

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

課程:4G/5G行動寬頻協同網路

實驗四

5G Emulator仿真模擬實驗

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Outline

- 實驗目的及實驗內容
- 5G Emulator-nukxDC(ee) 實驗環境
 - srsLTE Small Cell 架構
 - 軟硬體環境
- 5G Emulator-nukxDC(ee) 網路實驗平台建置
 - 安裝基礎 srsLTE網路環境
 - 設定srsLTE EPC
 - 設定srsLTE eNB
 - 設定srsLTE UE
- 執行程式暨測試
- 總結

實驗目的

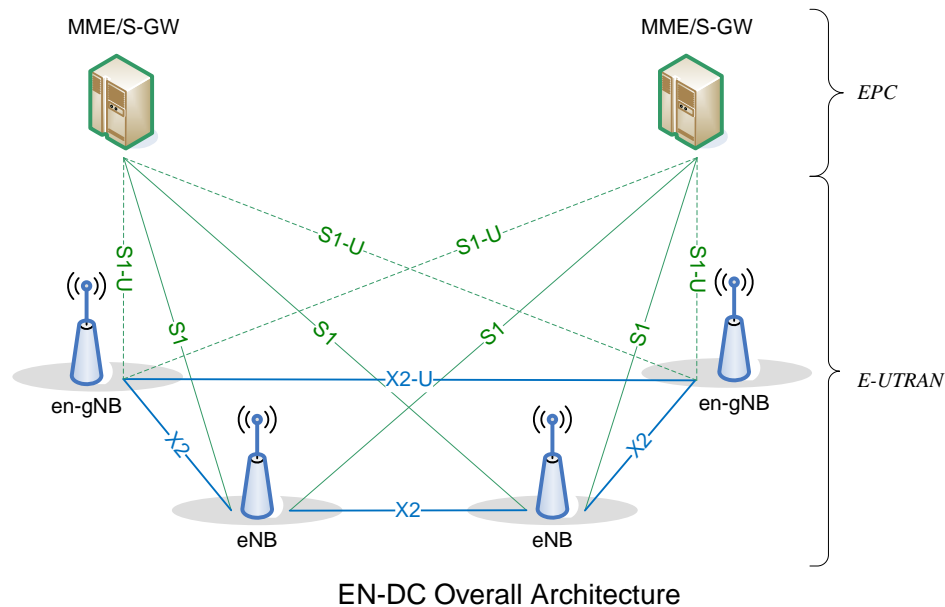
- 建置兩個小基站以模擬EN-DC的協同運作，讓學生熟悉NSA的5G協同網路架構
- 透過srsLTE網路環境了解到UE傳送封包後
 - 觀察封包如何在整體環境裡傳遞
 - 同時測量實驗環境的效率與協定

實驗內容

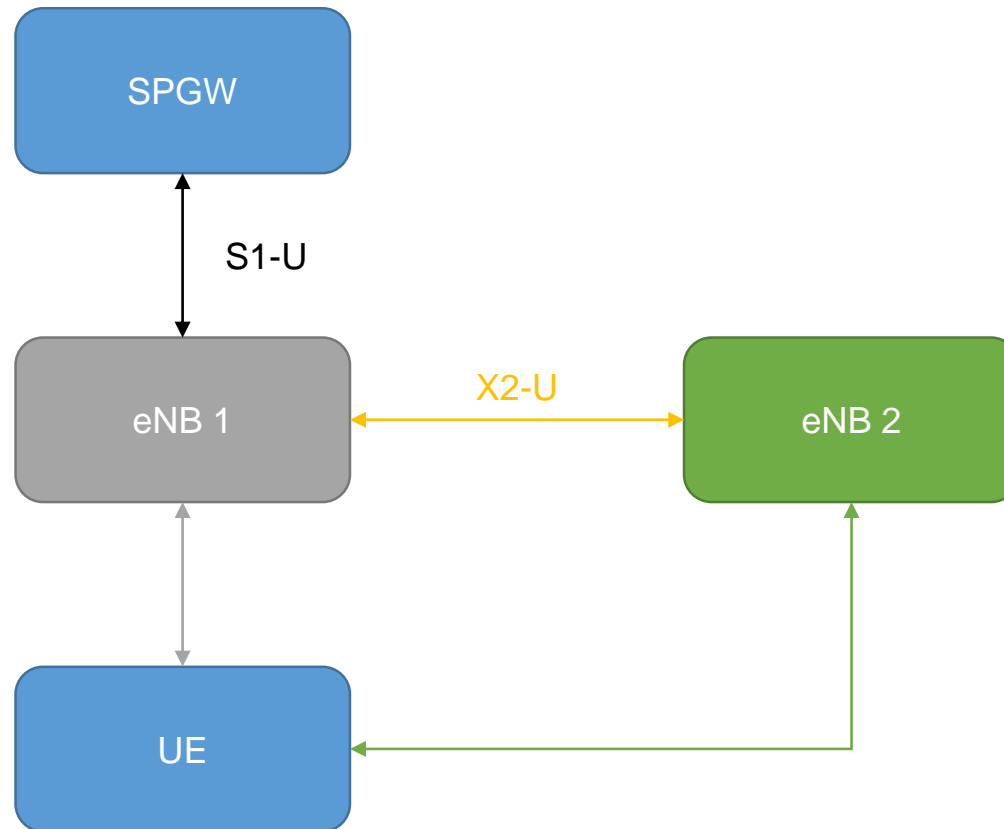
- 在三台主機上安裝和配置 UE 和 EPC 以及 eNB
- 設置 UE 和 eNB
- 執行 EPC 和 UE 以及 eNB
- 開啟 Wireshark
- 從 Wireshark 觀察各個主機間的封包訊息流向

EN-DC with the EPC

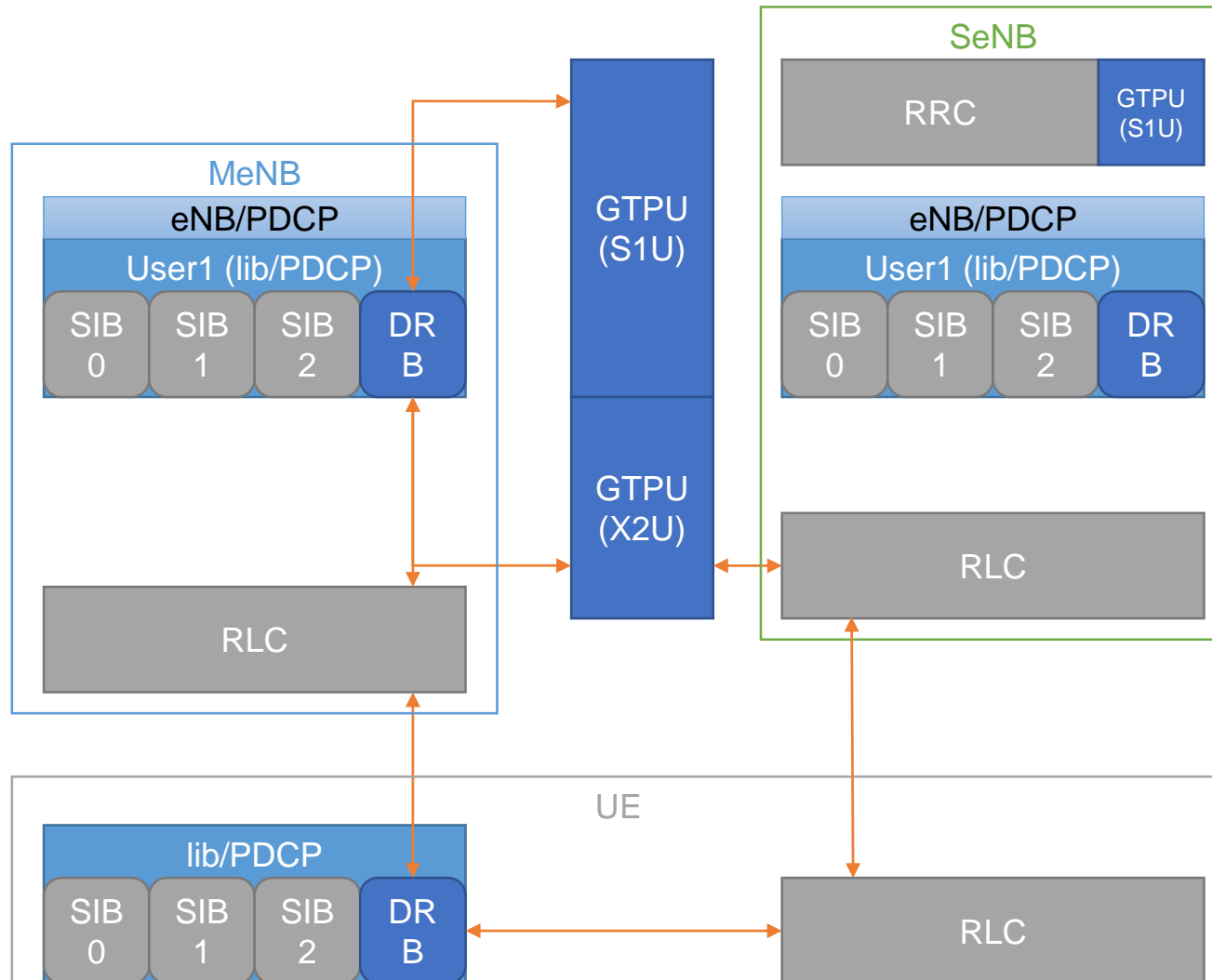
- E-UTRAN supports MR-DC via E-UTRA-NR Dual Connectivity (EN-DC), in which a UE is connected to one eNB that acts as a MN and one en-gNB that acts as a SN
- The eNB is connected to the EPC via the S1 interface and to the en-gNB via the X2 interface
- The en-gNB might also be connected to the EPC via the S1-U interface and other en-gNBs via the X2-U interface



Dual Connectivity Architecture (User Plane)



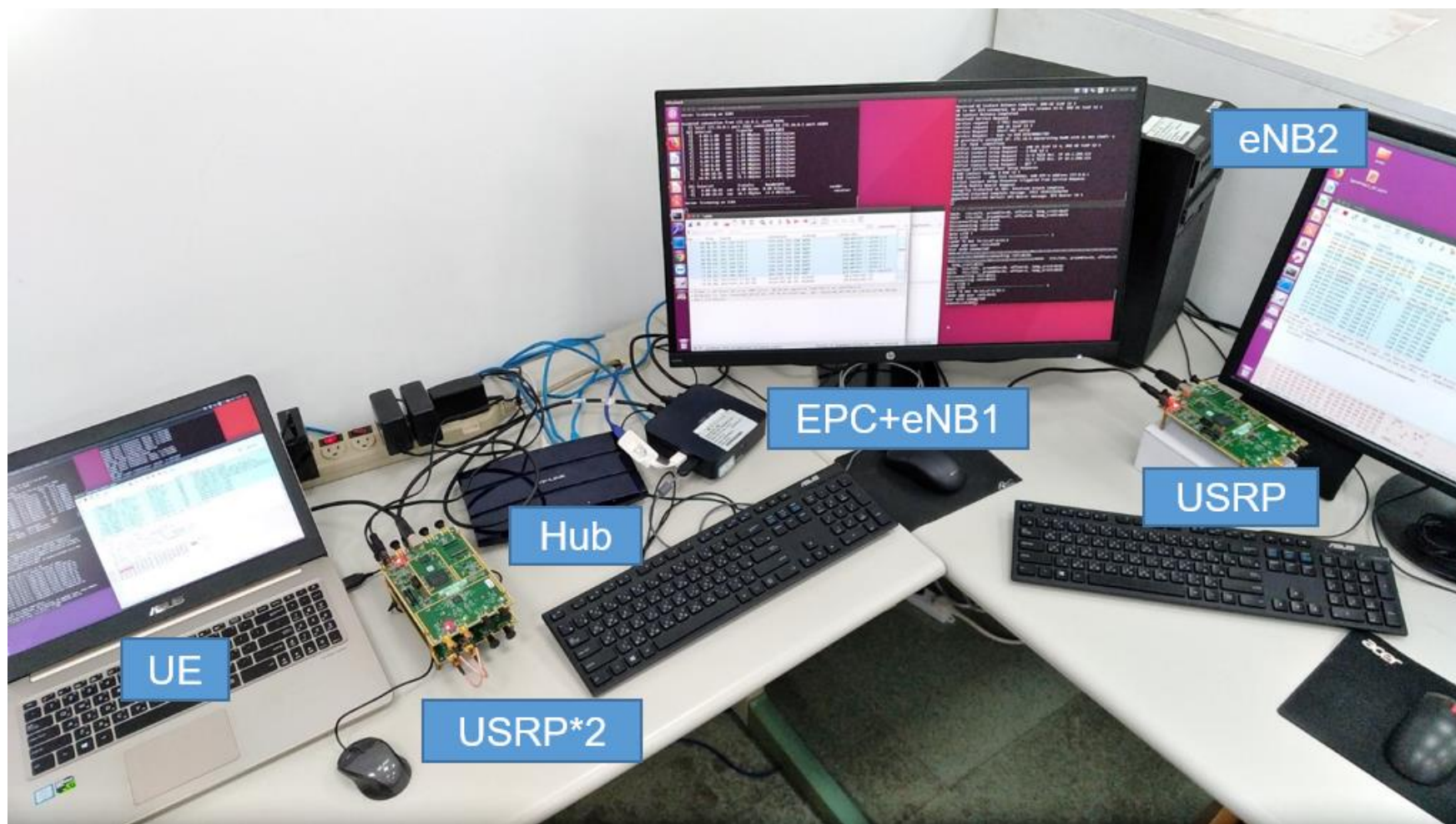
Dual Connectivity (User Plane)



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實驗環境



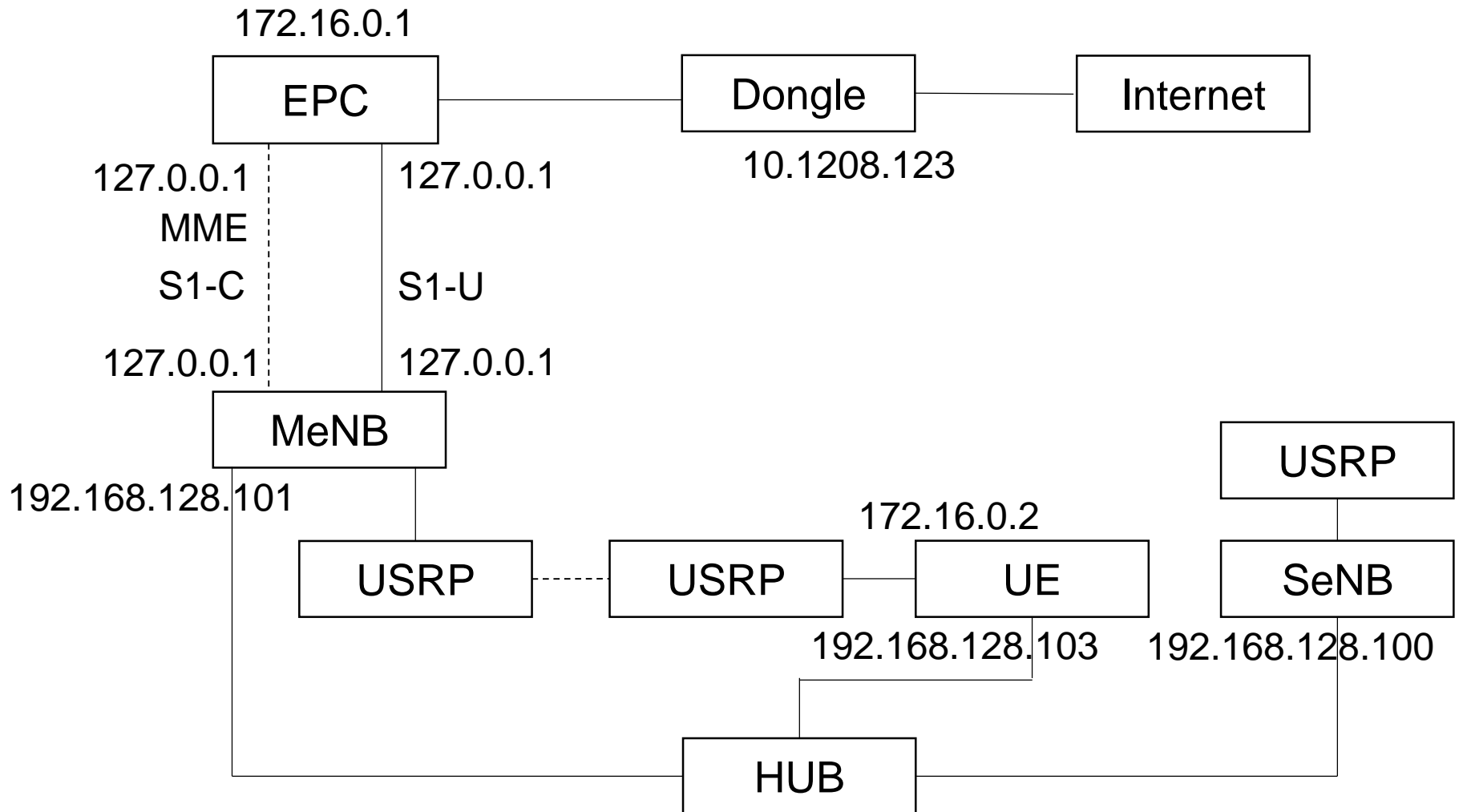
軟硬體環境－硬體

名稱	規格	數量	目的
EPC+eNB1	電腦型號： ASUS VivoMini UN65H	1	啟動MME, S-GW, P-GW
	Ethernet Network Cards	2	一張連接內部網路 (PCI-E：Realtek RTL8111/8168) 一張連接外部網路 (USB：TP-LINK UE300)
	USRP B210	1	啟動srsLTE eNB
eNB2	電腦規格： CPU：i7-6700，RAM：32G	1	模擬第二個基地站
	USRP B210	1	啟動srsLTE eNB
UE	電腦型號： ASUS NB M580V	1	模擬 UE
	USRP B210	1	啟動srsLTE UE
Hub	型號： TP-LINK WR1043ND	1	分配內部網路

軟硬體環境－軟體

名稱	軟體	版本
EPC	OS : Ubuntu	Ubuntu 16.04
		Kernel : 4.15.0-041500-lowlatency
	srsLTE EPC	srsLTE 18.06.1 470953bf9c5875646e4d5049c8f213d202fa84fd
eNB	OS : Ubuntu	Ubuntu 16.04
		Kernel : 4.15.0-041500-lowlatency
	srsLTE eNB	srsLTE 18.06.1 470953bf9c5875646e4d5049c8f213d202fa84fd
UE	OS : Ubuntu	Ubuntu 16.04
		Kernel : 4.15.0-041500-lowlatency
	srsLTE UE	srsLTE 18.06.1 470953bf9c5875646e4d5049c8f213d202fa84fd

srsLTE/nukxDC實驗架構



下載及安裝 Kernel

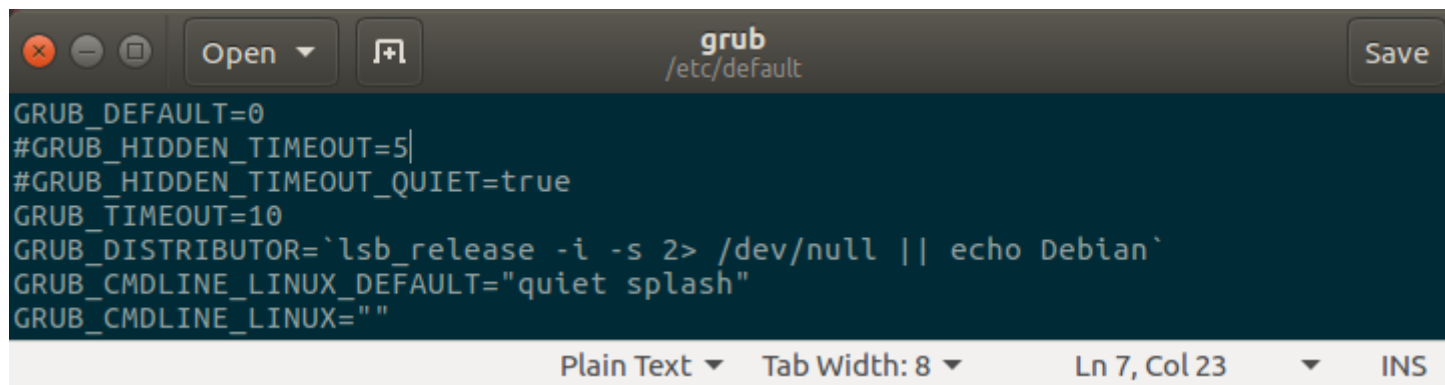
- 開啟一個終端機，並且依序輸入
- `wget -P ~/Downloads/kernel https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-headers-4.4.15-040415_4.4.15-040415.201607111333_all.deb`
- `wget -P ~/Downloads/kernel https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-headers-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb`
- `wget -P ~/Downloads/kernel https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-image-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb`

安裝過程

```
asus-medium@asusmedium-UN65H: ~  
  
asus-medium@asusmedium-UN65H:~$ wget -P ~/Downloads/kernel https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-headers-4.4.15-040415_4.4.15-040415.201607111333_all.deb  
--2019-07-12 10:23:21-- https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-headers-4.4.15-040415_4.4.15-040415.201607111333_all.deb  
Resolving kernel.ubuntu.com (kernel.ubuntu.com)... 91.189.94.216  
Connecting to kernel.ubuntu.com (kernel.ubuntu.com)|91.189.94.216|:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 9755644 (9.3M) [application/x-debian-package]  
Saving to: '/home/asus-medium/Downloads/kernel/linux-headers-4.4.15-040415_4.4.15-040415.201607111333_all.deb'  
  
linux-headers-4.4.15-0 100%[=====>] 9.30M 1.62MB/s in 7.2s  
  
2019-07-12 10:23:29 (1.30 MB/s) - '/home/asus-medium/Downloads/kernel/linux-headers-4.4.15-040415_4.4.15-040415.201607111333_all.deb' saved [9755644/9755644]  
  
asus-medium@asusmedium-UN65H:~$ wget -P ~/Downloads/kernel https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-headers-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb  
--2019-07-12 10:23:29-- https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-headers-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb  
Resolving kernel.ubuntu.com (kernel.ubuntu.com)... 91.189.94.216  
Connecting to kernel.ubuntu.com (kernel.ubuntu.com)|91.189.94.216|:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 748090 (731K) [application/x-debian-package]  
Saving to: '/home/asus-medium/Downloads/kernel/linux-headers-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb'  
  
linux-headers-4.4.15-0 100%[=====>] 730.56K 505KB/s in 1.4s  
  
2019-07-12 10:23:32 (505 KB/s) - '/home/asus-medium/Downloads/kernel/linux-headers-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb' saved [748090/748090]  
  
asus-medium@asusmedium-UN65H:~$ wget -P ~/Downloads/kernel https://kernel.ubuntu.com/~kernel-ppa/mainline/v4.4.15/linux-image-4.4.15-040415-lowlatency_4.4.15-040415.201607111333_amd64.deb
```

修改開機選單和設定

- 開啟終端機輸入以下指令
- `sudo gedit /etc/default/grub`
- 找到下列文字
`GRUB_HIDDEN_TIMEOUT=0`
`GRUB_HIDDEN_TIMEOUT_QUIET=true`
- 改成
`#GRUB_HIDDEN_TIMEOUT=0`
`#GRUB_HIDDEN_TIMEOUT_QUIET=true`



```
grub
/etc/default

GRUB_DEFAULT=0
#GRUB_HIDDEN_TIMEOUT=5
#GRUB_HIDDEN_TIMEOUT_QUIET=true
GRUB_TIMEOUT=10
GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
GRUB_CMDLINE_LINUX_DEFAULT="quiet splash"
GRUB_CMDLINE_LINUX=""

Plain Text ▾ Tab Width: 8 ▾ Ln 7, Col 23 ▾ INS
```

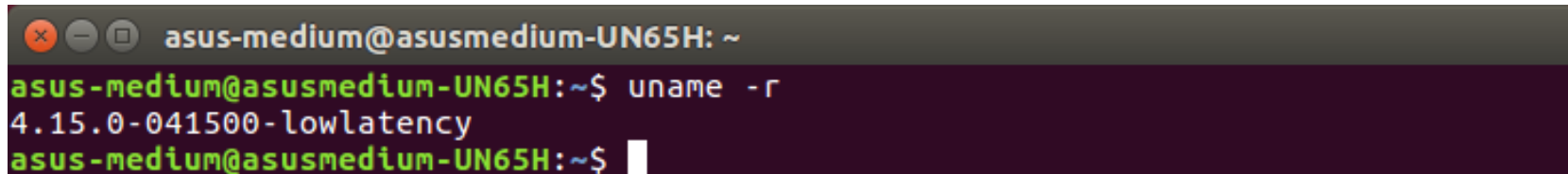
更新grub設定

- 在終端機輸入以下指令
- `sudo update-grub2`
- 接著輸入以下指令，重新啟動電腦
- `sudo reboot`
- 然後在開機選單選擇剛才安裝的lowlatency

```
asus-medium@asusmedium-UN65H: ~  
asus-medium@asusmedium-UN65H:~$ sudo update-grub2  
[sudo] password for asus-medium:  
Generating grub configuration file ...  
Found linux image: /boot/vmlinuz-4.15.0-041500-lowlatency  
Found initrd image: /boot/initrd.img-4.15.0-041500-lowlatency  
Found linux image: /boot/vmlinuz-4.15.0-041500-lowlatency  
Found initrd image: /boot/initrd.img-4.15.0-041500-lowlatency  
Found linux image: /boot/vmlinuz-4.15.0-47-generic  
Found initrd image: /boot/initrd.img-4.15.0-47-generic  
Found linux image: /boot/vmlinuz-4.15.0-46-generic  
Found initrd image: /boot/initrd.img-4.15.0-46-generic  
Found linux image: /boot/vmlinuz-4.15.0-30-lowlatency  
Found initrd image: /boot/initrd.img-4.15.0-30-lowlatency  
Adding boot menu entry for EFI firmware configuration  
done  
asus-medium@asusmedium-UN65H:~$
```


檢查Kernel版本

- 重新開機後在終端機輸入指令，確認版本
- `uname -r`

A screenshot of a Linux terminal window. The window title bar shows standard Linux window controls (close, maximize, and a third icon) followed by the text 'asus-medium@asusmedium-UN65H: ~'. The terminal content shows the prompt 'asus-medium@asusmedium-UN65H:~\$' followed by the command 'uname -r'. The output of the command is '4.15.0-041500-lowlatency'. Below the output, the prompt 'asus-medium@asusmedium-UN65H:~\$' is shown again with a white cursor block.

```
asus-medium@asusmedium-UN65H: ~  
asus-medium@asusmedium-UN65H:~$ uname -r  
4.15.0-041500-lowlatency  
asus-medium@asusmedium-UN65H:~$
```

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Install Packages

- `sudo apt-get install cmake libfftw3-dev libboost-all-dev libconfig++-dev libsctp-dev`

Install mbed TLS

- `wget https://tls.mbed.org/download/start/mbedtls-2.16.0-apache.tgz`
- `tar zxvf mbedtls-2.16.0-apache.tgz`
- `sudo mv /path/to/mbedtls-2.16.0 /usr/local`
- `cd /usr/local/mbedtls-2.16.0`
- `cmake .`
- `make`
- `make test`
- `cmake -DENABLE_TESTING=Off .`
- `cmake -DUSE_SHARED_MBEDTLS_LIBRARY=On .`
- `sudo make install library`

ref : <https://tls.mbed.org/kb/compiling-and-building/how-do-i-build-compile-mbedtls>

Install UHD

- `sudo add-apt-repository ppa:ettusresearch/uhd`
- `sudo apt-get update`
- `sudo apt-get install libuhd-dev libuhd003 uhd-host`
- `sudo ./usr/lib/uhd/utils/uhd_images_downloader.py`

Download and Build srsGUI

- `sudo apt-get install libboost-system-dev libboost-test-dev libboost-thread-dev libqwt-dev libqt4-dev`
- `git clone https://github.com/srsLTE/srsGUI.git`
- `cd srsgui`
- `mkdir build`
- `cd build`
- `cmake ../`
- `make`
- `make test`

Download and Build srsLTE

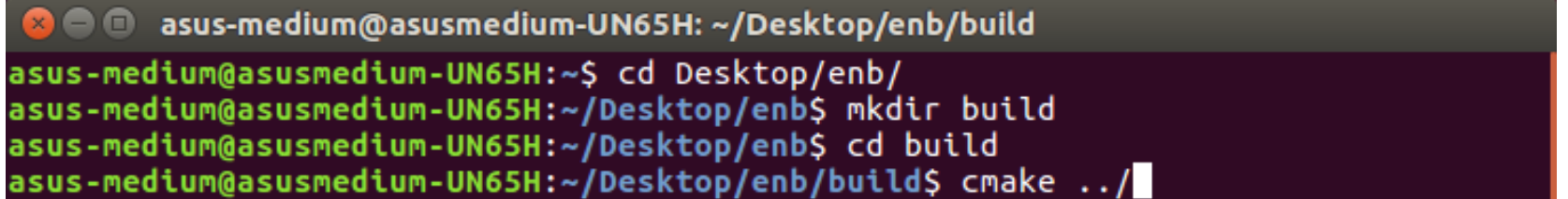
- `git clone https://github.com/nukcsie2066/nukxDC.git`
- `cd srsLTE`
- `mkdir build`
- `cd build`
- `cmake ../`
- `make`
- `make test`
- `sudo make install`

編譯前注意事項

- 三台電腦皆需要編譯，請注意充當的角色不同，路徑也不相同，以下用 `/path/to/` 取代。
 - e.g. epc&enb1 : `~/nukxDC/epc_enb1/`
 - e.g. enb2 : `~/nukxDc/enb2/`
 - e.g. ue : `~/nukxDC/ue/`

編譯 srsLTE - Step 1

- cd `/path/to/srsLTE`
- mkdir build
- cd build
- cmake `../`



```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/build
asus-medium@asusmedium-UN65H:~$ cd Desktop/enb/
asus-medium@asusmedium-UN65H:~/Desktop/enb$ mkdir build
asus-medium@asusmedium-UN65H:~/Desktop/enb$ cd build
asus-medium@asusmedium-UN65H:~/Desktop/enb/build$ cmake ../
```

編譯 srsLTE - Step 2

- make

```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/build
-- CMAKE_CXX_FLAGS is -march=native -Wall -Wno-comment -Wno-reorder -Wno-unused-but-set-variable -Wno-unused-variable -Wformat -Wmissing-field-initializers -Wtype-limits -std=c++03 -mfpmath=sse -mavx2 -DLV_HAVE_AVX2 -DLV_HAVE_AVX -DLV_HAVE_SSE -O3 -DBUILD_TYPE_RELEASE
-- Using install prefix: /usr/local
-- Building for version: 18.6.1
-- SRS GUI LIBRARIES SRS GUI_LIBRARIES-NOTFOUND
-- SRS GUI INCLUDE DIRS SRS GUI_INCLUDE_DIRS-NOTFOUND
-- Could NOT find SRS GUI (missing: SRS GUI_LIBRARIES SRS GUI_INCLUDE_DIRS)
-- SRS GUI LIBRARIES SRS GUI_LIBRARIES-NOTFOUND
-- SRS GUI INCLUDE DIRS SRS GUI_INCLUDE_DIRS-NOTFOUND
-- Could NOT find SRS GUI (missing: SRS GUI_LIBRARIES SRS GUI_INCLUDE_DIRS)
-- examples will be installed.
-- No post-build command defined
-- Building with srsUE
-- No post-build-UE command defined
-- No post-build command defined
-- Building with srsENB
-- Found LibConfig++: /usr/lib/x86_64-linux-gnu/libconfig++.so
-- static LibConfig++ path: /usr/lib/x86_64-linux-gnu/libconfig++.a
-- Found LibConfig: /usr/lib/x86_64-linux-gnu/libconfig.so
-- static LibConfig path: /usr/lib/x86_64-linux-gnu/libconfig.a
-- Checking for module 'sctp'
-- No package 'sctp' found
-- SCTP LIBRARIES: /usr/lib/x86_64-linux-gnu/libsctp.so
-- SCTP INCLUDE DIRS: /usr/include
-- Found SCTP: /usr/lib/x86_64-linux-gnu/libsctp.so
-- No post-build-ENB command defined
-- Building with srsEPC
-- Found LibConfig++: /usr/lib/x86_64-linux-gnu/libconfig++.so
-- static LibConfig++ path: /usr/lib/x86_64-linux-gnu/libconfig++.a
-- Found LibConfig: /usr/lib/x86_64-linux-gnu/libconfig.so
-- static LibConfig path: /usr/lib/x86_64-linux-gnu/libconfig.a
-- Checking for module 'sctp'
-- No package 'sctp' found
-- SCTP LIBRARIES: /usr/lib/x86_64-linux-gnu/libsctp.so
-- SCTP INCLUDE DIRS: /usr/include
-- No post-build-EPC command defined
-- Configuring done
-- Generating done
-- Build files have been written to: /home/asus-medium/Desktop/enb/build
asus-medium@asusmedium-UN65H:~/Desktop/enb/build$ make
```

編譯 srsLTE - Step 3

- make test

```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/build
[ 94%] Built target cell_search
Scanning dependencies of target usrp_capture_sync
[ 95%] Building C object lib/examples/CMakeFiles/usrp_capture_sync.dir/usrp_capture_sync.c.o
[ 95%] Linking C executable usrp_capture
[ 95%] Linking C executable usrp_capture_sync
[ 95%] Built target usrp_capture
Scanning dependencies of target srsue
[ 95%] Building CXX object srsue/src/CMakeFiles/srsue.dir/main.cc.o
[ 95%] Built target usrp_capture_sync
Scanning dependencies of target mac_test
[ 95%] Building CXX object srsue/test/mac/CMakeFiles/mac_test.dir/mac_test.cc.o
[ 96%] Linking CXX executable mac_test
[ 97%] Linking CXX executable srsmbms
[ 97%] Built target mac_test
Scanning dependencies of target srsenb
[ 97%] Built target srsmbms
[ 97%] Building CXX object srsue/src/CMakeFiles/srsue.dir/ue_base.cc.o
[ 97%] Building CXX object srsenb/src/CMakeFiles/srsenb.dir/main.cc.o
[ 97%] Linking CXX executable srsepc
[ 97%] Built target srsepc
Scanning dependencies of target ip_test_enb
[ 97%] Building CXX object srsenb/test/upper/CMakeFiles/ip_test_enb.dir/ip_test.cc.o
[ 98%] Building CXX object srsue/src/CMakeFiles/srsue.dir/ue.cc.o
[ 99%] Linking CXX executable ip_test_enb
[ 99%] Built target ip_test_enb
Scanning dependencies of target benchmark_radio
[ 99%] Building CXX object lib/src/radio/test/CMakeFiles/benchmark_radio.dir/benchmark_radio.cc.o
[ 99%] Linking CXX executable benchmark_radio
[ 99%] Built target benchmark_radio
[ 99%] Building CXX object srsenb/src/CMakeFiles/srsenb.dir/enb.cc.o
[ 99%] Building CXX object srsue/src/CMakeFiles/srsue.dir/metrics_stdout.cc.o
[ 99%] Building CXX object srsue/src/CMakeFiles/srsue.dir/metrics_csv.cc.o
[100%] Building CXX object srsenb/src/CMakeFiles/srsenb.dir/parser.cc.o
[100%] Linking CXX executable srsue
[100%] Building CXX object srsenb/src/CMakeFiles/srsenb.dir/enb_cfg_parser.cc.o
[100%] Built target srsue
[100%] Building CXX object srsenb/src/CMakeFiles/srsenb.dir/metrics_stdout.cc.o
[100%] Linking CXX executable srsenb
[100%] Built target srsenb
asus-medium@asusmedium-UN65H:~/Desktop/enb/build$ make test
```

編譯 srsLTE - Step 4

- `sudo make install`

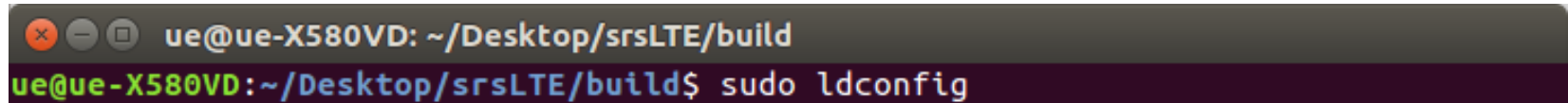
```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/build
439/456 Test #439: logger_test ..... Passed 0.01 sec
Start 440: msg_queue_test
440/456 Test #440: msg_queue_test ..... Passed 1.06 sec
Start 441: test_eea1
441/456 Test #441: test_eea1 ..... Passed 0.00 sec
Start 442: test_eea2
442/456 Test #442: test_eea2 ..... Passed 0.00 sec
Start 443: test_f12345
443/456 Test #443: test_f12345 ..... Passed 0.00 sec
Start 444: phy_dl_test
444/456 Test #444: phy_dl_test ..... Passed 0.40 sec
Start 445: rlc_am_data_test
445/456 Test #445: rlc_am_data_test ..... Passed 0.00 sec
Start 446: rlc_am_control_test
446/456 Test #446: rlc_am_control_test ..... Passed 0.00 sec
Start 447: rlc_am_test
447/456 Test #447: rlc_am_test ..... Passed 0.20 sec
Start 448: rlc_am_stress_test
448/456 Test #448: rlc_am_stress_test ..... Passed 5.08 sec
Start 449: rlc_um_stress_test
449/456 Test #449: rlc_um_stress_test ..... Passed 5.05 sec
Start 450: rlc_tm_stress_test
450/456 Test #450: rlc_tm_stress_test ..... Passed 5.05 sec
Start 451: rlc_um_data_test
451/456 Test #451: rlc_um_data_test ..... Passed 0.00 sec
Start 452: rlc_um_test
452/456 Test #452: rlc_um_test ..... Passed 0.03 sec
Start 453: metrics_test
453/456 Test #453: metrics_test ..... Passed 2.00 sec
Start 454: usim_test
454/456 Test #454: usim_test ..... Passed 0.00 sec
Start 455: rrc_reconfig_test
455/456 Test #455: rrc_reconfig_test ..... Passed 0.00 sec
Start 456: nas_test
456/456 Test #456: nas_test ..... Passed 0.02 sec

100% tests passed, 0 tests failed out of 456

Total Test time (real) = 98.16 sec
asus-medium@asusmedium-UN65H:~/Desktop/enb/build$ sudo make install
```

編譯 srsLTE - Step 5

- sudo ldconfig



```
ue@ue-X580VD: ~/Desktop/srsLTE/build  
ue@ue-X580VD:~/Desktop/srsLTE/build$ sudo ldconfig
```

編譯 srsLTE - Step 6

- #完成編譯過程

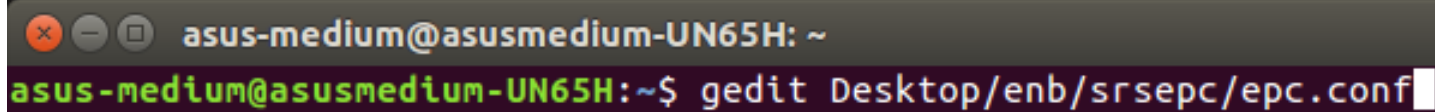
```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/build
-- Up-to-date: /usr/local/include/srslte/common/trace.h
-- Installing: /usr/local/lib/librslte_asn1.a
-- Installing: /usr/local/lib/librslte_common.a
-- Installing: /usr/local/lib/librslte_phy.a
-- Installing: /usr/local/lib/librslte_rf.so
-- Set runtime path of "/usr/local/lib/librslte_rf.so" to ""
-- Installing: /usr/local/lib/librslte_radio.a
-- Installing: /usr/local/lib/librslte_upper.a
-- Installing: /usr/local/include/srslte/version.h
-- Up-to-date: /usr/local/share/srslte/ue.conf.example
-- Installing: /usr/local/bin/srsue
-- Set runtime path of "/usr/local/bin/srsue" to ""
-- Up-to-date: /usr/local/bin/srsue
-- Installing: /usr/local/lib/librsue_phy.a
-- Installing: /usr/local/lib/librsue_mac.a
-- Installing: /usr/local/lib/librsue_upper.a
-- Up-to-date: /usr/local/share/srslte/enb.conf.example
-- Up-to-date: /usr/local/share/srslte/drb.conf.example
-- Up-to-date: /usr/local/share/srslte/rr.conf.example
-- Up-to-date: /usr/local/share/srslte/sib.conf.example
-- Installing: /usr/local/bin/srsenb
-- Set runtime path of "/usr/local/bin/srsenb" to ""
-- Up-to-date: /usr/local/bin/srsenb
-- Installing: /usr/local/lib/librsenb_phy.a
-- Installing: /usr/local/lib/librsenb_mac.a
-- Installing: /usr/local/lib/librsenb_upper.a
-- Up-to-date: /usr/local/share/srslte/epc.conf.example
-- Up-to-date: /usr/local/share/srslte/mbms.conf.example
-- Up-to-date: /usr/local/share/srslte/user_db.csv.example
-- Up-to-date: /usr/local/bin/srsepc_if_masq.sh
-- Installing: /usr/local/bin/srsepc
-- Set runtime path of "/usr/local/bin/srsepc" to ""
-- Installing: /usr/local/bin/srsmbms
-- Set runtime path of "/usr/local/bin/srsmbms" to ""
-- Up-to-date: /usr/local/bin/srsepc
-- Installing: /usr/local/lib/libsrsepc_mme.a
-- Installing: /usr/local/lib/libsrsepc_hss.a
-- Installing: /usr/local/lib/libsrsepc_sgw.a
-- Installing: /usr/local/lib/libsrsepc_mbms_gw.a
asus-medium@asusmedium-UN65H:~/Desktop/enb/build$
```

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 - 安裝基礎 srsLTE網路環境
 - 設定**srsLTE EPC**
 - 設定srsLTE eNB
 - 設定srsLTE UE
- 執行程式暨測試
- 總結

修改 EPC conf 檔

- gedit /path/to/srsepc/epc.conf



A terminal window screenshot with a dark background. The title bar shows window control icons and the text 'asus-medium@asusmedium-UN65H: ~'. The command prompt shows 'asus-medium@asusmedium-UN65H:~\$' followed by the command 'gedit Desktop/enb/srsepc/epc.conf' with a white cursor at the end.

```
asus-medium@asusmedium-UN65H: ~  
asus-medium@asusmedium-UN65H:~$ gedit Desktop/enb/srsepc/epc.conf
```


修改 mme_bind_addr

```
#####  
[mme] {tac, mcc, mnc} 注意eNB需要跟EPC的參數設定一致  
mme_code = 0x1a  
mme_group = 0x0001  
tac = 0x0007  
mcc = 001|  
mnc = 01  
mme_bind_addr = 127.0.0.1  
apn = srsapn  
dns_addr = 8.8.8.8  
#####
```

mme_bind_addr 請設為
127.0.0.1

修改 gtpu_bind_addr

```
#####  
[spgw] gtpu_bind_addr 請設為 #對外網址  
gtpu_bind_addr=10.1.208.123  
sgi_if_addr=172.16.0.1  
#####
```

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修改 eNB conf 檔

```
#####  
[enb]  
enb_id = 0x19B  
cell_id = 0x01  
phy_cell_id = 1  
tac = 0x0007  
mcc = 001  
mnc = 01  
mme_addr = 127.0.0.1  
gtp_bind_addr = 127.0.0.1  
s1c_bind_addr = 127.0.0.1  
n_prb = 25  
#tm = 4  
#nof_ports = 2  
#####
```

將這三個addr 都設為 127.0.0.1

修改 x2_addr

- #enb1及enb2皆需要更改

```
#####  
[expert]  
#pdsch_max_its      = 4  
#nof_phy_threads    = 2  
#pregenerate_signals = false  
#tx_amplitude        = 0.6  
#link_failure_nof_err = 50|  
rrc_inactivity_timer = 6000000  
#max_prach_offset_us = 30  
#enable_mbsfn        = false  
x2_bind_addr = 192.168.128.101  
x2_senb_addr = 192.168.128.100  
#####
```

x2_bind_addr

設為自己內網的網址

x2_senb_addr

設為另一個eNB內網的網址

編輯 lwaap_entity.h 檔案

- gedit /path/to/srsLTE/lib/include/srslte/upper/lwaap_entity.h

```
*****
#define WLAN_IF "eth0"
#define UE_MAC0 0x10
#define UE_MAC1 0x7b
#define UE_MAC2 0x44
#define UE_MAC3 0x23
#define UE_MAC4 0x07
#define UE_MAC5 0xba

#define ETH_TYPE_WIFI 0x9e65
#define LWAAP_HEADER_LEN 1
/*****
```

WLAN_IF 設為 eNB 內網
網卡名稱

UE_MAC 請設為UE 內網
網卡Mac_addr

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編輯 lwaap.h 檔案

- gedit /path/to/srsue/hdr/upper/lwaap.h

```
#define WIFI_IF
#define ENB_MAC0
#define ENB_MAC1
#define ENB_MAC2
#define ENB_MAC3
#define ENB_MAC4
#define ENB_MAC5
```

```
"enp2s0"
```

```
0x54
```

```
0xa0
```

```
0x50
```

```
0xd6
```

```
0x77
```

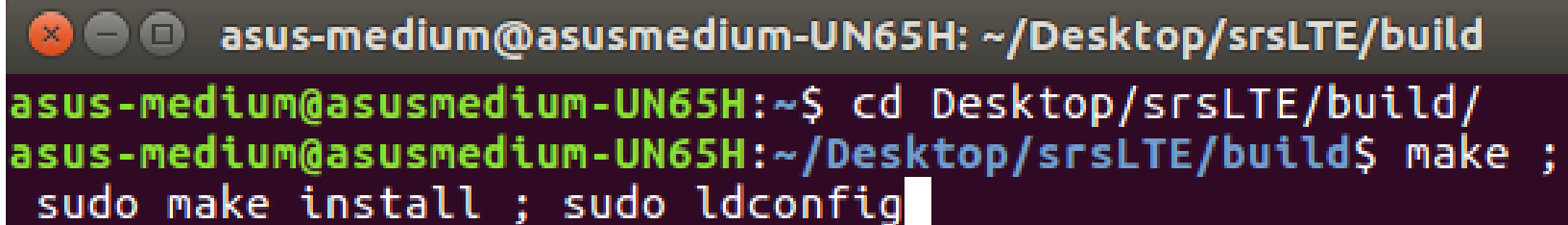
```
0x3f
```

WLAN_IF 設為 UE 內網
網卡名稱

ENB_MAC 設為 eNB1 內網
網卡MAC_addr

完成編譯

- 將上述檔案修改完成後，依序輸入下列指令
- `cd /path/to/srsLTE/build/`
- `make`
- `sudo make install`
- `sudo ldconfig`



```
asus-medium@asusmedium-UN65H: ~/Desktop/srsLTE/build  
asus-medium@asusmedium-UN65H:~$ cd Desktop/srsLTE/build/  
asus-medium@asusmedium-UN65H:~/Desktop/srsLTE/build$ make ;  
sudo make install ; sudo ldconfig
```

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 - 設定srsLTE eNB
 - 設定srsLTE UE
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- 總結

程式執行

- 順序： epc>enb1>enb2>ue
- EPC + eNB1
 - cd `/path/to/srsLTE/srsepc`
 - sudo srsepc_if_masq.sh `dongle` #請改成對外網卡名稱
 - sudo srsepc epc.conf
 - sudo ifconfig srs_spgw_sgi mtu 1460
 - cd `/path/to/srsLTE/srsenb`
 - sudo srsenb enb1.conf #enb1

EPC+eNB1 - Step 1

- cd /path/to/srsLTE/srsepc
- sudo srsepc_if_masq.sh dongle #請改成對外網卡名稱
- sudo srsepc epc.conf

```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/srsepc
asus-medium@asusmedium-UN65H:~/Desktop/enb/srsepc$ sudo srsepc_if_masq.sh dongle
[sudo] password for asus-medium:
Masquerading Interface dongle
asus-medium@asusmedium-UN65H:~/Desktop/enb/srsepc$ sudo srsepc epc.conf

--- Software Radio Systems EPC ---

Reading configuration file epc.conf...
HSS Initialized.
MME GTP-C Initialized
MME Initialized.
SP-GW Initialized.
```

查看介面

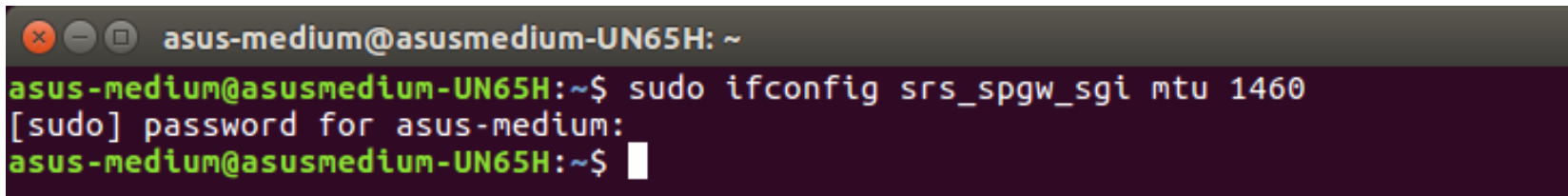
- #當 EPC 啟動完成後，會產生一個 srs_spgw_sgi 的網卡介面
- 在終端機輸入 ifconfig

```
srs_spgw_sgi Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
    inet addr:172.16.0.1 P-t-P:172.16.0.1 Mask:255.255.255.0
    UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
    RX packets:0 errors:0 dropped:0 overruns:0 frame:0
    TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:500
    RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)

asus-medium@asusmedium-UN65H:~$
```

EPC+eNB1 - Step 2

- #開啟新的 terminal
- `sudo ifconfig srs_spgw_sgi mtu 1460`

A screenshot of a terminal window. The title bar shows window control icons and the text 'asus-medium@asusmedium-UN65H: ~'. The terminal content shows the prompt 'asus-medium@asusmedium-UN65H:~\$' followed by the command 'sudo ifconfig srs_spgw_sgi mtu 1460'. The next line shows '[sudo] password for asus-medium:' followed by a blank line. The final line shows the prompt 'asus-medium@asusmedium-UN65H:~\$' with a cursor.

```
asus-medium@asusmedium-UN65H: ~  
asus-medium@asusmedium-UN65H:~$ sudo ifconfig srs_spgw_sgi mtu 1460  
[sudo] password for asus-medium:  
asus-medium@asusmedium-UN65H:~$
```

EPC+eNB1 - Step 3

- #開啟新的 terminal
- `cd /path/to/srsLTE/srsenb`
- `sudo srsenb enb.conf`

```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/srsenb
asus-medium@asusmedium-UN65H:~/Desktop/enb/srsenb$ sudo srsenb enb1.conf
[sudo] password for asus-medium:
--- Software Radio Systems LTE eNodeB ---

Reading configuration file enb1.conf...
[INFO] [UHD] linux; GNU C++ version 5.4.0 20160609; Boost_105800; UHD_3.14.0.0-release
Opening USRP with args: type=b200,master_clock_rate=30.72e6
[INFO] [B200] Detected Device: B210
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 30.720000 MHz...
[INFO] [B200] Actually got clock rate 30.720000 MHz.
Setting frequency: DL=2160.0 Mhz, UL=1970.0 Mhz
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Setting Sampling frequency 5.76 MHz

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

eNB2

- `cd /path/to/srsLTE/srsenb`
- `sudo srsenb enb.conf`

```
jin@jin-D620MT-D620SF-BM3CF: ~/Desktop/enb2/srsenb
jin@jin-D620MT-D620SF-BM3CF:~/Desktop/enb2/srsenb$ sudo srsenb enb2.conf
[sudo] password for jin:
--- Software Radio Systems LTE eNodeB ---

Reading configuration file enb2.conf...
[INFO] [UHD] linux; GNU C++ version 5.4.0 20160609; Boost_105800; UHD_3.14.0.0-release
Opening USRP with args: type=b200, master_clock_rate=30.72e6
[INFO] [B200] Detected Device: B210
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 30.720000 MHz...
[INFO] [B200] Actually got clock rate 30.720000 MHz.
Setting frequency: DL=2685.0 Mhz, UL=2565.0 Mhz
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Setting Sampling frequency 5.76 MHz

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


程式執行

- UE
 - cd `/path/to/srsLTE/srsue`
 - `sudo srsue ue.conf`
 - #開啟新的 terminal
 - `sudo route del default`
 - `sudo route add default gw 172.16.0.2 tun_srsue`
#EPC 分配給 UE 的 IP_addr

UE - Step 1

- cd
/path/to/srsLTE/srs
ue
- sudo srsue ue.conf

```
ue@ue-X580VD: ~/Desktop/ue_lwaap/srsue
ue@ue-X580VD:~/Desktop/ue_lwaap/srsue$ sudo srsue ue.conf
[sudo] password for ue:
Reading configuration file ue.conf...

Built in Release mode using commit 0a69e56 on branch develop_ue.

Buffer capacity 10240
Buffer capacity 40960
--- Software Radio Systems LTE UE ---

Opening RF device with 1 RX antennas...
[INFO] [UHD] linux; GNU C++ version 5.4.0 20160609; Boost_105800; UHD_3.14.0.0-r
elease
Opening USRP with args: type=b200,master_clock_rate=30.72e6
[INFO] [B200] Detected Device: B210
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 30.720000 MHz...
[INFO] [B200] Actually got clock rate 30.720000 MHz.
LWAAP MAC 10:7b:44:23:7:ba
Waiting PHY to initialize...
...
Attaching UE...
Searching cell in DL EARFCN=500, f_dl=2160.0 MHz, f_ul=1970.0 MHz
.
Found Cell: PCI=1, PRB=25, Ports=1, CF0=1.1 KHz
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Found PLMN: Id=00101, TAC=7
Random Access Transmission: seq=0, ra-rnti=0x2
RRC Connected
Random Access Complete.
Network attach successful IP: 172.16.0.2
Software Radio Systems LTE (srsue)
```

這是EPC分配給
UE的 IP_addr

UE - Step 2

- #開啟新的 terminal
- sudo route del default
- sudo route add default gw 172.16.0.2 tun_srsue
#EPC 分配給 UE 的 IP_addr

```
ue@ue-X580VD: ~  
ue@ue-X580VD:~$ sudo route del default  
[sudo] password for ue:  
ue@ue-X580VD:~$ sudo route add default gw 172.16.0.2 tun_srsue  
ue@ue-X580VD:~$
```

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Ping 指令測試

- #UE 利用 USRP 傳送 ICMP 封包給 eNB1
- ping 172.16.0.1 -c 10

```
ue@ue-X580VD: ~  
ue@ue-X580VD:~$ sudo route del default  
[sudo] password for ue:  
ue@ue-X580VD:~$ sudo route add default gw 172.16.0.2 tun_srsue  
ue@ue-X580VD:~$ ping 172.16.0.1 -c 10  
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=1.02 ms  
64 bytes from 172.16.0.1: icmp_seq=2 ttl=64 time=0.813 ms  
64 bytes from 172.16.0.1: icmp_seq=3 ttl=64 time=1.03 ms  
64 bytes from 172.16.0.1: icmp_seq=4 ttl=64 time=1.30 ms  
64 bytes from 172.16.0.1: icmp_seq=5 ttl=64 time=0.858 ms  
64 bytes from 172.16.0.1: icmp_seq=6 ttl=64 time=0.996 ms  
64 bytes from 172.16.0.1: icmp_seq=7 ttl=64 time=1.04 ms  
64 bytes from 172.16.0.1: icmp_seq=8 ttl=64 time=0.844 ms  
64 bytes from 172.16.0.1: icmp_seq=9 ttl=64 time=0.784 ms  
64 bytes from 172.16.0.1: icmp_seq=10 ttl=64 time=1.45 ms  
  
--- 172.16.0.1 ping statistics ---  
10 packets transmitted, 10 received, 0% packet loss, time 9050ms  
rtt min/avg/max/mdev = 0.784/1.015/1.457/0.208 ms  
ue@ue-X580VD:~$
```

Wireshark 查看

UE Wireshark

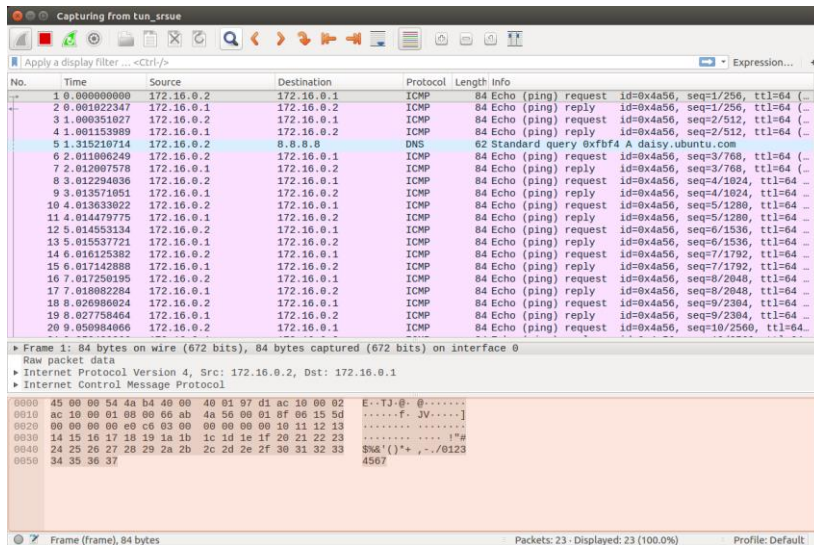


Table 1: Network Traffic Log (UE Wireshark)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=1/256, ttl=64
2	0.001022347	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=1/256, ttl=64
3	1.000351027	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=2/512, ttl=64
4	1.001153089	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=2/512, ttl=64
5	1.315210714	172.16.0.2	8.8.8.8	DNS	62	Standard query 0xfbf4 A daisy.ubuntu.com
6	2.011006249	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=3/768, ttl=64
7	2.012007578	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=3/768, ttl=64
8	3.012294036	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=4/1024, ttl=64
9	3.013571051	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=4/1024, ttl=64
10	4.013633022	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=5/1280, ttl=64
11	4.014479775	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=5/1280, ttl=64
12	5.014553134	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=6/1536, ttl=64
13	5.015537721	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=6/1536, ttl=64
14	6.016125382	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=7/1792, ttl=64
15	6.017142888	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=7/1792, ttl=64
16	7.017250195	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=8/2048, ttl=64
17	7.018002284	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=8/2048, ttl=64
18	8.026980624	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=9/2304, ttl=64
19	8.027758464	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0x4a56, seq=9/2304, ttl=64
20	9.050984066	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0x4a56, seq=10/2560, ttl=64

Frame 1: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0
Raw packet data
Internet Protocol Version 4, Src: 172.16.0.2, Dst: 172.16.0.1
Internet Control Message Protocol

0000 45 00 00 54 4a b4 40 00 40 01 97 d1 ac 10 00 02 E-13-B-@-.....
0010 ac 10 00 01 08 00 66 ab 4a 56 00 01 8f 06 15 5df-JV.....
0020 00 00 00 00 e0 c3 00 00 00 00 00 10 11 12 13
0030 14 15 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23
0040 24 25 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 36 37 4507 84a(')*,-/0123

eNB1 Wireshark

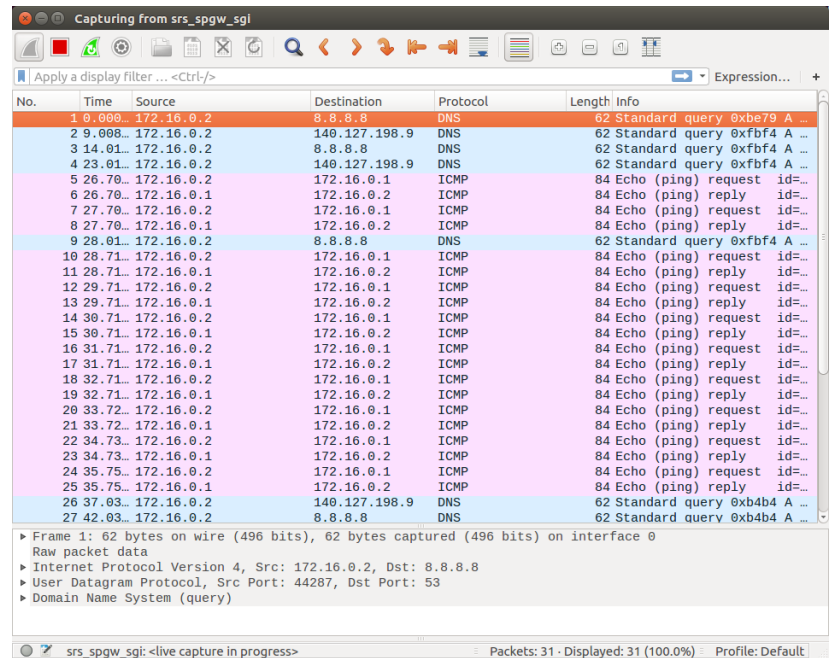


Table 2: Network Traffic Log (eNB1 Wireshark)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.0.2	8.8.8.8	DNS	62	Standard query 0xfbf4 A ...
2	9.000000000	172.16.0.2	140.127.198.9	DNS	62	Standard query 0xfbf4 A ...
3	14.010000000	172.16.0.2	8.8.8.8	DNS	62	Standard query 0xfbf4 A ...
4	23.010000000	172.16.0.2	140.127.198.9	DNS	62	Standard query 0xfbf4 A ...
5	26.700000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
6	26.700000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
7	27.700000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
8	27.700000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
9	28.010000000	172.16.0.2	8.8.8.8	DNS	62	Standard query 0xfbf4 A ...
10	28.710000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
11	28.710000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
12	29.710000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
13	29.710000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
14	30.710000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
15	30.710000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
16	31.710000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
17	31.710000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
18	32.710000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
19	32.710000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
20	33.720000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
21	33.720000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
22	34.730000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
23	34.730000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
24	35.750000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=...
25	35.750000000	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=...
26	37.030000000	172.16.0.2	140.127.198.9	DNS	62	Standard query 0xb4b4 A ...
27	42.030000000	172.16.0.2	8.8.8.8	DNS	62	Standard query 0xb4b4 A ...

Frame 1: 62 bytes on wire (496 bits), 62 bytes captured (496 bits) on interface 0
Raw packet data
Internet Protocol Version 4, Src: 172.16.0.2, Dst: 8.8.8.8
User Datagram Protocol, Src Port: 44287, Dst Port: 53
Domain Name System (query)

iPerf3 測試

- iperf3 -s #eNB1
- iperf3 -c 172.16.0.1 -b 100B -w 1k #UE

```
ue@ue-X580VD:~$ iperf3 -c 172.16.0.1 -b 100b -w 1k
Connecting to host 172.16.0.1, port 5201
[ 4] local 172.16.0.2 port 49278 connected to 172.16.0.1 port 5201
[ ID] Interval      Transfer    Bandwidth  Retr  Cwnd
[ 4] 0.00-1.00    sec  3.94 KBytes 32.3 Kbits/sec  0    5.62 KBytes
[ 4] 1.00-2.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 2.00-3.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 3.00-4.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 4.00-5.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 5.00-6.00    sec  2.25 KBytes 18.4 Kbits/sec  0    5.62 KBytes
[ 4] 6.00-7.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 7.00-8.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 8.00-9.00    sec  2.81 KBytes 23.0 Kbits/sec  0    5.62 KBytes
[ 4] 9.00-10.00   sec  2.25 KBytes 18.4 Kbits/sec  0    5.62 KBytes
- - - - -
[ ID] Interval      Transfer    Bandwidth  Retr
[ 4] 0.00-10.00   sec  28.1 KBytes 23.0 Kbits/sec  0
[ 4] 0.00-10.00   sec  27.0 KBytes 22.1 Kbits/sec

sender
receiver
```

UE
iperf3

```
asus-medium@asusmedium-UN65H: ~
asus-medium@asusmedium-UN65H:~$ iperf3 -s
Server listening on 5201
Accepted connection from 172.16.0.2, port 49276
[ 5] local 172.16.0.1 port 5201 connected to 172.16.0.2 port 49278
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.00-1.00    sec  2.25 KBytes 18.4 Kbits/sec
[ 5] 1.00-2.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 2.00-3.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 3.00-4.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 4.00-5.00    sec  2.25 KBytes 18.4 Kbits/sec
[ 5] 5.00-6.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 6.00-7.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 7.00-8.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 8.00-9.00    sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 9.00-10.00   sec  2.25 KBytes 18.4 Kbits/sec
[ 5] 10.00-10.04  sec  576 Bytes  121 Kbits/sec
- - - - -
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.00-10.04   sec  0.00 Bytes  0.00 bits/sec
[ 5] 0.00-10.04   sec  27.0 KBytes 22.0 Kbits/sec

sender
receiver
```

eNB1
iperf3

調配封包傳送比例

- #在eNB1 的 terminal 輸入 “r”並按下” enter”
#接著輸入 1 1
#比例僅能輸入整數

```
asus-medium@asusmedium-UN65H: ~/Desktop/enb/srsenb
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 30.720000 MHz...
[INFO] [B200] Actually got clock rate 30.720000 MHz.
Setting frequency: DL=2160.0 Mhz, UL=1970.0 Mhz
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Setting Sampling frequency 5.76 MHz

==== eNodeB started ====
Type <t> to view trace
RACH: tti=6101, preamble=0, offset=0, temp_crnti=0x46
Data LCID 3
Data LCID ----- 3
LWAAP TX MAC 78:24:af:4:55:3
LWAAP add user rnti=0x46
User 0x46 connected
r
Enter lwa ratio:1 1
```

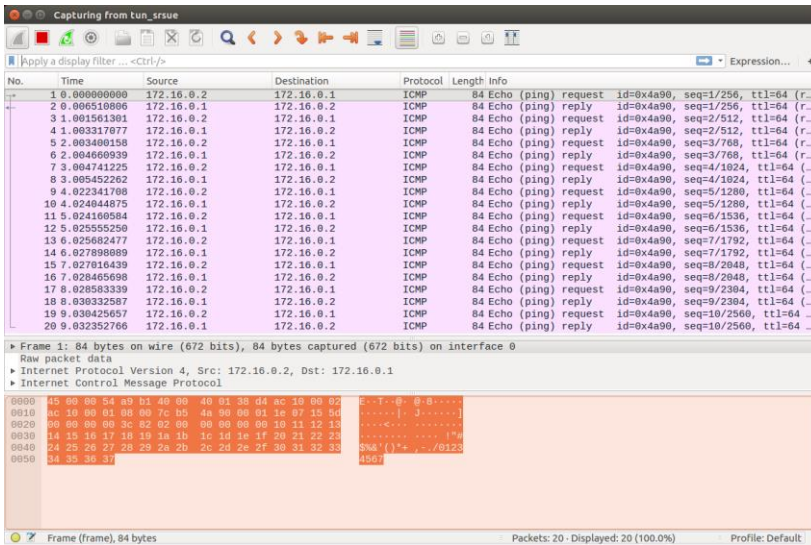

Ping 指令測試

- #UE 利用 USRP 傳送 ICMP 封包給 eNB1
- ping 172.16.0.1 -c 10

```
ue@ue-X580VD: ~  
ue@ue-X580VD:~$ ping 172.16.0.1 -c 10  
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=6.51 ms  
64 bytes from 172.16.0.1: icmp_seq=2 ttl=64 time=1.76 ms  
64 bytes from 172.16.0.1: icmp_seq=3 ttl=64 time=1.28 ms  
64 bytes from 172.16.0.1: icmp_seq=4 ttl=64 time=0.721 ms  
64 bytes from 172.16.0.1: icmp_seq=5 ttl=64 time=1.73 ms  
64 bytes from 172.16.0.1: icmp_seq=6 ttl=64 time=1.40 ms  
64 bytes from 172.16.0.1: icmp_seq=7 ttl=64 time=2.22 ms  
64 bytes from 172.16.0.1: icmp_seq=8 ttl=64 time=1.46 ms  
64 bytes from 172.16.0.1: icmp_seq=9 ttl=64 time=1.76 ms  
64 bytes from 172.16.0.1: icmp_seq=10 ttl=64 time=1.94 ms  
  
--- 172.16.0.1 ping statistics ---  
10 packets transmitted, 10 received, 0% packet loss, time 9030ms  
rtt min/avg/max/mdev = 0.721/2.081/6.518/1.529 ms  
ue@ue-X580VD:~$
```

Wireshark 查看

UE Wireshark



Frame 1: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0

Raw packet data

Internet Protocol Version 4, Src: 172.16.0.2, Dst: 172.16.0.1

Internet Control Message Protocol

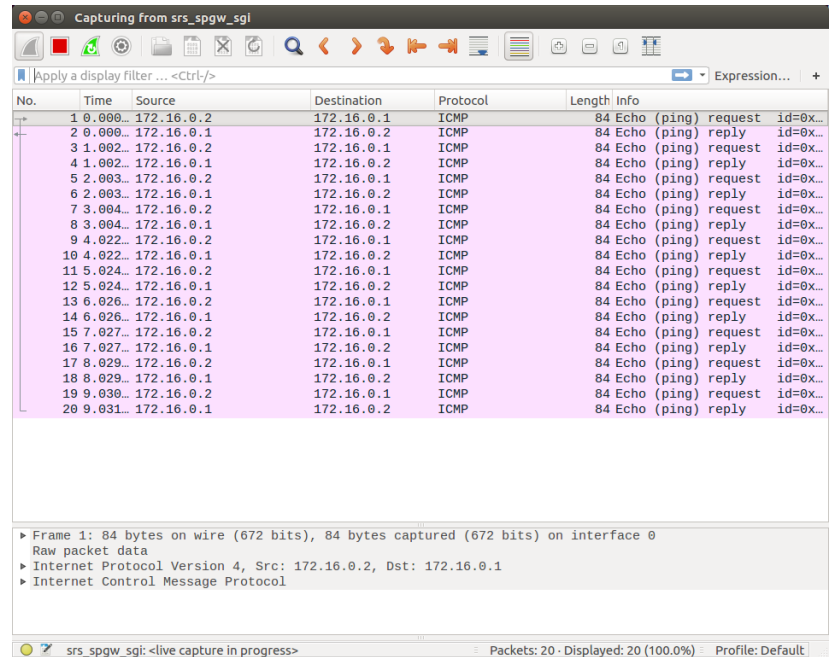
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=1/256, ttl=64 (r...
2	0.006510896	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=1/256, ttl=64 (r...
3	1.001561301	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=2/512, ttl=64 (r...
4	1.003317077	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=2/512, ttl=64 (r...
5	2.003400158	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=3/768, ttl=64 (r...
6	2.004606939	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=3/768, ttl=64 (r...
7	3.004741225	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=4/1024, ttl=64 (r...
8	3.005452262	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=4/1024, ttl=64 (r...
9	4.022341708	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=5/1280, ttl=64 (r...
10	4.024844475	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=5/1280, ttl=64 (r...
11	5.024160504	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=6/1536, ttl=64 (r...
12	5.025552590	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=6/1536, ttl=64 (r...
13	6.025682477	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=7/1792, ttl=64 (r...
14	6.027898889	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=7/1792, ttl=64 (r...
15	7.027816439	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=8/2048, ttl=64 (r...
16	7.028465598	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=8/2048, ttl=64 (r...
17	8.028583339	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=9/2304, ttl=64 (r...
18	8.030332587	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=9/2304, ttl=64 (r...
19	9.030425057	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=10/2560, ttl=64 (r...
20	9.032352766	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=10/2560, ttl=64 (r...

Frame (frame), 84 bytes

Packets: 20 - Displayed: 20 (100.0%)

Profile: Default

eNB1 Wireshark



Frame 1: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0

Raw packet data

Internet Protocol Version 4, Src: 172.16.0.2, Dst: 172.16.0.1

Internet Control Message Protocol

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=1/256, ttl=64 (r...
2	0.006510896	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=1/256, ttl=64 (r...
3	1.001561301	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=2/512, ttl=64 (r...
4	1.003317077	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=2/512, ttl=64 (r...
5	2.003400158	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=3/768, ttl=64 (r...
6	2.004606939	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=3/768, ttl=64 (r...
7	3.004741225	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=4/1024, ttl=64 (r...
8	3.005452262	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=4/1024, ttl=64 (r...
9	4.022341708	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=5/1280, ttl=64 (r...
10	4.024844475	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=5/1280, ttl=64 (r...
11	5.024160504	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=6/1536, ttl=64 (r...
12	5.025552590	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=6/1536, ttl=64 (r...
13	6.025682477	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=7/1792, ttl=64 (r...
14	6.027898889	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=7/1792, ttl=64 (r...
15	7.027816439	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=8/2048, ttl=64 (r...
16	7.028465598	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=8/2048, ttl=64 (r...
17	8.028583339	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=9/2304, ttl=64 (r...
18	8.030332587	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=9/2304, ttl=64 (r...
19	9.030425057	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request id=0xa90, seq=10/2560, ttl=64 (r...
20	9.032352766	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply id=0xa90, seq=10/2560, ttl=64 (r...

Frame 1: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0

Raw packet data

Internet Protocol Version 4, Src: 172.16.0.2, Dst: 172.16.0.1

Internet Control Message Protocol

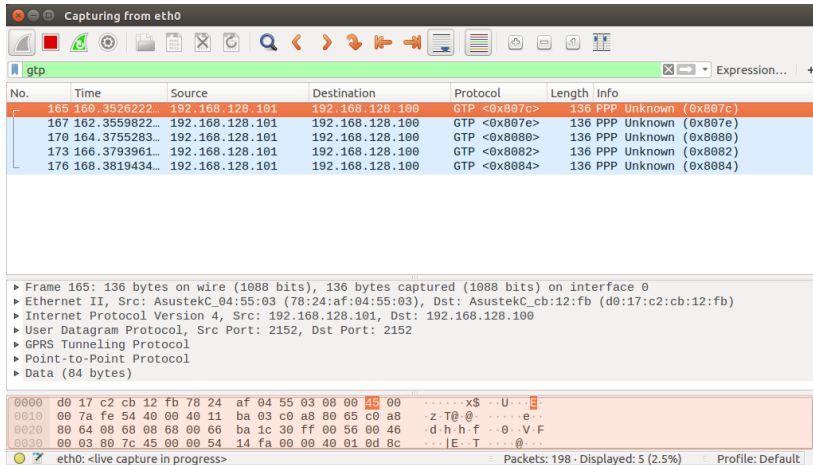
srs_spgw_sgi: <live capture in progress>

Packets: 20 - Displayed: 20 (100.0%)

Profile: Default

Wireshark 查看

eNB2
Wireshark
收封包情况

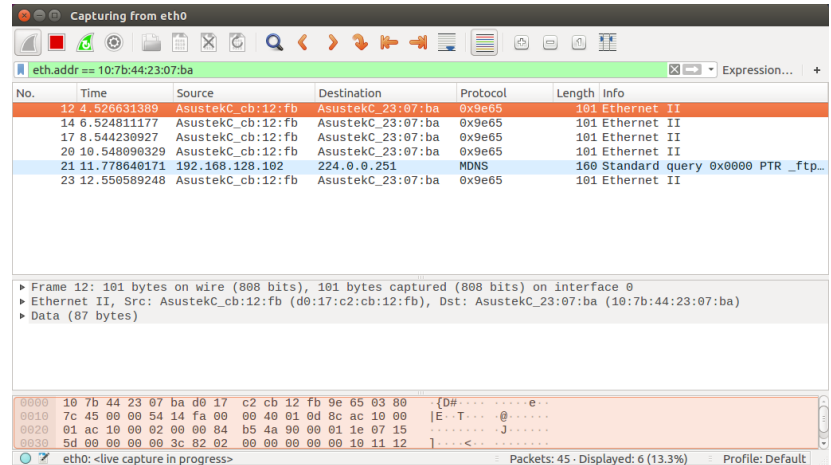


No.	Time	Source	Destination	Protocol	Length	Info
165	160.3526222...	192.168.128.101	192.168.128.100	GTP <0x007c>	136	PPP Unknown (0x007c)
167	162.3559822...	192.168.128.101	192.168.128.100	GTP <0x007e>	136	PPP Unknown (0x007e)
170	164.3755283...	192.168.128.101	192.168.128.100	GTP <0x0080>	136	PPP Unknown (0x0080)
173	166.3793961...	192.168.128.101	192.168.128.100	GTP <0x0082>	136	PPP Unknown (0x0082)
176	168.3819434...	192.168.128.101	192.168.128.100	GTP <0x0084>	136	PPP Unknown (0x0084)

Frame 165: 136 bytes on wire (1088 bits), 136 bytes captured (1088 bits) on interface 0
Ethernet II, Src: AsustekC_04:55:03 (78:24:af:04:55:03), Dst: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb)
Internet Protocol Version 4, Src: 192.168.128.101, Dst: 192.168.128.100
User Datagram Protocol, Src Port: 2152, Dst Port: 2152
GPRS Tunneling Protocol
Point-to-Point Protocol
Data (84 bytes)

eth0: <live capture in progress> Packets: 198 - Displayed: 5 (2.5%) Profile: Default

eNB2
Wireshark
送封包情况



No.	Time	Source	Destination	Protocol	Length	Info
12	4.526631389	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II
14	6.524811177	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II
17	8.544230927	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II
20	10.548090329	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II
21	11.778640171	192.168.128.102	224.0.0.251	MDNS	160	Standard query 0x0000 PTR _ftp...
23	12.559589248	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II

Frame 12: 101 bytes on wire (808 bits), 101 bytes captured (808 bits) on interface 0
Ethernet II, Src: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb), Dst: AsustekC_23:07:ba (10:7b:44:23:07:ba)
Data (87 bytes)

eth0: <live capture in progress> Packets: 45 - Displayed: 6 (13.3%) Profile: Default

iPerf3 測試

- iperf3 -s #eNB1
- iperf3 -c 172.16.0.1 -b 100B -w 1k #UE

```
ue@ue-X580VD:~$ iperf3 -c 172.16.0.1 -b 100b -w 1k
Connecting to host 172.16.0.1, port 5201
[ 4] local 172.16.0.2 port 49282 connected to 172.16.0.1 port 5201
[ ID] Interval      Transfer    Bandwidth   Retr   Cwnd
[ 4] 0.00-1.00  sec  3.94 KBytes 32.3 Kbits/sec    0   5.62 KBytes
[ 4] 1.00-2.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 2.00-3.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 3.00-4.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 4.00-5.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 5.00-6.00  sec  2.25 KBytes 18.4 Kbits/sec    0   5.62 KBytes
[ 4] 6.00-7.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 7.00-8.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 8.00-9.00  sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
[ 4] 9.00-10.00 sec  2.81 KBytes 23.0 Kbits/sec    0   5.62 KBytes
-----
[ ID] Interval      Transfer    Bandwidth   Retr
[ 4] 0.00-10.00  sec  28.7 KBytes 23.5 Kbits/sec    0
[ 4] 0.00-10.00  sec  27.0 KBytes 22.1 Kbits/sec
```

UE
iperf3

```
Server listening on 5201
Accepted connection from 172.16.0.2, port 49280
[ 5] local 172.16.0.1 port 5201 connected to 172.16.0.2 port 49282
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.00-1.00  sec  2.25 KBytes 18.4 Kbits/sec
[ 5] 1.00-2.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 2.00-3.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 3.00-4.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 4.00-5.00  sec  2.25 KBytes 18.4 Kbits/sec
[ 5] 5.00-6.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 6.00-7.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 7.00-8.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 8.00-9.00  sec  2.81 KBytes 23.0 Kbits/sec
[ 5] 9.00-10.00 sec  2.25 KBytes 18.4 Kbits/sec
[ 5] 10.00-10.04 sec  576 Bytes 118 Kbits/sec
-----
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.00-10.04  sec  0.00 Bytes 0.00 bits/sec
[ 5] 0.00-10.04  sec  27.0 KBytes 22.0 Kbits/sec
```

eNB1
iperf3

Wireshark 查看

UE Wireshark

eNB1 Wireshark

Capturing from tun_srsue

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

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.0.2	172.16.0.1	TCP	60	49280 → 5201 [SYN] Seq=0 Win=29696 Len=0 MSS=1460 S...
2	0.001159631	172.16.0.1	172.16.0.2	TCP	60	5201 → 49280 [SYN, ACK] Seq=0 Ack=1 Win=29696 Len=0 S...
3	0.001187893	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSva...
4	0.001220858	172.16.0.2	172.16.0.1	TCP	89	49280 → 5201 [PSH, ACK] Seq=1 Ack=1 Win=29696 Len=3...
5	0.002179330	172.16.0.1	172.16.0.2	TCP	52	5201 → 49280 [ACK] Seq=1 Ack=38 Win=29696 Len=0 TSv...
6	0.002577125	172.16.0.1	172.16.0.2	TCP	53	5201 → 49280 [PSH, ACK] Seq=1 Ack=38 Win=29696 Len=...
7	0.002590274	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=38 Ack=2 Win=29696 Len=0 TSv...
8	0.002626162	172.16.0.2	172.16.0.1	TCP	56	49280 → 5201 [PSH, ACK] Seq=38 Ack=2 Win=29696 Len=...
9	0.046130571	172.16.0.1	172.16.0.2	TCP	52	5201 → 49280 [ACK] Seq=2 Ack=42 Win=29696 Len=0 TSv...
10	0.046142609	172.16.0.2	172.16.0.1	TCP	164	49280 → 5201 [PSH, ACK] Seq=42 Ack=2 Win=29696 Len=...
11	0.047245753	172.16.0.1	172.16.0.2	TCP	52	5201 → 49280 [ACK] Seq=2 Ack=154 Win=29696 Len=0 TS...
12	0.047252769	172.16.0.1	172.16.0.2	TCP	53	5201 → 49280 [PSH, ACK] Seq=2 Ack=154 Win=29696 Len...
13	0.047313261	172.16.0.2	172.16.0.1	TCP	60	49282 → 5201 [SYN] Seq=0 Win=1152 Len=0 MSS=1460 SA...
14	0.048127539	172.16.0.1	172.16.0.2	TCP	60	5201 → 49282 [SYN, ACK] Seq=0 Ack=1 Win=1152 Len=0 ...
15	0.048134616	172.16.0.2	172.16.0.1	TCP	52	49282 → 5201 [ACK] Seq=1 Ack=1 Win=1152 Len=0 TSva...
16	0.048188765	172.16.0.2	172.16.0.1	TCP	89	49282 → 5201 [PSH, ACK] Seq=1 Ack=1 Win=1152 Len=37...
17	0.048842744	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1 Ack=38 Win=1115 Len=0 TSva...
18	0.090452241	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=154 Ack=3 Win=29696 Len=0 TS...
19	0.091407141	172.16.0.1	172.16.0.2	TCP	54	5201 → 49280 [PSH, ACK] Seq=3 Ack=154 Win=29696 Len...
20	0.091412820	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=154 Ack=5 Win=29696 Len=0 TS...
21	0.298496502	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK] Seq=38 Ack=1 Win=1152 Len=5...
22	0.299634002	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1 Ack=614 Win=539 Len=0 TSva...
23	0.299945633	172.16.0.1	172.16.0.2	TCP	52	[TCP Window Update] 5201 → 49282 [ACK] Seq=1 Ack=61...
24	0.596474861	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK] Seq=614 Ack=1 Win=1152 Len=...
25	0.598174739	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1 Ack=1190 Win=1152 Len=0 TS...
26	0.714724939	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK] Seq=1190 Ack=1 Win=1152 Len...
27	0.716257164	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1 Ack=1766 Win=1152 Len=0 TS...
28	0.922534988	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK] Seq=1766 Ack=1 Win=1152 Len...
29	0.923251064	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1 Ack=2342 Win=1152 Len=0 TS...

Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
Raw packet data
Internet Protocol Version 4, Src: 172.16.0.2, Dst: 172.16.0.1
Transmission Control Protocol, Src Port: 49280, Dst Port: 5201, Seq: 0, Len: 0

0000 45 00 00 3c 00 90 40 00 40 06 e2 08 0a 10 00 02 E<<<@ @<.....
0010 ac 10 00 01 c0 00 14 51 3c 33 6f 8d 00 00 00 00Q<30.....
0020 a0 02 72 10 8d 03 00 00 02 04 05 b4 04 02 08 0aP-C.....
0030 86 5b e9 77 00 00 00 00 01 03 03 0a[W.....

Bytes 12-15: Source (ip.src) Packets: 137 · Displayed: 137 (100.0%) Profile: Default

Capturing from srs_spgw_sgl

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

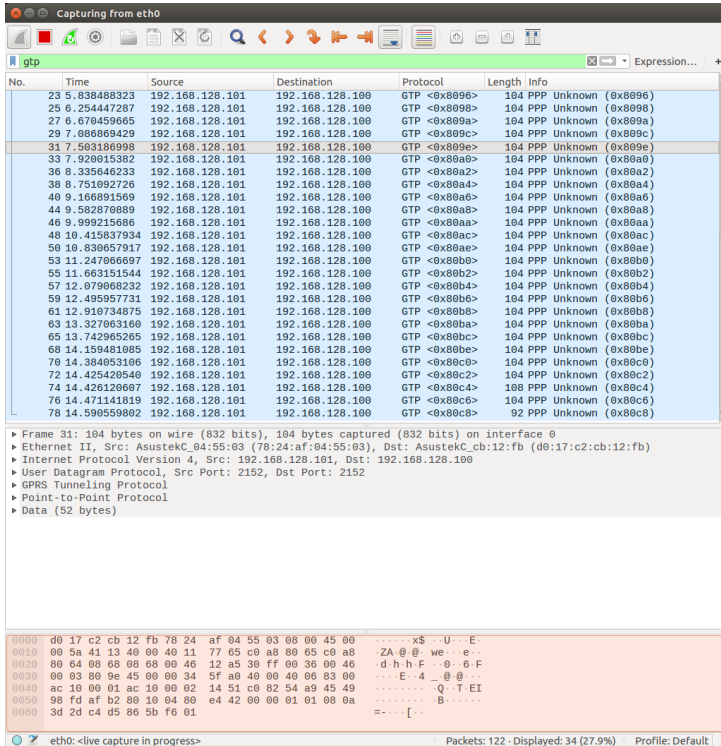
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000...	172.16.0.2	172.16.0.1	TCP	60	49280 → 5201 [SYN] Seq=0...
2	0.000...	172.16.0.1	172.16.0.2	TCP	60	5201 → 49280 [SYN, ACK]...
3	0.001...	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=1...
4	0.001...	172.16.0.2	172.16.0.1	TCP	89	49280 → 5201 [PSH, ACK]...
5	0.001...	172.16.0.2	172.16.0.2	TCP	52	5201 → 49280 [ACK] Seq=1...
6	0.001...	172.16.0.1	172.16.0.2	TCP	53	5201 → 49280 [PSH, ACK]...
7	0.002...	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=3...
8	0.002...	172.16.0.2	172.16.0.1	TCP	56	49280 → 5201 [PSH, ACK]...
9	0.045...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49280 [ACK] Seq=2...
10	0.046...	172.16.0.1	172.16.0.1	TCP	164	49280 → 5201 [PSH, ACK]...
11	0.046...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49280 [ACK] Seq=2...
12	0.046...	172.16.0.1	172.16.0.2	TCP	53	5201 → 49280 [PSH, ACK]...
13	0.047...	172.16.0.2	172.16.0.1	TCP	60	49282 → 5201 [SYN] Seq=0...
14	0.047...	172.16.0.1	172.16.0.2	TCP	60	5201 → 49282 [SYN, ACK]...
15	0.047...	172.16.0.2	172.16.0.1	TCP	52	49282 → 5201 [ACK] Seq=1...
16	0.048...	172.16.0.2	172.16.0.1	TCP	89	49282 → 5201 [PSH, ACK]...
17	0.048...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
18	0.090...	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [ACK] Seq=1...
19	0.090...	172.16.0.1	172.16.0.2	TCP	54	5201 → 49280 [PSH, ACK]...
20	0.091...	172.16.0.2	172.16.0.1	TCP	52	49280 → 5201 [PSH, ACK]...
21	0.298...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
22	0.298...	172.16.0.2	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
23	0.298...	172.16.0.1	172.16.0.2	TCP	52	[TCP Window Update] 5201...
24	0.596...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
25	0.597...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
26	0.714...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
27	0.715...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
28	0.922...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
29	0.922...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
30	1.130...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
31	1.130...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
32	1.338...	172.16.0.1	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
33	1.338...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
34	1.546...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
35	1.546...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
36	1.754...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
37	1.754...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
38	1.962...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...
39	1.962...	172.16.0.1	172.16.0.2	TCP	52	5201 → 49282 [ACK] Seq=1...
40	2.170...	172.16.0.2	172.16.0.1	TCP	628	49282 → 5201 [PSH, ACK]...

Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
Raw packet data
Internet Protocol Version 4, Src: 172.16.0.2, Dst: 172.16.0.1
Transmission Control Protocol, Src Port: 49280, Dst Port: 5201, Seq: 0, Len: 0

srs_spgw_sgl: alive capture in progress> Packets: 137 · Displayed: 137 (100.0%) Profile: Default

Wireshark 查看

eNB2
Wireshark
收封包情况

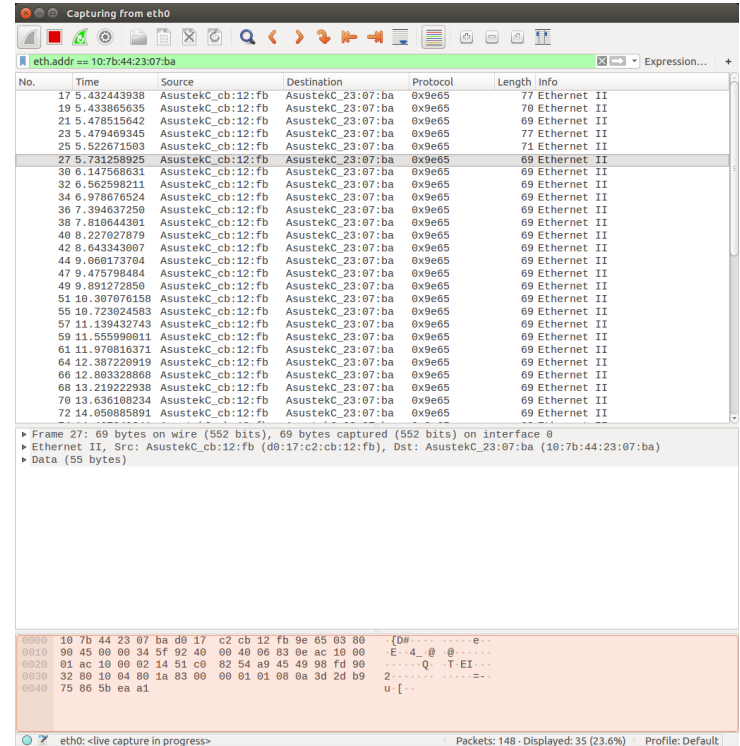


No.	Time	Source	Destination	Protocol	Length	Info
23	5.838488323	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
25	6.254447287	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
27	6.670459665	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
29	7.086069429	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
31	7.593186998	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
33	7.920615362	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
36	8.335646233	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
38	8.751992726	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
40	9.166891569	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
44	9.582870889	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
46	9.999215686	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
48	10.415837934	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
50	10.830657917	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
53	11.247066697	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
55	11.663151544	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
57	12.079068232	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
59	12.495957731	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
61	12.916734875	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
63	13.327063160	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
65	13.742965265	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
68	14.158401895	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
70	14.384953106	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
72	14.425429540	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
74	14.426120607	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
76	14.471141819	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)
78	14.596559802	192.168.128.101	192.168.128.100	GTP <0x8096>	104	PPP Unknown (0x8096)

Frame 31: 104 bytes on wire (832 bits), 104 bytes captured (832 bits) on interface 0
Ethernet II, Src: AsustekC_b2:17:0d:17:c2:cb:12:fb (d0:17:c2:cb:12:fb), Dst: 192.168.128.100
Internet Protocol Version 4, Src: 192.168.128.101, Dst: 192.168.128.100
User Datagram Protocol, Src Port: 2152, Dst Port: 2152
GPRS Tunneling Protocol
Point-to-Point Protocol
Data (52 bytes)

0000 00 17 c2 cb 12 fb 78 24 af 04 55 03 08 00 45 00 ...x\$ U...E
0010 00 5a 41 13 40 00 40 11 77 65 c0 a8 00 65 c0 a8 ...ZA @ @ we...e
0020 00 64 08 68 08 68 00 46 12 a5 30 ff 00 36 00 46 ...d.h.h.F _...6.F
0030 00 03 00 9e 45 00 00 34 5f a0 40 00 40 00 83 004 _...@...
0040 ac 10 00 01 ac 10 00 02 14 51 c0 82 54 a9 45 49 ...Q...T.EI...
0050 08 fd af b2 00 10 04 00 e4 42 00 00 01 01 00 0a ...B...
0060 3d 2d c4 d5 86 5b f6 01 ...=...[...]

eNB2
Wireshark
送封包情况



No.	Time	Source	Destination	Protocol	Length	Info
17	5.432443938	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	77	Ethernet II
19	5.433865635	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	70	Ethernet II
21	5.478515642	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
23	5.479469345	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	77	Ethernet II
25	5.522671503	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	71	Ethernet II
27	5.731258925	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
30	6.147560631	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
32	6.562598211	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
34	6.978676524	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
36	7.394637250	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
38	7.810644301	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
40	8.227027879	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
42	8.643343007	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
44	9.060137304	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
47	9.475798484	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
49	9.891272850	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
51	10.307676158	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
55	10.723024583	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
57	11.139432743	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
59	11.555990611	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
61	11.970816371	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
64	12.387220919	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
66	12.80328868	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
68	13.219222938	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
70	13.636180234	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II
72	14.050805891	AsustekC_b2:17:0d:17:c2:cb:12:fb	AsustekC_23:07:ba	0x9e05	69	Ethernet II

Frame 27: 69 bytes on wire (552 bits), 69 bytes captured (552 bits) on interface 0
Ethernet II, Src: AsustekC_b2:17:0d:17:c2:cb:12:fb (d0:17:c2:cb:12:fb), Dst: AsustekC_23:07:ba (10:7b:44:23:07:ba)
Data (55 bytes)

0000 10 7b 44 23 07 ba d0 17 c2 cb 12 fb 0e 65 03 00 ...[Dw...e...
0010 00 45 00 00 34 5f 92 40 00 40 06 83 0e ac 10 00 ...E..L.@...@...
0020 01 ac 10 00 02 14 51 c0 82 54 a9 45 49 fd 98 fd ...Q...T.EI...
0030 32 80 10 04 00 1a 83 00 00 01 01 08 0a 3d 2d b9 ...2...-...=...
0040 75 86 5b ea a1 ...u [...]

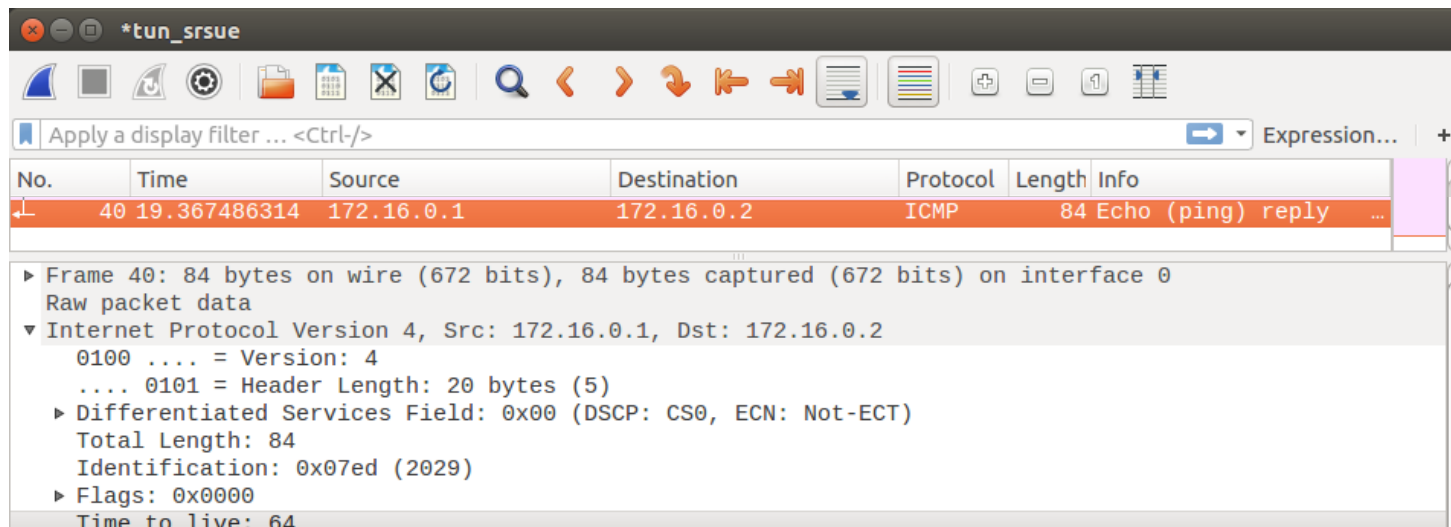
nukxDC(ee)設定及流量測試

- UE 預設開啟elwa模式
- eNB預設wifi和eth比率为1:1
- 在EPC開啟新的終端機並輸入
iperf3 -s
- 在UE開啟新的終端機並輸入
iperf3 -c 172.16.0.1 -M 100B

iperf3 測試結果

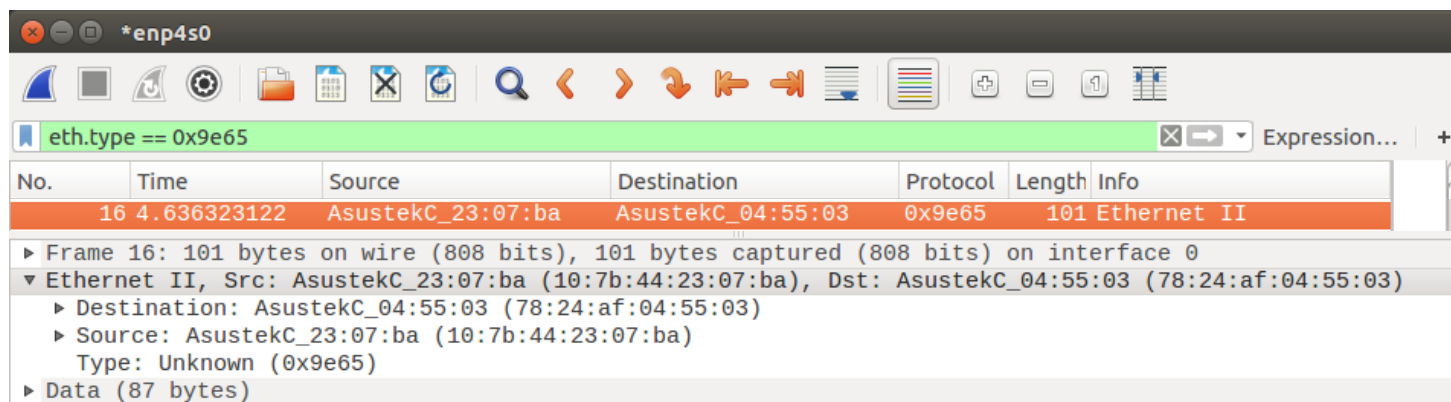
```
ue@ue-X580VD: ~  
ue@ue-X580VD:~$ iperf3 -c 172.16.0.1 -M 100B  
Connecting to host 172.16.0.1, port 5201  
[ 4] local 172.16.0.2 port 58362 connected to 172.16.0.1 port 5201  
[ ID] Interval      Transfer    Bandwidth    Retr  Cwnd  
[ 4]  0.00-1.00    sec  1.78 MBytes 14.9 Mbits/sec 36   9.54 KBytes  
[ 4]  1.00-2.00    sec  1.69 MBytes 14.2 Mbits/sec 14  14.2 KBytes  
[ 4]  2.00-3.00    sec  1.50 MBytes 12.6 Mbits/sec 40  14.3 KBytes  
[ 4]  3.00-4.00    sec  1.50 MBytes 12.6 Mbits/sec 36  13.8 KBytes  
[ 4]  4.00-5.00    sec  1.50 MBytes 12.6 Mbits/sec 19  14.1 KBytes  
[ 4]  5.00-6.00    sec  1.50 MBytes 12.6 Mbits/sec 9   18.0 KBytes  
[ 4]  6.00-7.00    sec  1.54 MBytes 12.9 Mbits/sec 21  11.2 KBytes  
[ 4]  7.00-8.00    sec  1.47 MBytes 12.3 Mbits/sec 1   15.9 KBytes  
[ 4]  8.00-9.00    sec  1.47 MBytes 12.3 Mbits/sec 36  16.1 KBytes  
[ 4]  9.00-10.00   sec  1.50 MBytes 12.6 Mbits/sec 20  10.8 KBytes  
- - - - -  
[ ID] Interval      Transfer    Bandwidth    Retr  
[ 4]  0.00-10.00   sec  15.5 MBytes 13.0 Mbits/sec 232  
[ 4]  0.00-10.00   sec  14.9 MBytes 12.5 Mbits/sec  
iperf Done.  
ue@ue-X580VD:~$ iperf3 -c 172.16.0.1 -M 100B  
Connecting to host 172.16.0.1, port 5201  
[ 4] local 172.16.0.2 port 58366 connected to 172.16.0.1 port 5201  
[ ID] Interval      Transfer    Bandwidth    Retr  Cwnd  
[ 4]  0.00-1.00    sec  1.76 MBytes 14.8 Mbits/sec 28   9.28 KBytes  
[ 4]  1.00-2.00    sec  1.57 MBytes 13.2 Mbits/sec 22  13.1 KBytes  
[ 4]  2.00-3.00    sec  1.65 MBytes 13.9 Mbits/sec 2   12.6 KBytes  
[ 4]  3.00-4.00    sec  1.47 MBytes 12.3 Mbits/sec 5   13.0 KBytes  
[ 4]  4.00-5.00    sec  1.47 MBytes 12.3 Mbits/sec 33  13.1 KBytes  
[ 4]  5.00-6.00    sec  1.47 MBytes 12.3 Mbits/sec 28   9.20 KBytes  
[ 4]  6.00-7.00    sec  1.50 MBytes 12.6 Mbits/sec 0   15.1 KBytes  
[ 4]  7.00-8.00    sec  1.50 MBytes 12.6 Mbits/sec 36  13.7 KBytes  
[ 4]  8.00-9.00    sec  1.47 MBytes 12.3 Mbits/sec 36  13.1 KBytes  
[ 4]  9.00-10.00   sec  1.50 MBytes 12.6 Mbits/sec 5   14.2 KBytes  
- - - - -  
[ ID] Interval      Transfer    Bandwidth    Retr  
[ 4]  0.00-10.00   sec  15.4 MBytes 12.9 Mbits/sec 195  
[ 4]  0.00-10.00   sec  14.9 MBytes 12.5 Mbits/sec  
iperf Done.  
ue@ue-X580VD:~$
```


Wireshark監看 - UE端



Wireshark packet capture window titled `*tun_srsue`. The display filter is `Apply a display filter ... <Ctrl-/>`. The packet list shows a selected packet (No. 40) at time 19.367486314, source 172.16.0.1, destination 172.16.0.2, protocol ICMP, length 84, and info Echo (ping) reply. The packet details pane shows the following structure:

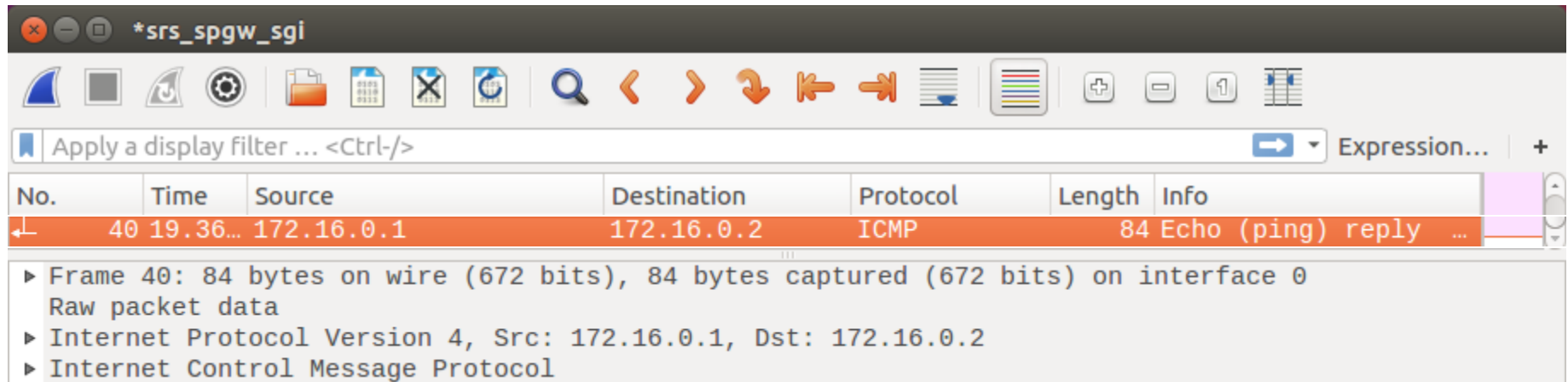
- Frame 40: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0
- Raw packet data
- Internet Protocol Version 4, Src: 172.16.0.1, Dst: 172.16.0.2
 - 0100 = Version: 4
 - 0101 = Header Length: 20 bytes (5)
 - Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 - Total Length: 84
 - Identification: 0x07ed (2029)
 - Flags: 0x0000
 - Time to live: 64



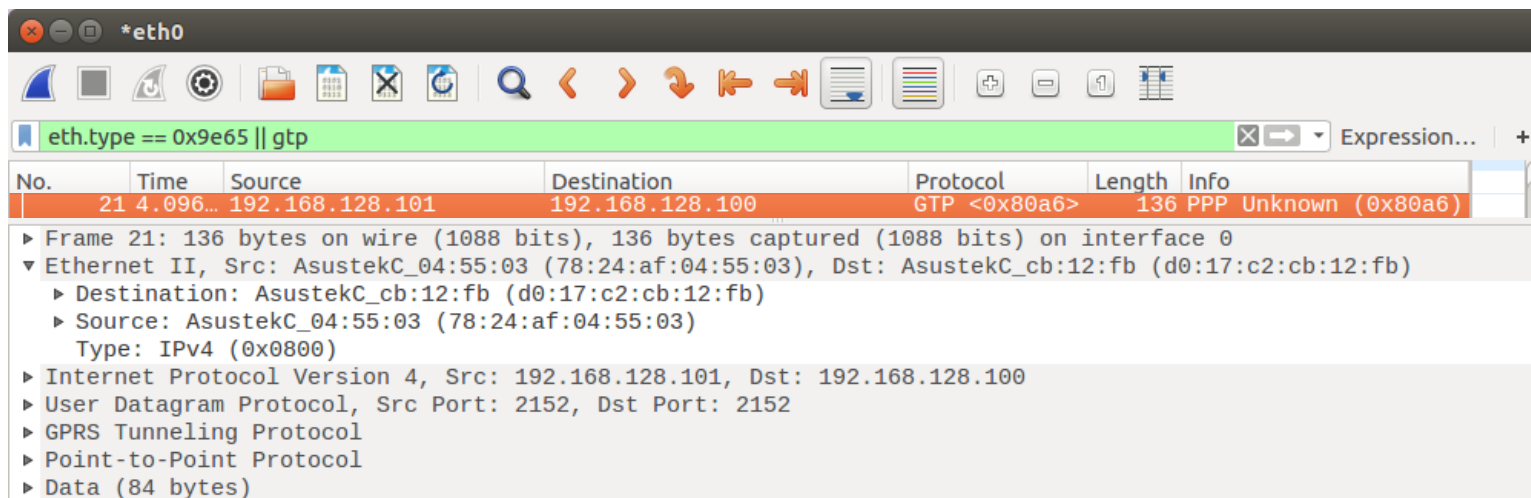
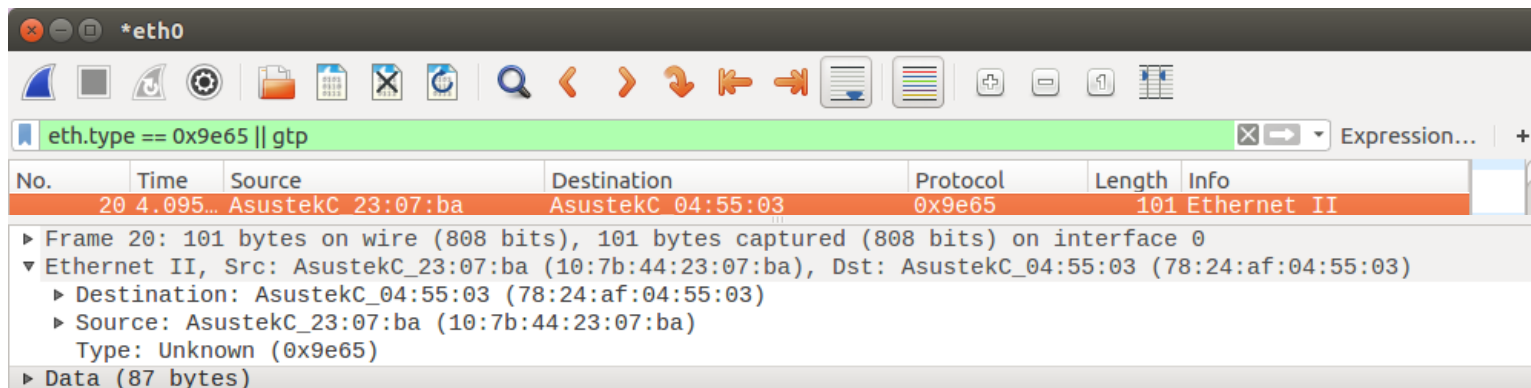
Wireshark packet capture window titled `*enp4s0`. The display filter is `eth.type == 0x9e65`. The packet list shows a selected packet (No. 16) at time 4.636323122, source AsustekC_23:07:ba, destination AsustekC_04:55:03, protocol 0x9e65, length 101, and info Ethernet II. The packet details pane shows the following structure:

- Frame 16: 101 bytes on wire (808 bits), 101 bytes captured (808 bits) on interface 0
- Ethernet II, Src: AsustekC_23:07:ba (10:7b:44:23:07:ba), Dst: AsustekC_04:55:03 (78:24:af:04:55:03)
 - Destination: AsustekC_04:55:03 (78:24:af:04:55:03)
 - Source: AsustekC_23:07:ba (10:7b:44:23:07:ba)
 - Type: Unknown (0x9e65)
- Data (87 bytes)

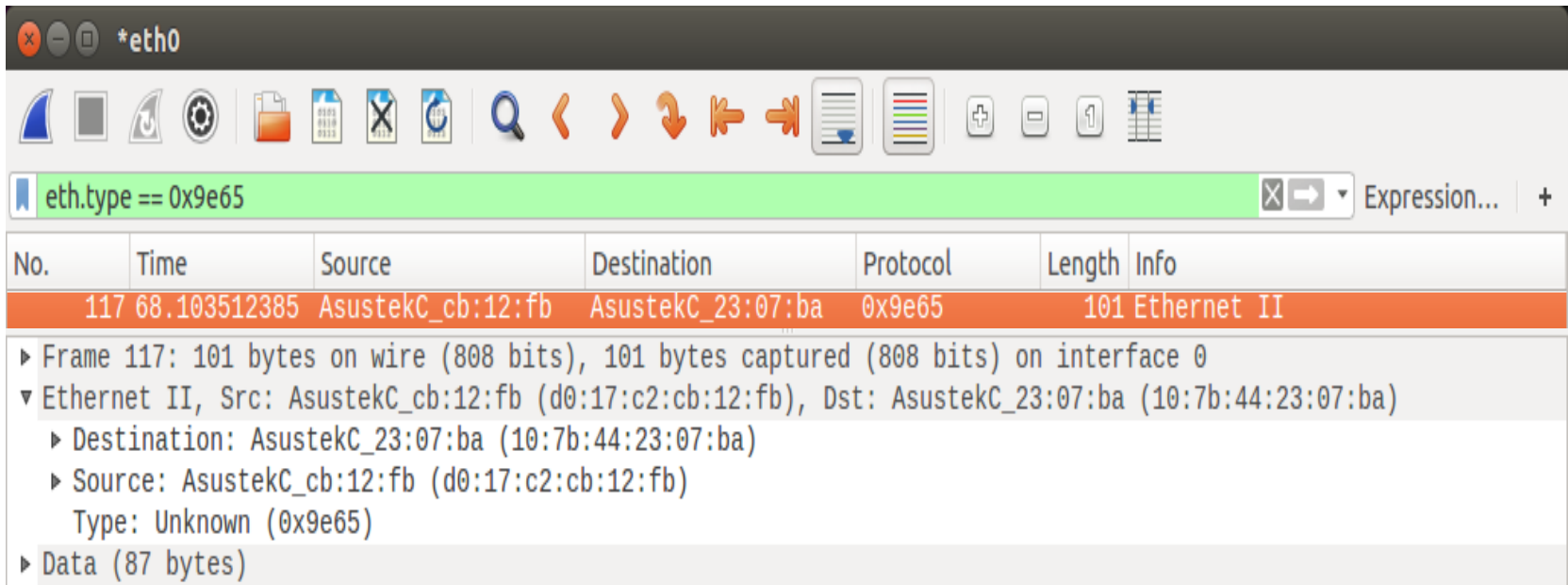
Wireshark監看 - eNB1端



Wireshark監看 - eNB1端



Wireshark監看 - eNB2端



Wireshark interface showing a packet capture on interface `eth0`. The filter bar displays the expression `eth.type == 0x9e65`.

No.	Time	Source	Destination	Protocol	Length	Info
117	68.103512385	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II

Packet details for Frame 117:

- Frame 117: 101 bytes on wire (808 bits), 101 bytes captured (808 bits) on interface 0
- Ethernet II, Src: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb), Dst: AsustekC_23:07:ba (10:7b:44:23:07:ba)
 - Destination: AsustekC_23:07:ba (10:7b:44:23:07:ba)
 - Source: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb)
 - Type: Unknown (0x9e65)
- Data (87 bytes)

nukxDC(ee)設定及流量測試

- 在enb1的終端機輸入“r”，然後按下“Enter”
接著輸入比率 1 0
※注意須為整數，兩數中間為空格

```
asus-medium@asusmedium-UN65H: ~/Desktop/dc_enb1/srsenb
[INFO] [UHD] linux; GNU C++ version 5.4.0 20160609; Boost_105800; UHD_3.14.0.0-release
Opening USRP with args: type=b200, master_clock_rate=30.72e6
[INFO] [B200] Detected Device: B210
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 30.720000 MHz...
[INFO] [B200] Actually got clock rate 30.720000 MHz.
Setting frequency: DL=2160.0 Mhz, UL=1970.0 Mhz
[INFO] [B200] Asking for clock rate 23.040000 MHz...
Failed to bind on address 192.168.128.101, port 2152
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Setting Sampling frequency 5.76 MHz

==== eNodeB started ====
Type <t> to view trace
rU
Enter lwa ratio:1 0
```

nukxDC(ee)設定及流量測試

- 在EPC端開啟新的終端機並輸入指令
iperf3 -s
- 在UE端開啟新的終端機並輸入指令
iperf3 -c 172.16.0.1 -M 100B

iperf3 測試結果

```
ue@ue-X580VD: ~  
[ 4] 0.00-1.00 sec 2.24 MBytes 18.8 Mbits/sec 26 10.3 KBytes  
[ 4] 1.00-2.00 sec 2.17 MBytes 18.2 Mbits/sec 7 16.1 KBytes  
[ 4] 2.00-3.00 sec 2.03 MBytes 17.0 Mbits/sec 54 11.1 KBytes  
[ 4] 3.00-4.00 sec 1.99 MBytes 16.7 Mbits/sec 35 12.2 KBytes  
[ 4] 4.00-5.00 sec 2.03 MBytes 17.0 Mbits/sec 7 14.2 KBytes  
[ 4] 5.00-6.00 sec 1.99 MBytes 16.7 Mbits/sec 21 13.8 KBytes  
[ 4] 6.00-7.00 sec 2.07 MBytes 17.4 Mbits/sec 14 14.3 KBytes  
[ 4] 7.00-8.00 sec 1.99 MBytes 16.7 Mbits/sec 4 17.6 KBytes  
[ 4] 8.00-9.00 sec 2.03 MBytes 17.0 Mbits/sec 5 15.6 KBytes  
[ 4] 9.00-10.00 sec 1.96 MBytes 16.4 Mbits/sec 35 11.9 KBytes  
- - - - -  
[ ID] Interval Transfer Bandwidth Retr sender receiver  
[ 4] 0.00-10.00 sec 20.5 MBytes 17.2 Mbits/sec 208  
[ 4] 0.00-10.00 sec 20.0 MBytes 16.7 Mbits/sec  
iperf Done.  
ue@ue-X580VD:~$ iperf3 -c 172.16.0.1 -M 100B  
Connecting to host 172.16.0.1, port 5201  
[ 4] local 172.16.0.2 port 58472 connected to 172.16.0.1 port 5201  
[ ID] Interval Transfer Bandwidth Retr Cwnd sender receiver  
[ 4] 0.00-1.00 sec 2.20 MBytes 18.5 Mbits/sec 29 11.1 KBytes  
[ 4] 1.00-2.00 sec 2.13 MBytes 17.9 Mbits/sec 10 16.6 KBytes  
[ 4] 2.00-3.00 sec 1.99 MBytes 16.7 Mbits/sec 12 15.6 KBytes  
[ 4] 3.00-4.00 sec 1.92 MBytes 16.1 Mbits/sec 45 16.1 KBytes  
[ 4] 4.00-5.00 sec 1.96 MBytes 16.4 Mbits/sec 65 11.9 KBytes  
[ 4] 5.00-6.00 sec 1.92 MBytes 16.1 Mbits/sec 23 13.7 KBytes  
[ 4] 6.00-7.00 sec 1.96 MBytes 16.4 Mbits/sec 13 15.6 KBytes  
[ 4] 7.00-8.00 sec 1.92 MBytes 16.1 Mbits/sec 55 14.8 KBytes  
[ 4] 8.00-9.00 sec 1.92 MBytes 16.1 Mbits/sec 47 15.0 KBytes  
[ 4] 9.00-10.00 sec 1.96 MBytes 16.4 Mbits/sec 1 19.9 KBytes  
- - - - -  
[ ID] Interval Transfer Bandwidth Retr sender receiver  
[ 4] 0.00-10.00 sec 19.9 MBytes 16.7 Mbits/sec 300  
[ 4] 0.00-10.00 sec 19.3 MBytes 16.2 Mbits/sec  
iperf Done.  
ue@ue-X580VD:~$
```

Wireshark監看 - UE端

Wireshark capture window titled "Capturing from enp4s0". The interface shows a packet list with one entry, packet 160, at time 64.454223970. The packet details pane shows the structure of an Ethernet II frame with source MAC AsustekC_23:07:ba and destination MAC AsustekC_04:55:03. The protocol is 0x9e65, length is 30 bytes, and the info is Ethernet II. The packet bytes pane shows the raw data of the frame.

No.	Time	Source	Destination	Protocol	Length	Info
160	64.454223970	AsustekC_23:07:ba	AsustekC_04:55:03	0x9e65	30	Ethernet II

▶ Frame 160: 30 bytes on wire (240 bits), 30 bytes captured (240 bits) on interface 0

▼ Ethernet II, Src: AsustekC_23:07:ba (10:7b:44:23:07:ba), Dst: AsustekC_04:55:03 (78:24:af:04:55:03)

- ▶ Destination: AsustekC_04:55:03 (78:24:af:04:55:03)
- ▶ Source: AsustekC_23:07:ba (10:7b:44:23:07:ba)
- Type: Unknown (0x9e65)

▶ Data (16 bytes)

Wireshark capture window titled "*tun_srsue". The interface shows a packet list with two entries, packets 39 and 40, at times 19.084708821 and 19.085255726 respectively. The packet details pane shows the structure of an ICMP Echo (ping) request and reply. The protocol is ICMP, length is 84 bytes, and the info is Echo (ping) request and Echo (ping) reply. The packet bytes pane shows the raw data of the packet.

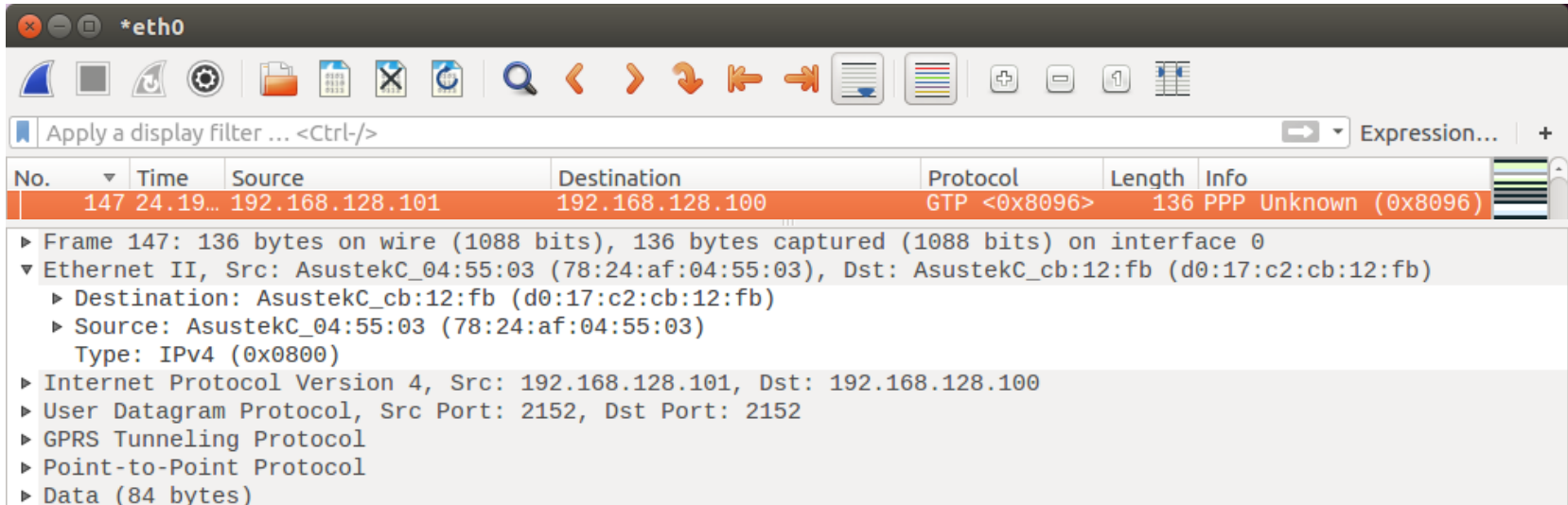
No.	Time	Source	Destination	Protocol	Length	Info
39	19.084708821	172.16.0.2	172.16.0.1	ICMP	84	Echo (ping) request ...
40	19.085255726	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply ...

▶ Frame 40: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0

Raw packet data

▼ Internet Protocol Version 4, Src: 172.16.0.1, Dst: 172.16.0.2

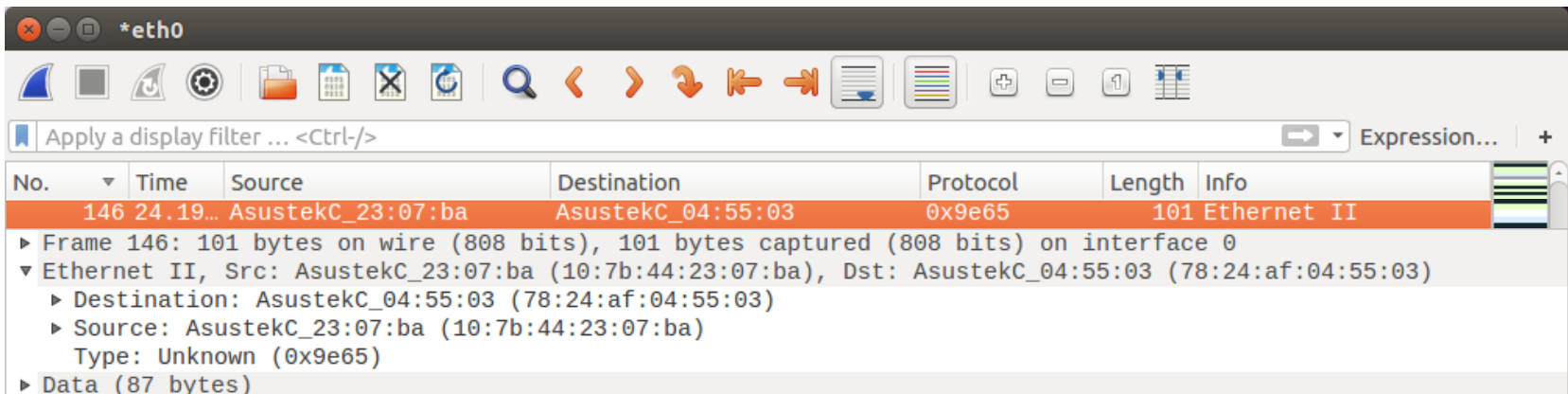
Wireshark監看 - eNB1端



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

No.	Time	Source	Destination	Protocol	Length	Info
147	24.19...	192.168.128.101	192.168.128.100	GTP <0x8096>	136	PPP Unknown (0x8096)

- ▶ Frame 147: 136 bytes on wire (1088 bits), 136 bytes captured (1088 bits) on interface 0
- ▼ Ethernet II, Src: AsustekC_04:55:03 (78:24:af:04:55:03), Dst: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb)
 - ▶ Destination: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb)
 - ▶ Source: AsustekC_04:55:03 (78:24:af:04:55:03)
 - Type: IPv4 (0x0800)
- ▶ Internet Protocol Version 4, Src: 192.168.128.101, Dst: 192.168.128.100
- ▶ User Datagram Protocol, Src Port: 2152, Dst Port: 2152
- ▶ GPRS Tunneling Protocol
- ▶ Point-to-Point Protocol
- ▶ Data (84 bytes)

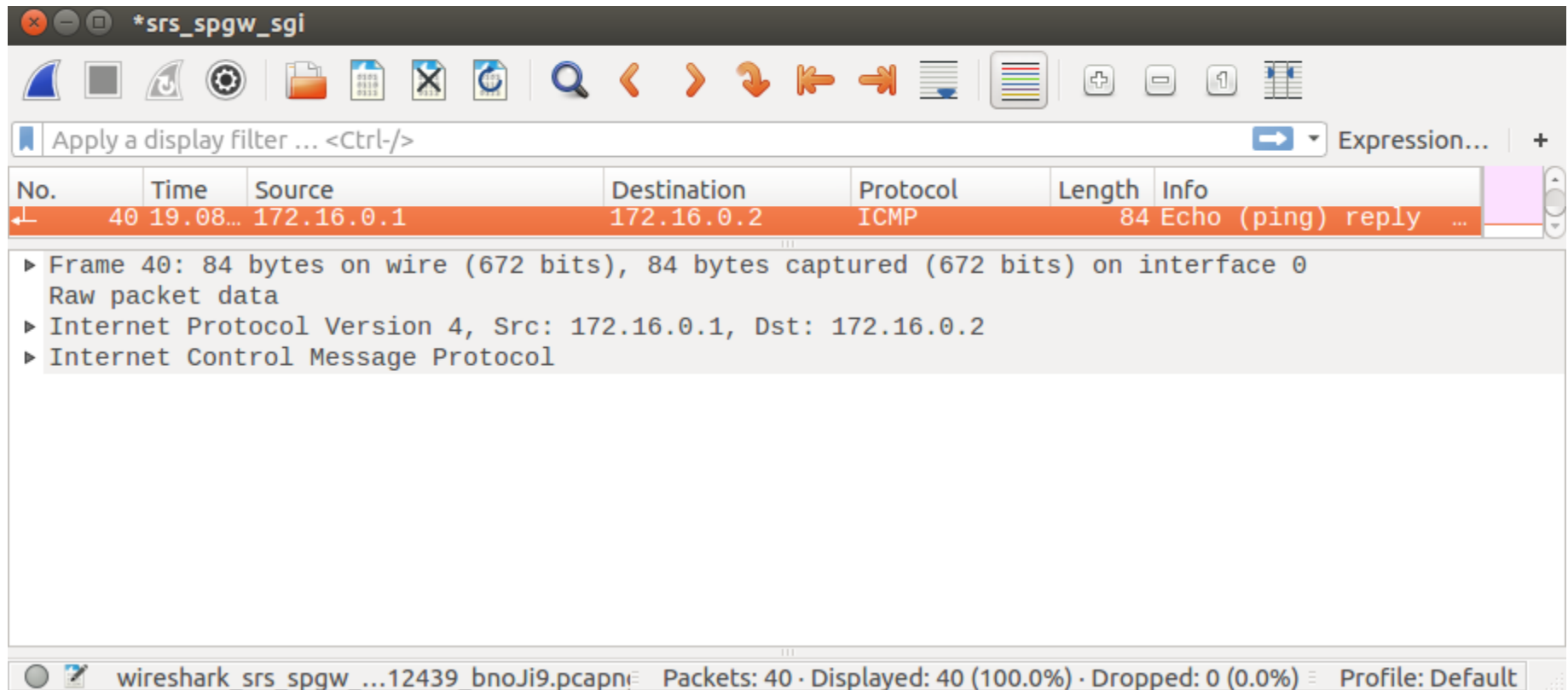


Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
146	24.19...	AsustekC_23:07:ba	AsustekC_04:55:03	0x9e65	101	Ethernet II

- ▶ Frame 146: 101 bytes on wire (808 bits), 101 bytes captured (808 bits) on interface 0
- ▼ Ethernet II, Src: AsustekC_23:07:ba (10:7b:44:23:07:ba), Dst: AsustekC_04:55:03 (78:24:af:04:55:03)
 - ▶ Destination: AsustekC_04:55:03 (78:24:af:04:55:03)
 - ▶ Source: AsustekC_23:07:ba (10:7b:44:23:07:ba)
 - Type: Unknown (0x9e65)
- ▶ Data (87 bytes)

Wireshark監看 - eNB1端



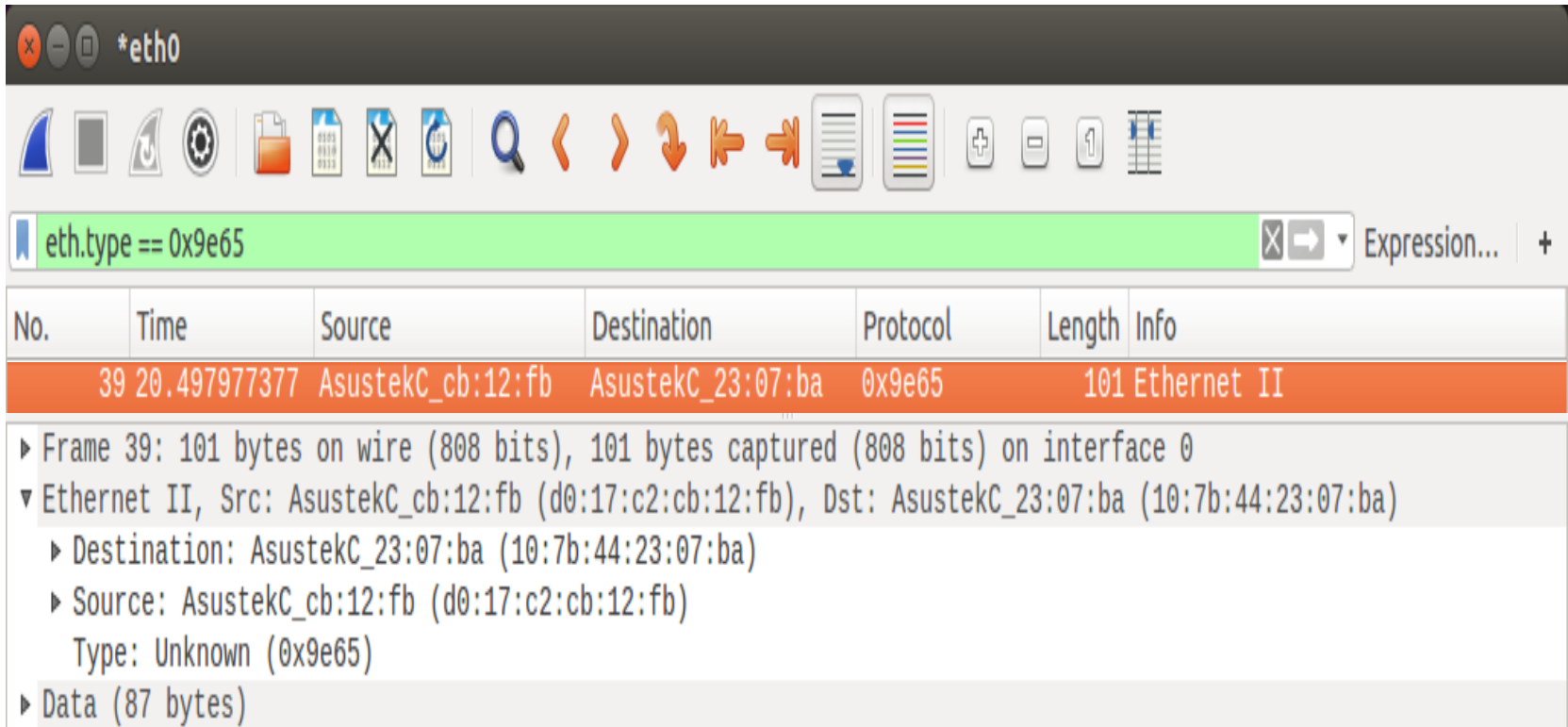
The image shows the Wireshark network protocol analyzer interface. The title bar indicates the file is named `*srs_spgw_sgi`. The interface includes a toolbar with various icons for file operations, search, and packet navigation. Below the toolbar is a display filter bar with the text "Apply a display filter ... <Ctrl-/>" and a search icon. The main packet list pane shows a single packet, No. 40, at time 19.08... from source 172.16.0.1 to destination 172.16.0.2, identified as ICMP, with a length of 84 bytes. The packet information pane shows the details of this packet: Frame 40: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0. The raw packet data is expanded, showing the Internet Protocol Version 4 (Src: 172.16.0.1, Dst: 172.16.0.2) and the Internet Control Message Protocol (ICMP Echo (ping) reply).

No.	Time	Source	Destination	Protocol	Length	Info
40	19.08...	172.16.0.1	172.16.0.2	ICMP	84	Echo (ping) reply ...

► Frame 40: 84 bytes on wire (672 bits), 84 bytes captured (672 bits) on interface 0
Raw packet data
► Internet Protocol Version 4, Src: 172.16.0.1, Dst: 172.16.0.2
► Internet Control Message Protocol

wireshark_srs_spgw_...12439_bnoJi9.pcapng Packets: 40 · Displayed: 40 (100.0%) · Dropped: 0 (0.0%) Profile: Default

Wireshark監看 - eNB2端



Wireshark interface showing a packet capture on interface `eth0`. The filter bar displays the expression `eth.type == 0x9e65`.

No.	Time	Source	Destination	Protocol	Length	Info
39	20.497977377	AsustekC_cb:12:fb	AsustekC_23:07:ba	0x9e65	101	Ethernet II

Packet details for Frame 39:

- Frame 39: 101 bytes on wire (808 bits), 101 bytes captured (808 bits) on interface 0
- Ethernet II, Src: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb), Dst: AsustekC_23:07:ba (10:7b:44:23:07:ba)
 - Destination: AsustekC_23:07:ba (10:7b:44:23:07:ba)
 - Source: AsustekC_cb:12:fb (d0:17:c2:cb:12:fb)
 - Type: Unknown (0x9e65)
- Data (87 bytes)

nukxDC(ee)設定及流量測試

- 在UE的終端機上輸入“e”並按下“Enter”
- 畫面會顯示 Disable elwa.

```
ue@ue-X580VD: ~/Desktop/dc_ue/srsue
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 30.720000 MHz...
[INFO] [B200] Actually got clock rate 30.720000 MHz.
LWAAP MAC f4:96:34:3:6a:a6
LWAAP IP packet receiver thread run_enable
Waiting PHY to initialize...
...
Attaching UE...
Searching cell in DL EARFCN=500, f_dl=2160.0 MHz, f_ul=1970.0 MHz
.
Found Cell: PCI=1, PRB=25, Ports=1, CFO=0.7 KHz
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Found PLMN: Id=00101, TAC=7
Random Access Transmission: seq=6, ra-rnti=0x2
Random Access Transmission: seq=42, ra-rnti=0x2
RRC Connected
Random Access Complete.      c-rnti=0x47, ta=0
Network attach successful. IP: 172.16.0.2
Software Radio Systems LTE (srsLTE)
e
Disable elwa.
█
```

Outline

- 實驗目的及實驗內容
- 5G Emulator-nukxDC(ee) 實驗環境
 - srsLTE Small Cell 架構
 - 軟硬體環境
- 5G Emulator-nukxDC(ee) 網路實驗平台建置
 - 安裝基礎 srsLTE網路環境
 - 設定srsLTE EPC
 - 設定srsLTE eNB
 - 設定srsLTE UE
- 執行程式暨測試
- 總結

總結

- 讓學生熟悉及建置 srsLTE 的實驗環境
- 在三台主機上安裝 srsLTE UE 和 EPC 和 eNB
 - 了解各個裝置的參數設定
 - 透過終端機訊息了解執行過程
 - 利用 Wireshark 觀測封包的內容及流向
- 透過設定 srsLTE 與網路配置
增進了解 5G 新的網路架構

問題

1. 當 eNB1 改變調配比例時，觀察 UE 傳輸速率的影響
2. 當 UE 使用 UDP 傳送封包時，比較 TCP 在相同比例下的差異
3. 當 UE 是否開啟elwa模式時，傳輸速率的差異