Supporting PDF

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1 Implementation and Results

In this pdf we have written everything based on our hardware implementation.

1.1 Environment Setup

2G Implementation :

First Ubuntu version 16.04/18.04 needs to be installed as this version is more compatible with the software needed to implement 2G network. Git version needs to be at least newer than 1.8.2. Update commands for git is shown below:-

$ sudo apt-get install software-properties-common python-software-properties

```
tasin@tasin-Inspiron-3558:~$ sudo apt-get install software-properties-common python-software-properties
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  aptdaemon python-apt python-pycurl python3-aptdaemon
  python3-aptdaemon.gtk3widgets python3-aptdaemon.pkcompat
  python3-software-properties software-properties-gtk
Suggested packages:
  python-apt-dbg python-apt-doc libcurl4-gnutls-dev python-pycurl-dbg
  python-pycurl-doc
The following NEW packages will be installed:
  python-apt python-pycurl python-software-properties
The following packages will be upgraded:
  aptdaemon python3-aptdaemon python3-aptdaemon.gtk3widgets
  python3-aptdaemon.pkcompat python3-software-properties
  software-properties-common software-properties-gtk
7 upgraded, 3 newly installed, 0 to remove and 425 not upgraded.
Need to get 420 kB of archives.
After this operation, 930 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-updates/main i386 python3-aptdaemon.pkcompat all 1.1.1+bzr98
Get:2 http://us.archive.ubuntu.com/ubuntu xenial-updates/main i386 python3-aptdaemon.gtk3widgets all 1.1.1+bz
Get:3 http://us.archive.ubuntu.com/ubuntu xenial-updates/main i386 aptdaemon all 1.1.1+bzr982-0ubuntu14.5 [13
Get:4 http://us.archive.ubuntu.com/ubuntu xenial-updates/main i386 python3-aptdaemon all 1.1.1+bzr982-0ubuntu
Get:5 http://us.archive.ubuntu.com/ubuntu xenial-updates/main i386 python-apt i386 1.1.0~beta1ubuntu0.16.04.1
Get:6 http://us.archive.ubuntu.com/ubuntu xenial-updates/main i386 software-properties-gtk all 0.96.20.10 [47
```

$ sudo add-apt-repository ppa:git-core/ppa
Press ENTER to continue

$ sudo apt-get update
$ sudo apt-get install git

```
Processing triggers for mime-support (3.59ubuntu1) ...
Setting up timeshift (19.08.1-0~201908111351~ubuntu16.04.1) ...
tasin@tasin-Inspiron-3558:~$ sudo add-apt-repository ppa:git-core/ppa
 The most current stable version of Git for Ubuntu.

For release candidates, go to https://launchpad.net/~git-core/+archive/candidate .
 More info: https://launchpad.net/~git-core/+archive/ubuntu/ppa
Press [ENTER] to continue or ctrl-c to cancel adding it

gpg: keyring `/tmp/tmp6hhxrnxu/secring.gpg' created
gpg: keyring `/tmp/tmp6hhxrnxu/pubring.gpg' created
gpg: requesting key E1DF1F24 from hkp server keyserver.ubuntu.com
gpg: /tmp/tmp6hhxrnxu/trustdb.gpg: trustdb created
gpg: key E1DF1F24: public key "Launchpad PPA for Ubuntu Git Maintainers" imported
gpg: Total number processed: 1
gpg:               imported: 1  (RSA: 1)
OK
tasin@tasin-Inspiron-3558:~$ sudo apt-get update
Get:1 http://ppa.launchpad.net/git-core/ppa/ubuntu xenial InRelease [23.8 kB]
Hit:2 http://us.archive.ubuntu.com/ubuntu xenial InRelease
Hit:3 http://security.ubuntu.com/ubuntu xenial-security InRelease
Hit:4 http://us.archive.ubuntu.com/ubuntu xenial-updates InRelease
Hit:5 http://ppa.launchpad.net/teejee2008/ppa/ubuntu xenial InRelease
Hit:6 http://us.archive.ubuntu.com/ubuntu xenial-backports InRelease
Get:7 http://ppa.launchpad.net/git-core/ppa/ubuntu xenial/main i386 Packages [3,380 B]
Get:8 http://ppa.launchpad.net/git-core/ppa/ubuntu xenial/main Translation-en [2,432 B]
Fetched 29.6 kB in 2s (14.2 kB/s)
Reading package lists... Done
tasin@tasin-Inspiron-3558:~$ sudo apt-get install git
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  git-man liberror-perl libpcre2-8-0
Suggested packages:
  git-daemon-run | git-daemon-sysvinit git-doc git-el git-email git-gui gitk
  gitweb git-cvs git-mediawiki git-svn
The following NEW packages will be installed:
  git git-man liberror-perl libpcre2-8-0
0 upgraded, 4 newly installed, 0 to remove and 425 not upgraded.
Need to get 8,177 kB of archives.
After this operation, 40.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

Next, the github repository needs to be cloned by running
$ git clone https://github.com/Range Networks/dev.git

```
git
Cloning into 'dev'...
remote: Enumerating objects: 158, done.
remote: Total 158 (delta 0), reused 0 (delta 0), pack-reused 158
Receiving objects: 100% (158/158), 44.87 KiB | 105.00 KiB/s, done.
Resolving deltas: 100% (99/99), done.
```

This will save the downloaded files on a folder named ‘dev’ on /home, running
$cd dev

We will move to the dev folder. Now running the clone.sh script will download all the components automatically.
$./clone.sh

Now to install all the components and all the dependencies including GNU-radio, UHD etc.We need to run the build.sh script along with the radio being used. Here we are using the USRP B200.

$./build.sh B200

```
AN/.*' -printf '%P\0' | LC_ALL=C sort -z | xargs -r0 md5sum > DEBIAN/md5sums) >/
dev/null
        chmod 0644 debian/range-configs/DEBIAN/md5sums
        chown 0:0 debian/range-configs/DEBIAN/md5sums
dh_builddeb
        find debian/range-configs -regex .\*\\.svn.\* -or -regex .\*\\.git.\* |
xargs rm -rf
        dpkg-deb --build debian/range-configs ..
dpkg-deb: warning: conffile name '/etc/bind/named.conf.options' is duplicated
dpkg-deb: warning: ignoring 1 warning about the control file(s)
dpkg-deb: building package 'range-configs' in '../range-configs_5.1-master_all.d
eb'.
# nothing to do
 dpkg-genchanges  >../range-configs_5.1-master_amd64.changes
dpkg-genchanges: including full source code in upload
 dpkg-source --after-build system-config
dpkg-buildpackage: full upload; Debian-native package (full source is included)
cd ..
mv range-configs_5.1-master_all.deb range-configs_5.1-master_amd64.changes range
-configs_5.1-master.dsc range-configs_5.1-master.tar.gz BUILDS/2020-11-10--13-15
-24
# - done
```

Now we will use the dpkg to install the packages
$ sudo dpkg -i BUILDS/timetamp/*.deb

```
      D     : show the differences between the versions
      Z     : start a shell to examine the situation
 The default action is to keep your current version.
*** odbcinst.ini (Y/I/N/O/D/Z) [default=N] ? y
Installing new version of config file /etc/odbcinst.ini ...
dpkg: dependency problems prevent configuration of range-configs:
 range-configs depends on ntp; however:
  Package ntp is not installed.
 range-configs depends on ntpdate; however:
  Package ntpdate is not installed.
 range-configs depends on bind9; however:
  Package bind9 is not installed.

dpkg: error processing package range-configs (--install):
 dependency problems - leaving unconfigured
Setting up sipauthserve (5.0) ...
Setting up smqueue (5.0) ...
Processing triggers for libc-bin (2.23-0ubuntu3) ...
Processing triggers for man-db (2.7.5-1) ...
Processing triggers for ureadahead (0.100.0-19) ...
ureadahead will be reprofiled on next reboot
Errors were encountered while processing:
 range-configs
```

If the upper command shows error about dependencies being missing, below

command needs to be run for resolving the dependency error.

$ sudo apt-get -f install

```
    N or O  : keep your currently-installed version
      D     : show the differences between the versions
      Z     : start a shell to examine the situation
 The default action is to keep your current version.
*** named.conf.options (Y/I/N/O/D/Z) [default=N] ? y
Installing new version of config file /etc/bind/named.conf.options ...

Configuration file '/etc/default/bind9'
 ==> File on system created by you or by a script.
 ==> File also in package provided by package maintainer.
   What would you like to do about it ?  Your options are:
    Y or I  : install the package maintainer's version
    N or O  : keep your currently-installed version
      D     : show the differences between the versions
      Z     : start a shell to examine the situation
 The default action is to keep your current version.
*** bind9 (Y/I/N/O/D/Z) [default=N] ? y
Installing new version of config file /etc/default/bind9 ...
nothing to configure
Processing triggers for libc-bin (2.23-0ubuntu3) ...
Processing triggers for systemd (229-4ubuntu7) ...
Processing triggers for ureadahead (0.100.0-19) ...
Processing triggers for ufw (0.35-0ubuntu2) ...
```

GSM configuration:

First we need to connect the USRP B200 with the computer using USB 3.0 connection port. The following command is used to make sure the device is properly connected and also upload the image and FPGA image to the SDR

$ uhd_usrp_probe

Next, we need to start up the network. Running OpenBTS automatically runs an instance of the transceiver and data is then transferred between OpenBTS and the transceiver using a UPD (User Data gram Protocol) socket.

$ cd/ OpenBTS

$ sudo./OpenBTS

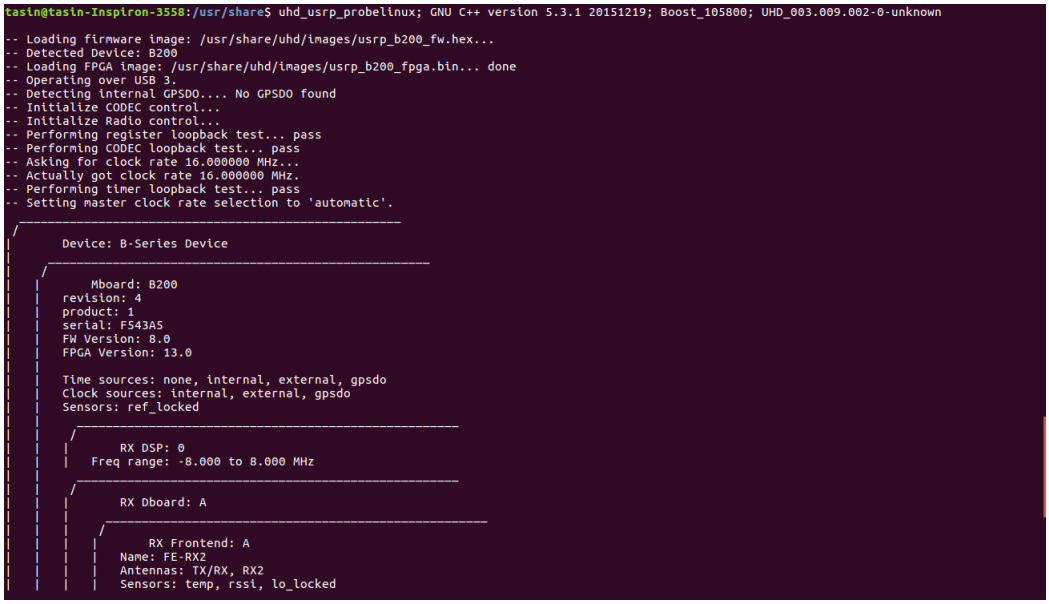
Configuring the band and the channel commands,

OpenBTS$\gg configGSM.Radio.Band < desiredband >$

$OpenBTS \gg configGSM.Radio.c0 < desiredchannel >$

$OpenBTS \gg devconfigGSM.Radio.RxGain10$

After that a handset needs to be connected to the network. For that we need to know the IMSI (International Mobile Subscribe Identity) of our SIM. We now start the System IP authentication server command by writing




```
tasin@tasin-Inspiron-3558:/OpenBTS$ sudo ./OpenBTS
ALERT 7991:7991 2021-03-24T13:31:44.8 OpenBTS.cpp:595:main: OpenBTS (re)starting, ver 5.0-m
ALERT 7991:7991 2021-03-24T13:31:44.8 OpenBTS.cpp:596:main: OpenBTS reading config file /et
1616571104.866673 3080357632:

OpenBTS
Copyright 2008, 2009, 2010 Free Software Foundation, Inc.
Copyright 2010 Kestrel Signal Processing, Inc.
Copyright 2011-2021 Range Networks, Inc.
Release 5.0-master+7766ef94f2 CommonLibs:76b71d509b P formal build date 2021-03-24T11:17:18
"OpenBTS" is a registered trademark of Range Networks, Inc.

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Incorporated L/GPL libraries and components:
  libortp, LGPL, 2.1 Copyright 2001 Simon MORLAT simon.morlat@linphone.org
  libusb, LGPL 2.1, various copyright holders, www.libusb.org
  libzmq, LGPL 3:
```
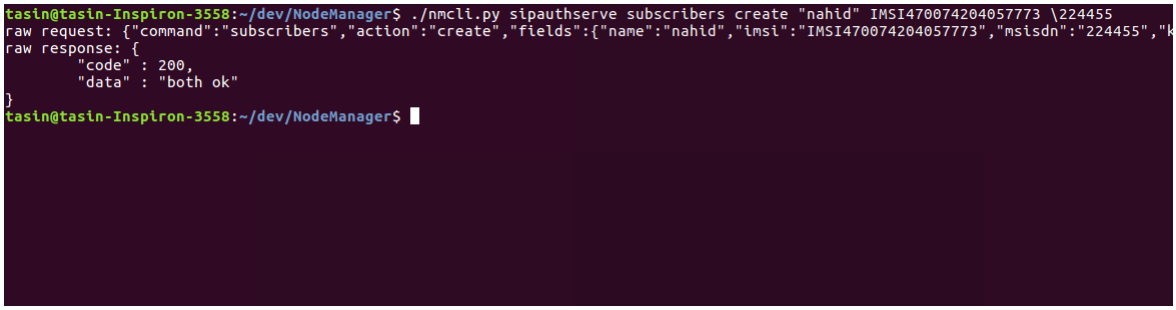

$ sudo /OpenBTS/sipauthserve

In order to manually add a subscriber to the network we can use nmcii.py Node-Manager which is in dev/NodeManager.
$ cd dev/NodeManager



$ ./nmcii.py sipauthserve subcribers create name imsi msisdn

If we use the below command we will be able to see the table of the subscribers connected to the network.

OpenBTS tmsis

```
OpenBTS> tmsis
IMSI            TMSI IMEI            AUTH CREATED ACCESSED TMSI_ASSIGNED
470074204057773 -    863728043914950 1    8m      141s     0
470039206246447 -    353679112101770 1    7m      267s     0


OpenBTS>
```

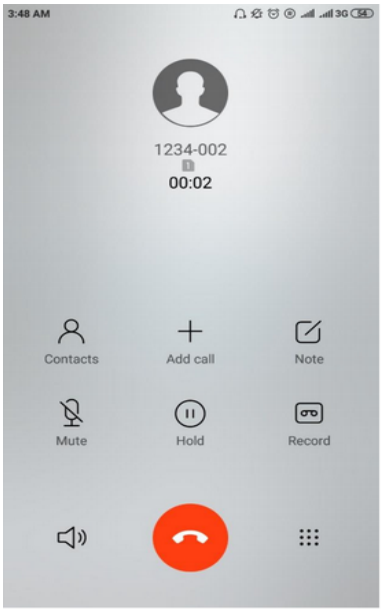
$ sudo /OpenBTS/smqueue

```
tasin@tasin-Inspiron-3558:~$ sudo /OpenBTS/smqueue
[sudo] password for tasin:
ALERT 4437:4437 2021-03-25T11:36:39.4 smqueue.cpp:2798:main: smqueue (re)star
smqueue logs to syslogd facility LOCAL7, so there's not much to see here
```

OUTPUT:

Messaging and Dialing:


4:45 PM | 3.2KB/s
224456
3:30 PM
Hi nahid
4:28 PM
hlw tasin
4:38 PM
Good work.Alhamdulliah.
great.its working.
Text message


3:48 AM
1234-002
00:02
Contacts
Add call
Note
Mute
Hold
Record

4G Implementation :

Firstly, Device identification and connection may be required. Manually write product id, vendor id etc in uhd folder. Then, we have to install UHD drivers by these commands. $ cd
$ git clone https://github.com/EttusResearch/uhd.git ;
$ cd uhd
$ git checkout UHD-3.15
$ mkdir host/build ;
$cd host/build
$ cmake ../
$ make
$ make test
$ sudo make install
$ sudo ldconfig

Secondly, we have to install FGPA images for current device. In our case it is USRP b200.
$ sudo uhd_images_downloader

```
tasin@tasin-Inspiron-3558:~$ uhd_usrp_probe
linux; GNU C++ version 5.3.1 20151219; Boost_105800; UHD_003.009.002-0-unknown

-- Loading firmware image: /usr/share/uhd/images/usrp_b200_fw.hex...
-- Detected Device: B200
-- Loading FPGA image: /usr/share/uhd/images/usrp_b200_fpga.bin... done
-- Operating over USB 2.
-- Detecting internal GPSDO.... No GPSDO found
-- Initialize CODEC control...
-- Initialize Radio control...
-- Performing register loopback test... pass
-- Performing CODEC loopback test... pass
-- Asking for clock rate 16.000000 MHz...
-- Actually got clock rate 16.000000 MHz.
-- Performing timer loopback test... pass
-- Setting master clock rate selection to 'automatic'.
 _____________________________________________________
/
|       Device: B-Series Device
|     _____________________________________________________
|    /
|    |       Mboard: B200
|    |   revision: 4
|    |   product: 1
|    |   serial: F543A5
|    |   FW Version: 8.0
|    |   FPGA Version: 13.0
|    |
|    |   Time sources: none, internal, external, gpsdo
|    |   Clock sources: internal, external, gpsdo
|    |   Sensors: ref_locked
|    |     ___________________________________________________
|    |    /
|    |    |       RX DSP: 0
|    |    |   Freq range: -8.000 to 8.000 MHz
|    |     ___________________________________________________
|    |    /
|    |    |       RX Dboard: A
|    |    |     _____________________________________________
```

Next,we have to install dependencies for srslte and usrp b200 by these commands
$ sudo apt-get install cmake libfftw3-dev libmbedtls-dev libboost-program-options-dev libconfig++-dev libsctp-dev
Then , Lets see our current network by "route" commands.We will able to show only one network by our ISP if our PC is connected to WIFI

```
tasin@tasin-Inspiron-3558:~$ route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
default         192.168.0.1     0.0.0.0         UG    600    0        0 wlp6s0
link-local      *               255.255.0.0     U     1000   0        0 wlp6s0
192.168.0.0     *               255.255.255.0   U     600    0        0 wlp6s0
tasin@tasin-Inspiron-3558:~$
```

Now,we have to implment another network by srsLTE which gives us a network address.So firstly, we have to install srsLTE by source
$ cd
$ git clone https://github.com/srsLTE/srsLTE.git

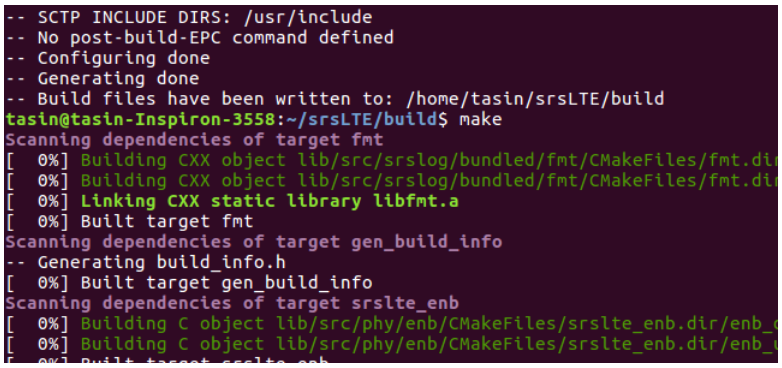
```
tasin@tasin-Inspiron-3558:~$ cd ~
tasin@tasin-Inspiron-3558:~$ git clone https://github.com/srsLTE/srsLTE.git
Cloning into 'srsLTE'...
remote: Enumerating objects: 85647, done.
remote: Total 85647 (delta 0), reused 0 (delta 0), pack-reused 85647
Receiving objects: 100% (85647/85647), 35.94 MiB | 517.00 KiB/s, done.
Resolving deltas: 100% (64852/64852), done.
tasin@tasin-Inspiron-3558:~$ cd srsLTE
tasin@tasin-Inspiron-3558:~/srsLTE$ mkdir build
tasin@tasin-Inspiron-3558:~/srsLTE$ cd build
tasin@tasin-Inspiron-3558:~/srsLTE/build$
```

$ cd srsLTE
$ mkdir build
$ cd build

$ cmake ../

graphics[scale = 0.7]4xx.png

$ make



$ make test

$ sudo make install

Sometimes, it required some optional Configurations like file Merge or create copy files for testing purpose
Then , Lets Run srsLTE.It will initialize and start all network components,packet cores for LTE network.
$ cd /srsLTE/srsepc
$ sudo srsepc epc.conf

In another terminal, we have to run our base station by this command.It will

```
Errors while running CTest
Makefile:127: recipe for target 'test' failed
make: *** [test] Error 8
tasin@tasin-Inspiron-3558:~/srsLTE/build$ sudo make install
[sudo] password for tasin:
Install the project...
-- Install configuration: "Release"
-- Installing: /usr/local/bin/srslte_install_configs.sh
-- Up-to-date: /usr/local/include
-- Installing: /usr/local/include/srslte
-- Installing: /usr/local/include/srslte/interfaces
-- Installing: /usr/local/include/srslte/interfaces/ue_interfaces.h
-- Installing: /usr/local/include/srslte/interfaces/enb_rrc_interface_type
-- Installing: /usr/local/include/srslte/interfaces/mac_interface_types.h
-- Installing: /usr/local/include/srslte/interfaces/ue_nr_interfaces.h
-- Installing: /usr/local/include/srslte/interfaces/rrc_interface_types.h
-- Installing: /usr/local/include/srslte/interfaces/enb_command_interface.
-- Installing: /usr/local/include/srslte/interfaces/enb_interfaces.h
-- Installing: /usr/local/include/srslte/interfaces/radio_interfaces.h
```

show us a output like eNodeB started.That means our base Station is working
$ cd /srsLTE/srsenb
$ sudo srsenb enb.conf

```
tasin@tasin-Inspiron-3558:~$ cd ~/srsLTE/srsenb
tasin@tasin-Inspiron-3558:~/srsLTE/srsenb$ sudo srsenb enb.conf
[sudo] password for tasin:
srsenb: error while loading shared libraries: libsrslte_rf.so.0: cannot op
tasin@tasin-Inspiron-3558:~/srsLTE/srsenb$ sudo srsenb enb.conf
linux; GNU C++ version 5.3.1 20151219; Boost_105800; UHD_003.009.002-0-unk

---  Software Radio Systems LTE eNodeB  ---

Reading configuration file enb.conf...
WARNING: cpu0 scaling governor is not set to performance mode. Realtime pr
e before running the application.

Built in Release mode using commit 45486b6e2 on branch master.

Opening 1 channels in RF device=default with args=default
Opening USRP channels=1, args: type=b200,master_clock_rate=23.04e6
-- Detected Device: B200
-- Operating over USB 2.
-- Initialize CODEC control...
-- Initialize Radio control...
-- Performing register loopback test... pass
-- Performing CODEC loopback test... pass
-- Asking for clock rate 23.040000 MHz...
-- Actually got clock rate 23.040000 MHz.
-- Performing timer loopback test... pass
Setting frequency: DL=2680.0 Mhz, UL=2560.0 MHz for cc_idx=0

==== eNodeB started ===
Type <t> to view trace
```

Now using Route command,we will able to show multiple networks.Network

address is 172.16.0.0 and interface name srs_spgw_ sgi.From this network,we will give default gateway first ip adress 172.16.0.1 for the base station

```
tasin@tasin-Inspiron-3558:~$ route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
default         192.168.0.1     0.0.0.0         UG    600    0        0 wlp6s0
link-local      *               255.255.0.0     U     1000   0        0 wlp6s0
172.16.0.0      *               255.255.255.0   U     0      0        0 srs_spgw_sgi
192.168.0.0     *               255.255.255.0   U     600    0        0 wlp6s0
tasin@tasin-Inspiron-3558:~$
```

Finally , we test our network.As a primary testing, we ping srsLTE network which is workingas a BTS for USRP b200(Default gateway)): ping 172.16.0.1

```
tasin@tasin-Inspiron-3558:~$ 172.16.0.1
172.16.0.1: command not found
tasin@tasin-Inspiron-3558:~$ ping 172.16.0.1
PING 172.16.0.1 (172.16.0.1) 56(84) bytes of data.
64 bytes from 172.16.0.1: icmp_seq=1 ttl=64 time=0.021 ms
64 bytes from 172.16.0.1: icmp_seq=2 ttl=64 time=0.047 ms
64 bytes from 172.16.0.1: icmp_seq=3 ttl=64 time=0.047 ms
64 bytes from 172.16.0.1: icmp_seq=4 ttl=64 time=0.048 ms
64 bytes from 172.16.0.1: icmp_seq=5 ttl=64 time=0.046 ms
64 bytes from 172.16.0.1: icmp_seq=6 ttl=64 time=0.046 ms
64 bytes from 172.16.0.1: icmp_seq=7 ttl=64 time=0.048 ms
64 bytes from 172.16.0.1: icmp_seq=8 ttl=64 time=0.047 ms
64 bytes from 172.16.0.1: icmp_seq=9 ttl=64 time=0.032 ms
64 bytes from 172.16.0.1: icmp_seq=10 ttl=64 time=0.047 ms
```

OUTPUT:

Messaging and Dialing:

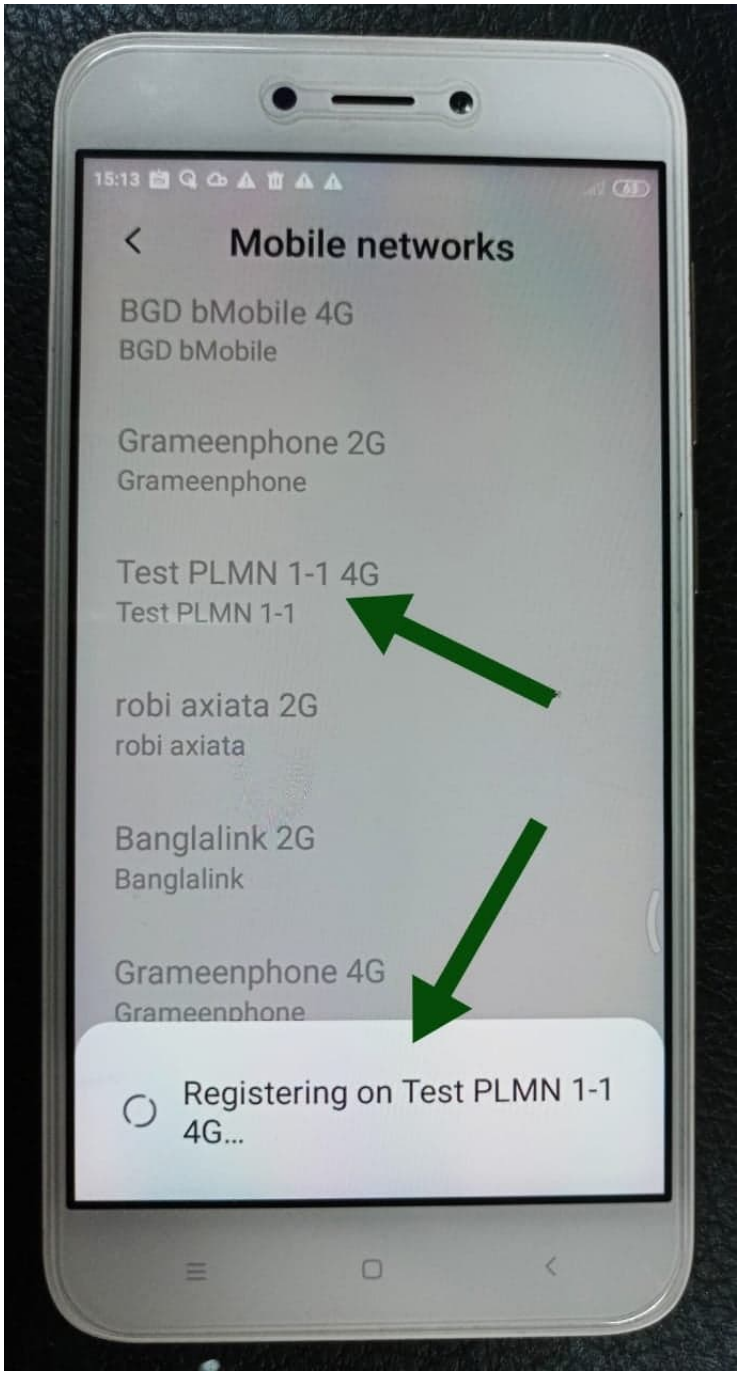


Figure 1: Captured 4G network named Test plmn 1

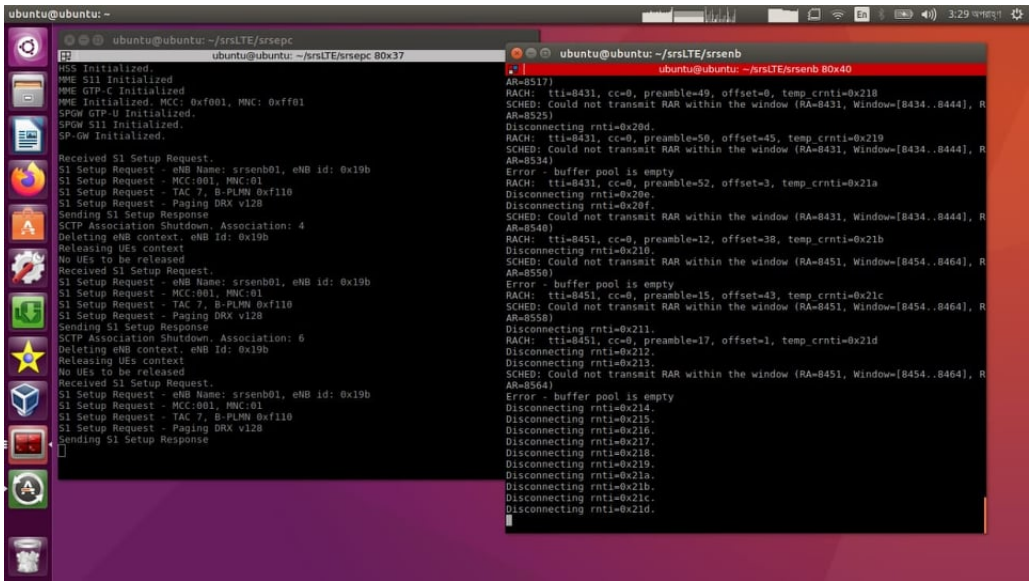


Figure 2: Right most part of the last picture shows the log of radio channel (RACH) status of the LTE network at an instant.