

教育部「5G行動寬頻人才培育跨校教學聯盟計畫」

5G行動網路協定與核網技術聯盟中心

「5G行動寬頻協同網路」課程模組

# 實驗三

## SBA建置與協定分析

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助教：魏宏修

國立高雄大學 資訊工程學系

# Outline

- 實驗目的及實驗內容
- Free5GC 實驗環境
  - LTE 架構
  - 5G 架構
  - 軟硬體環境
- Free5GC 網路實驗平台建置
  - Add Another Bridge NIC( First )
  - MongoDB MongoDB Setup
  - Free5gc Git Clone and Compile
  - Configing the Core Network and Adding User Information
  - How to Configure eNodeB
  - Rebuild Project
  - Free5GC Demo
  - Annex A
- 總結

# 實驗目的

- 建置支援SBA的5GC開源系統，讓學生學會建立5GC核網系統並了解5G核網架構
- 設定4G的UE及eNB並連接5GC，讓學生觀察4G與5G網路的協同運作並分析協定

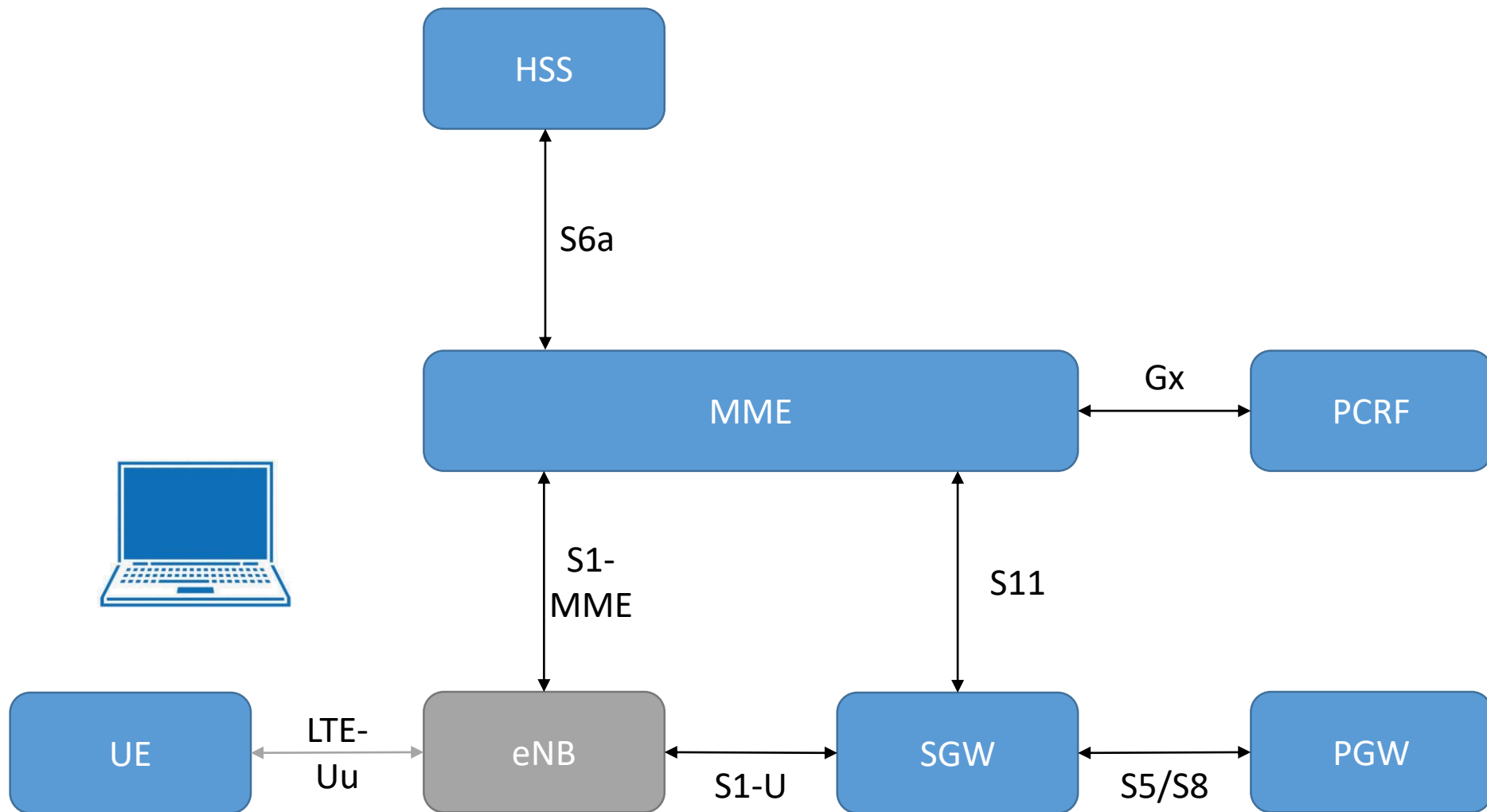
# 實驗內容

- 在兩台主機上安裝Free5GC HSS、AMF、SMF、PCRF和UPF
  - 設置Free5GC Core Network和eNB
  - 執行Free5GC HSS、AMF、SMF、PCRF和UPF
  - 透過wireshark 觀察封包的收發會經過哪些節點和封包的變化

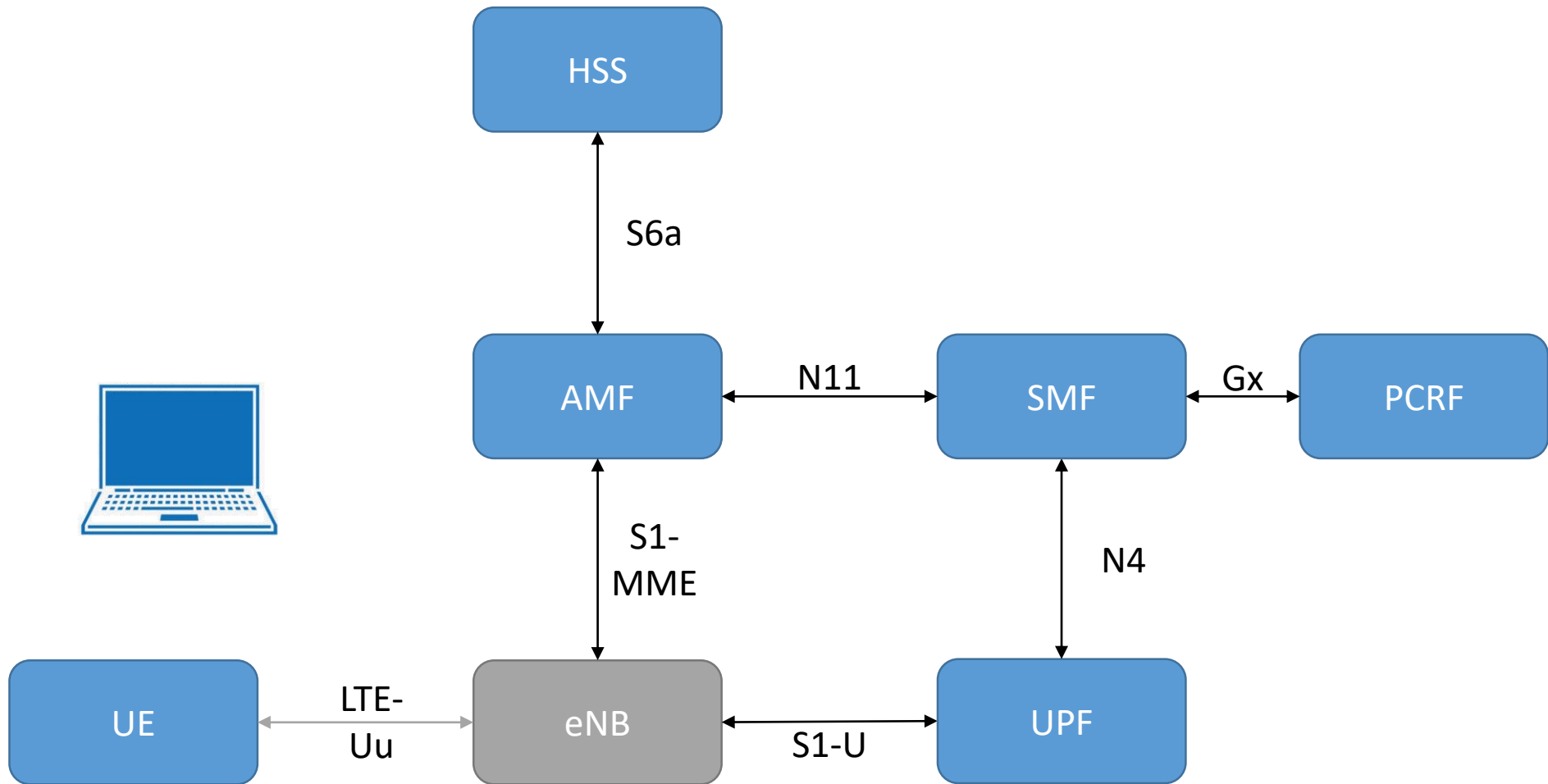
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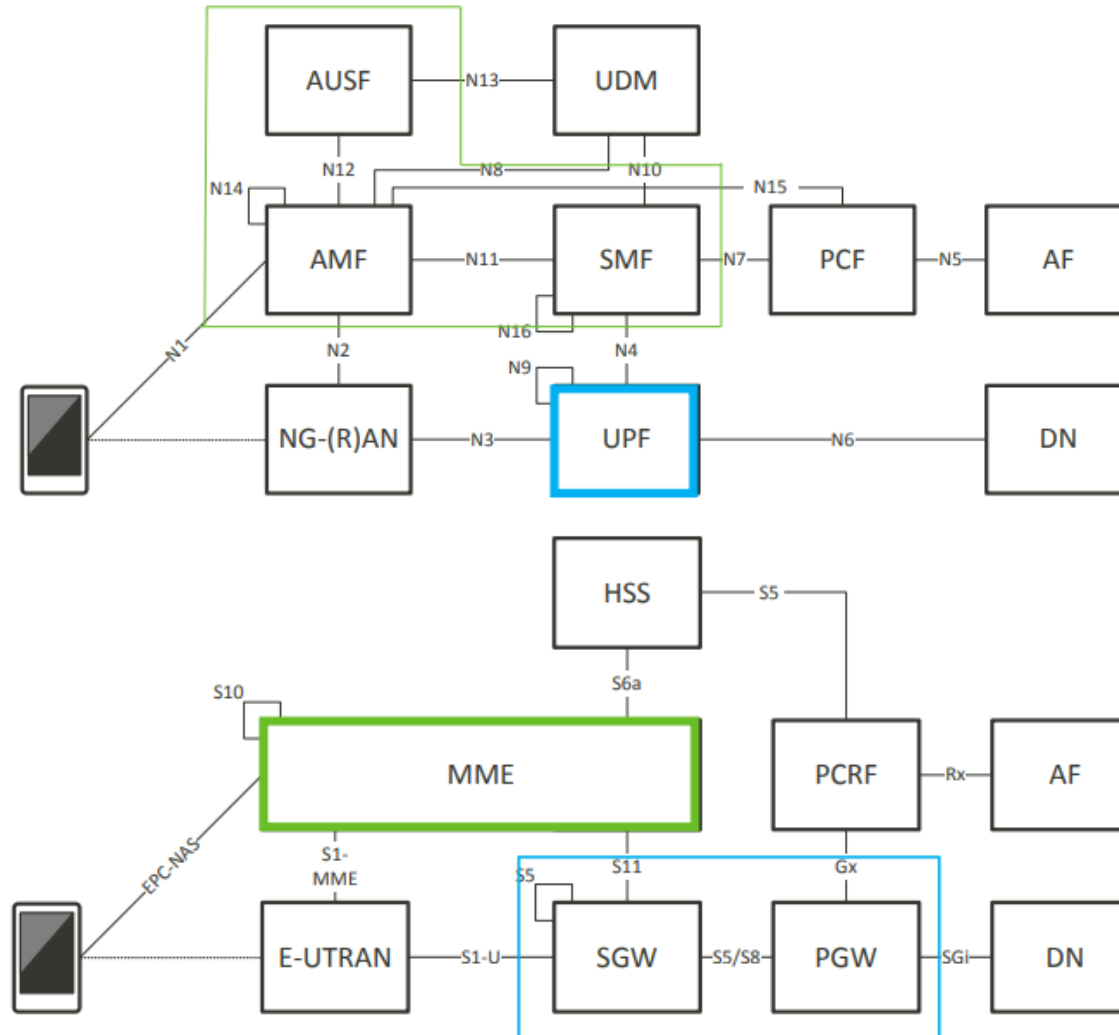
# LTE 實驗架構



# Free5GC 實驗架構



# EPC <> 5GC





# EPC<>5GC Correspondence

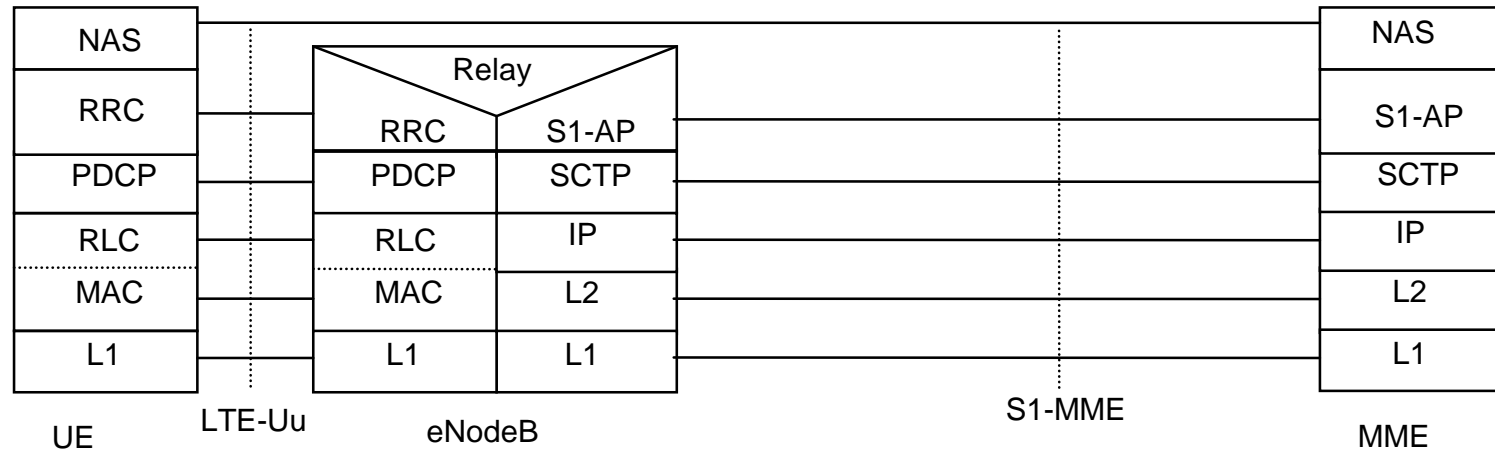
EPC <> 5GC Correspondence

EPC		5GC
MME	↔	AMF + SMF + AUSF
SGW	↔	UPF
PGW	↔	UPF
PCRF	↔	PCF
HSS	↔	UDM

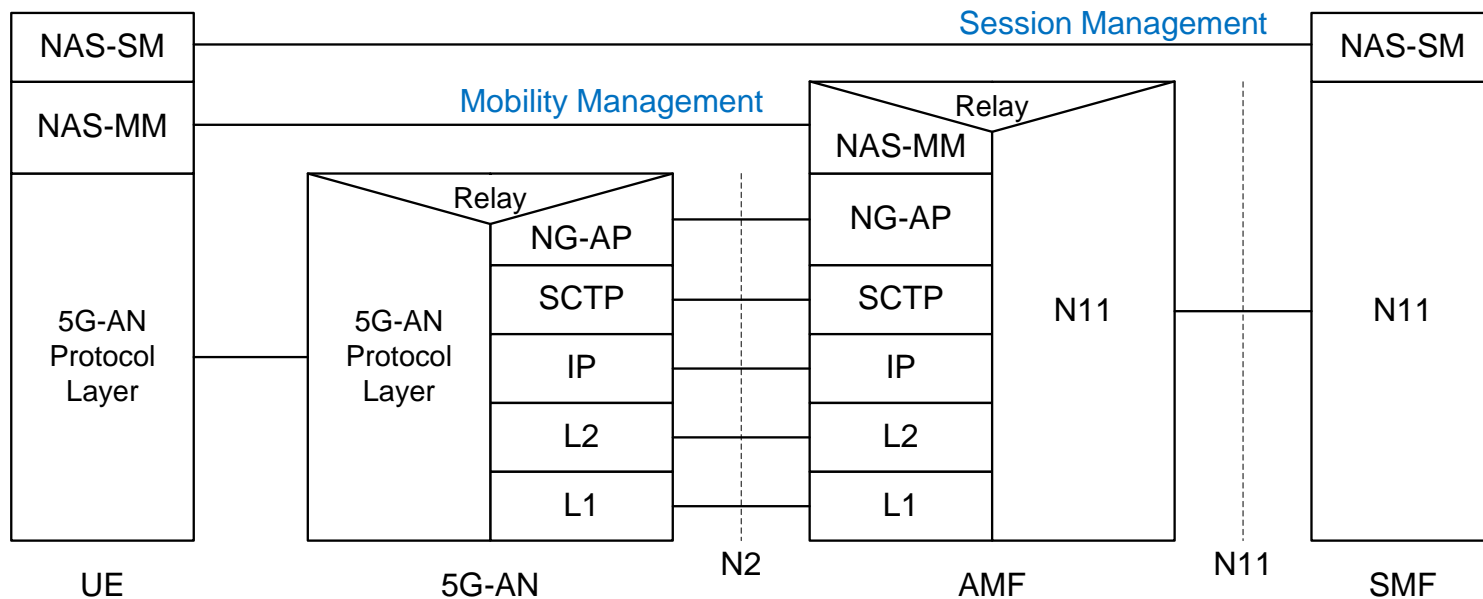
EPC		5GC
EPC-NAS	↔	N1
S1-MME	↔	N2
S1-U	↔	N3
S11	↔	N4
Rx	↔	N5
SGi	↔	N6

# LTE/5G Control Plane Protocol Stack

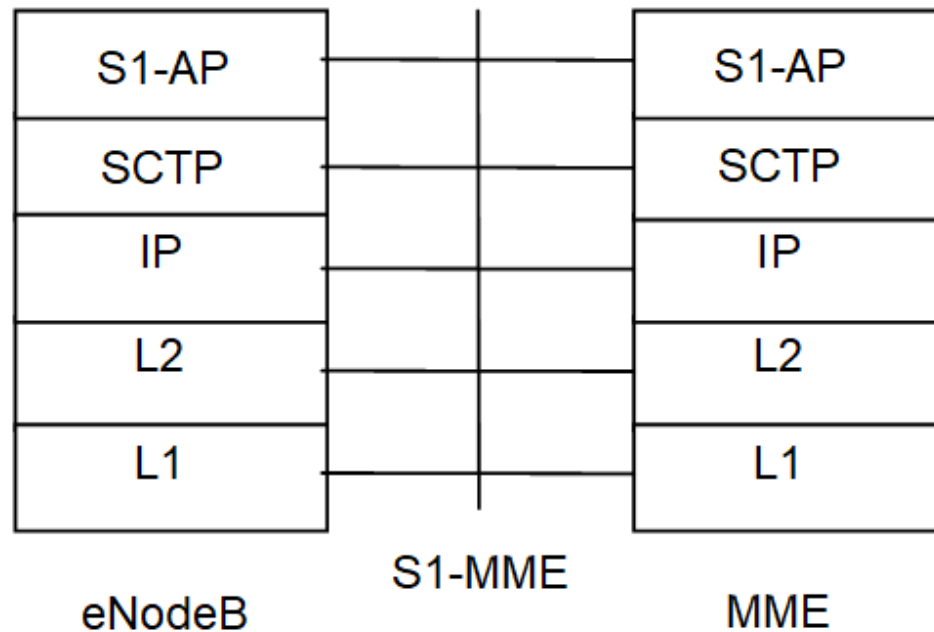
## LTE (Option 1)



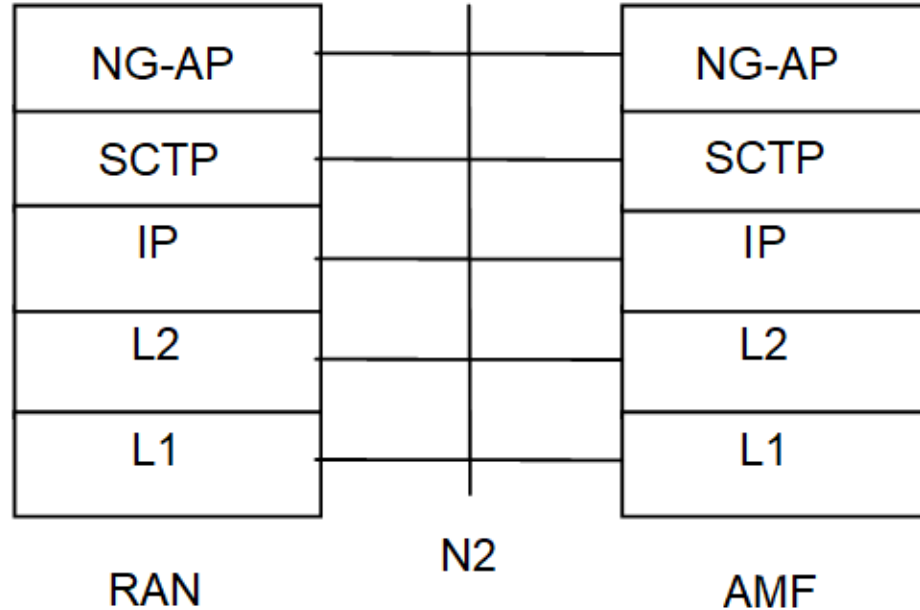
## 5G (Option 2)



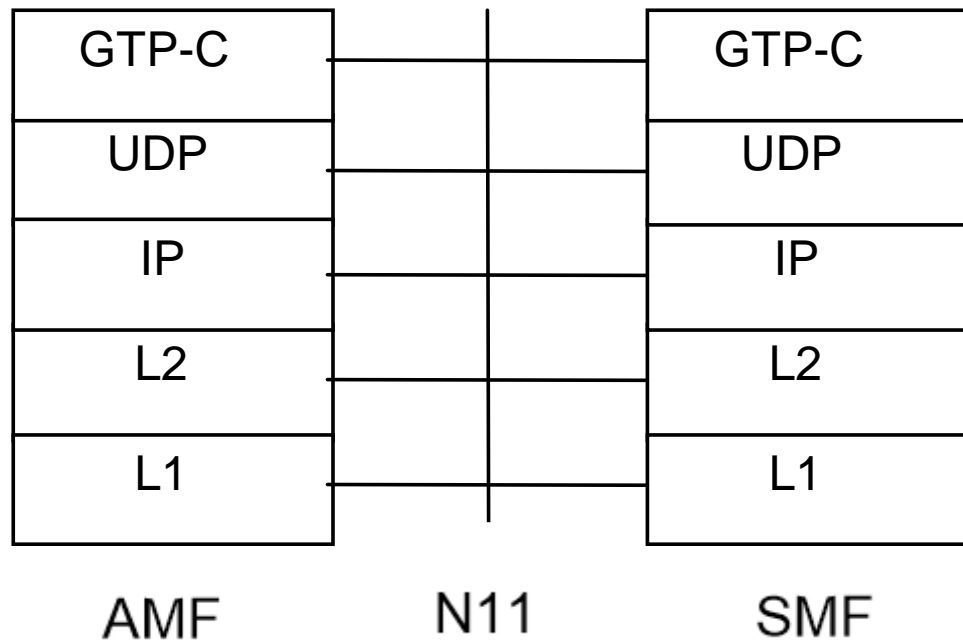
# UE to AMF (S1AP)



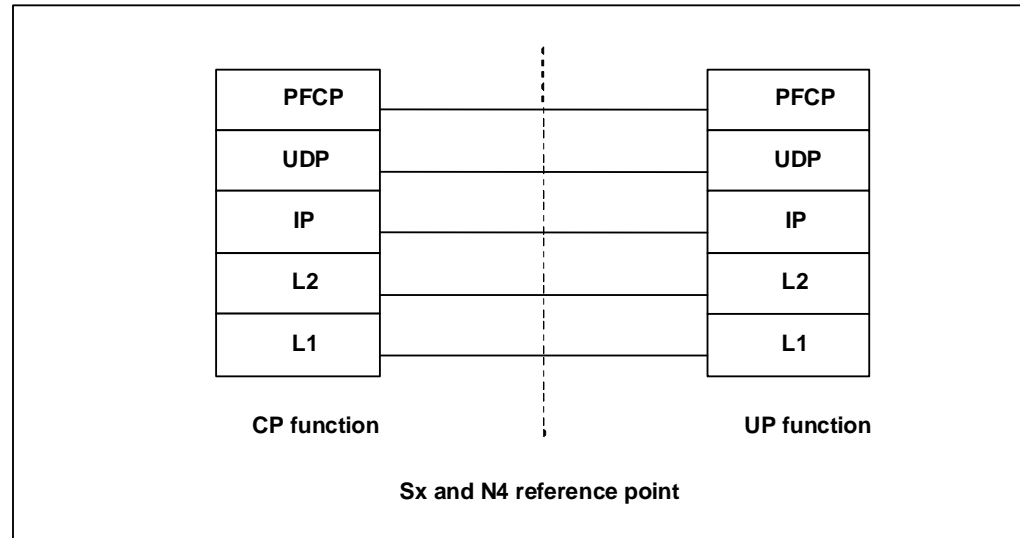
# UE to AMF (NGAP)



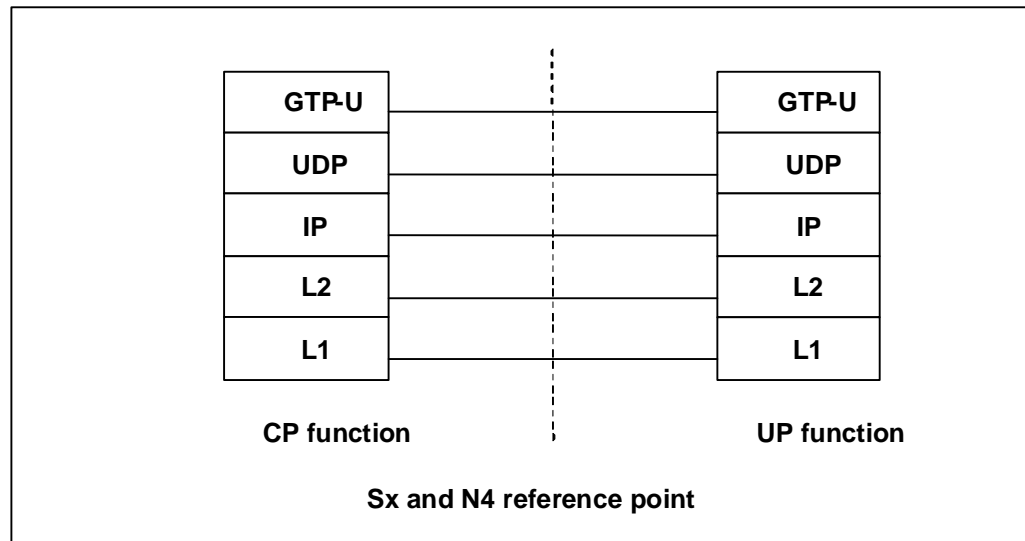
# AMF to SMF(N11)



# SMF to UPF (N4)



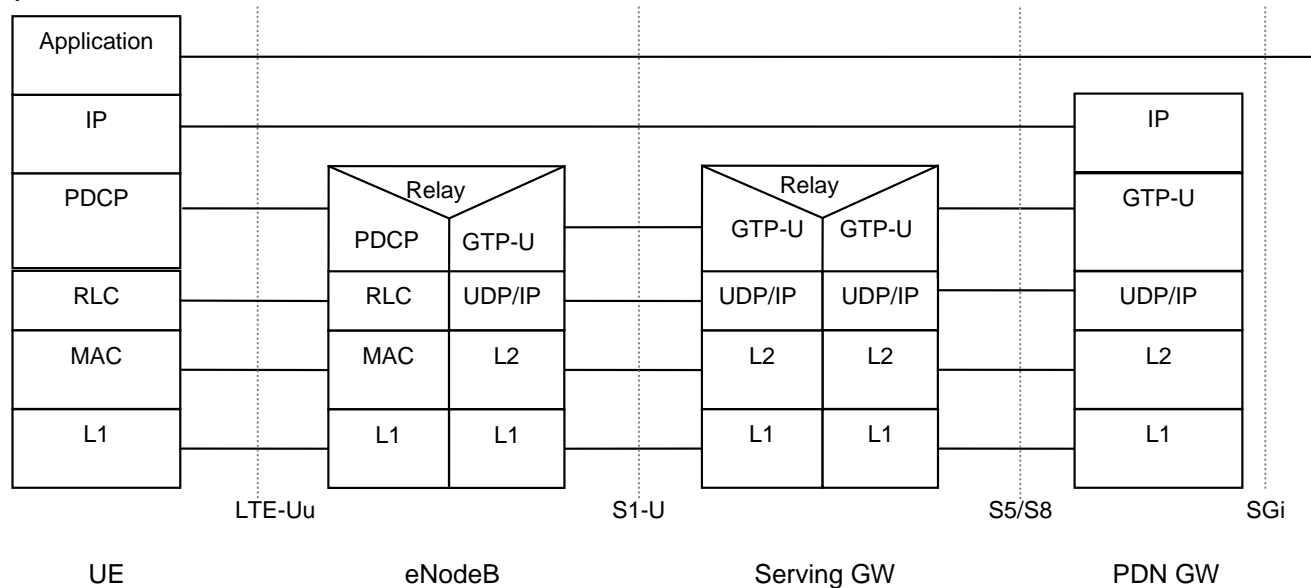
Control Plane



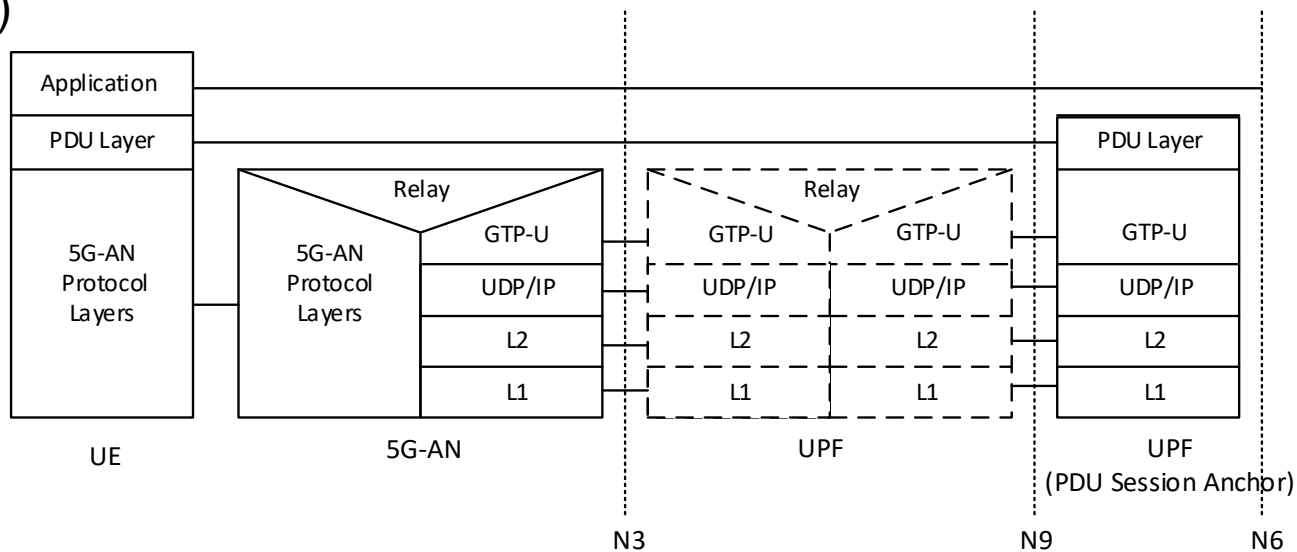
User Plane

# LTE/5G User Plane Protocol Stack for 3GPP Access

## LTE (Option 1)

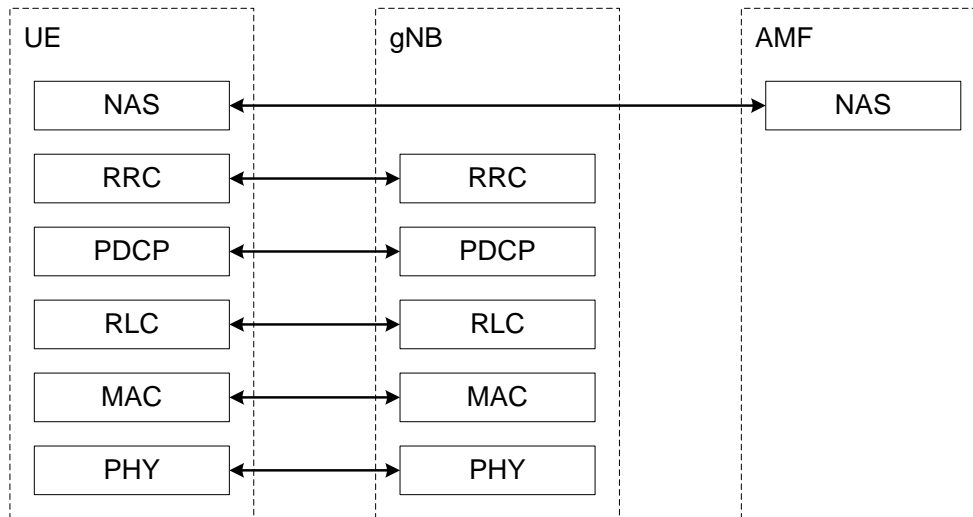


## 5G (Option 2)

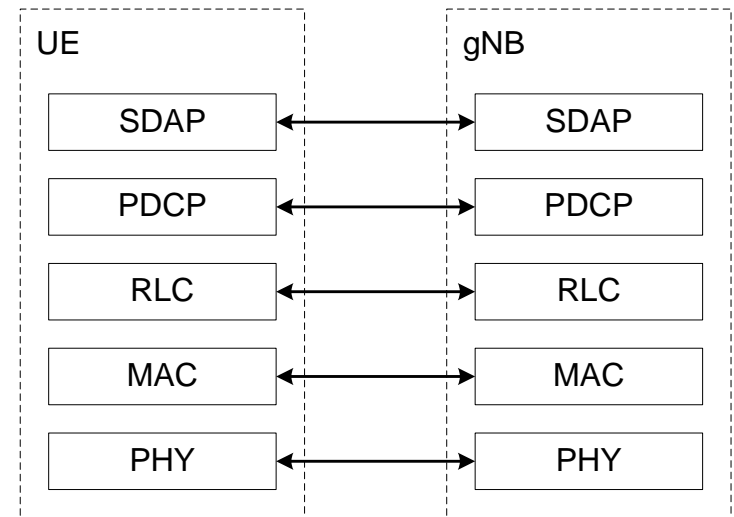


# Protocol Stack

## Control Plane



## User Plane



SDAP (Service Data Adaptation Protocol) layer

- Mapping between a QoS flow and a data radio bearer
- Marking QoS flow ID (QFI) and reflective QoS (RQoS)



# 軟硬體環境 - 軟體

名稱	軟體	版本	目的
Free5GC	OS : Ubuntu	Ubuntu 18.04	啟動HSS、AMF、 SMF、PCRF和 UPF功能
		4.15.0-43-generic	
	Free5GC的軟體	<a href="https://bitbucket.org/nctu_5g/free5gc.git">https://bitbucket.org/nctu_5g/free5gc.git</a>	
	第三方擴充套件: Gcc GO MongoDB		

# 軟硬體環境 - 硬體

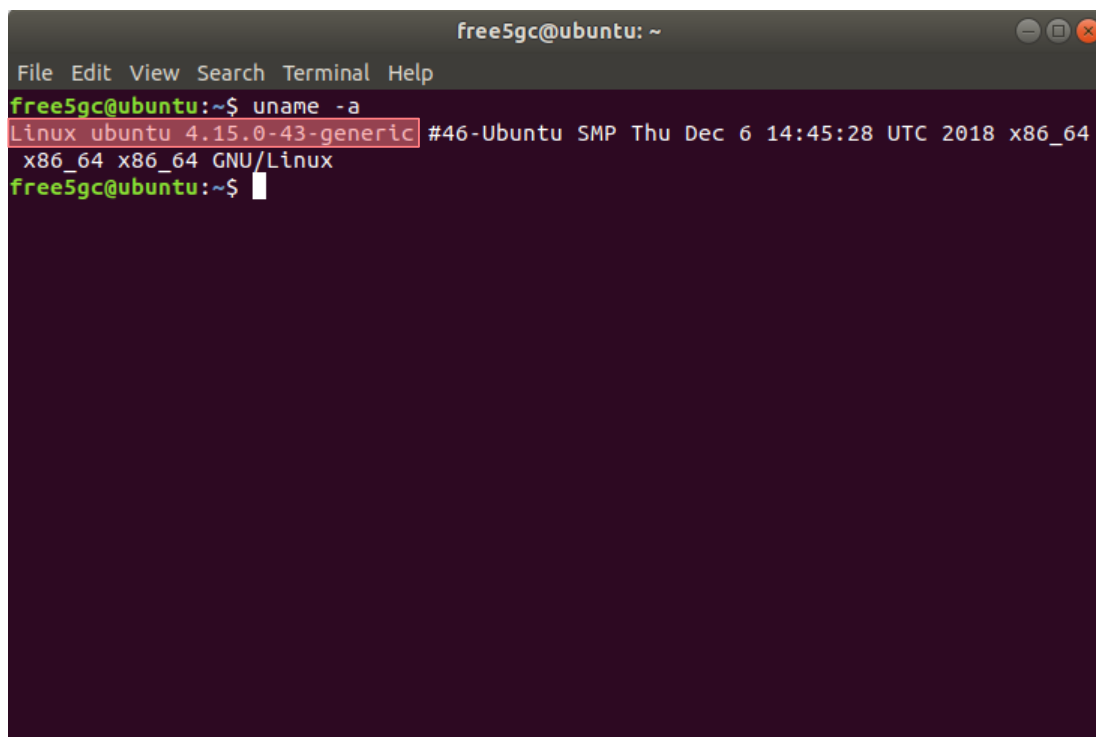
名稱	軟體	版本	目的
eNB	WNC OSQ4G-01E2 (4G LTE Small Cell )	3GPP Rel-13 compliance	啟動eNB功能
	D-Link DWR-1012 (4G LTE Small Cell)	3GPP Rel-12 compliance	
	GemTek WLTGFC-101 (4G LTE Small Cell)	3GPP Rel-9 compliance	

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# 檢查Kernel的設定

- 確認Kernel版本
- `uname -a`

A terminal window titled 'free5gc@ubuntu: ~' with a menu bar (File, Edit, View, Search, Terminal, Help). The prompt is 'free5gc@ubuntu:~\$'. The command 'uname -a' has been entered and executed. The output is displayed on the next line: 'Linux ubuntu 4.15.0-43-generic #46-Ubuntu SMP Thu Dec 6 14:45:28 UTC 2018 x86\_64 x86\_64 x86\_64 GNU/Linux'. The text 'Linux ubuntu 4.15.0-43-generic' is highlighted with a red box. The prompt 'free5gc@ubuntu:~\$' is followed by a cursor.

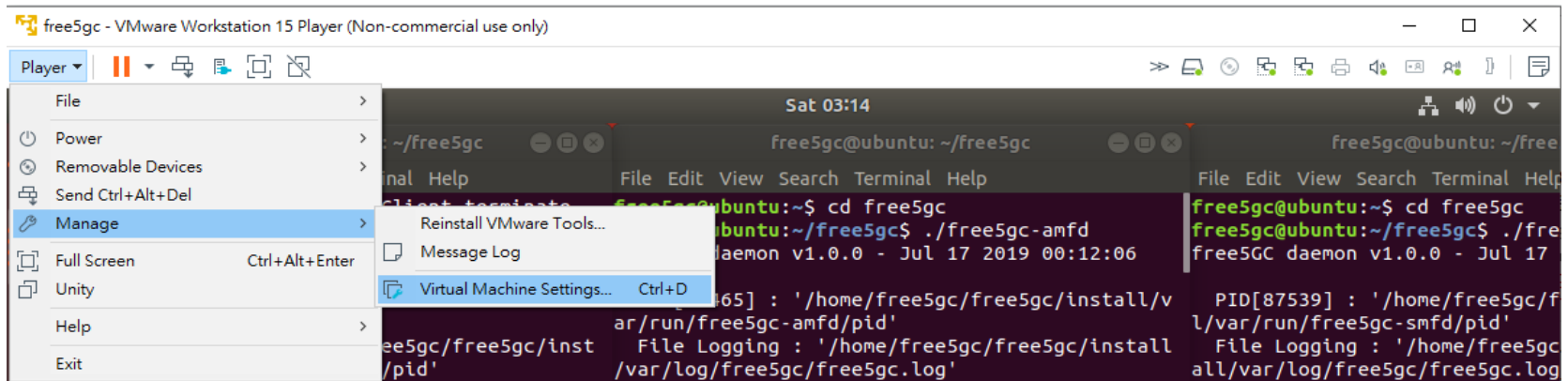
```
free5gc@ubuntu: ~
File Edit View Search Terminal Help
free5gc@ubuntu:~$ uname -a
Linux ubuntu 4.15.0-43-generic #46-Ubuntu SMP Thu Dec 6 14:45:28 UTC 2018 x86_64
x86_64 x86_64 GNU/Linux
free5gc@ubuntu:~$
```

# KVM Environment Setup

- VM NIC Cards :
  - NIC for connecting to the Internet :
    - Network source: Virtual network - NAT
    - Interface name in VM: ens33
  - NIC for connecting to eNB :
    - Network source: Host device <Host Interface Name>
    - Interface name in VM: ens38

# 0. Add Another Bridge NIC( First )

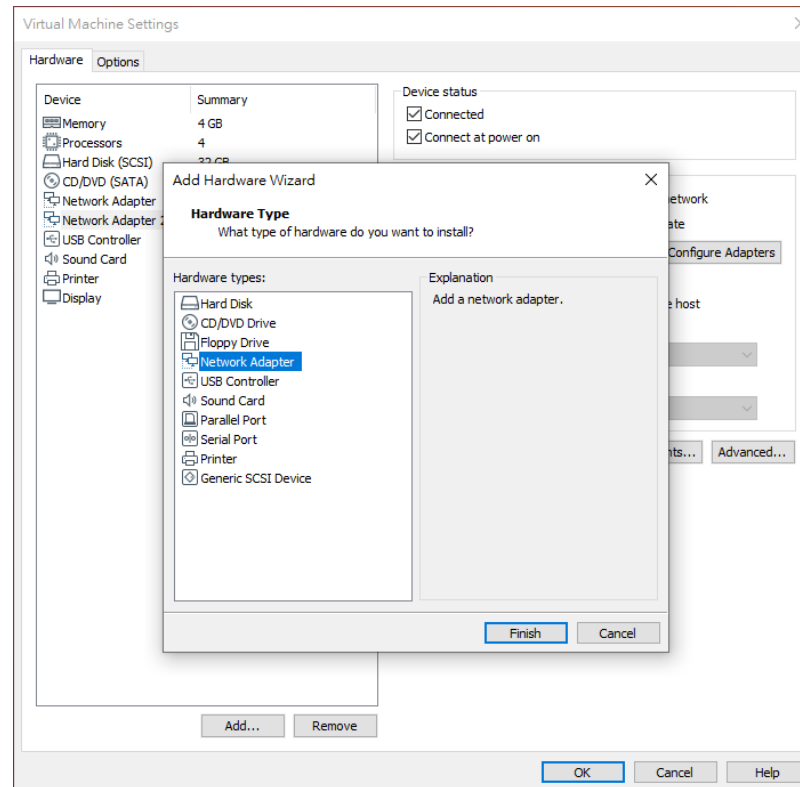
# Add another network adapter with bridge mode to connect to your eNodeB



- Go Player -> Manage -> Virtual Machine Setting

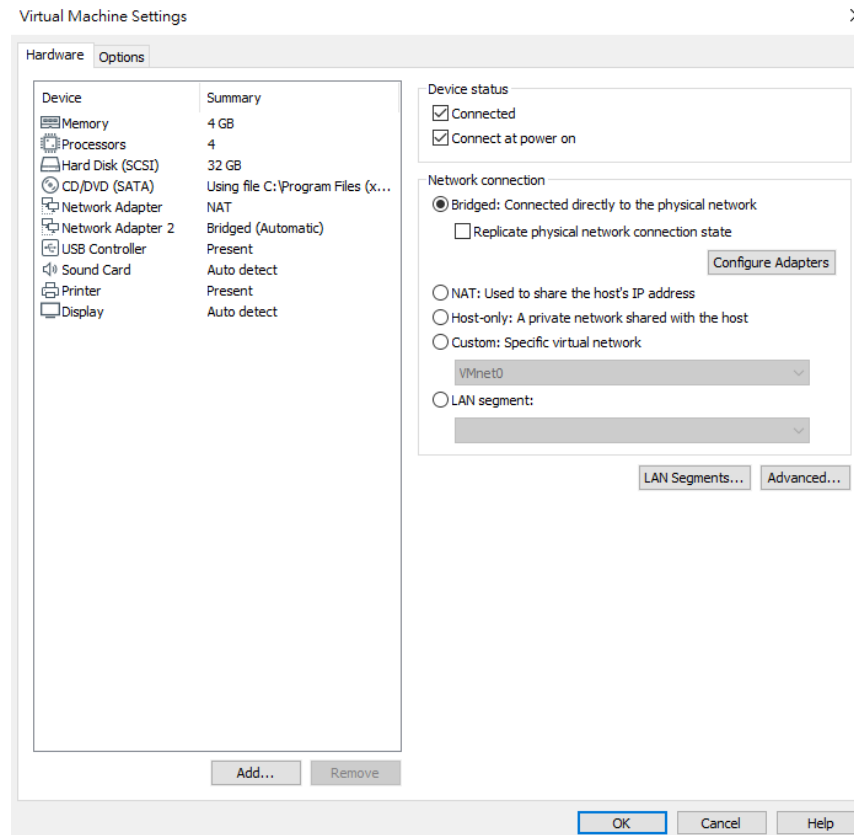
# Add Another Bridge NIC(cont.)

- Select Add to choose Hardware Type
- Select Network Adapter



# Add Another Bridge NIC(cont..)

- Network connection : Bridged
- Configure Adapters
- OK





# 1. MongoDB MongoDB Setup ( First )

# Install MongoDB 3.6.3, MongoDB 1.11.4.

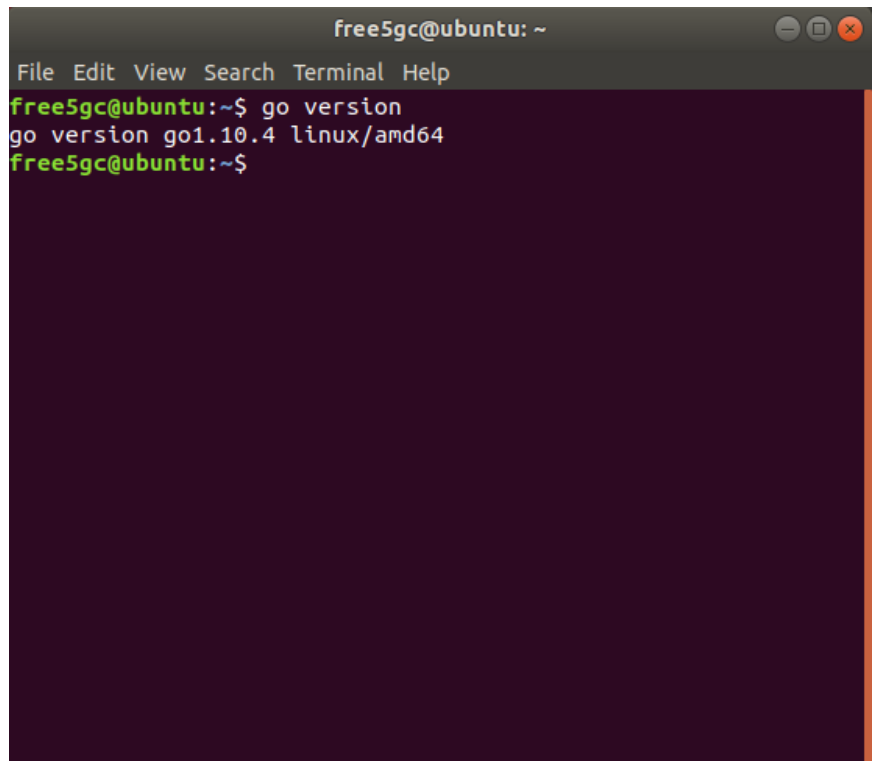
- sudo apt-get update
- sudo apt-get -y install mongodb wget git
- sudo systemctl start mongod  
- (if '/usr/bin/mongod' is not running)

```
File Edit View Search Terminal Help
free5gc@ubuntu: ~
free5gc@ubuntu:~$ sudo apt-get update
Get:1 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Hit:2 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Hit:3 http://ppa.launchpad.net/wireshark-dev/stable/ubuntu bionic InRelease
Get:4 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:5 http://security.ubuntu.com/ubuntu bionic-security/main amd64 Packages [451 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:7 http://us.archive.ubuntu.com/ubuntu bionic-updates/main i386 Packages [559 kB]
Get:8 http://security.ubuntu.com/ubuntu bionic-security/main i386 Packages [340 kB]
Get:9 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [682 kB]
Get:10 http://security.ubuntu.com/ubuntu bionic-security/main amd64 DEP-11 Metadata [24.2 kB]
Get:11 http://security.ubuntu.com/ubuntu bionic-security/main DEP-11 48x48 Icons [10.4 kB]
Get:12 http://security.ubuntu.com/ubuntu bionic-security/main DEP-11 64x64 Icons [31.7 kB]
Get:13 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 Packages [572 kB]
Get:14 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 DEP-11 Metadata [283 kB]
Get:15 http://us.archive.ubuntu.com/ubuntu bionic-updates/main DEP-11 48x48 Icons [66.7 kB]
Get:16 http://security.ubuntu.com/ubuntu bionic-security/universe i386 Packages [565 kB]
Get:17 http://us.archive.ubuntu.com/ubuntu bionic-updates/main DEP-11 64x64 Icons [138 kB]
Get:18 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 Packages [972 kB]
Get:19 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 DEP-11 Metadata [41.3 kB]
Get:20 http://security.ubuntu.com/ubuntu bionic-security/universe DEP-11 48x48 Icons [16.4 kB]
Get:21 http://security.ubuntu.com/ubuntu bionic-security/universe DEP-11 64x64 Icons [111 kB]
Get:22 http://security.ubuntu.com/ubuntu bionic-security/multiverse amd64 DEP-11 Metadata [2,464 B]
Get:23 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe i386 Packages [955 kB]
Get:24 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe Translation-en [294 kB]
Get:25 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 DEP-11 Metadata [249 kB]
Get:26 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe DEP-11 48x48 Icons [195 kB]
Get:27 http://us.archive.ubuntu.com/ubuntu bionic-updates/universe DEP-11 64x64 Icons [419 kB]
Get:28 http://us.archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 DEP-11 Metadata [2,468 B]
Get:29 http://us.archive.ubuntu.com/ubuntu bionic-backports/universe amd64 DEP-11 Metadata [7,224 B]
Fetched 7,240 kB in 14s (513 kB/s)
Reading package lists... Done
free5gc@ubuntu:~$ sudo apt-get -y install mongodb wget git
Reading package lists... Done
Building dependency tree
Reading state information... Done
git is already the newest version (1:2.17.1-1ubuntu0.4).
wget is already the newest version (1.19.4-1ubuntu2.2).
mongodb is already the newest version (1:3.6.3-0ubuntu1.1).
The following packages were automatically installed and are no longer required:
  amd64-microcode intel-microcode iucode-tool libmongoc-1.0-0 libsnappy-dev
  thermald
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 51 not upgraded.
free5gc@ubuntu:~$ sudo systemctl start mongod
```

# Check Golang Version

# Check if golang is installed

- go version

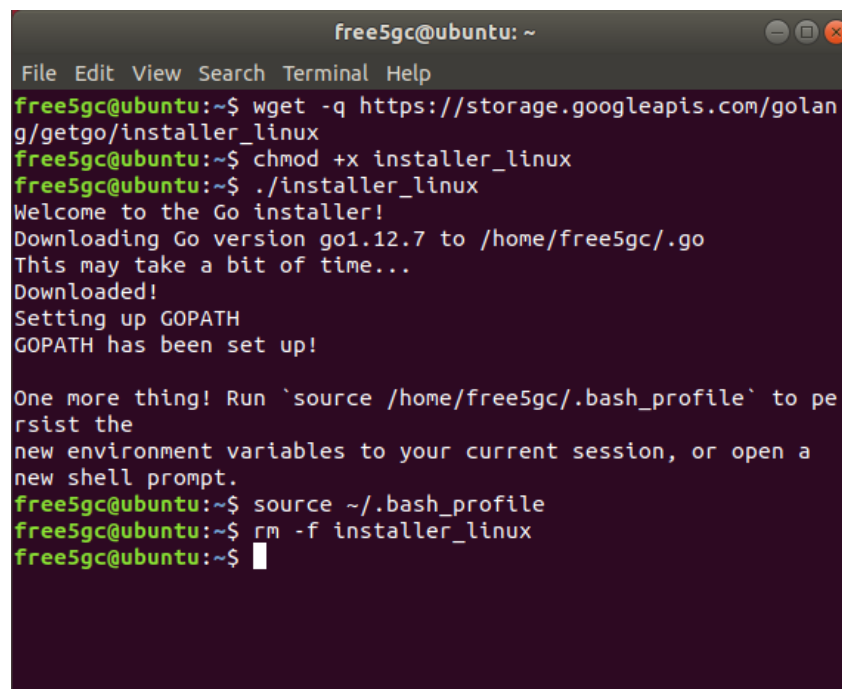
A terminal window titled 'free5gc@ubuntu: ~' with a dark purple background. The window has a menu bar with 'File', 'Edit', 'View', 'Search', 'Terminal', and 'Help'. The terminal shows the command 'go version' being executed, resulting in the output 'go version go1.10.4 linux/amd64'. The prompt 'free5gc@ubuntu:~\$' is visible at the start and end of the command line.

```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ go version  
go version go1.10.4 linux/amd64  
free5gc@ubuntu:~$
```

# Golang安裝

# If not, run commands below

- `wget -q https://storage.googleapis.com/golang/getgo/installer_linux`
- `chmod +x installer_linux`
- `./installer_linux`
- `source ~/.bash_profile`
- `rm -f installer_linux`

A terminal window titled 'free5gc@ubuntu: ~' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the execution of several commands to install Golang. The output includes the download of the installer, setting permissions, running the installer, and setting the GOPATH environment variable. The installer also provides instructions on how to persist the environment variables by sourcing the bash profile.

```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ wget -q https://storage.googleapis.com/golang/getgo/installer_linux  
free5gc@ubuntu:~$ chmod +x installer_linux  
free5gc@ubuntu:~$ ./installer_linux  
Welcome to the Go installer!  
Downloading Go version go1.12.7 to /home/free5gc/.go  
This may take a bit of time...  
Downloaded!  
Setting up GOPATH  
GOPATH has been set up!  
  
One more thing! Run `source /home/free5gc/.bash_profile` to persist the  
new environment variables to your current session, or open a  
new shell prompt.  
free5gc@ubuntu:~$ source ~/.bash_profile  
free5gc@ubuntu:~$ rm -f installer_linux  
free5gc@ubuntu:~$
```

# Golang安裝(cont.)

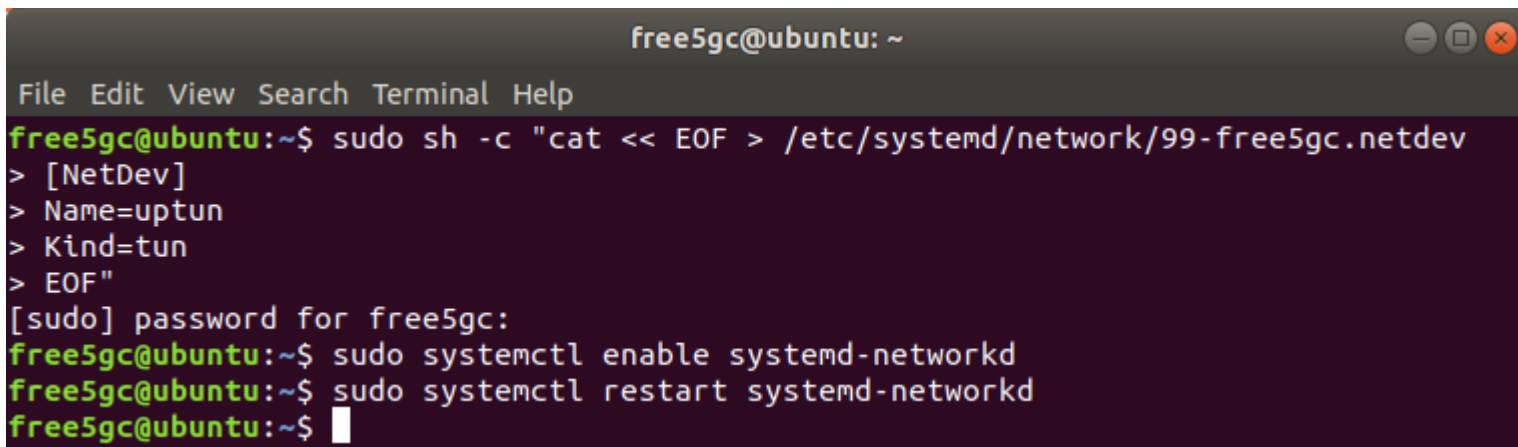
- `go get -u -v "github.com/gorilla/mux"`
- `go get -u -v "golang.org/x/net/http2"`
- `go get -u -v "golang.org/x/sys/unix"`

```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ wget -q https://storage.googleapis.com/golang/getgo/installer_linux  
free5gc@ubuntu:~$ chmod +x installer_linux  
free5gc@ubuntu:~$ ./installer_linux  
Welcome to the Go installer!  
Downloading Go version go1.12.7 to /home/free5gc/.go  
This may take a bit of time...  
Downloaded!  
Setting up GOPATH  
GOPATH has been set up!  
  
One more thing! Run `source /home/free5gc/.bash_profile` to persist the  
new environment variables to your current session, or open a  
new shell prompt.  
free5gc@ubuntu:~$ source ~/.bash_profile  
free5gc@ubuntu:~$ rm -f installer_linux  
free5gc@ubuntu:~$ go get -u -v "github.com/gorilla/mux"  
github.com/gorilla/mux (download)  
free5gc@ubuntu:~$ go get -u -v "golang.org/x/net/http2"  
Fetching https://golang.org/x/net/http2?go-get=1  
Parsing meta tags from https://golang.org/x/net/http2?go-get=1  
(status code 200)
```

# TUN Device

#Write the configuration file for the TUN device.

- `sudo sh -c "cat << EOF > /etc/systemd/network/99-free5gc.netdev`
- `[NetDev]`
- `Name=uptun`
- `Kind=tun`
- `EOF"`
- `sudo systemctl enable systemd-networkd`
- `sudo systemctl restart systemd-networkd`

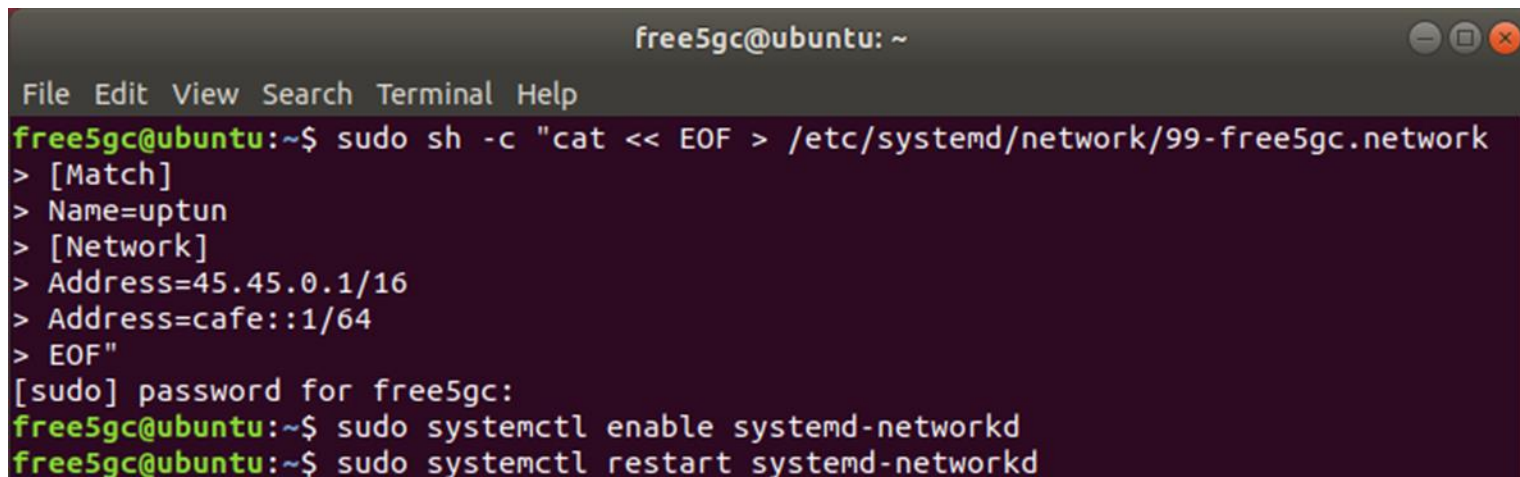
A terminal window titled 'free5gc@ubuntu: ~' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the following commands and output:

```
free5gc@ubuntu:~$ sudo sh -c "cat << EOF > /etc/systemd/network/99-free5gc.netdev
> [NetDev]
> Name=uptun
> Kind=tun
> EOF"
[sudo] password for free5gc:
free5gc@ubuntu:~$ sudo systemctl enable systemd-networkd
free5gc@ubuntu:~$ sudo systemctl restart systemd-networkd
free5gc@ubuntu:~$
```

# IPv6 Disabled for TUN Device

#If IPv6 is disabled for TUN device, please  
remove Address=cafe::1/64 from below

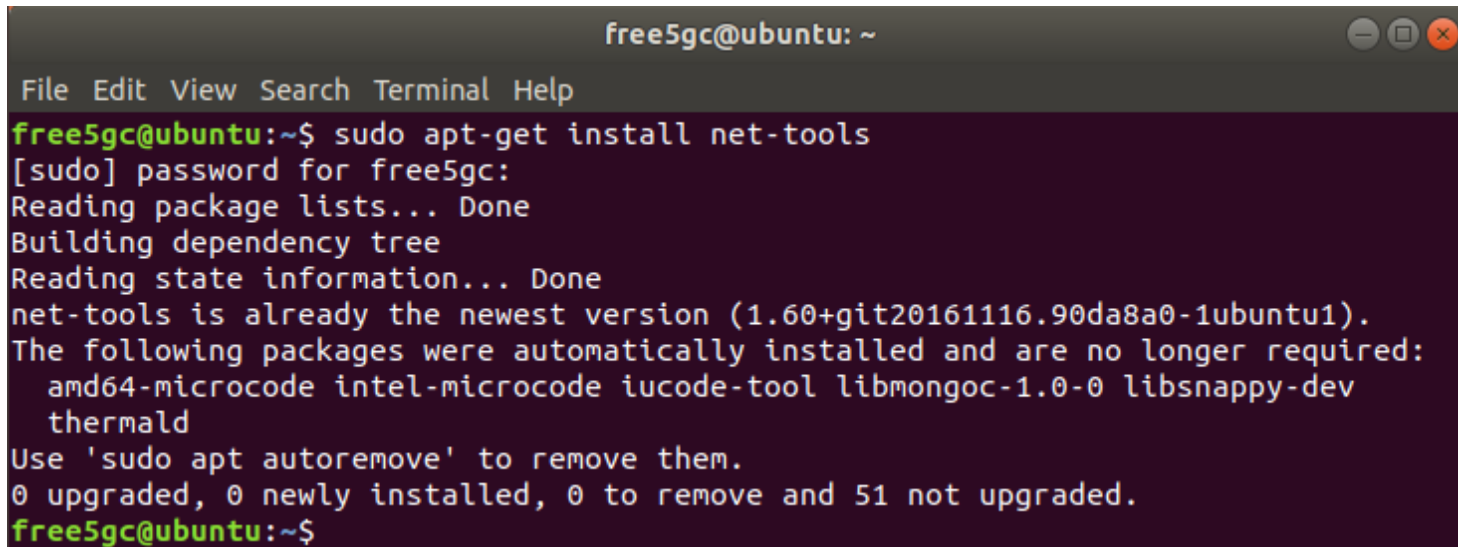
- `sudo sh -c "cat << EOF > /etc/systemd/network/99-free5gc.network"`
- `[Match]`
- `Name=uptun`
- `[Network]`
- `Address=45.45.0.1/16`
- `Address=cafe::1/64`
- `EOF`
- `sudo systemctl enable systemd-networkd`
- `sudo systemctl restart systemd-networkd`



```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ sudo sh -c "cat << EOF > /etc/systemd/network/99-free5gc.network  
> [Match]  
> Name=uptun  
> [Network]  
> Address=45.45.0.1/16  
> Address=cafe::1/64  
> EOF"  
[sudo] password for free5gc:  
free5gc@ubuntu:~$ sudo systemctl enable systemd-networkd  
free5gc@ubuntu:~$ sudo systemctl restart systemd-networkd
```

# Check if Uptun is Up

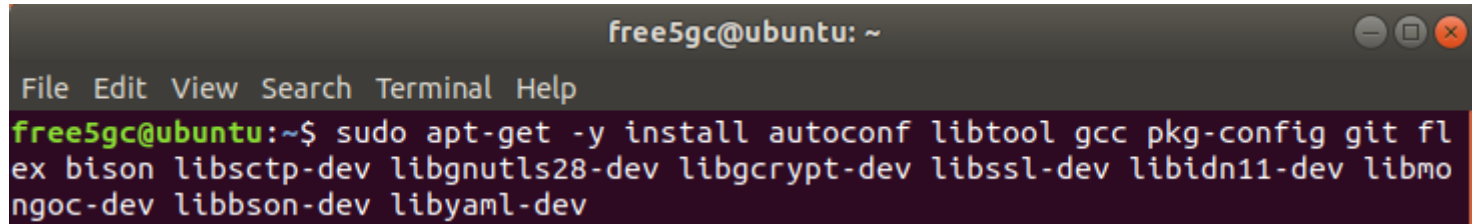
- `sudo apt-get install net-tools`

A terminal window titled 'free5gc@ubuntu: ~' with standard window controls. The terminal shows the command 'sudo apt-get install net-tools' being executed. The output indicates that 'net-tools' is already the newest version and lists several packages that were automatically installed and are no longer required: amd64-microcode, intel-microcode, iucode-tool, libmongoc-1.0-0, libsnappy-dev, and thermald. It suggests using 'sudo apt autoremove' to remove them. The final status is '0 upgraded, 0 newly installed, 0 to remove and 51 not upgraded.'

```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ sudo apt-get install net-tools  
[sudo] password for free5gc:  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
net-tools is already the newest version (1.60+git20161116.90da8a0-1ubuntu1).  
The following packages were automatically installed and are no longer required:  
  amd64-microcode intel-microcode iucode-tool libmongoc-1.0-0 libsnappy-dev  
  thermald  
Use 'sudo apt autoremove' to remove them.  
0 upgraded, 0 newly installed, 0 to remove and 51 not upgraded.  
free5gc@ubuntu:~$
```

# Install the Dependencies for Building the Source

- `sudo apt-get -y install autoconf libtool gcc pkg-config git flex bison libsctp-dev libgnutls28-dev libgcrypt-dev libssl-dev libidn11-dev libmongoc-dev libbson-dev libyaml-dev`

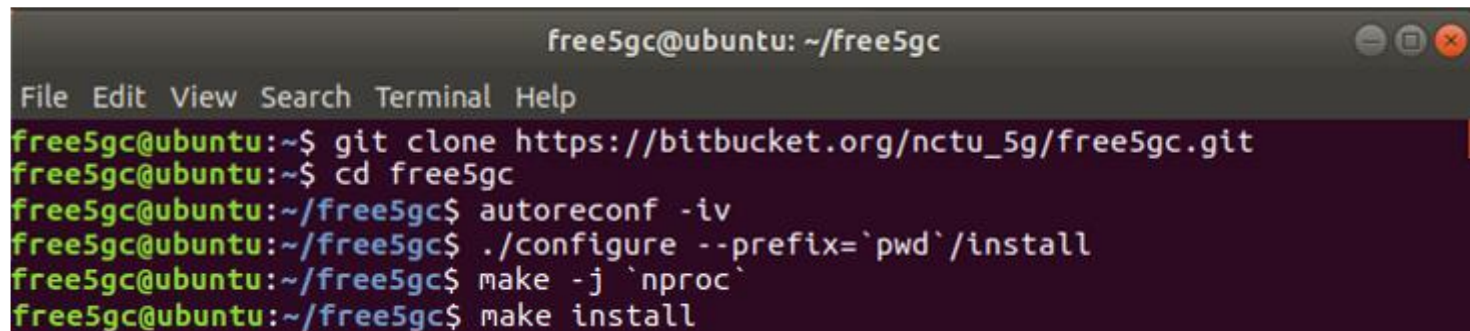
A screenshot of a terminal window titled 'free5gc@ubuntu: ~'. The window has a menu bar with 'File', 'Edit', 'View', 'Search', 'Terminal', and 'Help'. The terminal shows the command 'sudo apt-get -y install autoconf libtool gcc pkg-config git flex bison libsctp-dev libgnutls28-dev libgcrypt-dev libssl-dev libidn11-dev libmongoc-dev libbson-dev libyaml-dev' being entered at the prompt 'free5gc@ubuntu:~\$'.

```
free5gc@ubuntu: ~
File Edit View Search Terminal Help
free5gc@ubuntu:~$ sudo apt-get -y install autoconf libtool gcc pkg-config git fl
ex bison libsctp-dev libgnutls28-dev libgcrypt-dev libssl-dev libidn11-dev libmo
ngoc-dev libbson-dev libyaml-dev
```



## 2. Free5gc Git Clone and Compile

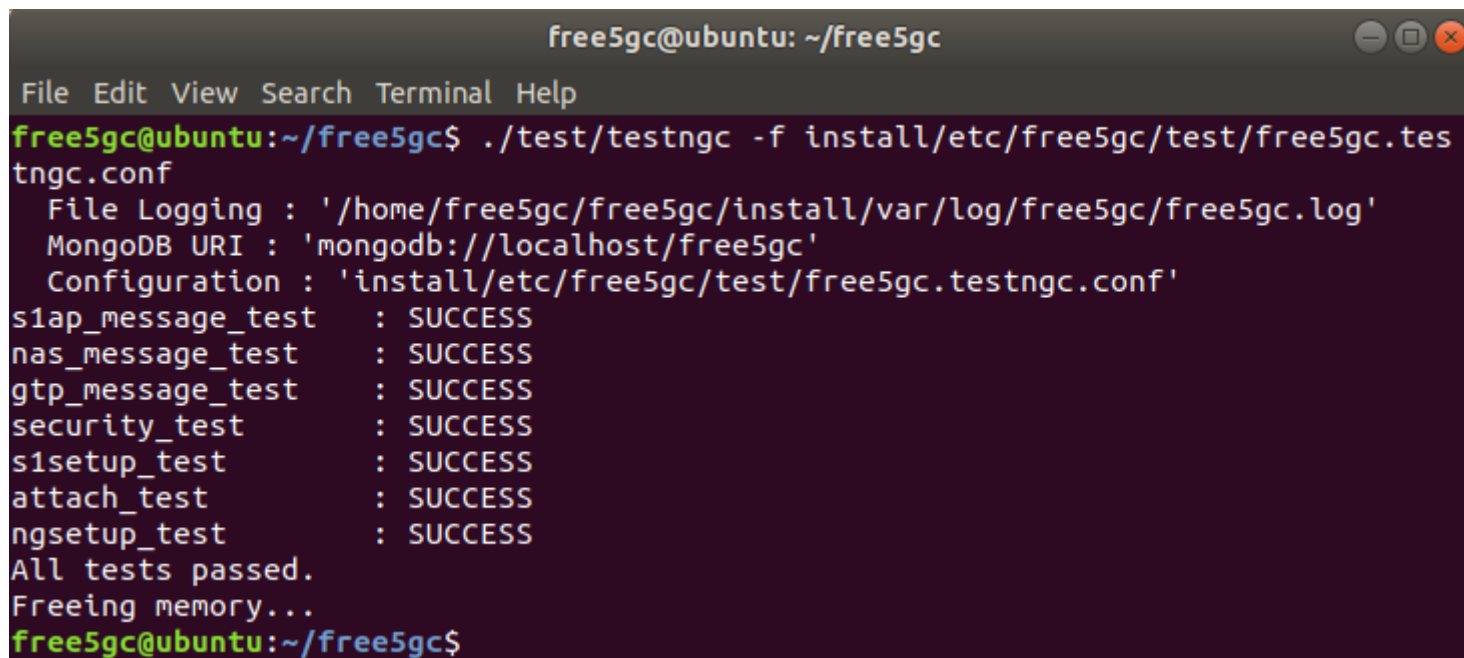
- `git clone https://bitbucket.org/nctu_5g/free5gc.git`
- `cd free5gc`
- `autoreconf -iv`
- `./configure --prefix=`pwd`/install`
- `make -j `nproc``
- `make install`



```
free5gc@ubuntu: ~/free5gc
File Edit View Search Terminal Help
free5gc@ubuntu:~$ git clone https://bitbucket.org/nctu_5g/free5gc.git
free5gc@ubuntu:~$ cd free5gc
free5gc@ubuntu:~/free5gc$ autoreconf -iv
free5gc@ubuntu:~/free5gc$ ./configure --prefix=`pwd`/install
free5gc@ubuntu:~/free5gc$ make -j `nproc`
free5gc@ubuntu:~/free5gc$ make install
```

# 確認安裝

- `./test/testngc -f install/etc/free5gc/test/free5gc.testngc.conf`



```
free5gc@ubuntu: ~/free5gc
File Edit View Search Terminal Help
free5gc@ubuntu:~/free5gc$ ./test/testngc -f install/etc/free5gc/test/free5gc.testngc.conf
  File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
  MongoDB URI  : 'mongodb://localhost/free5gc'
  Configuration : 'install/etc/free5gc/test/free5gc.testngc.conf'
s1ap_message_test      : SUCCESS
nas_message_test       : SUCCESS
gtp_message_test       : SUCCESS
security_test          : SUCCESS
s1setup_test           : SUCCESS
attach_test            : SUCCESS
ngsetup_test           : SUCCESS
All tests passed.
Freeing memory...
free5gc@ubuntu:~/free5gc$
```

# (發生問題&解決方法)

- 查詢前面MongoDB, Golang是否有成功啟動/安裝。

# Check the Environment of NIC

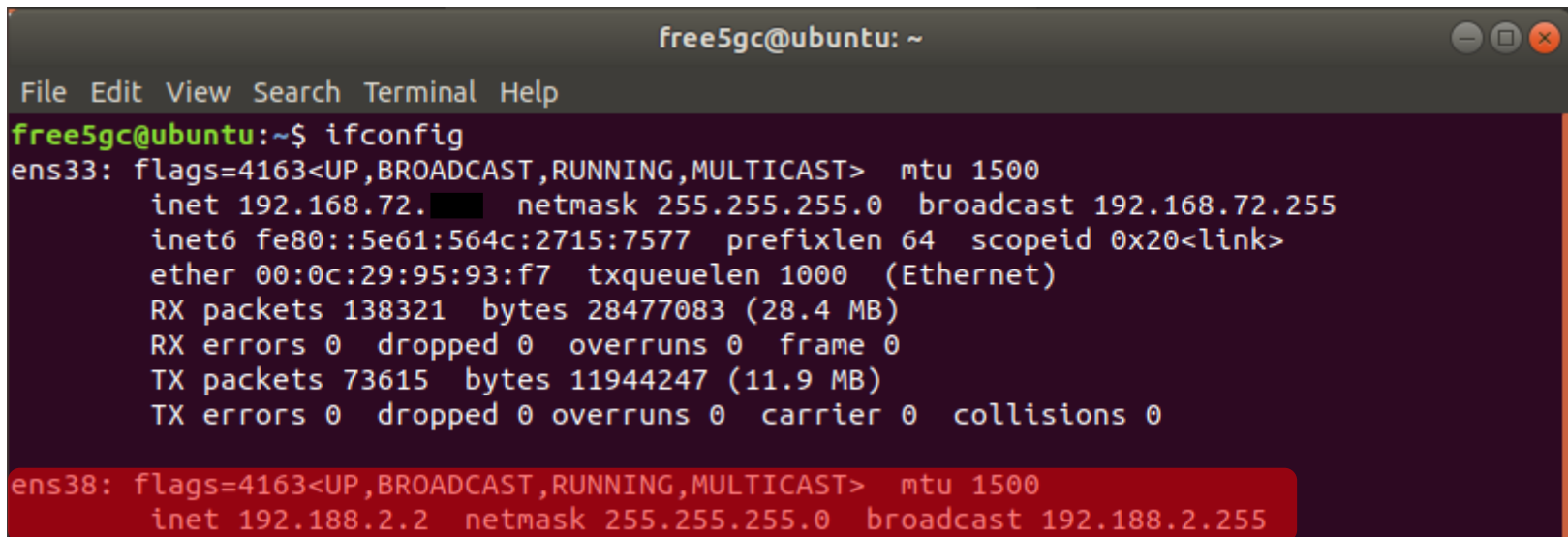
#NIC for connecting to the Internet :

- ens33

#NIC for connecting to eNB :

- Ens38

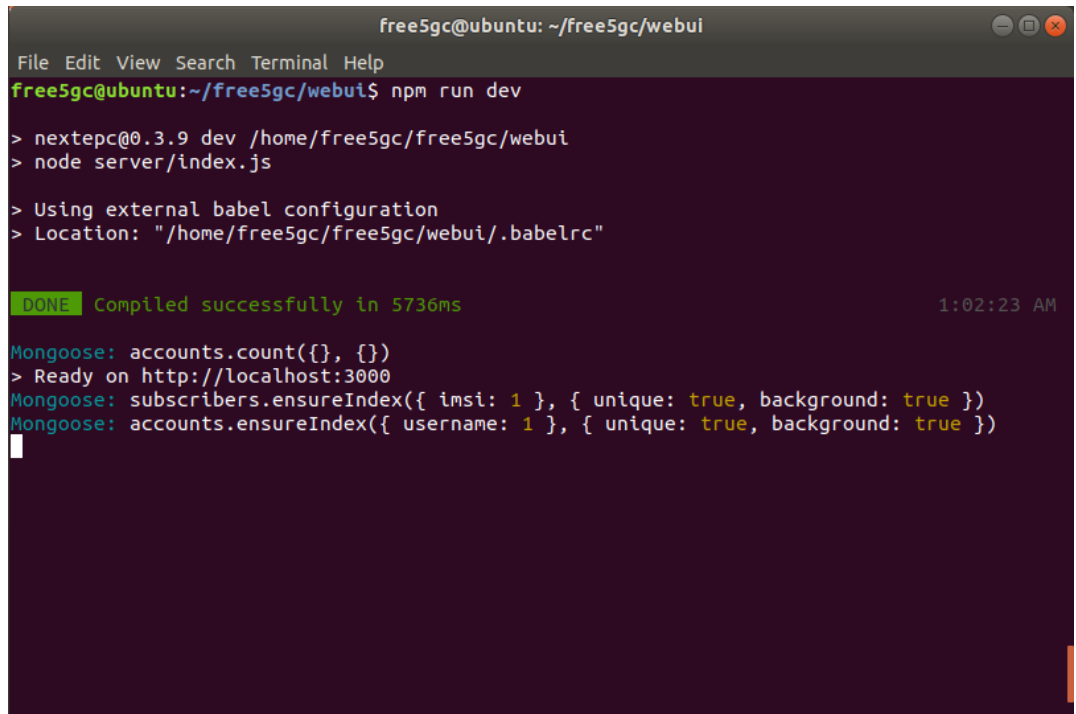
- ifconfig



```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ ifconfig  
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
    inet 192.168.72.1 netmask 255.255.255.0 broadcast 192.168.72.255  
    inet6 fe80::5e61:564c:2715:7577 prefixlen 64 scopeid 0x20<link>  
    ether 00:0c:29:95:93:f7 txqueuelen 1000 (Ethernet)  
    RX packets 138321 bytes 28477083 (28.4 MB)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 73615 bytes 11944247 (11.9 MB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
ens38: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
    inet 192.188.2.2 netmask 255.255.255.0 broadcast 192.188.2.255
```

### 3. Configuring the Core Network and Adding User Information

- `sudo ifconfig ens38 192.188.2.2`
- `cd free5gc/webui/`
- `sudo apt install npm`
- `npm install`
- `npm run dev`



```
free5gc@ubuntu: ~/free5gc/webui
File Edit View Search Terminal Help
free5gc@ubuntu:~/free5gc/webui$ npm run dev
> nextepc@0.3.9 dev /home/free5gc/free5gc/webui
> node server/index.js

> Using external babel configuration
> Location: "/home/free5gc/free5gc/webui/.babelrc"

DONE Compiled successfully in 5736ms 1:02:23 AM

Mongoose: accounts.count({}, {})
> Ready on http://localhost:3000
Mongoose: subscribers.ensureIndex({ imsi: 1 }, { unique: true, background: true })
Mongoose: accounts.ensureIndex({ username: 1 }, { unique: true, background: true })
```

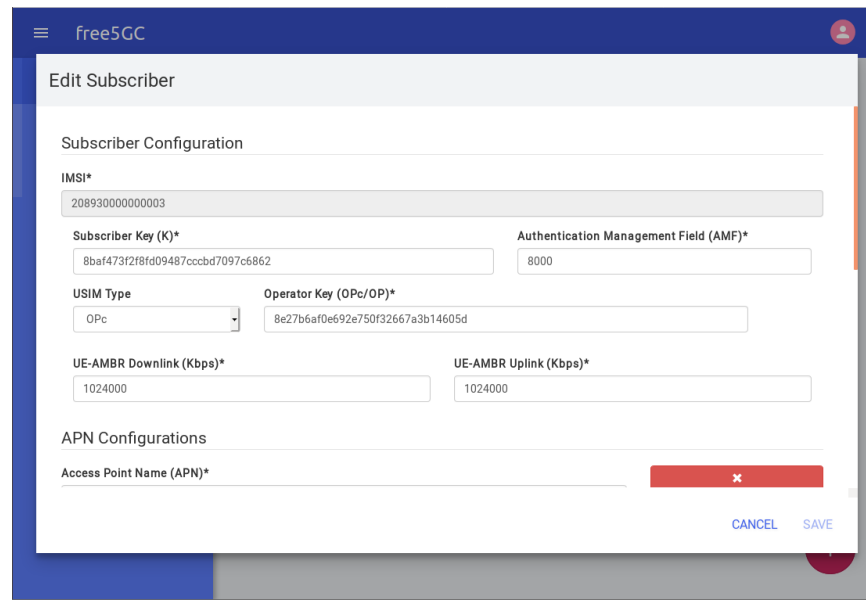
# Successfully

#Successfully visit <http://localhost:3000>

```
free5gc@ubuntu: ~/free5gc/webui
File Edit View Search Terminal Help
DONE Compiled successfully in 8286ms 1:09:42 AM
WAIT Compiling... 1:09:45 AM
DONE Compiled successfully in 2390ms 1:09:48 AM
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
Mongoose: accounts.findOne({ '$or': [ { username: 'admin' } ] }, { fields: { hash: 0, salt: 0 } })
```

# Add User Information

- Visit <http://localhost:3000>
  - Username : admin
  - Password : 1423
- Add a subscriber with IMSI, K, OPc
  - USIM information (in this example)
    - IMSI 208930000000003
    - K 8baf473f2f8fd09487cccbd7097c6862
    - OPc 8e27b6af0e692e750f32667a3b14605d
- Save



The screenshot shows the 'free5GC' web interface for editing a subscriber. The form is titled 'Edit Subscriber' and contains the following sections and fields:

- Subscriber Configuration**
  - IMSI\***: 208930000000003
  - Subscriber Key (K)\***: 8baf473f2f8fd09487cccbd7097c6862
  - Authentication Management Field (AMF)\***: 8000
  - USIM Type**: OPc (selected from a dropdown)
  - Operator Key (OPc/OP)\***: 8e27b6af0e692e750f32667a3b14605d
  - UE-AMBR Downlink (Kbps)\***: 1024000
  - UE-AMBR Uplink (Kbps)\***: 1024000
- APN Configurations**
  - Access Point Name (APN)\***: (empty field)

At the bottom right, there are 'CANCEL' and 'SAVE' buttons, and a red button with a close icon (X) is visible above the 'SAVE' button.

## (發生問題&解決方法)

- 查詢npm install是否安裝正確，npm套件可能在安裝中打結。



## 4. Rebuild Project

- (Ctrl-C kill free5gc-ngcd)
- make maintainer-clean
- rm -rf ./install
- git pull
- autoreconf -iv
- ./configure --prefix=`pwd`/install
- make -j `nproc`
- make install
- ./free5gc-ngcd

# (發生問題&解決方法)

- 查詢前面MongoDB, Golang是否有成功啟動/安裝。

## 5. 安裝並設定OAI的eNB軟體

1. 安裝Ubuntu 14.04 Linux 3.19 Low-latency Kernel
2. 取得認證並下載OAI 的eNB軟體
3. 設定eNB的網卡
4. eNB軟體設定

# 安裝 Ubuntu 14.04 (ubuntu-14.04.4-desktop-amd64)

- A. 安裝時選擇英文。
- B. 開啟終端機輸入以下指令將更新所有已安裝套件。
  - `sudo apt-get update`
  - `sudo apt-get upgrade`

## 下載及安裝必要套件和Kernel

在eNB上開啟一個新的終端機，並且輸入

- `sudo apt-get install linux-image-3.19.0-61-lowlatency  
linux-headers-3.19.0-61-lowlatency`
- `sudo apt-get install cpufrequtils`
- `sudo apt-get install i7z`

## 修改開機選單和設定

在終端機輸入以下指令

- `sudo gedit /etc/default/grub`

"GRUB\_HIDDEN\_TIMEOUT=0" 改成  
"#GRUB\_HIDDEN\_TIMEOUT=60"

然後把

GRUB\_CMDLINE\_LINUX\_DEFAULT = ""

改成

GRUB\_CMDLINE\_LINUX\_DEFAULT="quiet  
intel\_pstate=disable processor.max\_cstate=1  
intel\_idle.max\_cstate=0 idle=poll"

## 修改開機選單和設定(2)

在終端機輸入以下指令

- `sudo gedit /etc/default/cpufrequtils`

新增以下這行指令

**GOVERNOR="performance"**

然後儲存並關閉

## 更新剛才的設定

在終端機輸入以下指令

- `sudo update-grub2`
- `sudo update-rc.d ondemand disable`

然後終端機輸入以下指令，重啟電腦

- `sudo reboot`



# 下載git套件並取得認證

開啟一個新的終端機，並且輸入

- `sudo apt-get install subversion git`
- `git config --global user.name "輸入你的名稱"`
- `git config --global user.email "輸入你的電子信箱"`
- `sudo su`
- `echo -n | openssl s_client -showcerts -connect gitlab.eurecom.fr:443  
2>/dev/null | sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIFICATE-/p' >>  
/etc/ssl/certs/ca-certificates.crt`
- `exit`

➤ 請先前往Gitlab註冊

➤ 如果這一頁的指令執行正確，終端機是不會有任何訊息產生

## 下載源始碼並 安裝OAI eNB軟體所需的套件

在終端機輸入

- `git clone https://gitlab.eurecom.fr/oai/openairinterface5g.git`

在終端機輸入以下指令來下載並安裝OAI eNB軟體所需的套件

- `cd ~/openairinterface5g`
- `source oaienv`
- `cd cmake_targets`
- `./build_oai -l --eNB -x --install-system-files -w USRP --install-optional-packages`

# 修改eNB的設定檔

在終端機輸入

- `gedit ~/openairinterface5g/targets/PROJECTS/GENERIC-LTE-EPC/CONF/enb.band39.tm1.usrpb210.conf`

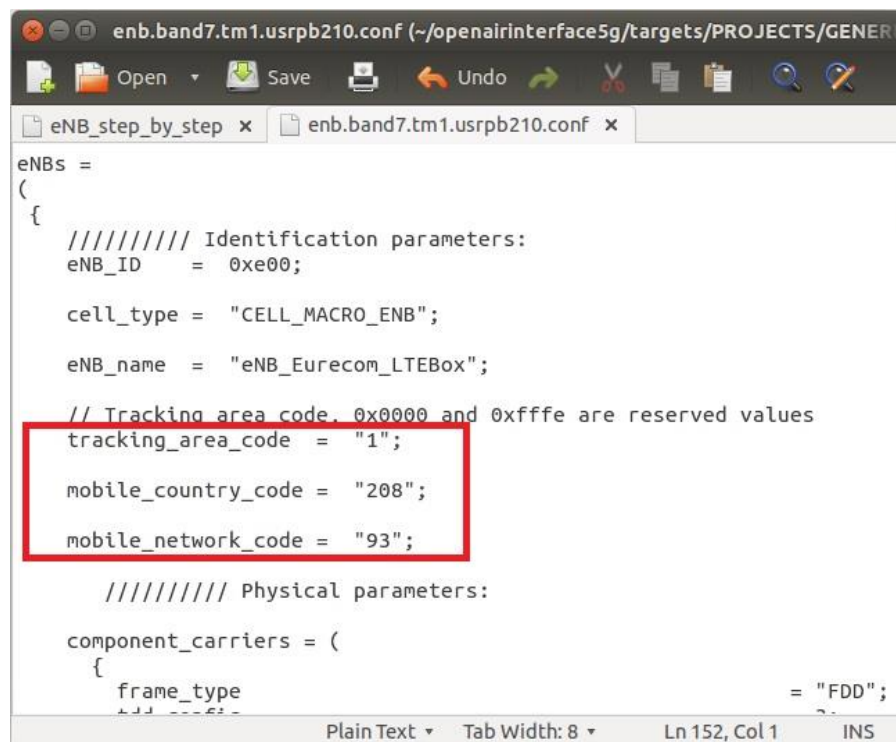
或

- `gedit ~/openairinterface5g/targets/PROJECTS/GENERIC-LTE-EPC/CONF/enb.band7.tm1.usrpb210.conf`

➤ 在“~/openairinterface5g/targets/PROJECTS/GENERIC-LTE-EPC/CONF/”目錄下有很多種eNB的設定檔，當eNB啓動時會載入這些設定檔，有需要的話可以修改訊號頻率，這裡是使用Band 39 和 Band 7

## 修改eNB的設定檔(2)

修改以下設定



```
eNBs =
(
{
////////// Identification parameters:
eNB_ID      = 0xe00;

cell_type   = "CELL_MACRO_ENB";

eNB_name    = "eNB_Eurecom_LTEBox";

// Tracking area code. 0x0000 and 0xfffe are reserved values
tracking_area_code = "1";

mobile_country_code = "208";
mobile_network_code = "93";

////////// Physical parameters:

component_carriers = (
{
    frame_type = "FDD";
```

- 設定mobile\_country\_code、mobile\_network\_code、tracking\_area\_code這三個部分，須確定跟EPC的資料庫及SIM卡中的MCC、MNC、TAC這三部分對應

## 修改eNB的設定檔(3)

設定eNB所連接的EPC的IP位址

**ipv4 = "EPC 對內網卡的IP"**

**ENB\_INTERFACE\_NAME\_FOR\_S1\_MME = "eNB的網卡名稱"**

**ENB\_IPV4\_ADDRESS\_FOR\_S1\_MME = "eNB的網卡IP"**

**ENB\_INTERFACE\_NAME\_FOR\_S1U = "eNB的網卡名稱"**

**ENB\_IPV4\_ADDRESS\_FOR\_S1U = "eNB的網卡IP"**

## 修改eNB的設定檔(3)-本例

- 設定eNB所連接的5GC的IP位址

```
140
141 ////////////// MME parameters:
142 nme_ip_address = ( [ ipv4      = "192.188.2.2";
143                    ipv6      = "192:168:30::17";
144                    active    = "yes";
145                    preference = "ipv4";
146                    ]
147                );
148
149 NETWORK_INTERFACES :
150 {
151     ENB_INTERFACE_NAME_FOR_S1_MME      = "enp0s31f6";
152     ENB_IPV4_ADDRESS_FOR_S1_MME        = "192.188.2.253/24";
153
154     ENB_INTERFACE_NAME_FOR_S1U         = "enp0s31f6";
155     ENB_IPV4_ADDRESS_FOR_S1U           = "192.188.2.253/24";
156     ENB_PORT_FOR_S1U                   = 2152; # Spec 2152
157 };
158
```

## 重新編譯eNB

在終端機輸入

- `cd ~/openairinterface5g`
- `source oaienv`
- `./cmake_targets/build_oai -w USRP -x -c --eNB`
- `cd cmake_targets/lte_build_oai/build`

# (發生問題&解決方法)

- 檢查CPU的效能設定

- (在終端機輸入)

- sudo i7z (確認CPU頻率)

- cpufreq-info (CPU Frequency Scaling從Powersave模式變為Performance模式)

- 確認Kernel版本

- uname -a

```
enb@enb:~$ sudo i7z
Cpu speed from cpufreq 3591.00Mhz
cpufreq might be wrong if cpufreq is enabled. To guess correctly try estimating
Linux's inbuilt cpu_khz code emulated now
True Frequency (without accounting Turbo) 3591 MHz
CPU Multiplier 36x || Bus clock frequency (BCLK) 99.75 MHz

Socket [0] - [physical cores=4, logical cores=8, max online cores ever=4]
TURBO ENABLED on 4 Cores, Hyper Threading ON
Max Frequency without considering Turbo 3690.75 MHz (99.75 x [37])
Max TURBO Multiplier (if Enabled) with 1/2/3/4 Cores is 40x/40x/39x/38x
Real Current Frequency 3790.40 MHz [99.75 x 38.00] (Max of below)
Core [core-id] :Actual Freq (Mult.) C0% Halt(C1)% C3 % C6 %
Core 1 [0]: 3790.40 (38.00x) 100 0 0 0
Core 2 [1]: 3790.40 (38.00x) 100 0 0 0
Core 3 [2]: 3790.40 (38.00x) 100 0 0 0
Core 4 [3]: 3790.40 (38.00x) 100 0 0 0

C0 = Processor running without halting
C1 = Processor running with halts (States >C0 are power saver)
C3 = Cores running with PLL turned off and core cache turned off
C6 = Everything in C3 + core state saved to last level cache
Above values in table are in percentage over the last 1 sec
```

```
enb@enb:~$ cpufreq-info
cpufrequtils 008: cpufreq-info (C) Dominik Brodowski 2004-2009
Report errors and bugs to cpufreq@vger.kernel.org, please.
analyzing CPU 0:
  driver: intel_pstate
  CPUs which run at the same hardware frequency: 0
  CPUs which need to have their frequency coordinated by software: 0
  maximum transition latency: 0.97 ms.
  hardware limits: 800 MHz - 4.00 GHz
  available cpufreq governors: performance, powersave
  current policy: frequency should be within 800 MHz and 4.00 GHz.
                   The governor "performance" may decide which speed to use
                   within this range.
  current CPU frequency is 3.80 GHz.
```

```
enb@enb:~$ uname -a
Linux enb 3.19.0-61-lowlatency #69~14.04.1-Ubuntu SMP
enb@enb:~$
```



## 6.Free5GC Demo

#啟動五個Terminal分別執行

- ./nextepc-hssd
- ./free5gc-amfd
- ./free5gc-smfd
- ./nextepc-pcrfd
- ./free5gc-upfd

# 執行hssd

- cd free5gc
- ./nextepc-hssd

```
free5gc@ubuntu: ~/free5gc
File Edit View Search Terminal Help
free5gc@ubuntu:~$ cd free5gc
free5gc@ubuntu:~/free5gc$ ./next-hssd
bash: ./next-hssd: No such file or directory
free5gc@ubuntu:~/free5gc$ ./nextepc-hssd
free5GC daemon v1.0.0 - Jul 17 2019 00:12:06

PID[87364] : '/home/free5gc/free5gc/install/var/run/nextepc-hssd/pid'
File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
MongoDB URI : 'mongodb://localhost/free5gc'
Configuration : '/home/free5gc/free5gc/install/etc/free5gc/free5gc.conf'
[07/22 23:29:48.305] HSS try to initialize
[07/22 23:29:48.369] HSS initialize...done

[07/22 23:29:48.369] INFO: free5GC daemon start (main.c:157)
^C[07/22 23:30:13.880] INFO: SIGINT received (main.c:50)
[07/22 23:30:13.881] INFO: free5GC daemon terminating... (main.c:160)
[07/22 23:30:13.881] HSS try to terminate
[07/22 23:30:13.895] freeDiameter[6]: Initiating freeDiameter shutdown sequence (3)
[07/22 23:30:14.179] HSS terminate...done
[07/22 23:30:14.179] DB-Client try to terminate
[07/22 23:30:14.191] DB-Client terminate...done
free5gc@ubuntu:~/free5gc$ ./nextepc-hssd
free5GC daemon v1.0.0 - Jul 17 2019 00:12:06

PID[87425] : '/home/free5gc/free5gc/install/var/run/nextepc-hssd/pid'
File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
MongoDB URI : 'mongodb://localhost/free5gc'
Configuration : '/home/free5gc/free5gc/install/etc/free5gc/free5gc.conf'
[07/22 23:30:19.309] HSS try to initialize
[07/22 23:30:19.356] HSS initialize...done

[07/22 23:30:19.356] INFO: free5GC daemon start (main.c:157)
[07/22 23:30:52.061] INFO: CONNECTED TO 'amf.localdomain' (TCP,soc#8): (fd_logger.c:93)
```

# 執行amfd

- cd free5gc
- ./free5gc-amfd

```
free5gc@ubuntu: ~/free5gc
File Edit View Search Terminal Help
free5gc@ubuntu:~$ cd free5gc
free5gc@ubuntu:~/free5gc$ ./free5gc-amfd
free5GC daemon v1.0.0 - Jul 17 2019 00:12:06

PID[87465] : '/home/free5gc/free5gc/install/var/run/free5gc-amfd/pid'
File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
MongoDB URI : 'mongodb://localhost/free5gc'
Configuration : '/home/free5gc/free5gc/install/etc/free5gc/free5gc.conf'
[07/22 23:30:50.126] AMF try to initialize
[07/22 23:30:52.002] AMF initialize...done

[07/22 23:30:52.002] INFO: free5GC daemon start (main.c:157)
[07/22 23:30:52.008] sip_server() [192.188.2.2]:36412
[07/22 23:30:52.080] INFO: CONNECTED TO 'hss.localdomain' (TCP,soc#10): (fd_logger.c:93)
[07/23 06:30:56.001] AM4G overload_start (load_avg/n_cores=2.34, threshold=0.80)
[07/23 06:35:44.900] AMF4G overload_stop (load_avg/n_cores=0.76, threshold=0.80)
[07/23 07:02:40.429] AM4G overload_start (load_avg/n_cores=1.12, threshold=0.80)
[07/23 07:05:13.082] AMF4G overload_stop (load_avg/n_cores=0.73, threshold=0.80)
[07/23 18:29:50.165] AM4G overload_start (load_avg/n_cores=1.05, threshold=0.80)
[07/23 18:31:12.941] AMF4G overload_stop (load_avg/n_cores=0.68, threshold=0.80)
[07/24 05:26:14.151] AM4G overload_start (load_avg/n_cores=2.48, threshold=0.80)
[07/24 05:30:33.873] AMF4G overload_stop (load_avg/n_cores=0.80, threshold=0.80)
[07/24 05:57:31.262] AM4G overload_start (load_avg/n_cores=1.45, threshold=0.80)
[07/24 05:58:43.459] AMF4G overload_stop (load_avg/n_cores=0.74, threshold=0.80)
[07/24 06:28:20.411] AM4G overload_start (load_avg/n_cores=1.64, threshold=0.80)
[07/24 06:30:21.532] AMF4G overload_stop (load_avg/n_cores=0.79, threshold=0.80)
[07/24 07:30:37.785] AM4G overload_start (load_avg/n_cores=0.90, threshold=0.80)
[07/24 07:31:27.969] AMF4G overload_stop (load_avg/n_cores=0.77, threshold=0.80)
[07/24 08:01:11.528] AM4G overload_start (load_avg/n_cores=0.99, threshold=0.80)
[07/24 08:01:41.589] AMF4G overload_stop (load_avg/n_cores=0.73, threshold=0.80)
[07/24 08:31:48.005] AM4G overload_start (load_avg/n_cores=0.81, threshold=0.80)
[07/24 08:32:52.316] AMF4G overload_stop (load_avg/n_cores=0.68, threshold=0.80)
[07/24 09:03:00.526] AM4G overload_start (load_avg/n_cores=0.87, threshold=0.80)
[07/24 09:04:14.193] AMF4G overload_stop (load_avg/n_cores=0.76, threshold=0.80)
[07/24 09:34:22.002] AM4G overload_start (load_avg/n_cores=1.14, threshold=0.80)
[07/24 09:34:52.100] AMF4G overload_stop (load_avg/n_cores=0.69, threshold=0.80)
[07/24 10:04:45.318] AM4G overload_start (load_avg/n_cores=1.13, threshold=0.80)
[07/24 10:05:25.824] AMF4G overload_stop (load_avg/n_cores=0.68, threshold=0.80)
```

# 執行smfd

- `cd free5gc`
- `./free5gc-smfd`

```
free5gc@ubuntu: ~/free5gc
File Edit View Search Terminal Help
free5gc@ubuntu:~$ cd free5gc
free5gc@ubuntu:~/free5gc$ ./free5gc-smfd
free5GC daemon v1.0.0 - Jul 17 2019 00:12:06

  PID[87539] : '/home/free5gc/free5gc/install/var/run/free5gc-smfd/pid'
  File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
  MongoDB URI : 'mongodb://localhost/free5gc'
  Configuration : '/home/free5gc/free5gc/install/etc/free5gc/free5gc.conf'
[07/22 23:31:20.703] SMF try to initialize
[07/22 23:31:21.080] pfcps_server() [127.0.0.2]:8805
[07/22 23:31:21.080] pfcps_connect() [192.188.2.2]:8805
[07/22 23:31:21.080] pfcps_xact_local_create 1 not freed in pfcps_xact_pool[64] of PFCP
Transaction
[07/22 23:31:21.080] SMF initialize...done

[07/22 23:31:21.081] INFO: free5GC daemon start (main.c:157)
[07/22 23:31:21.083] ERRR: corek_rcvfrom(len:8192) failed(111:Connection refused) (unix/socket.c:635)
[07/22 23:31:21.083] WARN: core_rcv failed(111:Connection refused) (pfcps_path.c:208)
[07/22 23:31:24.086] ERRR: corek_rcvfrom(len:8192) failed(111:Connection refused) (unix/socket.c:635)
[07/22 23:31:24.087] WARN: core_rcv failed(111:Connection refused) (pfcps_path.c:208)
[07/22 23:31:27.097] ERRR: corek_rcvfrom(len:8192) failed(111:Connection refused) (unix/socket.c:635)
[07/22 23:31:27.098] WARN: core_rcv failed(111:Connection refused) (pfcps_path.c:208)
[07/22 23:31:30.104] WARN: [1] LOCAL No Reponse. Give up! for step 1 type 5 peer [192.188.2.2]:8805 (pfcps_xact.c:671)
[07/22 23:31:57.911] INFO: CONNECTED TO 'pcrf.localdomain' (TCP,soc#9): (fd_logger.c:93)
[07/24 05:27:32.382] ERRR: DROPPED 'Answer received with no corresponding sent request' (fd_logger.c:116)
```

# 執行pcrfd

- cd free5gc
- ./nextepc-pcrfd

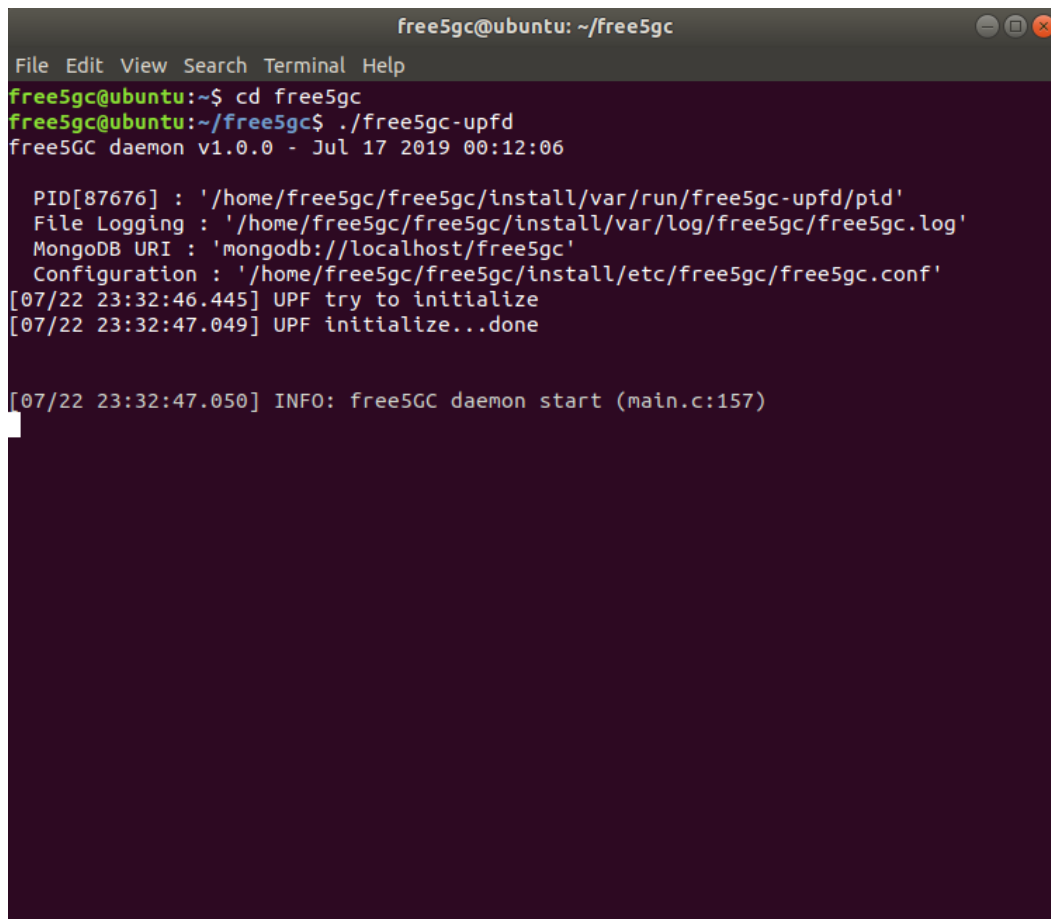
```
free5gc@ubuntu: ~/free5gc
File Edit View Search Terminal Help
free5gc@ubuntu:~$ cd free5gc
free5gc@ubuntu:~/free5gc$ ./nextepc-pcrfd
free5GC daemon v1.0.0 - Jul 17 2019 00:12:00

PID[87607] : '/home/free5gc/free5gc/install/var/run/nextepc-pcrfd/pid'
File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
MongoDB URI : 'mongodb://localhost/free5gc'
Configuration : '/home/free5gc/free5gc/install/etc/free5gc/free5gc.conf'
[07/22 23:31:57.884] PCRf try to initialize
[07/22 23:31:57.910] PCRf initialize...done

[07/22 23:31:57.910] INFO: free5GC daemon start (main.c:157)
[07/22 23:31:57.912] INFO: CONNECTED TO 'smf.localdomain' (TCP,soc#10): (fd_logger.c:93)
[07/24 05:27:32.451] ERROR: DROPPED 'Answer received with no corresponding sent request.' (fd_init.c:116)
[07/24 05:27:35.846] ERROR: 'Device-Watchdog-Answer' (fd_init.c:116)
[07/24 05:27:35.846] ERROR: Version: 0x01 (fd_init.c:116)
[07/24 05:27:35.846] ERROR: Length: 88 (fd_init.c:116)
[07/24 05:27:35.846] ERROR: Flags: 0x00 (----) (fd_init.c:116)
[07/24 05:27:35.846] ERROR: Command Code: 280 (fd_init.c:116)
[07/24 05:27:35.846] ERROR: ApplicationId: 0 (fd_init.c:116)
[07/24 05:27:35.846] ERROR: Hop-by-Hop Identifier: 0x1A73F796 (fd_init.c:116)
[07/24 05:27:35.846] ERROR: End-to-End Identifier: 0x9DDD28FD (fd_init.c:116)
[07/24 05:27:35.846] ERROR: {internal data}: src:smf.localdomain(15) rwb:(nil) rt:0 c
b:(nil),(nil)((nil)) gry:(nil) asso:0 sess:(nil) (fd_init.c:116)
[07/24 05:27:35.846] ERROR: AVP: 'Result-Code'(268) l=12 f=-M val='DIAMETER_SUCCESS'
(2001 (0x7d1)) (fd_init.c:116)
[07/24 05:27:35.846] ERROR: AVP: 'Origin-Host'(264) l=23 f=-M val="smf.localdomain" (
fd_init.c:116)
[07/24 05:27:35.846] ERROR: AVP: 'Origin-Realm'(296) l=19 f=-M val="localdomain" (fd_
init.c:116)
[07/24 05:27:35.846] ERROR: AVP: 'Origin-State-Id'(278) l=12 f=-M val=1563863481 (0x5
d36a9b9) (fd_init.c:116)
[07/24 05:29:03.004] INFO: CONNECTED TO 'smf.localdomain' (TCP,soc#9): (fd_logger.c:93)
```

# 執行upfd

- `cd free5gc`
- `./free5gc-upfd`

A terminal window titled 'free5gc@ubuntu: ~/free5gc' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the following commands and output:

```
free5gc@ubuntu:~$ cd free5gc
free5gc@ubuntu:~/free5gc$ ./free5gc-upfd
free5GC daemon v1.0.0 - Jul 17 2019 00:12:06

  PID[87676] : '/home/free5gc/free5gc/install/var/run/free5gc-upfd/pid'
  File Logging : '/home/free5gc/free5gc/install/var/log/free5gc/free5gc.log'
  MongoDB URI : 'mongodb://localhost/free5gc'
  Configuration : '/home/free5gc/free5gc/install/etc/free5gc/free5gc.conf'
[07/22 23:32:46.445] UPF try to initialize
[07/22 23:32:47.049] UPF initialize...done

[07/22 23:32:47.050] INFO: free5GC daemon start (main.c:157)
```

# 執行eNB

在另一台電腦的終端機輸入以下其中一個指令，選擇不同的Band

- `sudo -E ./lte-softmodem -O $OPENAIR_DIR/targets/PROJECTS/GENERIC-LTE-EPC/CONF/enb.band39.tm1.usrpb210.conf -d`

# eNB運行成功

- 若運行成功，會出現以下訊息



# SIM Card資料

- 此例的SIM Card資料是使用Free5gc官方所提供的SIM Card資料範例，可跟據自己的情況來燒錄SIM Card的資料
- IMSI 208930000000003
- K 8baf473f2f8fd09487cccbd7097c6862
- OPc 8e27b6af0e692e750f32667a3b14605d
- MCC: 208 (FR)
- MNC: 93 (new MNO MNC)

# 使用智慧型手機ASUS Z016D 設定APN(Access Point Names)

## 設定APN

- 名稱設為eur
- APN設為oai.ipv4
- 承載系統為LTE

編輯存取點

名稱  
eur

APN  
oai.ipv4

Proxy  
未設定

連接埠  
未設定

使用者名稱  
未設定

密碼  
未設定

伺服器  
未設定

MMSC  
未設定

編輯存取點

APN 類型  
未設定

APN 通訊協定  
IPv4

APN 漫遊通訊協定  
IPv4

APN 啟用/停用  
APN 已啟用

承載系統  
LTE

MVNO 類型  
無

MVNO 值  
未設定

# 手機設定ASUS Z016D

## 注意

- 某些手機可能要關掉VoLTE通話
- 某些手機要設定只能使用LTE
- 以上設置根據不同手機有不同的設置方法



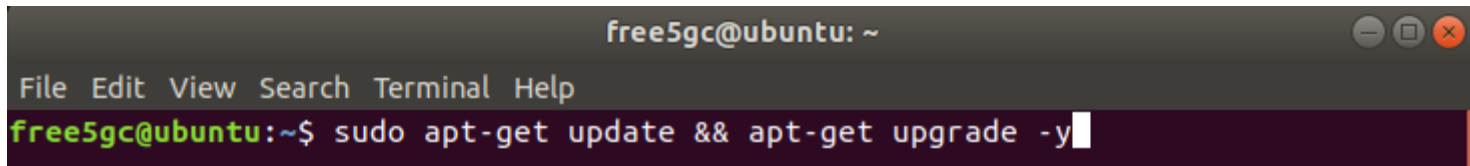
# ASUS Z016D

## 手機主動搜尋基地台



# Annex A : Program SIM Card

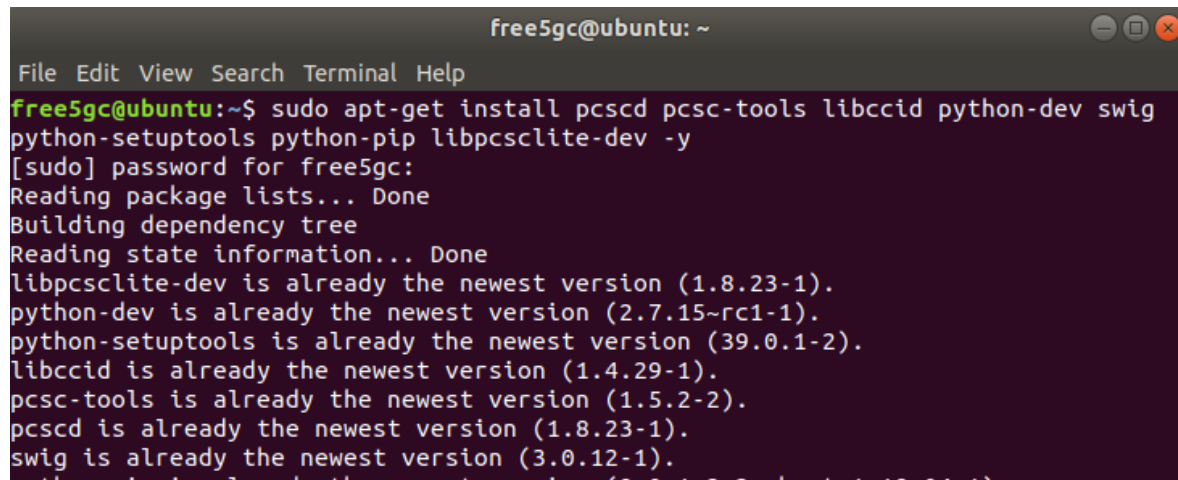
- `sudo apt-get update && sudo apt-get upgrade -y`

A screenshot of a terminal window titled 'free5gc@ubuntu: ~'. The window has a menu bar with 'File', 'Edit', 'View', 'Search', 'Terminal', and 'Help'. The terminal prompt is 'free5gc@ubuntu:~\$' and the command 'sudo apt-get update && apt-get upgrade -y' is being entered, with a cursor at the end of the line.

```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ sudo apt-get update && apt-get upgrade -y
```

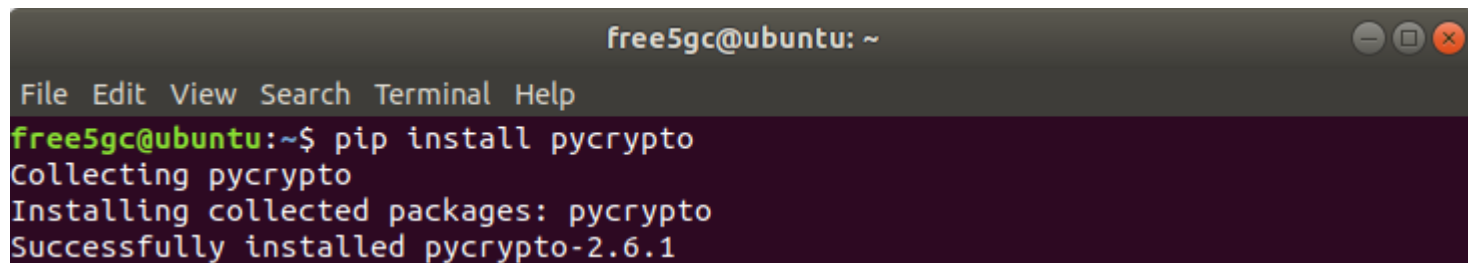
# Install Essential Packages

- `sudo apt-get install pcscd pcsc-tools libccid python-dev swig python-setuptools python-pip libpcsclite-dev -y`



```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ sudo apt-get install pcscd pcsc-tools libccid python-dev swig  
python-setuptools python-pip libpcsclite-dev -y  
[sudo] password for free5gc:  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
libpcsclite-dev is already the newest version (1.8.23-1).  
python-dev is already the newest version (2.7.15-rc1-1).  
python-setuptools is already the newest version (39.0.1-2).  
libccid is already the newest version (1.4.29-1).  
pcsc-tools is already the newest version (1.5.2-2).  
pcscd is already the newest version (1.8.23-1).  
swig is already the newest version (3.0.12-1).
```

- `pip install pycrypto`



```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~$ pip install pycrypto  
Collecting pycrypto  
Installing collected packages: pycrypto  
Successfully installed pycrypto-2.6.1
```

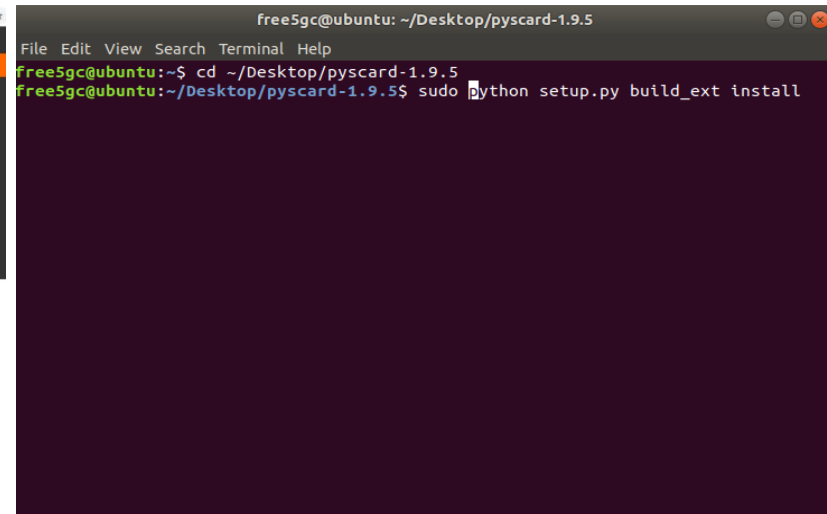
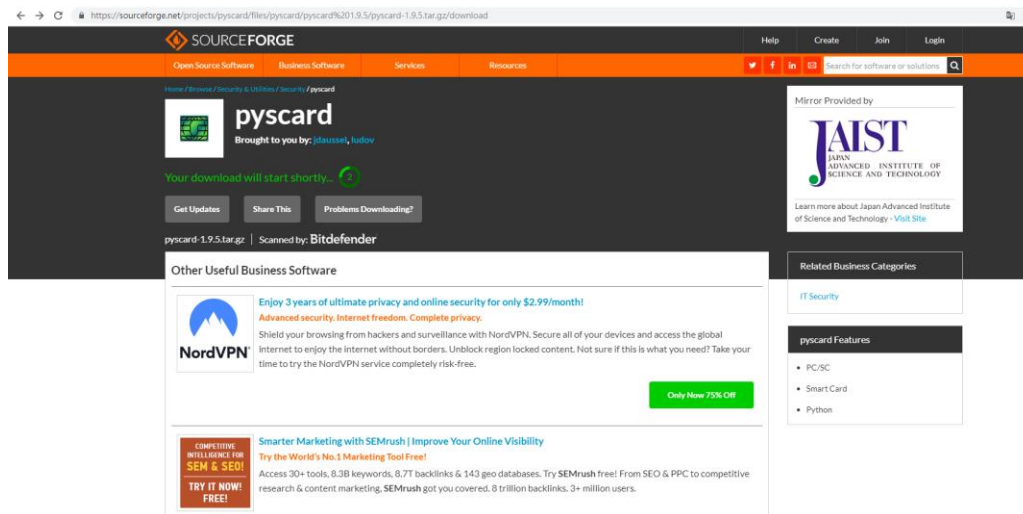
# Install Pyscard

- Go web
- <https://sourceforge.net/projects/pyscard/files/pyscard/pyscard%201.9.5/pyscard-1.9.5.tar.gz/download>

- Extract it to Home directory

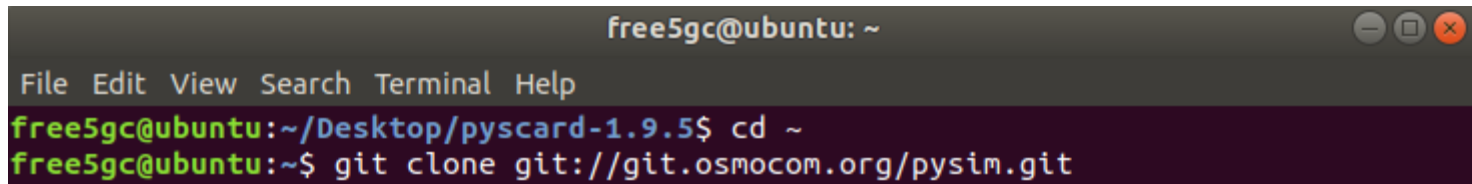
Open New Terminal

- `cd ~/Desktop/pyscard-1.9.5`
- `sudo python setup.py build_ext install`



# Build Pysim

- `cd ~`
- `git clone git://git.osmocom.org/pysim.git`

A terminal window titled 'free5gc@ubuntu: ~' with standard window controls. The menu bar includes 'File', 'Edit', 'View', 'Search', 'Terminal', and 'Help'. The terminal shows two commands being executed: first, 'cd ~' from the prompt 'free5gc@ubuntu:~/Desktop/pyscard-1.9.5\$', and second, 'git clone git://git.osmocom.org/pysim.git' from the prompt 'free5gc@ubuntu:~\$'.

```
free5gc@ubuntu: ~  
File Edit View Search Terminal Help  
free5gc@ubuntu:~/Desktop/pyscard-1.9.5$ cd ~  
free5gc@ubuntu:~$ git clone git://git.osmocom.org/pysim.git
```



# Run Pysim & Connect SIM Card Reader

- `cd pysim/`
- `sudo pcsc_scan`

```
free5gc@ubuntu: ~/pysim
File Edit View Search Terminal Help
free5gc@ubuntu:~$ cd pysim
free5gc@ubuntu:~/pysim$ sudo pcsc_scan
[sudo] password for free5gc:
PC/SC device scanner
V 1.5.2 (c) 2001-2017, Ludovic Rousseau <ludovic.rousseau@free.fr>
Using reader plug'n play mechanism
Scanning present readers...
Waiting for the first reader... -
```

```
free5gc@ubuntu: ~/pysim
File Edit View Search Terminal Help
free5gc@ubuntu:~/pysim$ sudo pcsc_scan
[sudo] password for free5gc:
PC/SC device scanner
V 1.5.2 (c) 2001-2017, Ludovic Rousseau <ludovic.rousseau@free.fr>
Using reader plug'n play mechanism
Scanning present readers...
Waiting for the first reader...found one
Scanning present readers...
0: VMware Virtual USB CCID 00 00

Thu Jul 25 04:42:45 2019
Reader 0: VMware Virtual USB CCID 00 00
Card state: Card inserted,
ATR: 3B 9F 95 80 1F C3 80 31 E0 73 FE 21 13 57 86 81 02 86 98 44 18 A8
ATR: 3B 9F 95 80 1F C3 80 31 E0 73 FE 21 13 57 86 81 02 86 98 44 18 A8
+ TS = 3B --> Direct Convention
+ T0 = 9F, Y(1): 1001, K: 15 (historical bytes)
TA(1) = 95 --> Fi=512, Di=16, 32 cycles/ETU
125000 bits/s at 4 MHz, fMax for Fi = 5 MHz => 156250 bits/s
TD(1) = 80 --> Y(i+1) = 1000, Protocol T = 0
-----
TD(2) = 1F --> Y(i+1) = 0001, Protocol T = 15 - Global interface bytes followi
ng
-----
TA(3) = C3 --> Clock stop: no preference - Class accepted by the card: (3G) A
5V B 3V
+ Historical bytes: 80 31 E0 73 FE 21 13 57 86 81 02 86 98 44 18
Category indicator byte: 80 (compact TLV data object)
Tag: 3, len: 1 (card service data byte)
Card service data byte: E0
- Application selection: by full DF name
- Application selection: by partial DF name
- BER-TLV data objects available in EF.DIR
- EF.DIR and EF.ATR access services: by GET RECORD(s) command
- Card with MF
Tag: 7, len: 3 (card capabilities)
Selection methods: FE
- DF selection by full DF name
- DF selection by partial DF name
- DF selection by path
- DF selection by file identifier
- Implicit DF selection
- Short EF identifier supported
```

# Run Pysim & Connect SIM Card Reader(cont.)

```
free5gc@ubuntu: ~/pysim
File Edit View Search Terminal Help
- DF selection by path
- DF selection by file identifier
- Implicit DF selection
- Short EF identifier supported
- Record number supported
Data coding byte: 21
- Behaviour of write functions: proprietary
- Value 'FF' for the first byte of BER-TLV tag fields: invalid
- Data unit in quartets: 2
Command chaining, length fields and logical channels: 13
- Logical channel number assignment: by the card
- Maximum number of logical channels: 4
Tag: 5, len: 7 (card issuer's data)
Card issuer data: 86 81 02 86 98 44 18
+ TCK = A8 (correct checksum)

Possibly identified card (using /usr/share/pcsc/smartcard_list.txt):
BB 9F 95 80 1F C3 80 31 E0 73 FE 21 13 57 86 81 02 86 98 44 18 A8
    GREEN CARD, Grcard (Hong Kong ) Co.,Limited, LTE Usim Card (Telecommunica
tion)
    Celcom Postpaid 3G (Telecommunication)
/
```

- Possibly identified card即成功讀取至SIM卡

# Burn Information to SIM Card

- Ctrl + C to exit the program
- `./pySim-read.py -p 0`

# Parameters of Pysim

- `./pySim-prog.py -p 0 -x 208 -y 93 -t sysmoUSIM-SJS1 -i 208930000000003 --op=8e27b6af0e692e750f32667a3b14605d -k 8baf473f2f8fd09487cccbd7097c6862 -s 8988211000000088313 -a 23605945`
- Explanation :
  - -x = MCC
  - -y = MNC
  - -t = tag
  - -i = IMSI
  - --op = OP
  - -k = KI
  - -s = ICCID
  - -a = ADM1

# Outline

- 實驗目的及實驗內容
- Free5GC 實驗環境
  - LTE 架構
  - 5G 架構
  - 軟硬體環境
- Free5GC 網路實驗平台建置
  - Add Another Bridge NIC( First )
  - MongoDB MongoDB Setup
  - Free5gc Git Clone and Compile
  - Configing the Core Network and Adding User Information
  - How to Configure eNodeB
  - Rebuild Project
  - Free5GC Demo
  - Annex A
- 總結

# 總結

- 讓學生熟悉新建置Free5GC的實驗環境
- 在主機上安裝和配置Free5GC
  - 了解Free5GC 參數之設置
  - Free5GC 之執行過程及狀況
  - 從Free5GC 觀察 UE 、eNB和EPC之間的訊息流程
  - 從Free5GC 觀察 UE 和eNB之間的底層訊息的狀況
- 透過設定Free5GC 配置，了解5G的運作架構及流程

# 問題

1. 使用手機連上網路，觀察行動通訊網路的相關參數
2. 當SIM卡連上eNB時，在HSS上觀察sim卡資訊（截圖）
3. 當sim卡在AMF認證成功時，使用wireshark看到認證成功並取得ip（截圖）