/universe amd64 libsqlite0 amd64 2.8.17-12fakesync1 [139 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu xenial/main amd64 libsqlite3-dev amd64 3.11.0-1ubuntu1 [508 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu xenial/universe amd64 sqlite3 amd64 2.8.17-12fakesync1 [14.5 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu xenial/main amd64 sqlite3 amd64 3.11.0-1ubuntu1 [515 kB]
Fetched 1,177 kB in 17s (69.1 kB/s)
Selecting previously unselected package libsqlite0.
(Reading database ... 177482 files and directories currently installed.)
Preparing to unpack .../libsqlite0_2.8.17-12fakesync1_amd64.deb ...
Unpacking libsqlite0 (2.8.17-12fakesync1) ...
Selecting previously unselected package libsqlite3-dev:amd64.
Preparing to unpack .../libsqlite3-dev_3.11.0-1ubuntu1_amd64.deb ...
Unpacking libsqlite3-dev:amd64 (3.11.0-1ubuntu1) ...
Selecting previously unselected package sqlite3.
Preparing to unpack .../sqlite3_2.8.17-12fakesync1_amd64.deb ...
Unpacking sqlite3 (2.8.17-12fakesync1) ...
Selecting previously unselected package sqlite3.
Preparing to unpack .../sqlite3_3.11.0-1ubuntu1_amd64.deb ...
Unpacking sqlite3 (3.11.0-1ubuntu1) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up libsqlite0 (2.8.17-12fakesync1) ...
Setting up libsqlite3-dev:amd64 (3.11.0-1ubuntu1) ...
Setting up sqlite3 (2.8.17-12fakesync1) ...
Setting up sqlite3 (3.11.0-1ubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
leo@ubuntu:~$
```

1.10.sudo apt-get install libxml2 libxml2-dev

```
leo@ubuntu:~$ sudo apt-get install libxml2 libxml2-dev
Preparing to unpack .../sqlite3_3.11.0-1ubuntu1_amd64.deb ...
Unpacking sqlite3 (3.11.0-1ubuntu1) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up libsqlite0 (2.8.17-12fakesync1) ...
Setting up libsqlite3-dev:amd64 (3.11.0-1ubuntu1) ...
Setting up sqlite3 (2.8.17-12fakesync1) ...
Setting up sqlite3 (3.11.0-1ubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
leo@ubuntu:~$ sudo apt-get install libxml2 libxml2-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
libxml2 is already the newest version (2.9.3+dfsg1-1ubuntu0.1).
libxml2 set to manually installed.
The following additional packages will be installed:
  tcl-devtools libtcl-dev
Suggested packages:
  tcl-doc
The following NEW packages will be installed:
  tcl-devtools libtcl-dev libxml2-dev
0 upgraded, 3 newly installed, 0 to remove and 12 not upgraded.
Need to get 9,453 kB of archives.
After this operation, 45.0 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu xenial/main amd64 tcl-devtools amd64 55.1-7 [165 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu xenial/main amd64 libtcl-dev amd64 55.1-7 [8,546 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 libxml2-dev amd64 2.9.3+dfsg1-1ubuntu0.1 [743 kB]
Fetched 9,453 kB in 2min 0s (78.7 kB/s)
Selecting previously unselected package tcl-devtools.
(Reading database ... 177492 files and directories currently installed.)
Preparing to unpack .../tcl-devtools_55.1-7_amd64.deb ...
Unpacking tcl-devtools (55.1-7) ...
Selecting previously unselected package libtcl-dev:amd64.
Preparing to unpack .../libtcl-dev_55.1-7_amd64.deb ...
Unpacking libtcl-dev:amd64 (55.1-7) ...
Selecting previously unselected package libxml2-dev:amd64.
Preparing to unpack .../libxml2-dev_2.9.3+dfsg1-1ubuntu0.1_amd64.deb ...
Unpacking libxml2-dev:amd64 (2.9.3+dfsg1-1ubuntu0.1) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up tcl-devtools (55.1-7) ...
Setting up libtcl-dev:amd64 (55.1-7) ...
Setting up libxml2-dev:amd64 (2.9.3+dfsg1-1ubuntu0.1) ...
leo@ubuntu:~$
```

1.11.sudo apt-get install libgtk2.0-0 libgtk2.0-dev

```
leo@ubuntu:~$ sudo apt-get install libgtk2.0-0 libgtk2.0-dev
Setting up libpcrecpp0v5:amd64 (2:8.38-3.1) ...
Setting up autotools-dev (20150820.1) ...
Setting up po-debconf (1.0.19) ...
Setting up libfile-stripopndeterminism-perl (0.015-1) ...
Setting up glib-2.0-gtk-2.0 (2.24.30-1ubuntu1) ...
Setting up libpcre3-2:amd64 (2:8.38-3.1) ...
Setting up libpcre3-dev:amd64 (2:8.38-3.1) ...
Setting up zlib1g-dev:amd64 (1:1.2.8.dfsg-2ubuntu4) ...
Setting up libglib2.0-dev (2.48.1-1ubuntu16.04.1) ...
Setting up libatk1.0-dev (2.18.0-1) ...
Setting up libcairo-script-interpreter2:amd64 (1.14.0-1) ...
Setting up libexpat1-dev:amd64 (2.1.0-7ubuntu0.16.04.2) ...
Setting up libpng12-dev:amd64 (1.2.54-1ubuntu1) ...
Setting up libfreetype-dev:amd64 (2.6.1-0-1ubuntu2) ...
Setting up libfontconfig1-dev:amd64 (2.11.94-0ubuntu1.1) ...
Setting up x11proto-render-dev (2:0.11.2-2) ...
Setting up libxrender-dev:amd64 (1:0.9.9-0ubuntu1) ...
Setting up libice-dev:amd64 (2:1.0.9-1) ...
Setting up libsm-dev:amd64 (2:1.2.2-1) ...
Setting up libptxman-1-dev (0.33.6-1) ...
Setting up libxcb-shm0-dev:amd64 (1.11.1-1ubuntu1) ...
Setting up libcairo2-dev (1.14.0-1) ...
Setting up libgdk-pixbuf2.0-dev (2.32.2-1ubuntu1.2) ...
Setting up libharfbuzz-gobject0:amd64 (1.0.1-1ubuntu0.1) ...
Setting up libharfbuzz-dev (1.0.1-1ubuntu0.1) ...
Setting up libxft-dev (2.3.2-1) ...
Setting up libpango1.0-dev (1.38.1-1) ...
Setting up x11proto-xinerama-dev (1.2.1-2) ...
Setting up libxinerama-dev:amd64 (2:1.1.3-1) ...
Setting up libx11-dev (2:1.7.0-3) ...
Setting up x11proto-randr-dev (1.5.0-1) ...
Setting up libxrandr-dev:amd64 (2:1.5.0-1) ...
Setting up libxcursor-dev:amd64 (1:1.1.14-1) ...
Setting up x11proto-composite-dev (1:0.4.2-2) ...
Setting up libxcomposite-dev (1:0.4.4-1) ...
Setting up libx11-0-utls (2.9.3+dfsg1-1ubuntu0.1) ...
Setting up libgtk2.0-dev (2.24.30-1ubuntu1) ...
Setting up libsys-hostname-long-perl (1.5-1) ...
Setting up libmail-sendmail-perl (0.79.16-1) ...
Setting up dh-strip-nondeterminism (0.015-1) ...
Setting up debhelper (9.2016011ubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
leo@ubuntu:~$
```

1.12.sudo apt-get install vtun lxc

```
leo@ubuntu:~$ sudo apt-get install uncrustify
Unpacking uidmap (1:4.2-3.1ubuntu5) ...
Selecting previously unselected package vtun.
Preparing to unpack .../vtun_3.0.3-2.1_and64.deb ...
Unpacking vtun (3.0.3-2.1) ...
Selecting previously unselected package cloud-image-utils.
Preparing to unpack .../cloud-image-utils_0.27-0ubuntu24_all.deb ...
Unpacking cloud-image-utils (0.27-0ubuntu24) ...
Selecting previously unselected package debootstrap.
Preparing to unpack .../debootstrap_1.0.78+nmu1ubuntu1.2_all.deb ...
Unpacking debootstrap (1.0.78+nmu1ubuntu1.2) ...
Processing triggers for man-db (2.7.5-1) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
Processing triggers for ureadahead (0.100.0-19) ...
Processing triggers for systemd (229-4ubuntu13) ...
Setting up libiscsi2:amd64 (1:12.0-2) ...
Setting up bridge-utils (1.5-9ubuntu1) ...
Setting up distro-info (0.14build1) ...
Setting up libatlas-base-dev (3.10.4-2) ...
Setting up libboost-random1.58.0:amd64 (1.58.0+dfsg-Subunit3.1) ...
Setting up libboost-thread1.58.0:amd64 (1.58.0+dfsg-Subunit3.1) ...
Setting up libpam-cgfs (2.0.5-0ubuntu1-ubuntu16.04.1) ...
Setting up librados2 (10.2.3-0ubuntu0.16.04.2) ...
Setting up librbdi (10.2.3-0ubuntu0.16.04.2) ...
Setting up lxcfs (2.0.5-0ubuntu1-ubuntu16.04.1) ...
Setting up qemu-block-extra:amd64 (1:2.5+dfsg-Subunit0.6) ...
Setting up qemu-utils (1:2.5+dfsg-Subunit0.6) ...
Setting up sharutils (1:4.15.2-1) ...
Setting up uidmap (1:4.2-3.1ubuntu5) ...
Setting up vtun (3.0.3-2.1) ...
Setting up cloud-image-utils (0.27-0ubuntu24) ...
Setting up debootstrap (1.0.78+nmu1ubuntu1.2) ...
Setting up liblxc1 (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up python3-lxc (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc1 (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc-dnsmasq configuration.
Setting up lxc (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc-templates (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc-common (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
Processing triggers for systemd (229-4ubuntu13) ...
Processing triggers for ureadahead (0.100.0-19) ...
leo@ubuntu:~$
```

1.13.sudo apt-get install uncrustify

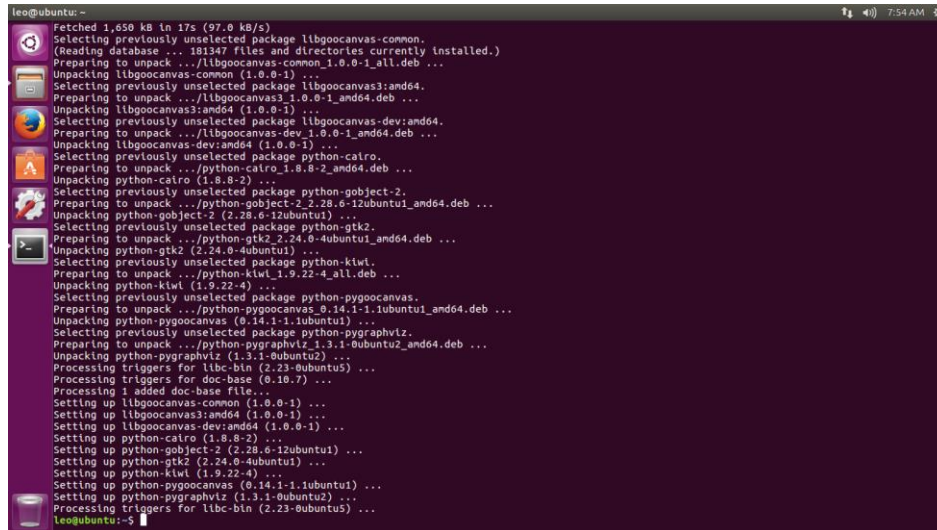
```
leo@ubuntu:~$ sudo apt-get install uncrustify
Setting up distro-info (0.14build1) ...
Setting up libatlas-base-dev (3.10.4-2) ...
Setting up libboost-random1.58.0:amd64 (1.58.0+dfsg-Subunit3.1) ...
Setting up libboost-thread1.58.0:amd64 (1.58.0+dfsg-Subunit3.1) ...
Setting up libpam-cgfs (2.0.5-0ubuntu1-ubuntu16.04.1) ...
Setting up librados2 (10.2.3-0ubuntu0.16.04.2) ...
Setting up librbdi (10.2.3-0ubuntu0.16.04.2) ...
Setting up lxcfs (2.0.5-0ubuntu1-ubuntu16.04.1) ...
Setting up qemu-block-extra:amd64 (1:2.5+dfsg-Subunit0.6) ...
Setting up qemu-utils (1:2.5+dfsg-Subunit0.6) ...
Setting up sharutils (1:4.15.2-1) ...
Setting up uidmap (1:4.2-3.1ubuntu5) ...
Setting up vtun (3.0.3-2.1) ...
Setting up cloud-image-utils (0.27-0ubuntu24) ...
Setting up debootstrap (1.0.78+nmu1ubuntu1.2) ...
Setting up liblxc1 (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up python3-lxc (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc1 (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc-dnsmasq configuration.
Setting up lxc (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc-templates (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Setting up lxc-common (2.0.6-0ubuntu1-ubuntu16.04.1) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
Processing triggers for systemd (229-4ubuntu13) ...
Processing triggers for ureadahead (0.100.0-19) ...
leo@ubuntu:~$ sudo apt-get install uncrustify
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  uncrustify
0 upgraded, 1 newly installed, 0 to remove and 12 not upgraded.
Need to get 199 kB of archives.
After this operation, 684 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu xenial/universe amd64 uncrustify amd64 0.59+dfsg1-1.1 [199 kB]
Fetched 199 kB in 6s (29.5 kB/s)
Selecting previously unselected package uncrustify.
(Reading database ... 181140 files and directories currently installed.)
Preparing to unpack .../uncrustify_0.59+dfsg1-1.1_and64.deb ...
Unpacking uncrustify (0.59+dfsg1-1.1) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up uncrustify (0.59+dfsg1-1.1) ...
leo@ubuntu:~$
```

1.14.sudo apt-get install doxygen graphviz imagemagick

```
leo@ubuntu:~$ sudo apt-get install doxygen graphviz imagemagick
Unpacking libobjc4:amd64 (5.4.0-6ubuntu1-16.04.4) ...
Selecting previously unselected package libobjc5-dev:amd64.
Preparing to unpack .../libobjc5-dev_5.4.0-6ubuntu1-16.04.4_and64.deb ...
Unpacking libobjc5-dev:amd64 (5.4.0-6ubuntu1-16.04.4) ...
Selecting previously unselected package libclang1-3.6:amd64.
Preparing to unpack .../libclang1-3.6_1:3.6.2-3ubuntu2_and64.deb ...
Unpacking libclang1-3.6:amd64 (1:3.6.2-3ubuntu2) ...
Selecting previously unselected package doxygen.
Preparing to unpack .../doxygen_1.8.11-1_and64.deb ...
Unpacking doxygen (1.8.11-1) ...
Selecting previously unselected package libcdt5.
Preparing to unpack .../libcdt5_2.38.0-12ubuntu2_and64.deb ...
Unpacking libcdt5 (2.38.0-12ubuntu2) ...
Selecting previously unselected package libgraph6.
Preparing to unpack .../libgraph6_2.38.0-12ubuntu2_and64.deb ...
Unpacking libgraph6 (2.38.0-12ubuntu2) ...
Selecting previously unselected package libpathplan4.
Preparing to unpack .../libpathplan4_2.38.0-12ubuntu2_and64.deb ...
Unpacking libpathplan4 (2.38.0-12ubuntu2) ...
Selecting previously unselected package libgv6.
Preparing to unpack .../libgv6_2.38.0-12ubuntu2_and64.deb ...
Unpacking libgv6 (2.38.0-12ubuntu2) ...
Selecting previously unselected package libgvpr2.
Preparing to unpack .../libgvpr2_2.38.0-12ubuntu2_and64.deb ...
Unpacking libgvpr2 (2.38.0-12ubuntu2) ...
Selecting previously unselected package graphviz.
Preparing to unpack .../graphviz_2.38.0-12ubuntu2_and64.deb ...
Unpacking graphviz (2.38.0-12ubuntu2) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
Setting up liblvm3-ovs:amd64 (1:3.6.2-3ubuntu2) ...
Setting up libobjc4:amd64 (5.4.0-6ubuntu1-16.04.4) ...
Setting up libobjc5-dev:amd64 (5.4.0-6ubuntu1-16.04.4) ...
Setting up libclang1-3.6:amd64 (1:3.6.2-3ubuntu2) ...
Setting up doxygen (1.8.11-1) ...
Setting up libcdt5 (2.38.0-12ubuntu2) ...
Setting up libgraph6 (2.38.0-12ubuntu2) ...
Setting up libpathplan4 (2.38.0-12ubuntu2) ...
Setting up libgv6 (2.38.0-12ubuntu2) ...
Setting up libgvpr2 (2.38.0-12ubuntu2) ...
Setting up graphviz (2.38.0-12ubuntu2) ...
Processing triggers for libc-bin (2.23-0ubuntu5) ...
leo@ubuntu:~$
```

1.15.sudo apt-get install python-pygraphviz python-kiwi python

pygoocanvas libgoocanvas-dev



```
leo@ubuntu:~$  
Fetched 1,650 kB in 17s (97.0 kB/s)  
Selecting previously unselected package libgoocanvas-common.  
(Reading database ... 181347 files and directories currently installed.)  
Preparing to unpack .../libgoocanvas-common_1.0.0-1_all.deb ...  
Unpacking libgoocanvas-common (1.0.0-1) ...  
Selecting previously unselected package libgoocanvas3:amd64.  
Preparing to unpack .../libgoocanvas3_1.0.0-1_amd64.deb ...  
Unpacking libgoocanvas3:amd64 (1.0.0-1) ...  
Selecting previously unselected package libgoocanvas-dev:amd64.  
Preparing to unpack .../libgoocanvas-dev_1.0.0-1_amd64.deb ...  
Unpacking libgoocanvas-dev:amd64 (1.0.0-1) ...  
Selecting previously unselected package python-cairo.  
Preparing to unpack .../python-cairo_1.8.8-2_amd64.deb ...  
Unpacking python-cairo (1.8.8-2) ...  
Selecting previously unselected package python-gobject-2.  
Preparing to unpack .../python-gobject-2_2.28.6-12ubuntu1_amd64.deb ...  
Unpacking python-gobject-2 (2.28.6-12ubuntu1) ...  
Selecting previously unselected package python-gtk2.  
Preparing to unpack .../python-gtk2_2.24.0-4ubuntu1_amd64.deb ...  
Unpacking python-gtk2 (2.24.0-4ubuntu1) ...  
Selecting previously unselected package python-kiwi.  
Preparing to unpack .../python-kiwi_1.9.22-4_all.deb ...  
Unpacking python-kiwi (1.9.22-4) ...  
Selecting previously unselected package python-pygoocanvas.  
Preparing to unpack .../python-pygoocanvas_0.14.1-1.1ubuntu1_amd64.deb ...  
Unpacking python-pygoocanvas (0.14.1-1.1ubuntu1) ...  
Selecting previously unselected package python-pygraphviz.  
Preparing to unpack .../python-pygraphviz_1.3.1-0ubuntu2_amd64.deb ...  
Unpacking python-pygraphviz (1.3.1-0ubuntu2) ...  
Processing triggers for libc-bin (2.23-0ubuntu2) ...  
Processing triggers for doc-base (0.10.7) ...  
Processing 1 added doc-base file...  
Setting up libgoocanvas-common (1.0.0-1) ...  
Setting up libgoocanvas3:amd64 (1.0.0-1) ...  
Setting up libgoocanvas-dev:amd64 (1.0.0-1) ...  
Setting up python-cairo (1.8.8-2) ...  
Setting up python-gobject-2 (2.28.6-12ubuntu1) ...  
Setting up python-gtk2 (2.24.0-4ubuntu1) ...  
Setting up python-kiwi (1.9.22-4) ...  
Setting up python-pygoocanvas (0.14.1-1.1ubuntu1) ...  
Setting up python-pygraphviz (1.3.1-0ubuntu2) ...  
Processing triggers for libc-bin (2.23-0ubuntu2) ...  
leo@ubuntu:~$
```

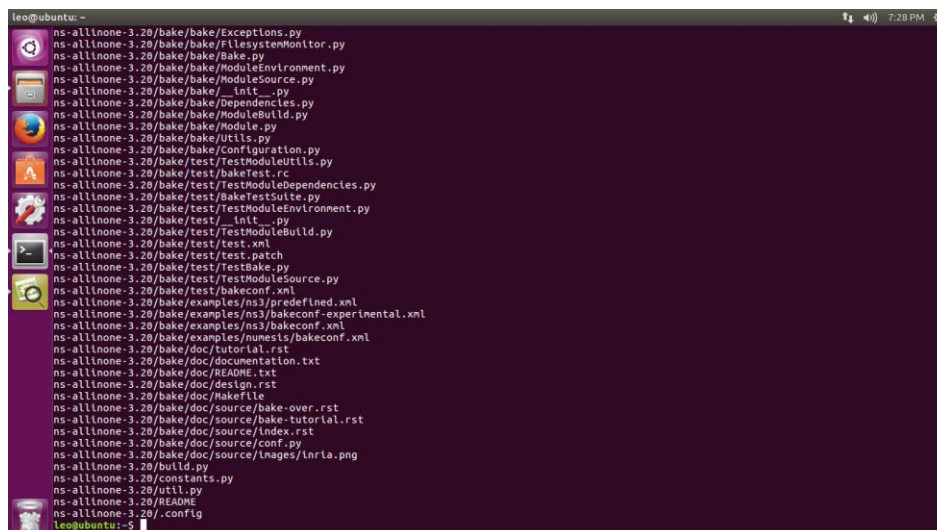
2.Install NS3

2. 1. 下載 NS3 安裝包並解壓，官網上（www.nsnam.org）下載的 3.20 版本格式為

ns-allinone-3.20.tar.bz2，在終端運行以下命令進行解壓縮：

```
bzip2 -d ns-allinone-3.20.tar.bz2
```

```
tar xvf ns-allinone-3.20.tar
```



```
leo@ubuntu:~$  
ns-allinone-3.20/bake/bake/Exceptions.py  
ns-allinone-3.20/bake/bake/FileSystemMonitor.py  
ns-allinone-3.20/bake/bake/bake.py  
ns-allinone-3.20/bake/bake/ModuleEnvironment.py  
ns-allinone-3.20/bake/bake/ModuleSource.py  
ns-allinone-3.20/bake/bake/_init_.py  
ns-allinone-3.20/bake/bake/Dependencies.py  
ns-allinone-3.20/bake/bake/ModuleBuild.py  
ns-allinone-3.20/bake/bake/Module.py  
ns-allinone-3.20/bake/bake/Utils.py  
ns-allinone-3.20/bake/bake/configuration.py  
ns-allinone-3.20/bake/test/TestModuleUtils.py  
ns-allinone-3.20/bake/test/bakeTest.rc  
ns-allinone-3.20/bake/test/TestModuleDependencies.py  
ns-allinone-3.20/bake/test/BakeTestSuite.py  
ns-allinone-3.20/bake/test/TestModuleEnvironment.py  
ns-allinone-3.20/bake/test/_init_.py  
ns-allinone-3.20/bake/test/TestModuleBuild.py  
ns-allinone-3.20/bake/test/test.xml  
ns-allinone-3.20/bake/test/test.patch  
ns-allinone-3.20/bake/test/TestBake.py  
ns-allinone-3.20/bake/test/TestModuleSource.py  
ns-allinone-3.20/bake/test/bakeconf.xml  
ns-allinone-3.20/bake/examples/ns3/predefined.xml  
ns-allinone-3.20/bake/examples/ns3/bakeconf_experimental.xml  
ns-allinone-3.20/bake/examples/ns3/bakeconf.xml  
ns-allinone-3.20/bake/examples/numesis/bakeconf.xml  
ns-allinone-3.20/bake/doc/tutorial.rst  
ns-allinone-3.20/bake/doc/documentation.txt  
ns-allinone-3.20/bake/doc/README.txt  
ns-allinone-3.20/bake/doc/design.rst  
ns-allinone-3.20/bake/doc/Makefile  
ns-allinone-3.20/bake/doc/source/bake-over.rst  
ns-allinone-3.20/bake/doc/source/bake-tutorial.rst  
ns-allinone-3.20/bake/doc/source/index.rst  
ns-allinone-3.20/bake/doc/source/conf.py  
ns-allinone-3.20/bake/doc/source/images/lnria.png  
ns-allinone-3.20/build.py  
ns-allinone-3.20/constants.py  
ns-allinone-3.20/util.py  
ns-allinone-3.20/README  
ns-allinone-3.20/config
```

2. 2 進入解壓縮檔夾 ns-allinone-3.20，執行命令

```
./build.py
```



```

leo@ubuntu: ~/ns-allinone-3.20
[1597/1611] Cxxprogram: build/utills/print-introspected-doxxygen.cc.4.o -> build/utills/ns3.20-print-introspected-doxxygen-debug
[1598/1611] Cxx: src/emu/model/emu-sock-creator.cc -> build/src/emu/model/emu-sock-creator.cc.4.o
[1599/1611] Cxx: src/emu/model/emu-encode-decode.cc -> build/src/emu/model/emu-encode-decode.cc.4.o
[1600/1611] Cxxprogram: build/src/emu/model/emu-sock-creator.cc.4.o build/src/emu/model/emu-encode-decode.cc.4.o -> build/src/emu/ns3.20-emu-sock-creator-debug
[1601/1611] Cxx: src/fd-net-device/helper/tap-device-creator.cc -> build/src/fd-net-device/helper/tap-device-creator.cc.4.o
[1602/1611] Cxx: src/fd-net-device/helper/encode-decode.cc -> build/src/fd-net-device/helper/encode-decode.cc.4.o
[1603/1611] Cxx: src/fd-net-device/helper/creator-utills.cc -> build/src/fd-net-device/helper/creator-utills.cc.4.o
[1604/1611] Cxxprogram: build/src/fd-net-device/helper/tap-device-creator.cc.4.o build/src/fd-net-device/helper/encode-decode.cc.4.o build/src/fd-net-device/helper/creator-utills.cc.4.o -> build/src/fd-net-device/ns3.20-tap-device-creator-debug
[1605/1611] Cxx: src/fd-net-device/helper/raw-sock-creator.cc -> build/src/fd-net-device/helper/raw-sock-creator.cc.5.o
[1606/1611] Cxx: src/fd-net-device/helper/encode-decode.cc -> build/src/fd-net-device/helper/encode-decode.cc.5.o
[1607/1611] Cxx: src/fd-net-device/helper/creator-utills.cc -> build/src/fd-net-device/helper/creator-utills.cc.5.o
[1608/1611] Cxxprogram: build/src/fd-net-device/helper/raw-sock-creator.cc.5.o build/src/fd-net-device/helper/encode-decode.cc.5.o build/src/fd-net-device/helper/creator-utills.cc.5.o -> build/src/fd-net-device/ns3.20-raw-sock-creator-debug
[1609/1611] Cxx: src/tap-bridge/model/tap-creator.cc -> build/src/tap-bridge/model/tap-creator.cc.4.o
[1610/1611] Cxx: src/tap-bridge/model/tap-encode-decode.cc -> build/src/tap-bridge/model/tap-encode-decode.cc.4.o
[1611/1611] Cxxprogram: build/src/tap-bridge/model/tap-creator.cc.4.o build/src/tap-bridge/model/tap-encode-decode.cc.4.o -> build/src/tap-bridge/ns3.20-tap-creator-debug
waf: Leaving directory '/home/leo/ns-allinone-3.20/ns-3.20/build'
'build' finished successfully (38m38.885s)

Modules built:
antenna      aodv      applications
bridge       buildings config-store
core         csma      csma-layout
dsdv         dsr       emu
energy       fd-net-device flow-monitor
internet     lr-wpan   lte
mesh         mobility  npt
netanim (no Python) network    nix-vector-routing
olsr         point-to-point point-to-point-layout
propagation  stixlopan spectrum
stats        tap-bridge test (no Python)
topology-read uan       virtual-net-device
wave         wifi      winmax

Modules not built (see ns-3 tutorial for explanation):
brite        click
visualizer   openflow

Leaving directory './ns-3.20'
leo@ubuntu:~/ns-allinone-3.20$

```

2.3 進入 ns-3.13 目錄 ns-allinone-3.20/ns-3.20，使用 waf 構建

`./waf -d optimized configure`

```

leo@ubuntu: ~/ns-allinone-3.20/ns-3.20
Checking for header net/ethernet.h : yes
Checking for header linux/if_tun.h : yes
Checking for header netpacket/packet.h : yes
Checking for NSC location : not found
Checking for 'sqlite3' : yes
Checking for header linux/if_tun.h : yes
Checking for program sudo : /usr/bin/sudo
Checking for program valgrind : /usr/bin/valgrind
Checking for 'gsl' : not found
Checking for compilation flag -Wno-error=deprecated-d... support : ok
Checking for compilation flag -Wno-error=deprecated-d... support : ok
Checking for compilation flag -fstrict-aliasing... support : ok
Checking for compilation flag -fstrict-aliasing... support : ok
Checking for compilation flag -fstrict-aliasing... support : ok
Checking for program doxygen : /usr/bin/doxygen
---- Summary of optional NS-3 features:
Build profile : optimized
Build directory : /home/leo/ns-allinone-3.20/ns-3.20/build
Python Bindings : not enabled (Python library or headers missing)
BRITE Integration : not enabled (BRITE not enabled (see option --with-brite))
NS-3 Click Integration : not enabled (nsclick not enabled (see option --with-nsclick))
GtkConfigStore : enabled
Xmlio : enabled
Threading Primitives : enabled
Real Time Simulator : enabled
Emulated Net Device : enabled
File descriptor NetDevice : enabled
Tap FdNetDevice : enabled
Emulation FdNetDevice : enabled
PlanetLab FdNetDevice : not enabled (PlanetLab operating system not detected (see option --force-planetlab))
Network Simulation Cradle : not enabled (NSC not found (see option --with-nsc))
MPT Support : not enabled (option --enable-mpt not selected)
NS-3 OpenFlow Integration : not enabled (Required boost libraries not found)
SQLite stats data output : enabled
Tap Bridge : enabled
Pyviz visualizer : not enabled (Python Bindings are needed but not enabled)
Use sudo to set sudo bit : not enabled (option --enable-sudo not selected)
Build tests : not enabled (defaults to disabled)
Build examples : not enabled (defaults to disabled)
GNU Scientific Library (GSL) : not enabled (GSL not found)
configure finished successfully (1h 47m)
leo@ubuntu:~/ns-allinone-3.20/ns-3.20$

```

`./waf -d debug configure`


```

leo@ubuntu:~/ns-allinone-3.20/ns-3.20$
Checking for header net/ethernet.h : yes
Checking for header linux/lf_tun.h : yes
Checking for header netpacket/packet.h : yes
Checking for NSC location : not found
Checking for 'sqlite3' : yes
Checking for header linux/lf_tun.h : yes
Checking for program sudo : /usr/bin/sudo
Checking for program valgrind : /usr/bin/valgrind
Checking for 'git' : not found
Checking for compilation flag -Wno-error=deprecated-d... support : ok
Checking for compilation flag -Wno-error=deprecated-d... support : ok
Checking for compilation flag -fstrict-aliasing... support : ok
Checking for compilation flag -fstrict-aliasing... support : ok
Checking for compilation flag -Wstrict-aliasing... support : ok
Checking for compilation flag -Wstrict-aliasing... support : ok
Checking for program doxygen : /usr/bin/doxygen
--- Summary of optional NS-3 features:
Build profile : debug
Build directory : /home/leo/ns-allinone-3.20/ns-3.20/build
Python Bindings : not enabled (Python library or headers missing)
BRITE integration : not enabled (BRITE not enabled (see option --with-brite))
NS-3 Click Integration : not enabled (nsclink not enabled (see option --with-nsclink))
GtkConfigStore : enabled
Xtlib : enabled
Threading Primitives : enabled
Real Time Simulator : enabled
Emulated Net Device : enabled
File descriptor NetDevice : enabled
Tap FdnetDevice : enabled
Emulation FdNetDevice : enabled
Planetlab FdNetDevice : not enabled (Planetlab operating system not detected (see option --force-planetlab))
Network Simulation Cradle : not enabled (RSC not found (see option --with-rsc))
MPI Support : not enabled (option --enable-mpi not selected)
NS-3 OpenFlow Integration : not enabled (Required boost libraries not found)
Sqlite stats data output : enabled
Tap Bridge : enabled
Pyviz visualizer : not enabled (Python Bindings are needed but not enabled)
Use sudo to set suid bit : not enabled (option --enable-sudo not selected)
Build tests : not enabled (defaults to disabled)
Build examples : not enabled (defaults to disabled)
GNU Scientific Library (GSL) : not enabled (GSL not found)
'configure' finished successfully (10-2495)
leo@ubuntu:~/ns-allinone-3.20/ns-3.20$

```

```
./build.py-enable examples—enable tests
```

```
leo@ubuntu:~/ns-allinone-3.26$
[2449/2479] Linking build/src/netanim/examples/ns3.26-wireless-antenna-debug
[2449/2479] Linking build/src/wave/examples/ns3.26-vanet-routing-compare-debug
[2450/2479] Linking build/src/mesh/examples/ns3.26-mesh-debug
[2451/2479] Linking build/src/netanim/examples/ns3.26-star-animation-debug
[2452/2479] Linking build/src/lte/examples/ns3.26-lena-rem-sector-antenna-debug
[2453/2479] Linking build/src/wave/examples/ns3.26-wave-single-device-debug
[2454/2479] Linking build/src/lte/examples/ns3.26-lena-rem-debug
[2457/2479] Linking build/examples/wireless/ns3.26-mixed-wireless-debug
[2458/2479] Linking build/src/lte/examples/ns3.26-lena-frequency-reuse-debug
[2459/2479] Linking build/src/lte/examples/ns3.26-lena-x2-handover-debug
[2460/2479] Linking build/src/lte/examples/ns3.26-lena-rlc-traces-debug
[2461/2479] Linking build/src/netanim/examples/ns3.26-grid-animation-debug
[2462/2479] Linking build/src/netanim/examples/ns3.26-resources-counters-debug
[2463/2479] Linking build/ltns3.26-netanim-test-debug.so
[2465/2479] Linking build/src/netanim/examples/ns3.26-colors-link-description-debug
[2467/2479] Linking build/ltns3.26-test-test-debug.so
[2468/2479] Linking build/utls/ns3.26-test-runner-debug
waf: Leaving directory '/home/leo/ns-allinone-3.26/ns-3.26/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (50m6.776s)

Modules built:
antenna          aodv          applications
bridge           buildings    config-store
core             csma         csma-layout
dsdv            dsr          energy
fd-net-device    flow-monitor Internet
Internet-apps    lr-wpan      lte
mesh             nobility     mpt
netanim (no Python) network       nix-vector-routing
olsr             point-to-point
propagation      sixlowpan    spectrum
stats            tap-bridge   test (no Python)
topology-read    traffic-control
virtual-net-device wave          wifi
wlnx

Modules not built (see ns-3 tutorial for explanation):
brte             click        openflow
visualizer

Leaving directory './ns-3.26'
leo@ubuntu:~/ns-allinone-3.26$
```

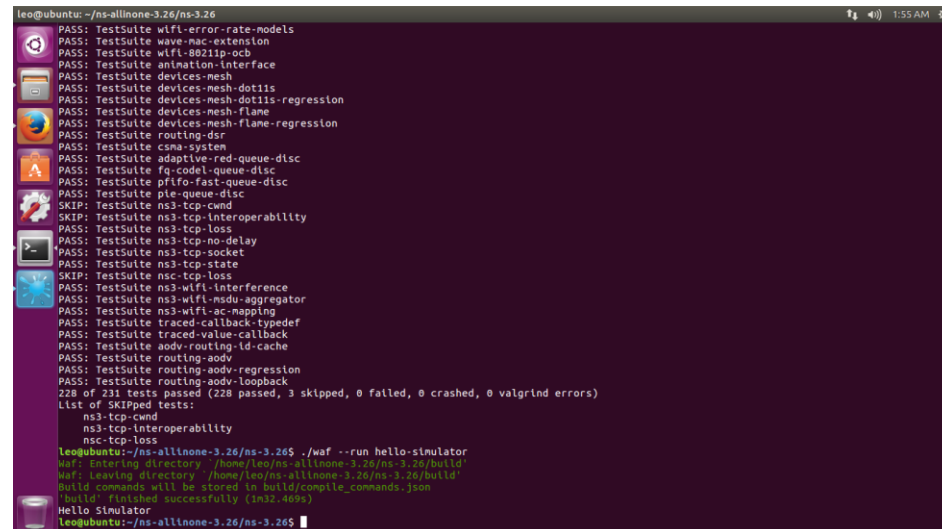
```
./test.py -c core
```

```
leo@ubuntu: ~/ns-allinone-3.20/ns-3.20$
PASS: TestSuite lte-spectrum-value-helper
PASS: TestSuite lte-pathloss-model
PASS: TestSuite lte-rlc-un-transmitter
PASS: TestSuite lte-rlc-am-transmitter
PASS: TestSuite lte-rlc-un-e2e
PASS: TestSuite lte-rlc-am-e2e
PASS: TestSuite epc-gtpu
PASS: TestSuite eps-tft-classifier
PASS: TestSuite epc-siu-downlink
PASS: TestSuite epc-siu-uplink
PASS: TestSuite lte-epc-e2e-data
PASS: TestSuite lte-antenna
PASS: TestSuite lte-phy-error-model
PASS: TestSuite lte-nlno
PASS: TestSuite lte-harq
PASS: TestSuite lte-rrc
PASS: TestSuite lte-x2-handover
PASS: TestSuite lte-x2-handover-measures
PASS: TestSuite test-asn1-encoding
PASS: TestSuite lte-ue-measurements
PASS: TestSuite lte-ue-measurements-piecewise-1
PASS: TestSuite lte-ue-measurements-piecewise-2
PASS: TestSuite lte-ue-measurements-handover
PASS: TestSuite lte-cell-selection
PASS: TestSuite lte-handover-delay
PASS: TestSuite lte-handover-target
PASS: TestSuite animation-interface
PASS: TestSuite csma-system
PASS: TestSuite global-routing
PASS: TestSuite static-routing
PASS: TestSuite mobility
PASS: TestSuite ns3-wifi-interference
PASS: TestSuite ns3-wifi-nsdu-aggregator
SKIP: TestSuite ns3-tcp-cwnd
SKIP: TestSuite ns3-tcp-interoparability
PASS: TestSuite ns3-tcp-loss
PASS: TestSuite ns3-tcp-no-delay
PASS: TestSuite ns3-tcp-socket
PASS: TestSuite ns3-tcp-state
SKIP: TestSuite nsc-tcp-loss
178 of 181 tests passed (178 passed, 3 skipped, 0 failed, 0 crashed, 0 valgrind errors)
List of SKIPPed tests: ns3-tcp-cwnd ns3-tcp-interoparability nsc-tcp-loss
leo@ubuntu: ~/ns-allinone-3.20/ns-3.20$
```

2.4. 脚本運行 進入 ns-3.13 目錄

./waf --run hello-simulator

output: hello simulator



```
leo@ubuntu: ~/ns-allinone-3.26/ns-3.26
PASS: TestSuite wifi-error-rate-models
PASS: TestSuite wave-mac-extension
PASS: TestSuite wifi-80211p-ocb
PASS: TestSuite animation-interface
PASS: TestSuite devices-mesh
PASS: TestSuite devices-mesh-dot11s
PASS: TestSuite devices-mesh-dot11s-regression
PASS: TestSuite devices-mesh-flame
PASS: TestSuite devices-mesh-flame-regression
PASS: TestSuite routing-dsr
PASS: TestSuite csma-system
PASS: TestSuite adaptive-red-queue-disc
PASS: TestSuite fq-codel-queue-disc
PASS: TestSuite pfifo-fast-queue-disc
PASS: TestSuite pie-queue-disc
SKIP: TestSuite ns3-tcp-cwnd
SKIP: TestSuite ns3-tcp-interoperability
PASS: TestSuite ns3-tcp-loss
PASS: TestSuite ns3-tcp-no-delay
PASS: TestSuite ns3-tcp-socket
PASS: TestSuite ns3-tcp-state
SKIP: TestSuite nsc-tcp-loss
PASS: TestSuite ns3-wifi-interference
PASS: TestSuite ns3-wifi-msdu-aggregator
PASS: TestSuite ns3-wifi-ac-mapping
PASS: TestSuite traced-callback-typedef
PASS: TestSuite traced-value-callback
PASS: TestSuite aodv-routing-id-cache
PASS: TestSuite routing-aodv
PASS: TestSuite routing-aodv-regression
PASS: TestSuite routing-aodv-loopback
228 of 231 tests passed (228 passed, 3 skipped, 0 failed, 0 crashed, 0 valgrind errors)
List of SKIPPED tests:
ns3-tcp-cwnd
ns3-tcp-interoperability
nsc-tcp-loss
leo@ubuntu:~/ns-allinone-3.26/ns-3.26$ ./waf --run hello-simulator
waf: Entering directory '/home/leo/ns-allinone-3.26/ns-3.26/build'
waf: Leaving directory '/home/leo/ns-allinone-3.26/ns-3.26/build'
Build commands will be stored in build/compile_commands.json
waf: Finished successfully (in 0.469s)
Hello Simulator
leo@ubuntu:~/ns-allinone-3.26/ns-3.26$
```

3. Build up topology and related parameters

Simulator: ns-3.20 **Platform:** Ubuntu 16.04.01

Protocol: TcpReno

Global Variables:

RouterLink Rate:{10Mbps};

RouterLink Delay:{100us};

Packet Generation Rate:{2MBPS};

Packet Length:{1400};

Max Segment Size:{1000};

Window Size:{20000};

Initial cwnd:{1}

DropTail related parameters:

Buffer Size:{1400,2800,4200,5600,7000};

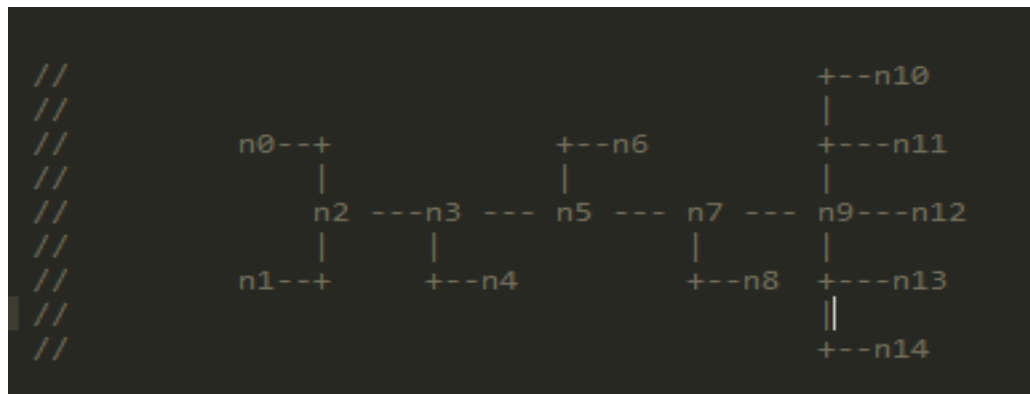
RED related parameters:

Max-threshold:{3}

Min-threshold:{1}

Buffer Size:{5600}

Topology



4.Programming and run script

```
#include <fstream>
#include <string>
#include <string>
#include <cassert>
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/animation-interface.h"
#include "ns3/internet-module.h"
#include "ns3/netanim-module.h"
#include "ns3/packet-sink.h"
#include "ns3/flow-monitor-helper.h"
#include "ns3/flow-monitor-module.h"
#include "ns3/ipv4-global-routing-helper.h"
#include "ns3/ipv4-flow-classifier.h"
#include "ns3/double.h"
#include "ns3/tcp-socket-base.h"
#include "ns3/tcp-l4-protocol.h"
```

```
using namespace ns3;
using namespace std;
```

```

NS_LOG_COMPONENT_DEFINE ("Project2");

//declaration of the MyApp Application that we put together to allow the Socket to be created at
configuration time
class MyApp : public Application
{
public:
    MyApp ();
    virtual ~MyApp();
    void Setup (Ptr<Socket> socket, Address address, uint32_t packetSize,uint32_t nPackets,
DataRate dataRate);

private:
    virtual void StartApplication (void);
    virtual void StopApplication (void);

    void ScheduleTx (void);
    void SendPacket (void);

    Ptr<Socket>      m_socket;
    Address          m_peer;
    uint32_t         m_packetSize;
    uint32_t         m_nPackets;
    DataRate         m_dataRate;
    EventId         m_sendEvent;
    bool             m_running;
    uint32_t         m_packetsSent;
};

//MyApp Application needs a constructor and a destructor
MyApp::MyApp ()
    : m_socket (0),
      m_peer (),
      m_packetSize (0),
      m_nPackets (0),
      m_dataRate (0),
      m_sendEvent (),
      m_running (false),
      m_packetsSent (0)
{
}

MyApp::~MyApp()
{

```

```

    m_socket = 0;
}

//the whole reason why we wrote this Application in the first place
void
MyApp::Setup (Ptr<Socket> socket, Address address, uint32_t packetSize,uint32_t
nPackets,DataRate dataRate)
{
    m_socket = socket;
    m_peer = address;
    m_packetSize = packetSize;
    m_nPackets = nPackets;
    m_dataRate = dataRate;
}

//We are just initializing member variables
void
MyApp::StartApplication (void)
{
    m_running = true;
    m_packetsSent = 0;
    m_socket->Bind ();
    m_socket->Connect (m_peer);
    SendPacket ();
}

//stop creating simulation events
void
MyApp::StopApplication (void)
{
    m_running = false;
    if (m_sendEvent.IsRunning ())
    {
        Simulator::Cancel (m_sendEvent);
    }
    if (m_socket)
    {
        m_socket->Close ();
    }
}

//Recall that StartApplication called SendPacket to start the chain of events that describes the
Application behavior.

```

```

void
MyApp::SendPacket (void)
{
    Ptr<Packet> packet = Create<Packet> (m_packetSize);
    m_socket->Send (packet);

    if (++m_packetsSent < m_nPackets)
    {
        ScheduleTx ();
    }
}

//call ScheduleTx to schedule another transmit event (a SendPacket) until the Application decides
it has sent enough.
void
MyApp::ScheduleTx (void)
{
    if (m_running)
    {
        Time tNext (Seconds (m_packetSize * 8 / static_cast<double> (m_dataRate.GetBitRate
)))));
        m_sendEvent = Simulator::Schedule (tNext, &MyApp::SendPacket, this);
    }
}

static void
PrintTxQueue (Ptr <Queue> q0,Ptr <Queue> q1, Ptr <Queue> q2, Ptr <Queue> q3, Ptr <Queue>
q4)
{
    Simulator::Schedule (Seconds (0.001), &PrintTxQueue, q0, q1, q2, q3, q4);
    std::cout << Simulator::Now ().GetSeconds () << "\t" << q0->GetNPackets()<< "\t"
<< q1->GetNPackets()<< "\t" << q2->GetNPackets()<< "\t" << q3->GetNPackets()<< "\t"
<< q4->GetNPackets()<< "\n";
}

//This function just logs the current simulation time and the new value of the congestion window
every time it is changed.
/*static void
CwndChange (uint32_t oldCwnd, uint32_t newCwnd)
{
    std::cout << Simulator::Now ().GetSeconds () << "\t" << newCwnd << "\n";
}*/
//

```

+--n10

```
//
//          n0--+          +--n6          +---n11
//          |          |          |
//          n2 ---n3 --- n5 --- n7 --- n9---n12
//          |          |          |          |
//          n1--+      +--n4          +--n8  +---n13
//          |
//          +--n14
```

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

    uint32_t nFlows=5;
    uint32_t packetSize=1400;
    uint32_t nPackets=2000;
    uint32_t j=1;

    for(j=1;j<=5;j++)
    {
        uint bufSize=j*packetSize;
        CommandLine cmd;
        cmd.AddValue("nFlows","Number of TCP Flows",nFlows);
        cmd.Parse(argc,argv);

        Config::SetDefault("ns3::TcpL4Protocol::SocketType",StringValue("ns3::TcpReno"));
        Config::SetDefault("ns3::DropTailQueue::Mode", StringValue("QUEUE_MODE_PACKETS"));
        Config::SetDefault("ns3::DropTailQueue::MaxPackets",UIntegerValue (j));
        /*Config::SetDefault ("ns3::RedQueue::Mode", StringValue ("QUEUE_MODE_PACKETS"));
        Config::SetDefault ("ns3::RedQueue::MinTh", DoubleValue (1));
        Config::SetDefault ("ns3::RedQueue::MaxTh", DoubleValue (3));
        Config::SetDefault ("ns3::RedQueue::QueueLimit", UIntegerValue (4));*/
        Config::SetDefault("ns3::TcpSocket::SegmentSize", UIntegerValue (1000));
        Config::SetDefault("ns3::TcpSocket::InitialCwnd", UIntegerValue (1));
        Config::SetDefault("ns3::TcpSocketBase::MaxWindowSize", UIntegerValue (20*1000));

        //在輸出和接收資料包後輸出 log 消息
        //LogComponentEnable ("PacketSink", LOG_LEVEL_ALL);

        NS_LOG_INFO ("Create Nodes.");
        NodeContainer nodes;
        nodes.Create (15);
        NodeContainer n0n2 = NodeContainer (nodes.Get (0), nodes.Get (2)); //h1r1
        NodeContainer n1n2 = NodeContainer (nodes.Get (1), nodes.Get (2)); //h2r1
        NodeContainer n2n3 = NodeContainer (nodes.Get (2), nodes.Get (3)); //r1r2
```

```
NodeContainer n3n4 = NodeContainer (nodes.Get (3), nodes.Get (4)); //r2h3
NodeContainer n3n5 = NodeContainer (nodes.Get (3), nodes.Get (5)); //r2r3
NodeContainer n5n6 = NodeContainer (nodes.Get (5), nodes.Get (6)); //r3h4
NodeContainer n5n7 = NodeContainer (nodes.Get (5), nodes.Get (7)); //r3r4
NodeContainer n7n8 = NodeContainer (nodes.Get (7), nodes.Get (8)); //r4h5
NodeContainer n7n9 = NodeContainer (nodes.Get (7), nodes.Get (9)); //r4r5
NodeContainer n9n10 = NodeContainer (nodes.Get (9), nodes.Get (10)); //r5h6
NodeContainer n9n11 = NodeContainer (nodes.Get (9), nodes.Get (11)); //r5h7
NodeContainer n9n12 = NodeContainer (nodes.Get (9), nodes.Get (12)); //r5h8
NodeContainer n9n13 = NodeContainer (nodes.Get (9), nodes.Get (13)); //r5h9
NodeContainer n9n14 = NodeContainer (nodes.Get (9), nodes.Get (14)); //r5h10
```

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

```
NS_LOG_INFO ("Create Channels.");
PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute ("DataRate", StringValue("10Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("100us"));
/*pointToPoint.SetQueue("ns3::RedQueue");*/
NetDeviceContainer d0d2 = pointToPoint.Install (n0n2);
NetDeviceContainer d1d2 = pointToPoint.Install (n1n2);
NetDeviceContainer d3d4 = pointToPoint.Install (n3n4);
NetDeviceContainer d5d6 = pointToPoint.Install (n5n6);
NetDeviceContainer d7d8 = pointToPoint.Install (n7n8);
NetDeviceContainer d9d10 = pointToPoint.Install (n9n10);
NetDeviceContainer d9d11 = pointToPoint.Install (n9n11);
NetDeviceContainer d9d12 = pointToPoint.Install (n9n12);
NetDeviceContainer d9d13 = pointToPoint.Install (n9n13);
NetDeviceContainer d9d14 = pointToPoint.Install (n9n14);
NetDeviceContainer d2d3 = pointToPoint.Install (n2n3);
NetDeviceContainer d3d5 = pointToPoint.Install (n3n5);
NetDeviceContainer d5d7 = pointToPoint.Install (n5n7);
NetDeviceContainer d7d9 = pointToPoint.Install (n7n9);
```

```
NS_LOG_INFO ("Assign IP Address5s.");
Ipv4AddressHelper ipv4;
ipv4.SetBase ("10.1.1.0", "255.255.255.0");
Ipv4InterfaceContainer i0i2 = ipv4.Assign (d0d2);
```

```
ipv4.SetBase ("10.1.2.0", "255.255.255.0");
Ipv4InterfaceContainer i1i2 = ipv4.Assign (d1d2);
```

```
ipv4.SetBase ("10.1.3.0", "255.255.255.0");
```

```
Ipv4InterfaceContainer i2i3 = ipv4.Assign (d2d3);

ipv4.SetBase ("10.1.4.0", "255.255.255.0");
Ipv4InterfaceContainer i3i4 = ipv4.Assign (d3d4);

ipv4.SetBase ("10.1.5.0", "255.255.255.0");
Ipv4InterfaceContainer i3i5 = ipv4.Assign (d3d5);

ipv4.SetBase ("10.1.6.0", "255.255.255.0");
Ipv4InterfaceContainer i5i6 = ipv4.Assign (d5d6);

ipv4.SetBase ("10.1.7.0", "255.255.255.0");
Ipv4InterfaceContainer i5i7 = ipv4.Assign (d5d7);

ipv4.SetBase ("10.1.8.0", "255.255.255.0");
Ipv4InterfaceContainer i7i8 = ipv4.Assign (d7d8);

ipv4.SetBase ("10.1.9.0", "255.255.255.0");
Ipv4InterfaceContainer i7i9 = ipv4.Assign (d7d9);

ipv4.SetBase ("10.1.10.0", "255.255.255.0");
Ipv4InterfaceContainer i9i10 = ipv4.Assign (d9d10);

ipv4.SetBase ("10.1.11.0", "255.255.255.0");
Ipv4InterfaceContainer i9i11 = ipv4.Assign (d9d11);

ipv4.SetBase ("10.1.12.0", "255.255.255.0");
Ipv4InterfaceContainer i9i12 = ipv4.Assign (d9d12);

ipv4.SetBase ("10.1.13.0", "255.255.255.0");
Ipv4InterfaceContainer i9i13 = ipv4.Assign (d9d13);

ipv4.SetBase ("10.1.14.0", "255.255.255.0");
Ipv4InterfaceContainer i9i14 = ipv4.Assign (d9d14);

NS_LOG_INFO ("Enable static global routing.");
Ipv4GlobalRoutingHelper::PopulateRoutingTables ();

/*set up tcp server connection*/
uint16_t port = 8000;
ApplicationContainer sinkApp;
Address sinkLocalAddress(InetSocketAddress (Ipv4Address::GetAny (), port));
PacketSinkHelper sinkHelper ("ns3::TcpSocketFactory", sinkLocalAddress);
```

```

sinkApp.Add(sinkHelper.Install(n9n10.Get(1)));
sinkApp.Add(sinkHelper.Install(n9n11.Get(1)));
sinkApp.Add(sinkHelper.Install(n9n12.Get(1)));
sinkApp.Add(sinkHelper.Install(n9n13.Get(1)));
sinkApp.Add(sinkHelper.Install(n9n14.Get(1)));

sinkApp.Start (Seconds (0.5));
sinkApp.Stop (Seconds (3.5));

/*create the socket and connect the trace source*/
Ptr<Socket> ns3TcpSocket1 = Socket::CreateSocket (nodes.Get (0),
TcpSocketFactory::GetTypeId ());
//ns3TcpSocket1->TraceConnectWithoutContext ("CongestionWindow", MakeCallback
(&CwndChange));
Ptr<Socket> ns3TcpSocket2 = Socket::CreateSocket (nodes.Get (1),
TcpSocketFactory::GetTypeId ());
//ns3TcpSocket2->TraceConnectWithoutContext ("CongestionWindow", MakeCallback
(&CwndChange));
Ptr<Socket> ns3TcpSocket3 = Socket::CreateSocket (nodes.Get (4),
TcpSocketFactory::GetTypeId ());
//ns3TcpSocket3->TraceConnectWithoutContext ("CongestionWindow", MakeCallback
(&CwndChange));
Ptr<Socket> ns3TcpSocket4 = Socket::CreateSocket (nodes.Get (6),
TcpSocketFactory::GetTypeId ());
//ns3TcpSocket4->TraceConnectWithoutContext ("CongestionWindow", MakeCallback
(&CwndChange));
Ptr<Socket> ns3TcpSocket5 = Socket::CreateSocket (nodes.Get (8),
TcpSocketFactory::GetTypeId ());
//ns3TcpSocket5->TraceConnectWithoutContext ("CongestionWindow", MakeCallback
(&CwndChange));

/**set up Application**/
Ptr<MyApp> clientApp1 = CreateObject<MyApp>();
Ptr<MyApp> clientApp2 = CreateObject<MyApp>();
Ptr<MyApp> clientApp3 = CreateObject<MyApp>();
Ptr<MyApp> clientApp4 = CreateObject<MyApp>();
Ptr<MyApp> clientApp5 = CreateObject<MyApp>();

/**make connection**/
Ipv4Address clientAddress1 = i0i2.GetAddress (0);
AddressValue localAddress1 (InetSocketAddress (clientAddress1, port));
Ipv4Address serverAddress1 = i9i10.GetAddress (1);
Address remoteAddress1 (InetSocketAddress (serverAddress1, port));

```

```

Ipv4Address clientAddress2 = i1i2.GetAddress (0);
AddressValue localAddress2 (InetSocketAddress (clientAddress2, port));
Ipv4Address serverAddress2 = i9i11.GetAddress (1);
Address remoteAddress2 (InetSocketAddress (serverAddress2, port));

Ipv4Address clientAddress3 = i3i4.GetAddress (1);
AddressValue localAddress3 (InetSocketAddress (clientAddress3, port));
Ipv4Address serverAddress3 = i9i12.GetAddress (1);
Address remoteAddress3 (InetSocketAddress (serverAddress3, port));

Ipv4Address clientAddress4 = i5i6.GetAddress (1);
AddressValue localAddress4 (InetSocketAddress (clientAddress4, port));
Ipv4Address serverAddress4 = i9i13.GetAddress (1);
Address remoteAddress4 (InetSocketAddress (serverAddress4, port));

Ipv4Address clientAddress5 = i7i8.GetAddress (1);
AddressValue localAddress5 (InetSocketAddress (clientAddress5, port));
Ipv4Address serverAddress5 = i9i14.GetAddress (1);
Address remoteAddress5 (InetSocketAddress (serverAddress5, port));

/*bind socket with application and connect to server*/
//set sending date and packet size
clientApp1->Setup(ns3TcpSocket1, remoteAddress1, packetSize,nPackets, DataRate("2Mbps"));
clientApp2->Setup(ns3TcpSocket2, remoteAddress2, packetSize,nPackets, DataRate("2Mbps"));
clientApp3->Setup(ns3TcpSocket3, remoteAddress3, packetSize,nPackets, DataRate("2Mbps"));
clientApp4->Setup(ns3TcpSocket4, remoteAddress4, packetSize,nPackets, DataRate("2Mbps"));
clientApp5->Setup(ns3TcpSocket5, remoteAddress5, packetSize,nPackets, DataRate("2Mbps"));

/*install application to Client*/
nodes.Get (0)->AddApplication(clientApp1);
nodes.Get (1)->AddApplication(clientApp2);
nodes.Get (4)->AddApplication(clientApp3);
nodes.Get (6)->AddApplication(clientApp4);
nodes.Get (8)->AddApplication(clientApp5);

/*set application start time and stop time*/
clientApp1->SetStartTime(Seconds(1.0));
clientApp1->SetStopTime(Seconds(3.0));
clientApp2->SetStartTime(Seconds(1.0));
clientApp2->SetStopTime(Seconds(3.0));
clientApp3->SetStartTime(Seconds(1.0));
clientApp3->SetStopTime(Seconds(3.0));
clientApp4->SetStartTime(Seconds(1.0));
clientApp4->SetStopTime(Seconds(3.0));

```

```

clientApp5->SetStartTime(Seconds(1.0));
clientApp5->SetStopTime(Seconds(3.0));

AsciiTraceHelper ascii;
pointToPoint.EnableAsciiAll (ascii.CreateFileStream ("pro2.tr"));

// Calculate Throughput using Flowmonitor
FlowMonitorHelper flowmon;
Ptr<FlowMonitor> monitor = flowmon.InstallAll();

/*
//queue length
Ptr<PointToPointNetDevice> net0 = DynamicCast <PointToPointNetDevice> (d0d2.Get (1));
Ptr <Queue> q0 = net0->GetQueue();
Ptr<PointToPointNetDevice> net1 = DynamicCast <PointToPointNetDevice> (d2d3.Get (0));
Ptr <Queue> q1 = net1->GetQueue();
Ptr<PointToPointNetDevice> net2 = DynamicCast <PointToPointNetDevice> (d3d5.Get (0));
Ptr <Queue> q2 = net2->GetQueue();
Ptr<PointToPointNetDevice> net3 = DynamicCast <PointToPointNetDevice> (d5d7.Get (0));
Ptr <Queue> q3 = net3->GetQueue();
Ptr<PointToPointNetDevice> net4 = DynamicCast <PointToPointNetDevice> (d7d9.Get (0));
Ptr <Queue> q4 = net4->GetQueue();
Simulator::Schedule (Seconds (0.0001), &PrintTxQueue, q0, q1, q2, q3, q4);
*/
NS_LOG_INFO ("Run Simulation.");
Simulator::Stop (Seconds(3));
Simulator::Run ();

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

std::cout<< "j" <<"\t";
std::cout <<" Buffer size " <<bufSize <<"\n" ;

for (std::map<FlowId, FlowMonitor::FlowStats>::const_iterator i = stats.begin (); i != stats.end
()); ++i)
{
    Ipv4FlowClassifier::FiveTuple t = classifier->FindFlow (i->first);

    std::cout << "Flow " << i->first << " (" << t.sourceAddress << " -> " <<
t.destinationAddress << ") - "<<"\n";
    std::cout << " Tx Bytes: " << i->second.txBytes << "\n";

```

```

        std::cout << "   Rx Bytes:   " << i->second.rxBytes << "\n";
        std::cout << "   PacketLoss: " << i->second.lostPackets << "\n";
        std::cout << "   Throughput: " << i->second.rxBytes * 8.0 /
(i->second.timeLastRxPacket.GetSeconds() -
i->second.timeFirstTxPacket.GetSeconds())/1024/1024 << " Mbps\n";
    }

    Simulator::Destroy ();
}
}

```

```
cp examples/tcp/project2.cc scratch/myproject2.cc
```

```
./waf
```

```
./waf --run scratch/myproject2
```

5. Comparison between DropTail and RED

5.1.Queue length for every router vs simulation time

Assuming Buffer Size=4 packets,

DropTail:

```

Config::SetDefault("ns3::TcpL4Protocol::SocketType",StringValue("ns3::TcpReno"));
Config::SetDefault("ns3::DropTailQueue::Mode", StringValue("QUEUE_MODE_PACKETS"));
Config::SetDefault("ns3::DropTailQueue::MaxPackets",UIntegerValue (4));

```

RED:

```

Config::SetDefault ("ns3::RedQueue::Mode", StringValue ("QUEUE_MODE_PACKETS"));
Config::SetDefault ("ns3::RedQueue::MinTh", DoubleValue (1));
Config::SetDefault ("ns3::RedQueue::MaxTh", DoubleValue (3));
Config::SetDefault ("ns3::RedQueue::QueueLimit", UintegerValue (4));

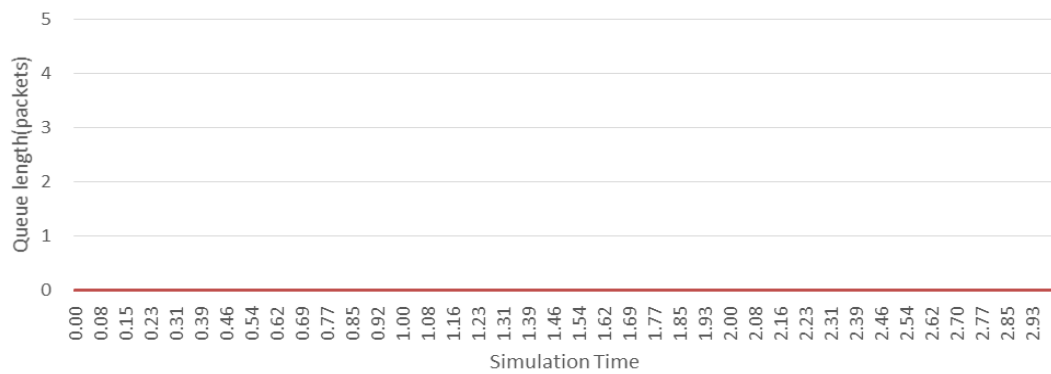
```

Get Router Nodes

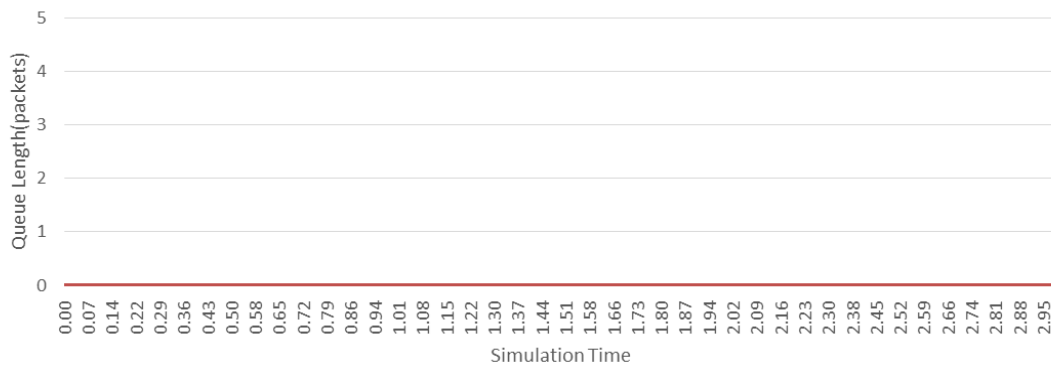
```
//queue length
Ptr<PointToPointNetDevice> net0 = DynamicCast <PointToPointNetDevice> (d0d2.Get (1));
Ptr <Queue> q0 = net0->GetQueue();

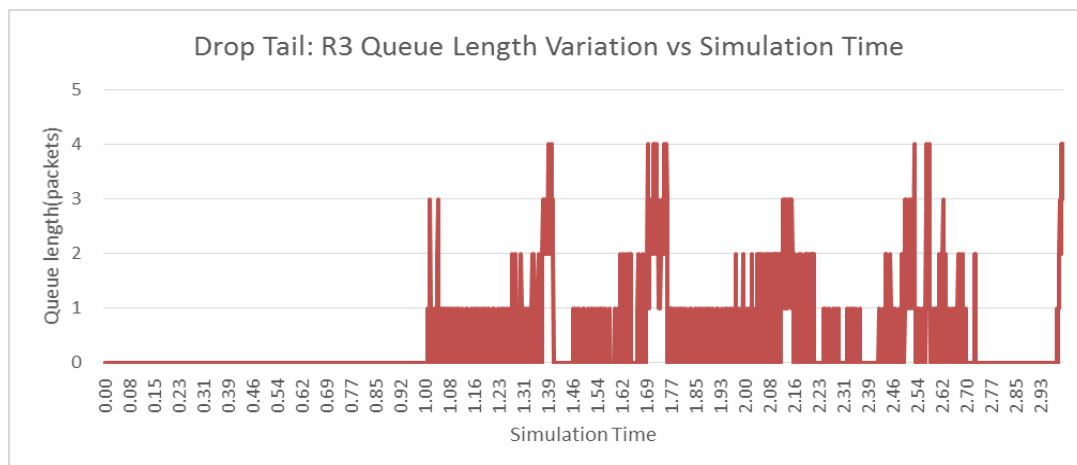
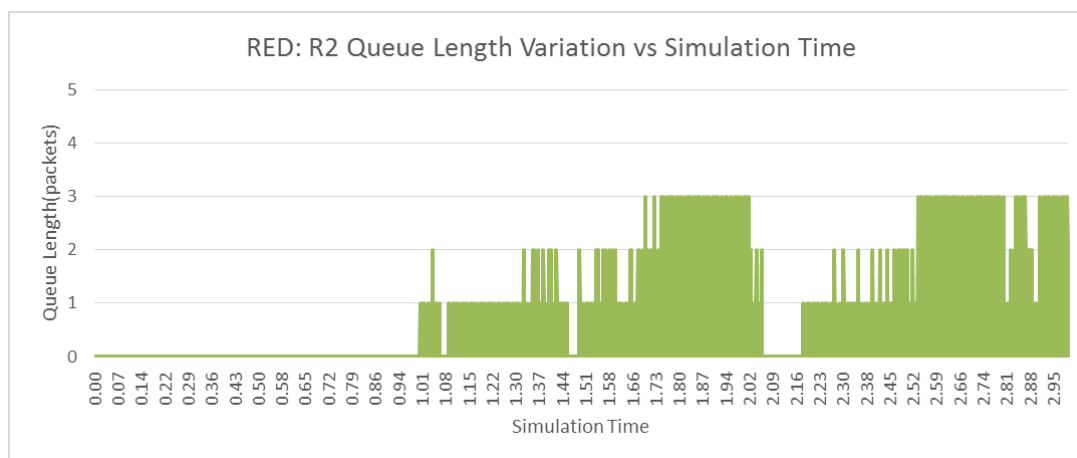
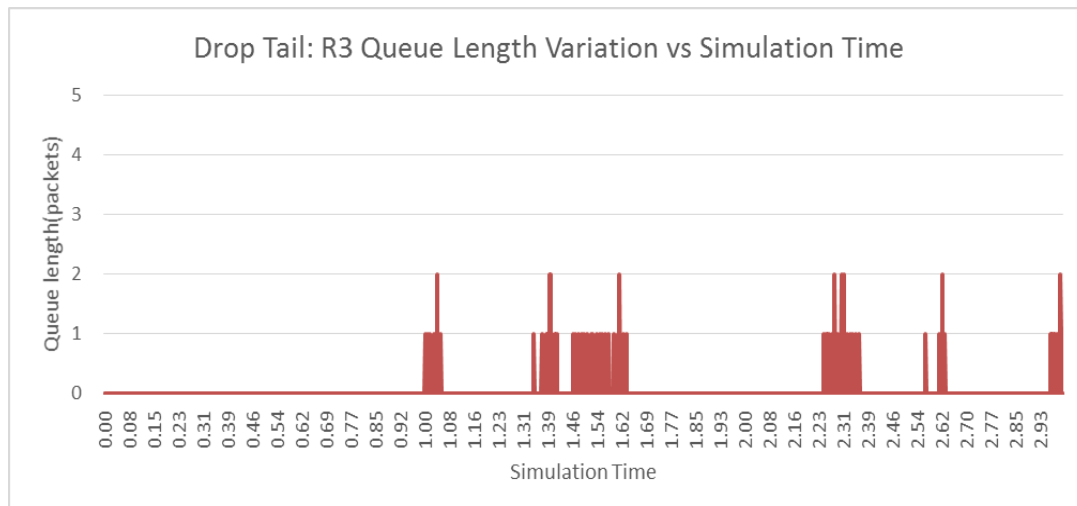
Ptr<PointToPointNetDevice> net1 = DynamicCast <PointToPointNetDevice> (d2d3.Get (0));
Ptr <Queue> q1 = net1->GetQueue();
Ptr<PointToPointNetDevice> net2 = DynamicCast <PointToPointNetDevice> (d3d5.Get (0));
Ptr <Queue> q2 = net2->GetQueue();
Ptr<PointToPointNetDevice> net3 = DynamicCast <PointToPointNetDevice> (d5d7.Get (0));
Ptr <Queue> q3 = net3->GetQueue();
Ptr<PointToPointNetDevice> net4 = DynamicCast <PointToPointNetDevice> (d7d9.Get (0));
Ptr <Queue> q4 = net4->GetQueue();
Simulator::Schedule (Seconds (0.0001), &PrintTxQueue, q0, q1, q2, q3, q4);
```

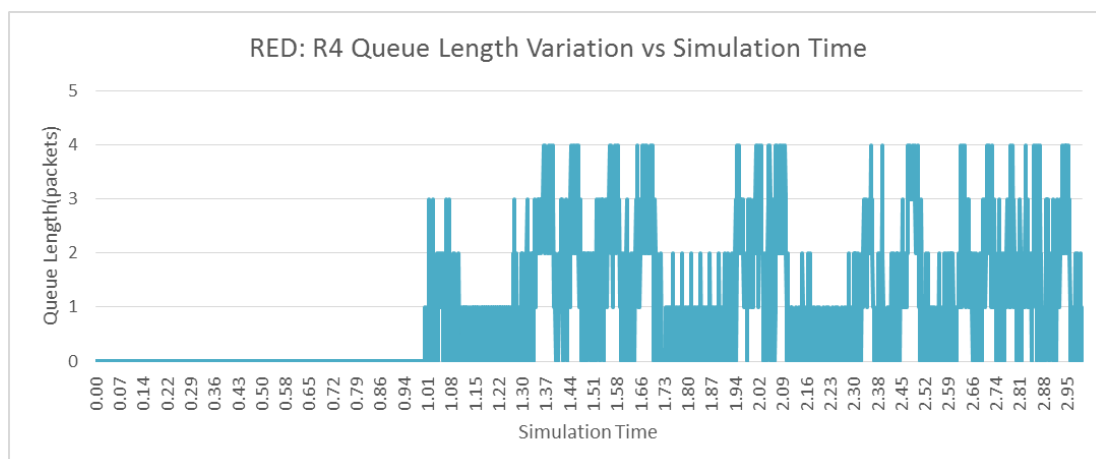
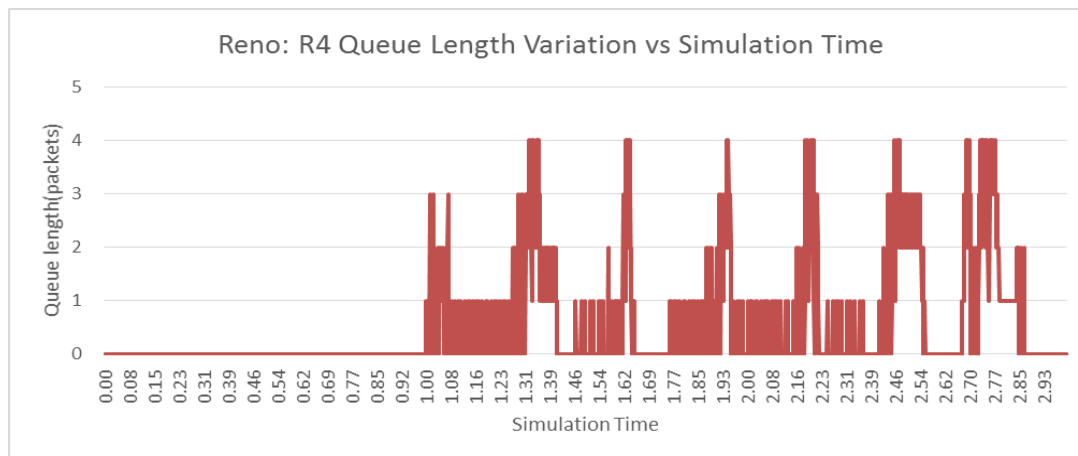
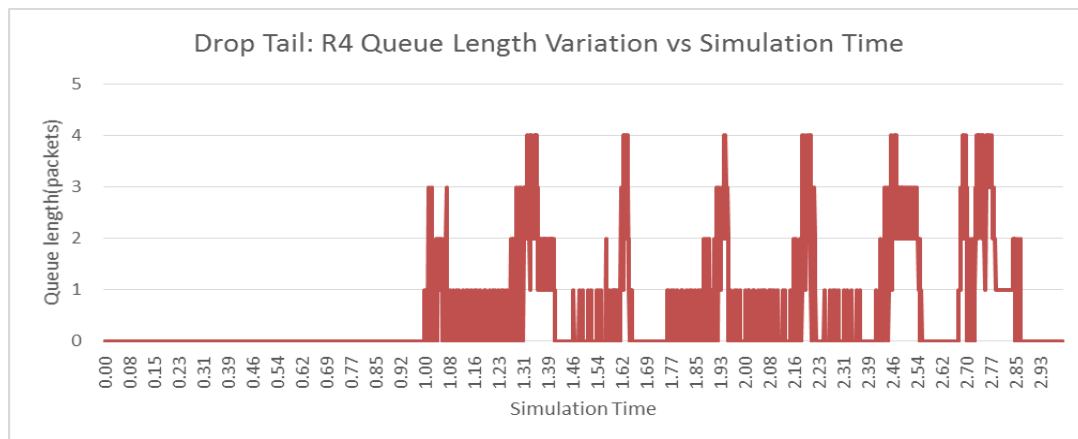
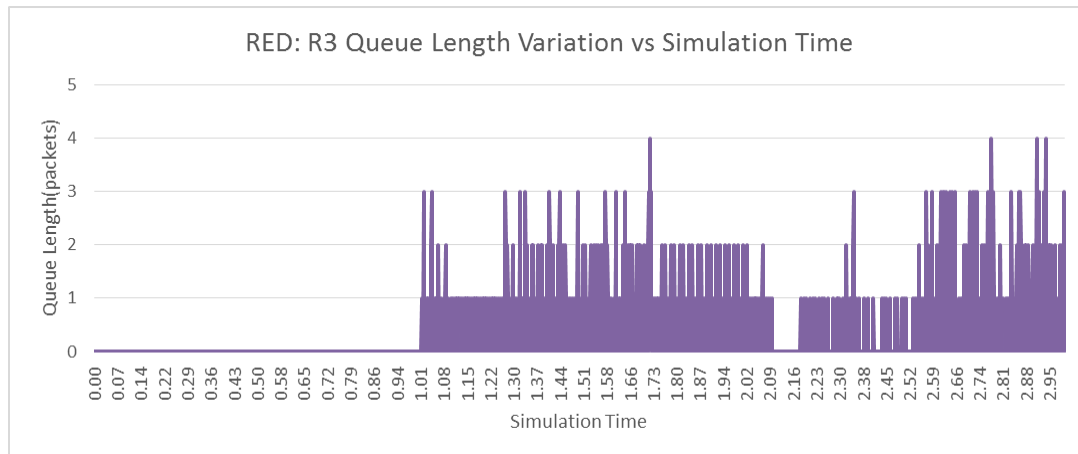
Drop Tail: R3 Queue Length Variation vs Simulation Time

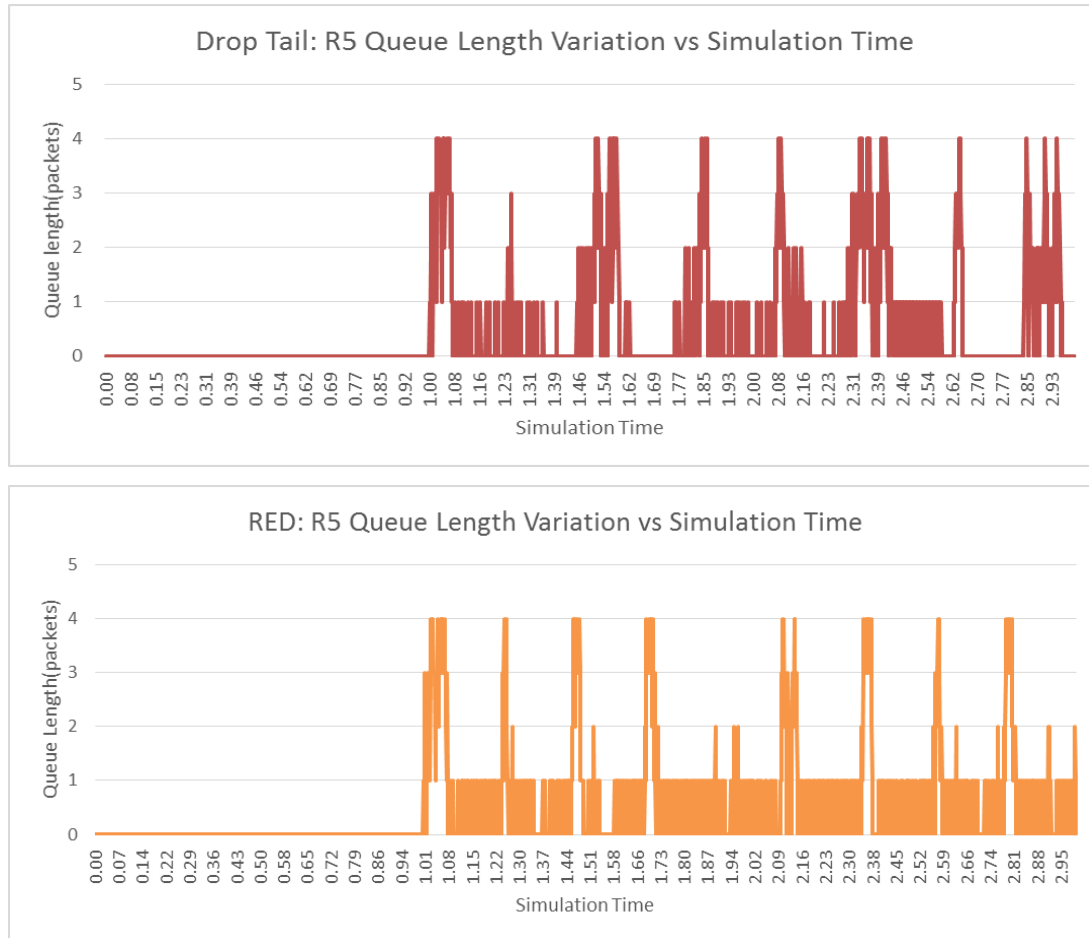


RED: R1 Queue Length Variation vs Simulation Time







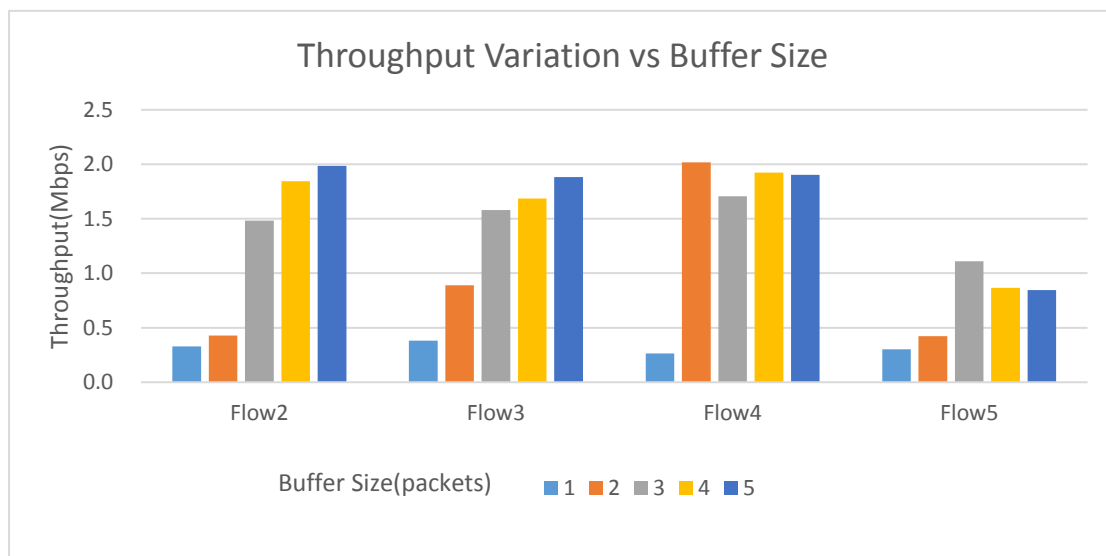


採用 DropTail 時， R1, R2,R3,R4, R5 的 queue length 逐漸增加，最大為 4 packets. R1 幾乎沒有排隊，但是每條 TCP flow 都要經過 R4 和 R5，R4 和 R5 的 queue length 變化也很相似，大量 packets 造成 queue length 時常很長，有很多達到最大值的點。

採用 RED 時，相對來說比較平均。因為 DropTail 不會區別對待，packets 越多排隊越長，超出限制就丟掉 tail 的 packet；RED 會控制在較為平均的 queue length，避免出現全域同步，小於 THmin 就全接收，大於 THmin 小於 THmax 就隨機丟掉 packet，大於 THmax 就全部丟掉了。

5.2.Throughput for every TCP flow vs router buffer size

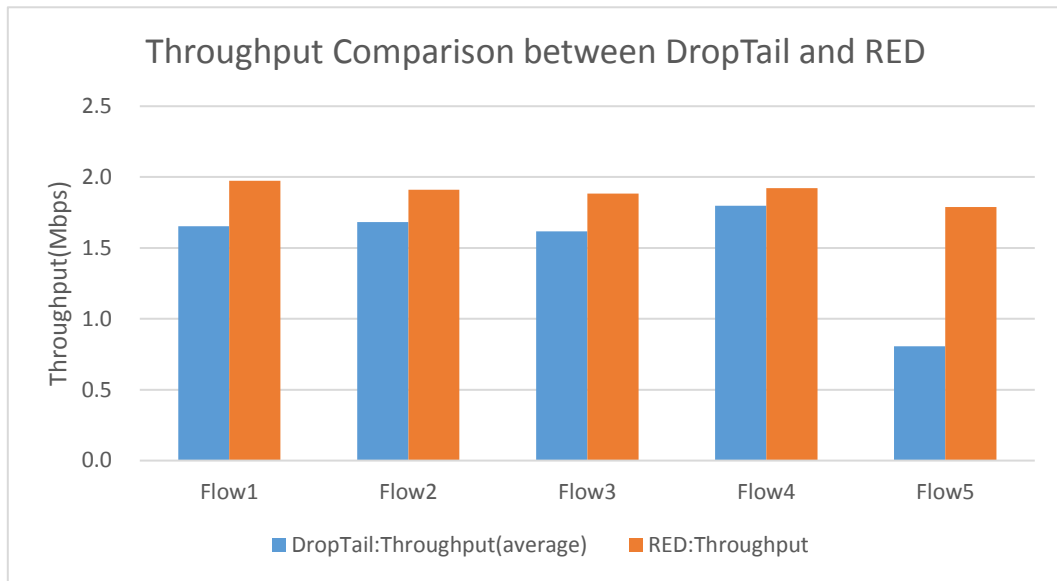
BufSize Throughput Flow	1	2	3	4	5
Flow1	0.301477	0.54478	1.73795	1.77511	1.92973
Flow2	0.328691	0.427846	1.48398	1.84585	1.9847
Flow3	0.382771	0.8888	1.57969	1.68576	1.88372
Flow4	0.264732	2.01654	1.70762	1.92446	1.90362
Flow5	0.302982	0.422648	1.1114	0.865775	0.845765



從上圖可以看出，throughput 普遍隨著 buffer size 的增加而增加，因為 buffer 越小，能夠存儲的 packet 越少，packet loss 越高，所以 throughput 越低。但是對於 Flow5 的提升相對來說不是很顯著，因為共用 Bandwidth 較會導致擁塞。

求出 5 個 Flow 在不同 buffer size 下的 throughput 平均值，進行比較如下表：

	DropTail: Throughput(average)	RED: Throughput
Flow1	1.654216467	1.973
Flow2	1.6815878	1.91153
Flow3	1.617876067	1.88412
Flow4	1.797158133	1.92242
Flow5	0.807084667	1.78915

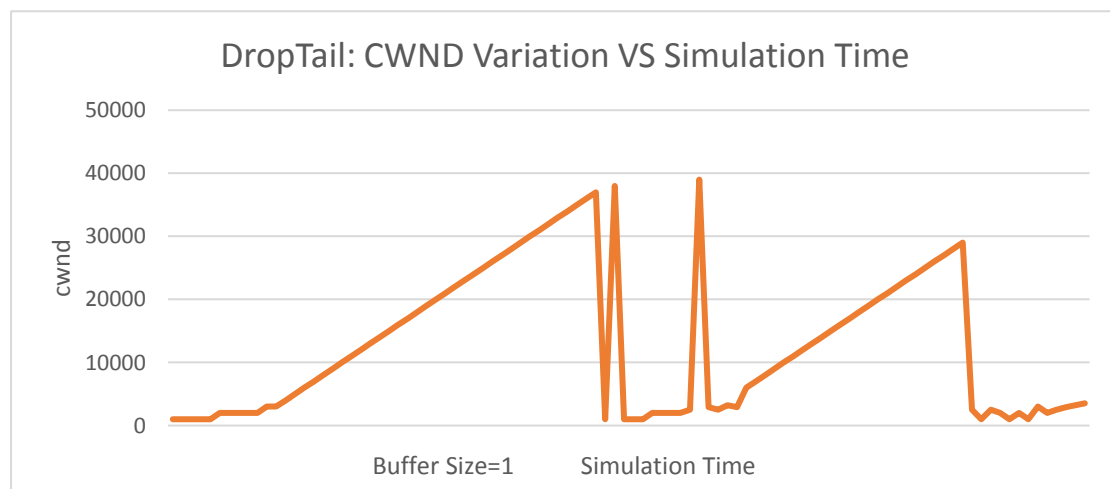


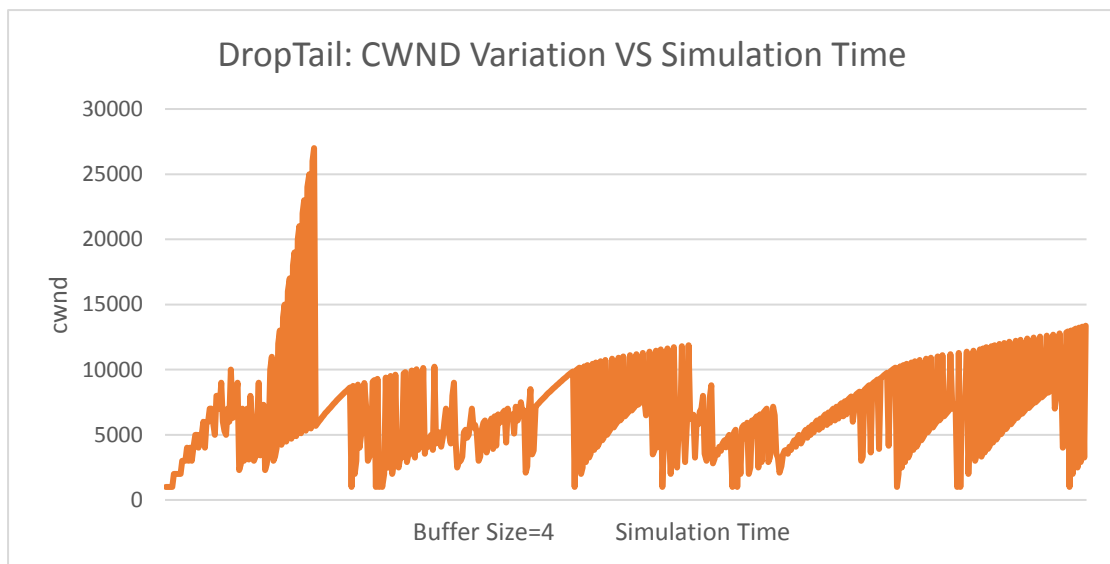
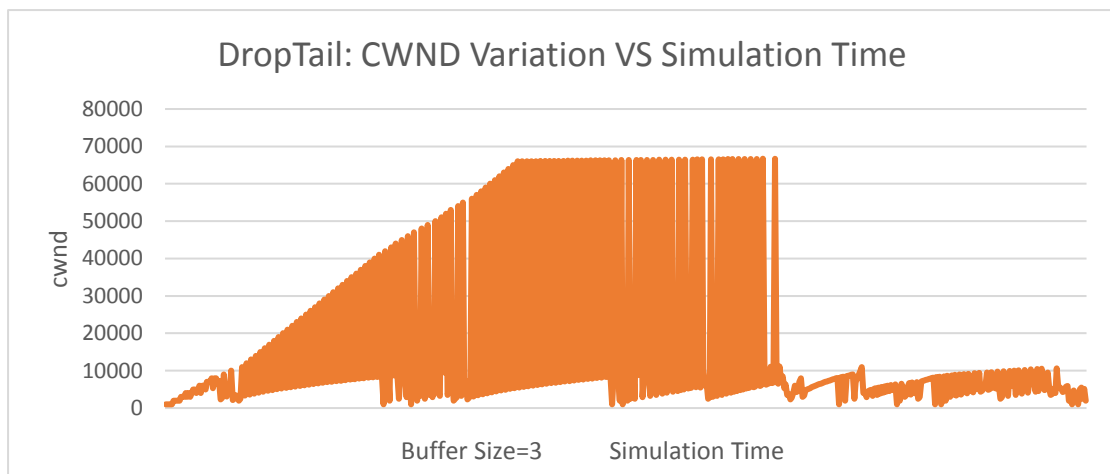
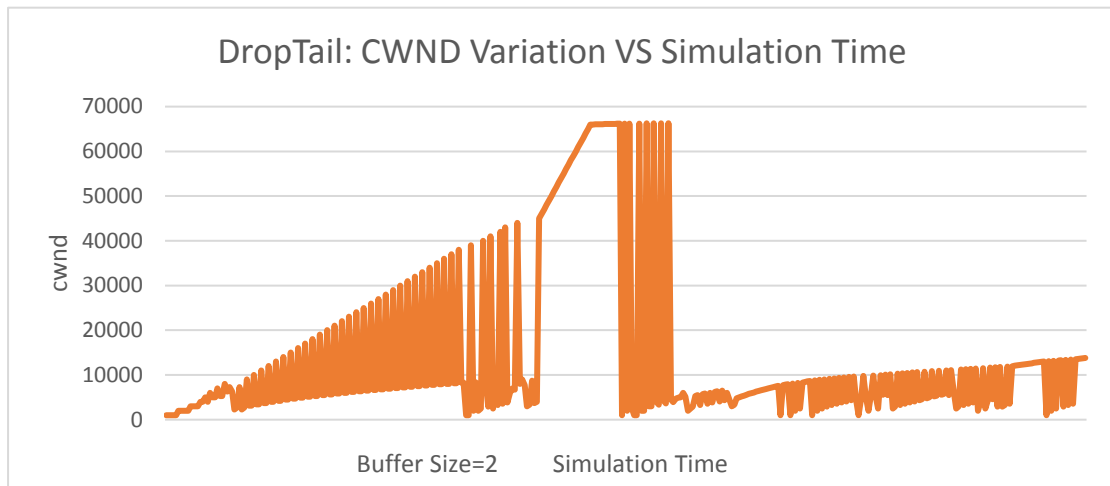
根據上文 RED 對 queue length 的影響，可知 RED 能有效降低 queue delay 和 packet loss 來提高 throughput.

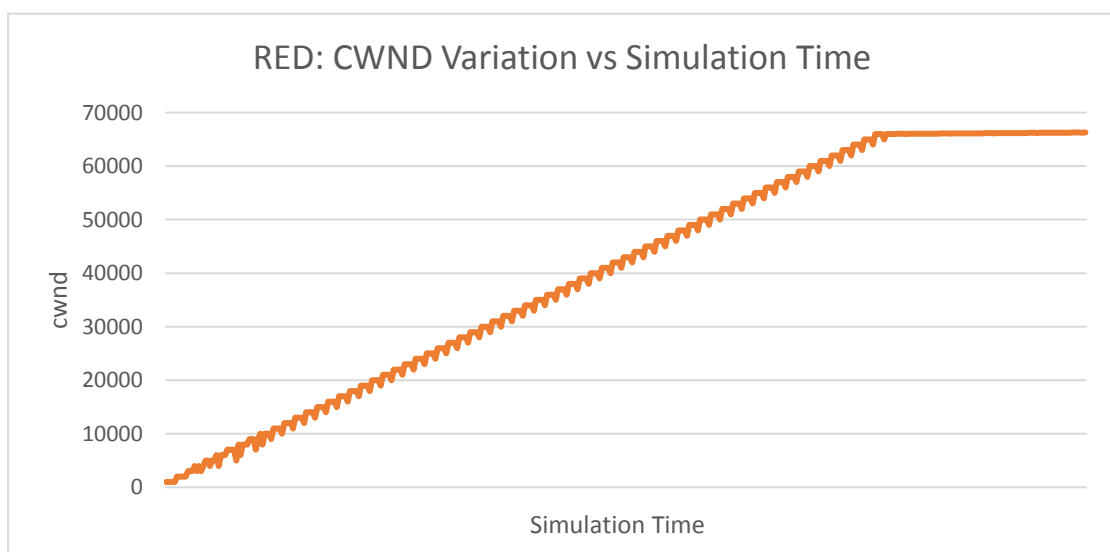
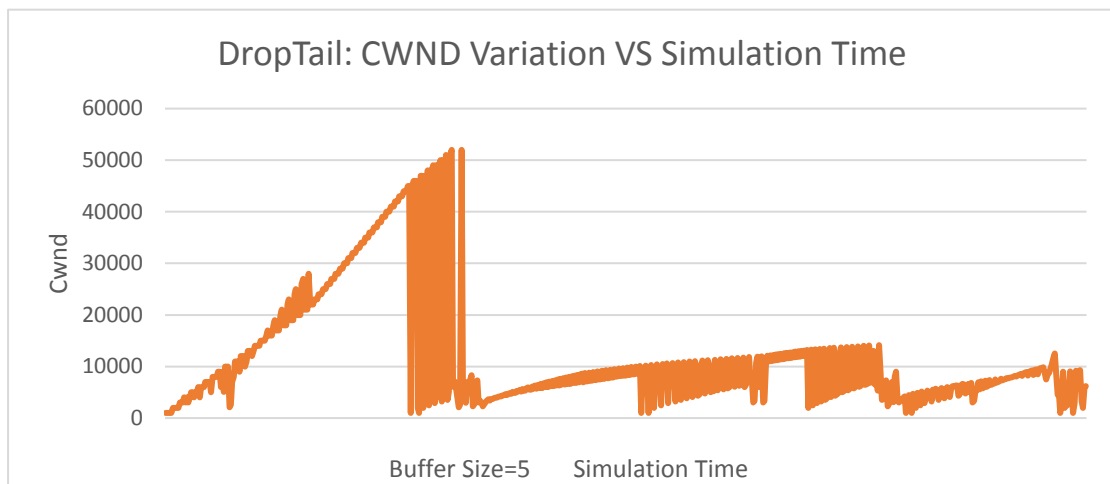
5.3.Variations of cwnd for every TCP flow vs simulation time

Trace cwnd under DropTail with different buffer size, and under RED

```
static void
CwndChange (uint32_t oldCwnd, uint32_t newCwnd)
{
    std::cout << Simulator::Now ().GetSeconds () << "\t" << newCwnd << "\n";
}
```







TCP Reno 擁塞控制有四個階段：slow start、congestion avoidance、fast retransmit 和 fast recovery.在 slow start 階段開始，實驗將 cwnd 初始化為 1 個資料包大小，sender 每收到一個 ACK 確認，cwnd 增加 1，cwnd 以指數速度遞增。當擁塞視窗達到 ssthresh 時，進入 congestion avoidance 階段，降為峰值的一半，此時發送端每隔一個 RTT 使 cwnd 增加 1，即採取線性速度增加 cwnd。在上述過程中，若 Receiver 收到 3 個或以上重複 ACK 確認，則認為網路中出現擁塞，進入 fast retransmit 和 fast recovery 階段，直至收到新的 ACK 確認，結束 fast recovery.這時 $cwnd = ssthreshold + 3 * (\text{segment size})$.

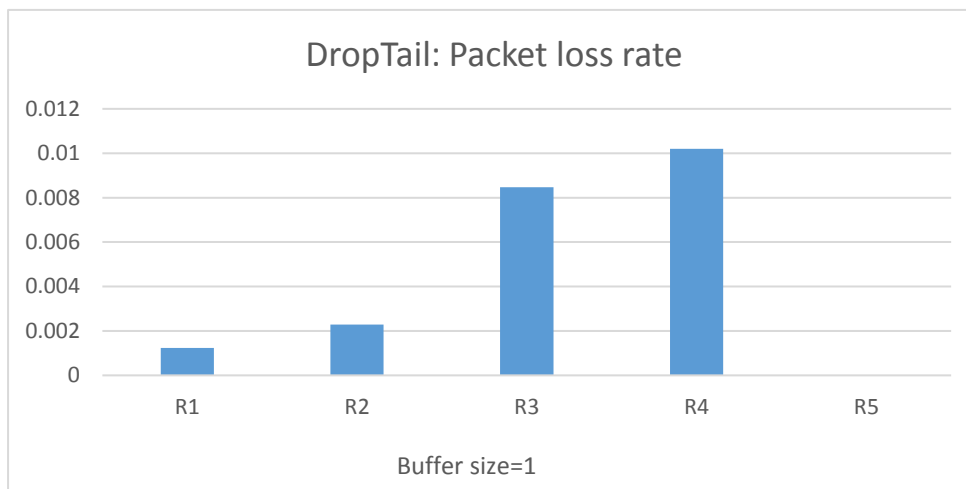
5.4.Packet loss rate in every router

得到.tr 文檔，用 packetloss.awk 文檔計算每個 router 的 packet loss rate

```
AsciiTraceHelper ascii;  
pointToPoint.EnableAsciiAll (ascii.CreateFileStream ("pro2.tr"));
```

When buffer size=1;

```
leo@ubuntu: ~/ns-allinone-3.20/ns-3.20$  
visualizer  
leo@ubuntu:~/ns-allinone-3.20/ns-3.20$ ./waf --run scratch/hw2  
waf: Entering directory '/home/leo/ns-allinone-3.20/ns-3.20/build'  
waf: Leaving directory '/home/leo/ns-allinone-3.20/ns-3.20/build'  
'build': finished successfully (0.643s)  
Throughput: 0.290281 Mbps  
Throughput: 0.319965 Mbps  
Throughput: 0.375411 Mbps  
Throughput: 0.272376 Mbps  
Throughput: 0.313203 Mbps  
Throughput: 0.00781647 Mbps  
Throughput: 0.00673609 Mbps  
Throughput: 0.00957013 Mbps  
Throughput: 0.00724174 Mbps  
Throughput: 0.00795277 Mbps  
leo@ubuntu:~/ns-allinone-3.20/ns-3.20$ awk -f packetloss.awk proj2.tr  
router1 received packets(A,B,router2): 932,786,702  
router1 dropped packets: 3  
router1 transmit packets total: 2423  
router1 packet loss rate: 0.123813%  
  
router2 received packets(router1,C,router3): 1485,925,1517  
router2 dropped packets: 9  
router2 transmit packets total: 3936  
router2 packet loss rate: 0.228659%  
  
router3 received packets(router2,D,router4): 2401,694,1935  
router3 dropped packets: 43  
router3 transmit packets total: 5073  
router3 packet loss rate: 0.847625%  
  
router4 received packets(router3,E,router5): 3052,753,2409  
router4 dropped packets: 64  
router4 transmit packets total: 6278  
router4 packet loss rate: 1.019433%  
  
router5 received packets(router4,A,B,C,D,E): 3741,439,493,586,419,475  
router5 dropped packets: 0  
router5 transmit packets total: 6153  
router5 packet loss rate: 0.000000%
```

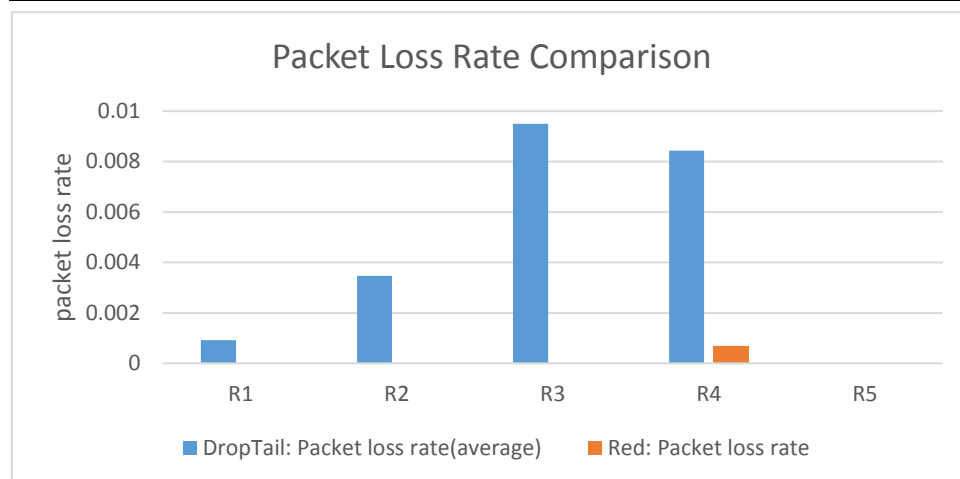


R3,R4 的 packet loss rate 較高，R5 的 packet loss rate 為 0.

求出 5 個 Router 在不同 buffer size 下的 packet loss rate 平均值，進行比較如

下表：

	DropTail: Packet loss rate(average)	Red: Packet loss rate
R1	0.000919726	0
R2	0.00346568	0
R3	0.009503138	0
R4	0.008433774	0.00066723
R5	0	0



RED 的丟棄演算法較為隨機，而 DropTail 總是丟棄隊尾的 packet。很明显，RED 的 packet loss rate 低於 DropTail.

5.5.Conclusion

RED 通過控制 average queue length，檢測網路當前狀態，並採取相應的措施，在 queue length 超過 THmax 後就隨機丟棄 packet，可以有效地控制 queue length，限制 queue delay 的大小，允許一定範圍的突發。同時，隨機丟包可以緩解 TCP 流的“全域同步”現象。由於 RED 可以控制 average queue length，調解短暫擁塞現象，並且可以提高 throughput 和獲得低延遲。但是 RED 也對於參數設置較為敏感，Queue length 的上下限也較難確定。