

4G Network Development as *OpenBTS* Using *Open5GS* with *Universal Software Radio Peripheral (USRP) B210* Device

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 <https://doi.org/10.37339/e-komtek.v8i1.1876>

Published by Politeknik Piki Ganesha Indonesia

Abstract

Artikel Info

Submitted:

15-06-2024

Revised:

23-06-2024

Accepted:

27-06-2024

Online first :

31-06-2024

There are a small number of villages across Indonesia that have access to telecommunications. Operators find it less profitable to build conventional telecommunications infrastructure in rural areas. 4G networks need to be developed in various ways, but the development has not yet achieved the quality of service that people need. This article evaluates the performance of developing an *OpenBTS* 4G Network using *Open5GS* with the *Universal Software Radio Peripheral (USRP) B210* device to make the network an economical communication solution for villagers. The system can be mobilized and set up whenever the cellular infrastructure is reactivated. After our configuration, the 4G network was detected on several cellular phones, but the transmitted network only covers 5m area, because the power used has not been able to cover a wider area. The development of this network is a solution in building a Network so that it will help people who live in blankspot areas. This research also aims to show that the *Universal Software Radio Peripheral (USRP) B210* can be used to provide and 4G Network.

Keywords: 4G Network; *OpenBTS*; *Open5GS*; *USRP B210*

Abstrak

Terdapat sebagian kecil Desa di seluruh Negara Indonesia yang memiliki akses telekomunikasi. Operator merasa kurang menguntungkan membangun infrastruktur telekomunikasi konvensional di daerah pedesaan. Jaringan 4G perlu dikembangkan dengan berbagai cara, namun pengembangannya belum mencapai kualitas layanan seperti yang dibutuhkan masyarakat. Artikel ini mengevaluasi performa pengembangan Jaringan 4G *OpenBTS* menggunakan *Open5GS* dengan perangkat *Universal Software Radio Peripheral (USRP) B210* menjadikan jaringan sebagai solusi komunikasi yang ekonomis bagi penduduk desa. Sistem ini dapat dimobilisasi dan disiapkan kapan saja infrastruktur seluler diaktifkan kembali. Setelah konfigurasi yang kami lakukan, Jaringan 4G terdeteksi pada beberapa telepon seluler, Jaringan yang dipancarkan hanya mencakup 10m area, karena power yang digunakan belum mampu untuk mencakup jangkauan area yang lebih luas. Pengembangan jaringan ini menjadi solusi dalam membangun Jaringan sehingga akan membantu masyarakat yang tinggal di daerah *blankspot*. Penelitian ini juga bertujuan untuk menunjukkan bahwa *Universal Software Radio Peripheral (USRP) B210* dapat digunakan untuk menyediakan dan Jaringan 4G.

Kata-kata kunci: Jaringan 4G; *OpenBTS*; *Open5GS*; *USRP B210*



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1. Introduction

The development of technology today encourages trade actors to establish technology businesses and compete for profits by offering various forms of technology products. However, of the 70,611 villages across the country of Indonesia, only a small percentage have access to telecommunications, despite the rural population reaching 119,321,070 people, or 50.21% of the total population [1]. Operators are hesitant to invest in rural areas because the high cost of building conventional telecommunications infrastructure is not worth the profit generated [2]. In addition, the limited spectrum that must be allocated hinders new operators who want to join the telecommunications industry by building telecommunications networks in remote areas [3]. Therefore, a 4G network using the Universal Software Radio Peripheral (USRP) B210 has been developed at this time. This software can be used directly and is an alternative to learning mobile communication technology [4].

The development process of 4G networks on cellular phones has a coverage area, the smallest area of cellular service is called a “cell”. Each “cell” requires an OpenBTS (Base Transceiver Station) [5]. OpenBTS is a BTS technology component that is very cost and resource efficient because it can replace physical BTS to provide cellular communication with 4G technology [6]. According to the Generation Partnership Project (3GPP), 4G is the fourth generation that has very high flexibility of mobile communication radio interfaces [7].

In this research, the software used is USRP (Universal Software Radio Peripheral) B210. Both hardware and software are used together to build a 4G Network without any other expensive infrastructure. Any type of 4G cell phone can be connected to an OpenBTS device [8]. If there is more than one cell phone registered to OpenBTS, it will form a local network where each cell phone user can connect to each other in the network [9]. Research is planned to find an communication solution for villagers using OpenBTS. The system is portable and can be mobilized and set up whenever the cellular infrastructure has been reactivated [10].

Therefore, this research will be built with the title "4G Network Development as OpenBTS Using Open5Gs with Universal Software Radio Peripheral (USRP) B210". As a solution in building BTS so that it will help people who live in remote areas and areas affected by natural disasters. This implementation aims to show that USRP B210 can be used to build a 4G Network.

2. Method

2.1 Research Framework

This research framework explains how the research flow process is carried out systematically. In conducting this research, there is a framework of stages in the research made in the form of an overall diagram, so that it can find out the stages achieved and become a blend in solving the problems in the research being carried out. **Figure 1** shows the framework/flow of research conducted by the author as a whole.

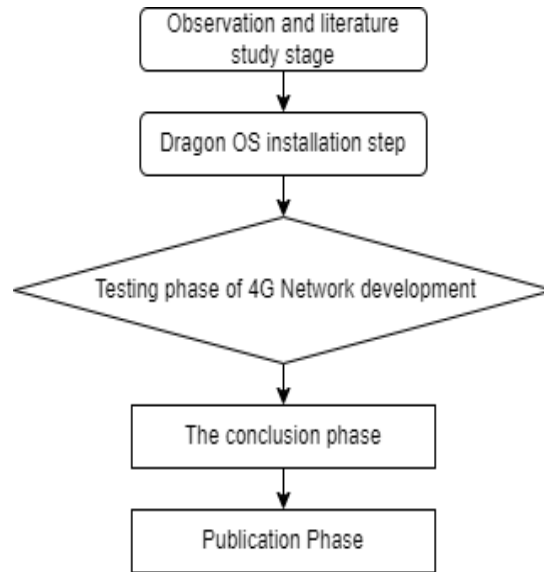


Figure 1. Overall Research Stages

2.2 Device Preparation

Preparation of devices both hardware and software to support the implementation of 4G network performance testing using Universal Software Radio Peripheral (USRP). The devices used in this research include a laptop with an operating system (Dragon). The following is an explanation of the research devices used

a. Hardware

The hardware used in this research is a laptop with a Linux operating system (Dragon) and the specifications are listed in **Table 1**.

Table 1. Hardware Specifications

Name of Product	Asus A455L
<i>Processor</i>	Intel Core i3 4005U Processor, 1.9 GHz
RAM	4,00 GB
<i>Smartphone</i>	6.74 inch, Resolusi 1600x720 ppi, 90 Hz
USRP B210	RF Coverage 70 MHz – 6 GHz, Full duplex (2Tx & 2 Rx), GNURadio and OpenBTS support
Antenna	VERT900

b. Software

The software used to configure the network in this study uses the Universal Software Radio Peripheral (USRP) B210, Operating System (OS) Linux (Dragon) version Release 2.6. Dragon R26 OS desktop view is presented in [Figure 2](#).

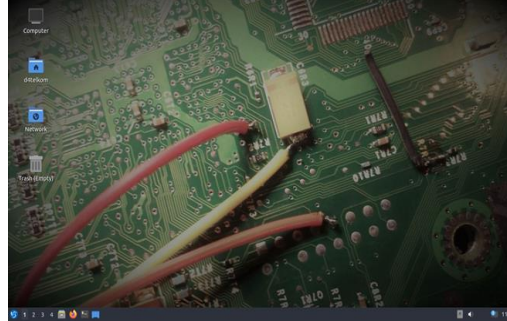


Figure 2. Dragon R26 OS Desktop View

2.3 Methods of Research

The research method used in this research is the Experiment method. The experimental method means trying, searching, and ensuring [\[11\]](#). A method that aims to test the effect of a variable on another variable or test how the causal relationship between one variable and another variable OpenBTS Connection Testing [\[12\]](#).

2.4 OpenBTS Connection Testing

This development framework explains how the testing flow process is carried out systematically. In developing this connection, there is a framework for the stages of developing connections in research made in the form of diagrams, so that it can find out the stages achieved and become a blend in solving problems in the tests carried out. [Figure 3](#) shows the framework/testing flow carried out by the author.

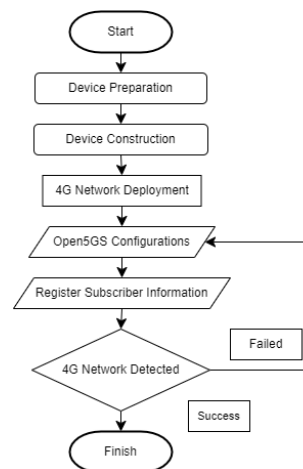


Figure 3. Testing Stages of 4G Network Development

3. Results and Discussion

3.1 4G Network Construction

a. Hardware Construction

Hardware is the implementation of the 4G network system development. Hardware development only includes USRP B210 and VERT900 Antenna. Install the VERT900 antenna for Tx and Rx, then connect the USRP B210 power cable on the Laptop. The hardware has been built, but at the moment it cannot be used due to the lack of communication drivers.

b. Software Construction

The software is carried out on a Laptop that uses the Dragon *Operating System* (OS). The first thing that must be built in the software is the UHD (USRP *Hardware Driver*). To link the USRP to the server, the UHD is used. Once the UHD is loaded on the server laptop to identify the USRP, new communication can begin. To select the UHD version to be used in this final project, the UHD installation is done using the source. The UHD installation steps are as follows:

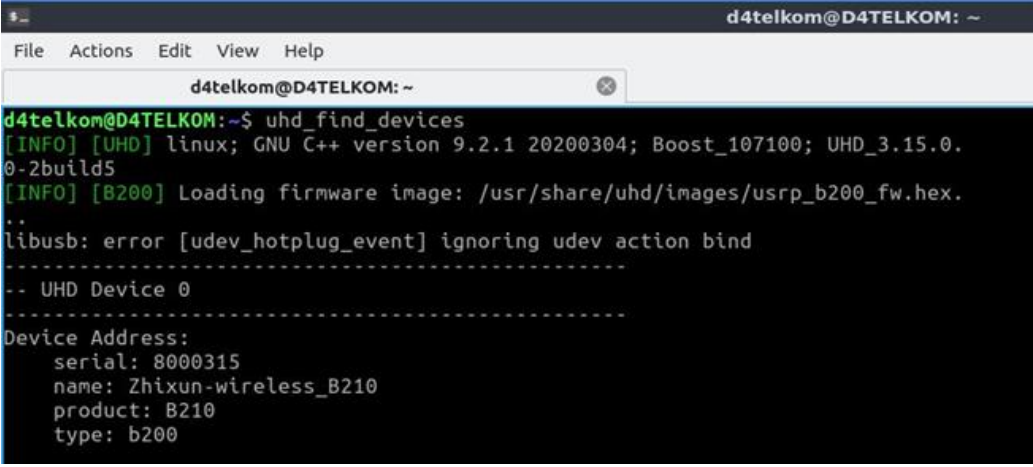
- 1) Installation of UHD dependency packages [15]

```
sudo apt-get install libuhd-dev uhd-host
```

- 2) Make sure the USRP B210 is detected to the device

```
uhd_find_devices
```

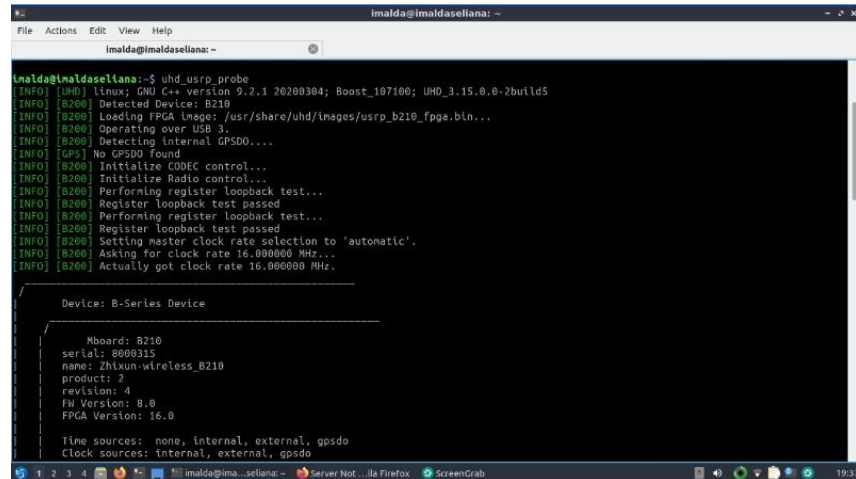
Result display that USRP B210 has been successfully detected is presented in [Figure 4](#).



```
d4telkom@D4TELKOM: ~  
File Actions Edit View Help  
d4telkom@D4TELKOM: ~  
d4telkom@D4TELKOM:~$ uhd_find_devices  
[INFO] [UHD] linux; GNU C++ version 9.2.1 20200304; Boost_107100; UHD_3.15.0.  
0-2build5  
[INFO] [B200] Loading firmware image: /usr/share/uhd/images/usrp_b200_fw.hex.  
..  
libusb: error [udev_hotplug_event] ignoring udev action bind  
..  
-- UHD Device 0  
-----  
Device Address:  
  serial: 8000315  
  name: Zhixun-wireless_B210  
  product: B210  
  type: b200
```

Figure 4. Result Display that USRP B210 has been Successfully Detected

3) Make sure the USRP can connect to the device



```

imalda@imaldasellana:~$ uhd_usrp_probe
[INFO] [0m] linux; GNU C++ version 9.2.1 20200304; Boost_107100; UHD_3.15.0.0-2build5
[INFO] [0200] Detected Device: B210
[INFO] [0200] Loading FPGA image: /usr/share/uhd/images/usrp_b210_fpga.bin...
[INFO] [0200] Operating over USB 3.
[INFO] [0200] Detecting internal GPSDO....
[INFO] [GPS] No GPSDO found
[INFO] [0200] Initialize CODEC control...
[INFO] [0200] Initialize Radio control...
[INFO] [0200] Performing register loopback test...
[INFO] [0200] Register loopback test passed
[INFO] [0200] Performing register loopback test...
[INFO] [0200] Register loopback test passed
[INFO] [0200] Setting master clock rate selection to 'automatic'.
[INFO] [0200] Asking for clock rate 16.000000 MHz...
[INFO] [0200] Actually got clock rate 16.000000 MHz.

Device: B-Series Device
-----
Mboard: B210
serial: 8000315
name: Zkxun-wireless_B210
product: 2
revision: 4
FW Version: 8.0
FPGA Version: 16.0

Time sources: none, internal, external, gpsdo
Clock sources: internal, external, gpsdo

```

Figure 5. Result Display that USRP B210 has been Successfully Connected

3.2 4G Network Development

The construction of the 4G network is the next stage. This is the most important stage, as it is where the 4G Network package starts.

a. Public Key Installation by Sistem Management

```

sudo apt update
sudo apt install gnupg
curl -fsSL https://pgp.mongodb.com/server-6.0.asc | sudo
gpg -o /usr/share/keyrings/mongodb-server-6.0.gpg --dearmor

```

b. Installation of MongoDB packages, as a database storage system

```

sudo apt update
sudo apt install -y mongodb-org
sudo systemctl start mongod
sudo systemctl enable mongod

```

c. OpenBTS installation, as a place to develop 4G private networks with open source

```

sudo add-apt-repository ppa:open5gs/latest
sudo apt update
sudo apt install open5gs

```

d. Installation of the Open5GS package

```

sudo zypper addrepo -f obs://home:mnhauke:open5gs
home:mnhauke:open5gs
sudo zypper install mongodb-server mongodb-shell
sudo zypper install open5gs

```

e. Installation of WebUI on Open5GS[13]

```

sudo apt update
sudo apt install -y ca-certificates curl gnupg
sudo mkdir -p /etc/apt/keyrings
curl -fsSL https://deb.nodesource.com/gpgkey/nodesource-
repo.gpg.key | sudo gpg --dearmor -o
/etc/apt/keyrings/nodesource.gpg
sudo apt update
sudo apt install nodejs -y
curl -fsSL https://open5gs.org/open5gs/assets/webui/install
| sudo -E bash -

```


f. Download and build srsRAN 4G [14]

```
sudo git clone https://github.com/srsRAN/srsRAN_4G.git
cd srsRAN_4G
mkdir build
cd build
cmake ../
make
make test
```

g. Installation srsRAN 4G

```
sudo make install
srsran install config.sh.user
```

3.3 Open5GS Configurations

1. Setup 4G NSA Core [16]

a. Modify `/etc/open5gs/mme.yaml` to set the IP, PLMN ID, and TAC.

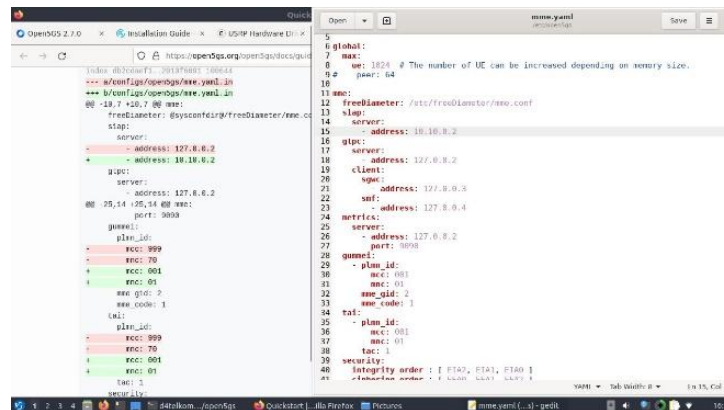


Figure 5. Display when configuring the mme.yaml file

b. Modify `/etc/open5gs/sgwu.yaml` to set the GTP-U IP address.

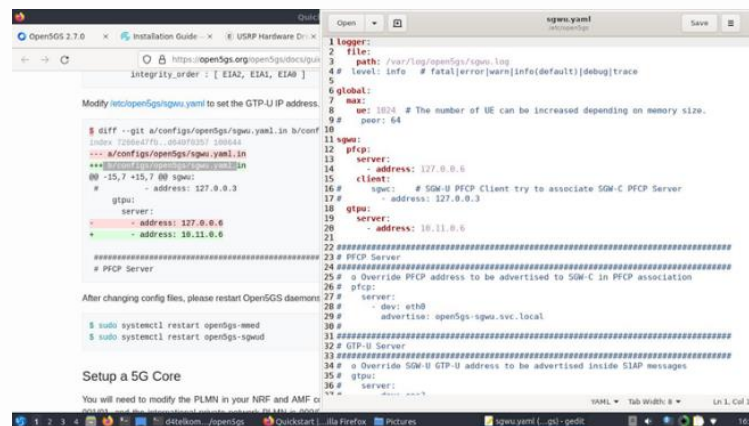


Figure 6. Display when Configuring the sgwu.yaml

c. After changing config files, please restart Open5GS daemons

```
sudo systemctl restart open5gs-mme
sudo systemctl restart open5gs-sgwud
```

- d. Modify `/etc/open5gs/nrf.yaml` to set the PLMN ID.

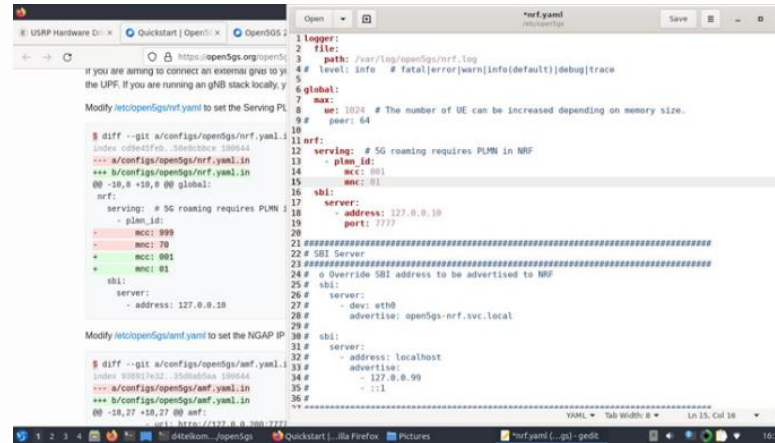


Figure 7. Display when configuring the nrf.yaml file

- e. Modify `/etc/open5gs/amf.yaml` to set the NGAP IP address, PLMN ID, TAC and NSSAI.

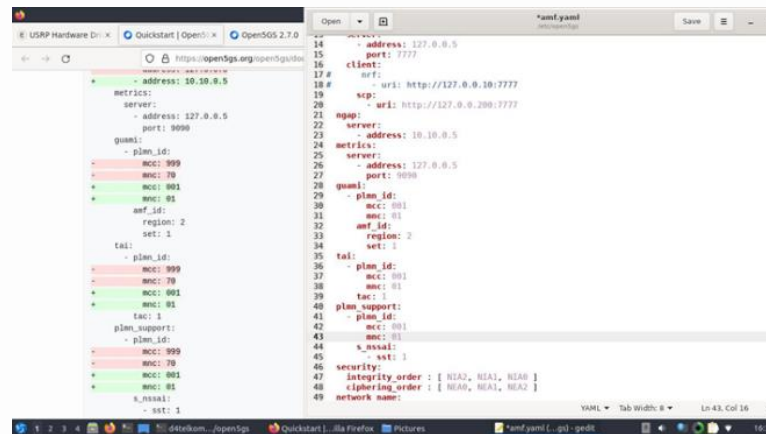


Figure 8. Display when configuring the amf.yaml file

- f. Modify `/etc/open5gs/upf.yaml` to set the -U address.

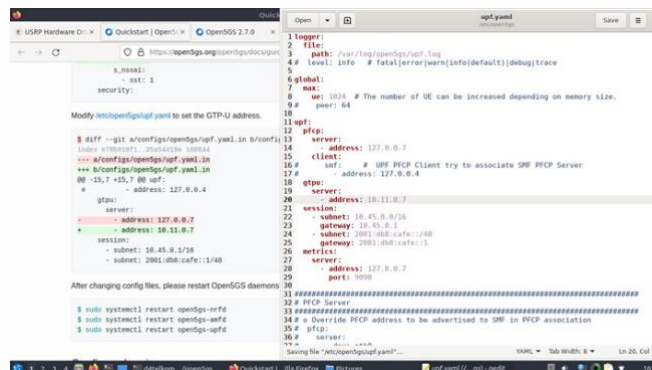


Figure 9. Display when Configuring the upf.yaml File

- g. After changing config files, please restart Open5GS daemons.

```
sudo systemctl restart open5gs-nrfd
sudo systemctl restart open5gs-amfd
sudo systemctl restart open5gs-upfd
```


- h. The Open5GS components log to /var/log/open5gs/*.log and to stderr by default.

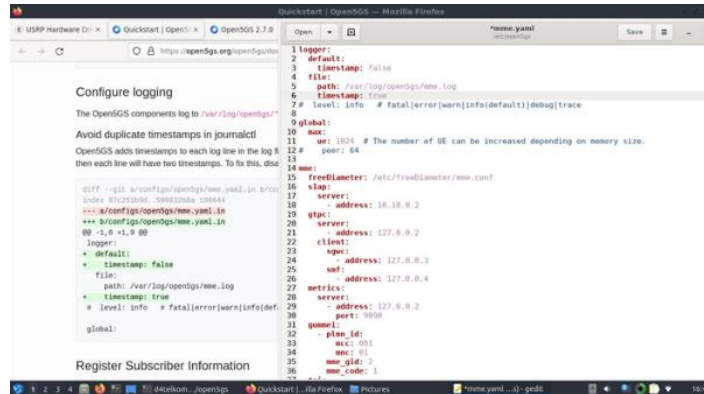


Figure 10. Display when disabling the timestamp configuration for stderr file upf.yaml

3.4 Register Subscriber Information

- a. Connect to <http://localhost:9999> and login with **admin** account.

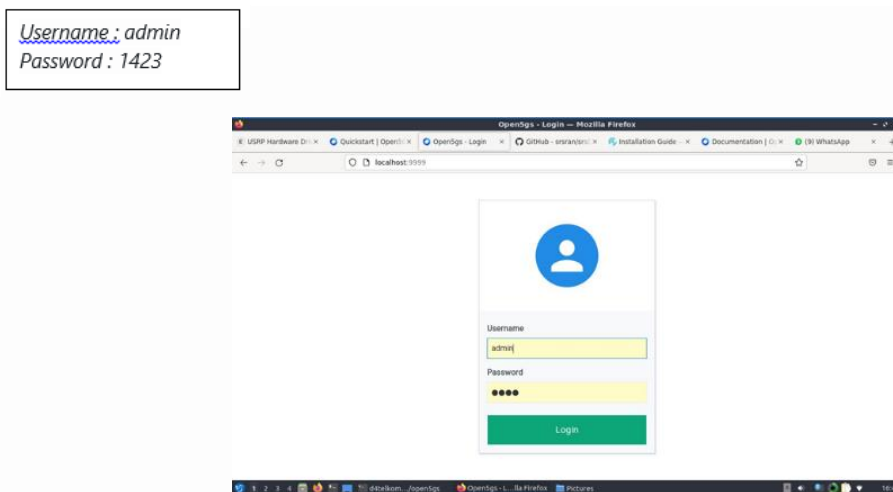


Figure 11. Login Page Display on Open5GS WebUI

- b. Add the IMSI number contained in the output

IMSI: 510103652535427

- c. Then register the IMSI number on the subscriber sub menu on the Open5GS WebUI.

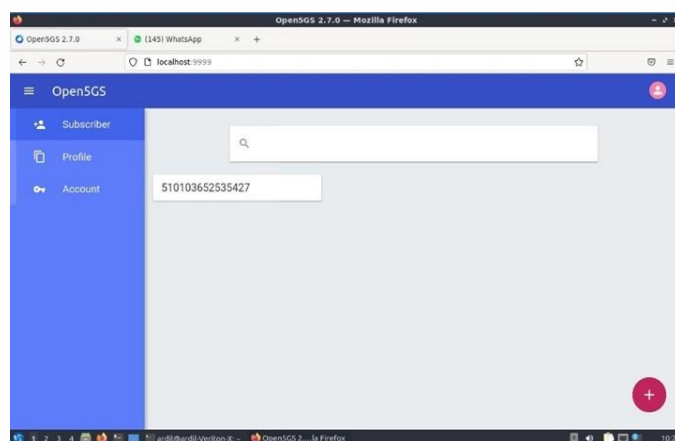


Figure 12. Display of registered IMSI number

- d. Open the network option on the phone and the 4G network has been detected



Figure 12. 4G Network Display from USRP B210 has been successfully detected with network name “00101 4G”

4. Conclusion

Based on the results of the network development that has been carried out, it can be concluded that:

1. 4G Network Development as OpenBTS Using Open5GS with Universal Software Radio Peripheral (USRP) B210 device was successfully built and developed.
2. The 4G network has been detected on cellphones, and it is possible to use and implement it in blankspot areas of Indonesia.

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