

Build Proxy Mobile IPv6

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Date: 2019/04/24



注意事項

❏ 實驗(三)上機實驗時間 (@ R204)

- 時間: 2019/5/01 14:20~17:10

❏ 實驗(三)展演及實驗結報繳交 (@ R204)

- 時間: 2019/5/08 14:20~15:30
- 實驗結報繳交方式:
 - 一律使用電子郵件繳交電子檔，請寄至 jet.lee@pcs.csie.ntu.edu.tw。
 - 郵件主旨範例如[CNL(實驗三)結報繳交_組別], 最晚當天繳交完畢。
 - 請特別注意信件內容要填寫，不然會被當成垃圾信。

❏ 下次上課 (@ R204)

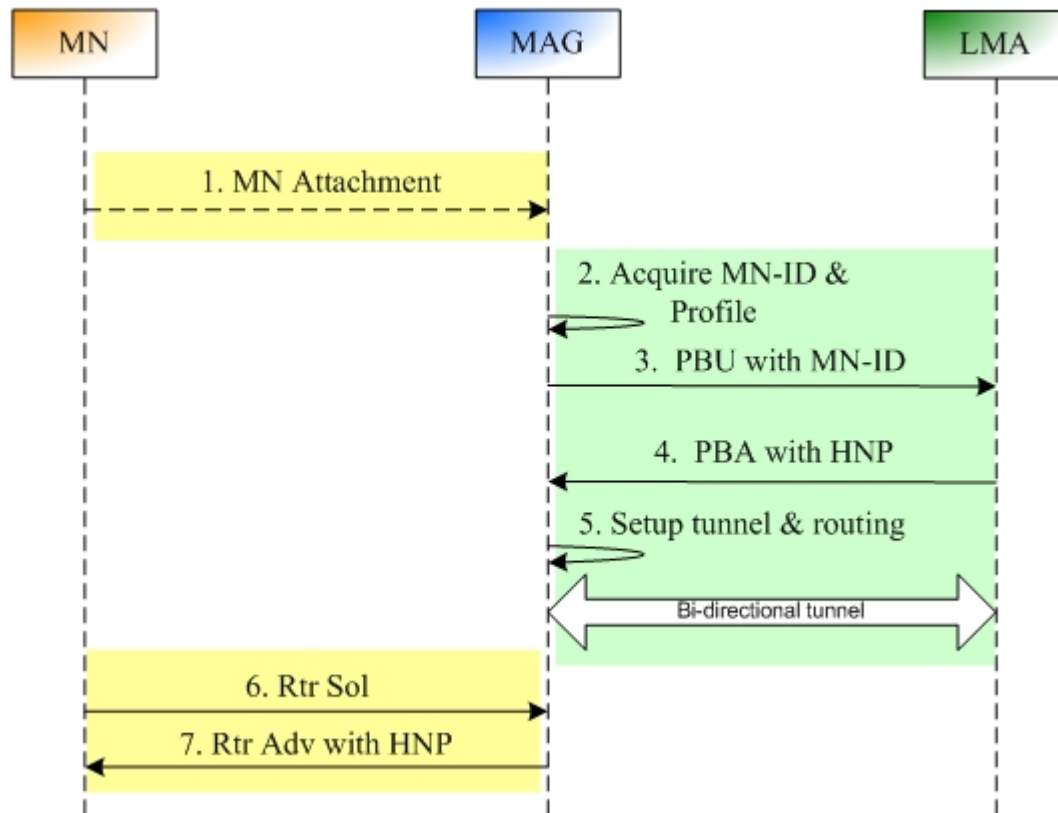
- 期末專題提案報告
 - 報告順序將隨機挑選，每一組10~15分鐘
 - 務必全組員當場，缺席請跟老師請假
- 時間: 2019/5/22 10:00~17:30

實驗說明與目的

- ❖ 建置PMIPv6網路環境，移動節點(Mobile Node)透過PMIPv6協定拿到一組固定的IPv6位址，使得MN在不同的MAG下移動時，維持相同的IPv6位址，讓學生們可以了解PMIPv6的運作方式與IP的移動性。
- ❖ 本實驗使用OpenAirInterface PMIPv6 (OAI PMIPv6) OpenSource 軟體，OAI PMIPv6基於Mobile IPv6 for Linux (MIPL)計畫，而Linux在2.6.29後的版本將MIPL模組納入Kernel當中。
- ❖ 在OAI PMIPv6中，AP與MAG之間利用SYSLOG訊息傳遞MN的attachment與detachment，而RADIUS被用來驗證MN的身分。

實驗原理

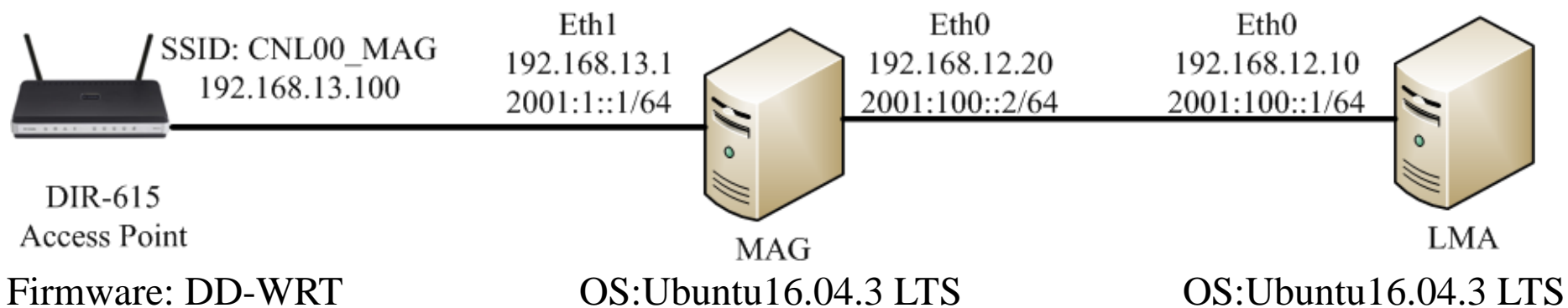
Proxy Mobile IPv6



圖一、PMIPv6流程

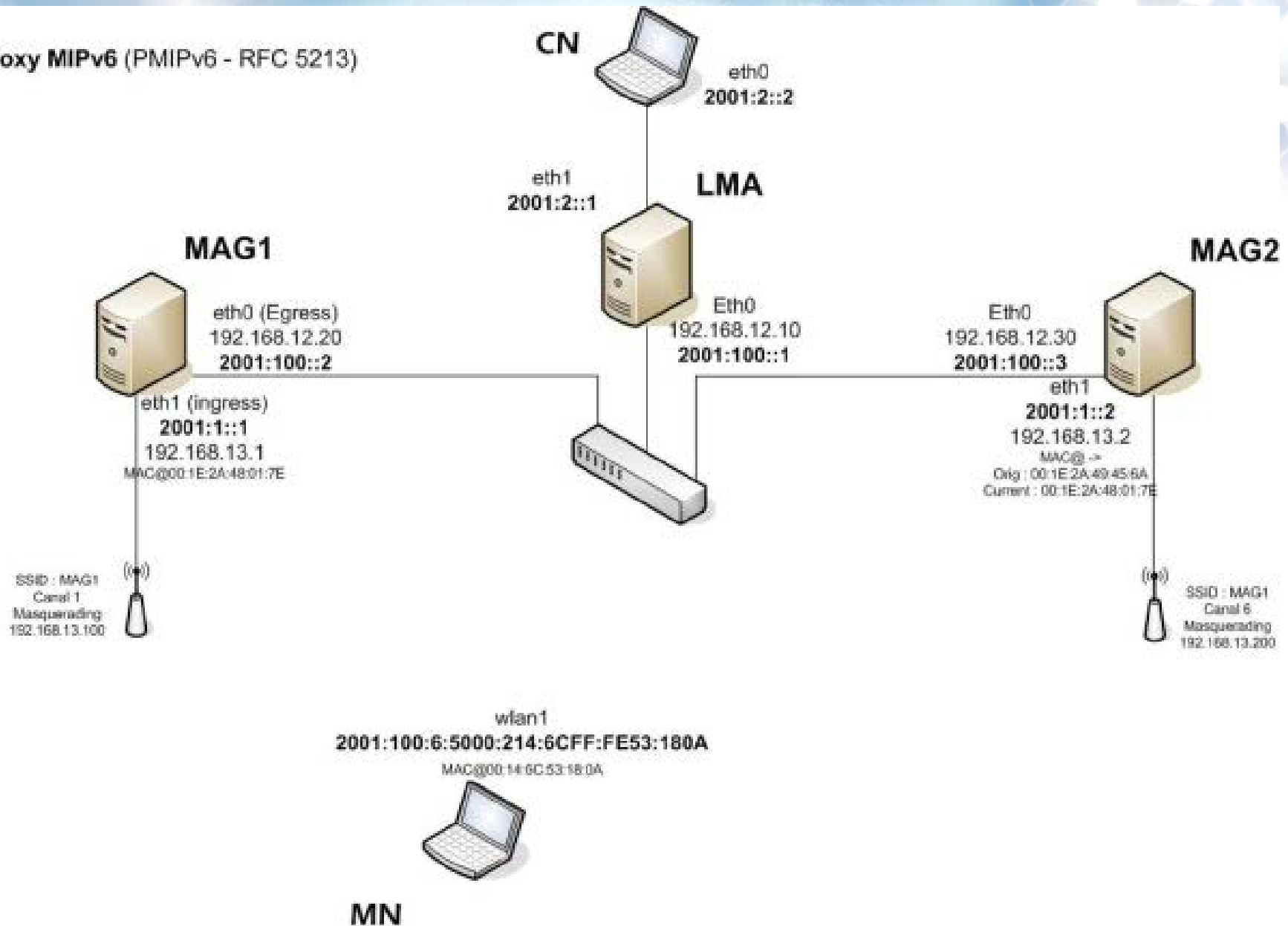
實驗器材與實驗架構

- ❖ 兩台PC當做LMA與MAG (本次實驗將使用VM替代PC)
 - VirtualBox 6.0.6
- ❖ 一台Notebook 當做MN (自備)
- ❖ 一台AP
- ❖ 兩條網路線
- ❖ IP設定部分只要設定IPv4就好，IPv6軟體會自動設定。



Firmware: DD-WRT

Proxy MIPv6 (PMIPv6 - RFC 5213)



Example of a real testbed

IPv4設定範例

Editing Wired connection 1

Connection name: Wired connection 1

General Ethernet 802.1x Security DCB **IPv4 Settings** IPv6 Settings

Method: Manual

Addresses

Address	Netmask	Gateway
192.168.12.10	24	192.168.12.10

Add Delete

DNS servers:

Search domains:

DHCP client ID:

☐ Require IPv4 addressing for this connection to complete

Routes...

Cancel Save

圖二a、IPv4網路設定 (LMA)

Editing Wired connection 1

Connection name: Wired connection 1

General Ethernet 802.1x Security DCB **IPv4 Settings** IPv6 Settings

Method: Manual

Addresses

Address	Netmask	Gateway
192.168.12.20	24	192.168.12.10

Add Delete

DNS servers:

Search domains:

DHCP client ID:

☐ Require IPv4 addressing for this connection to complete

Routes...

Cancel Save

圖二b、IPv4網路設定 (MAG)

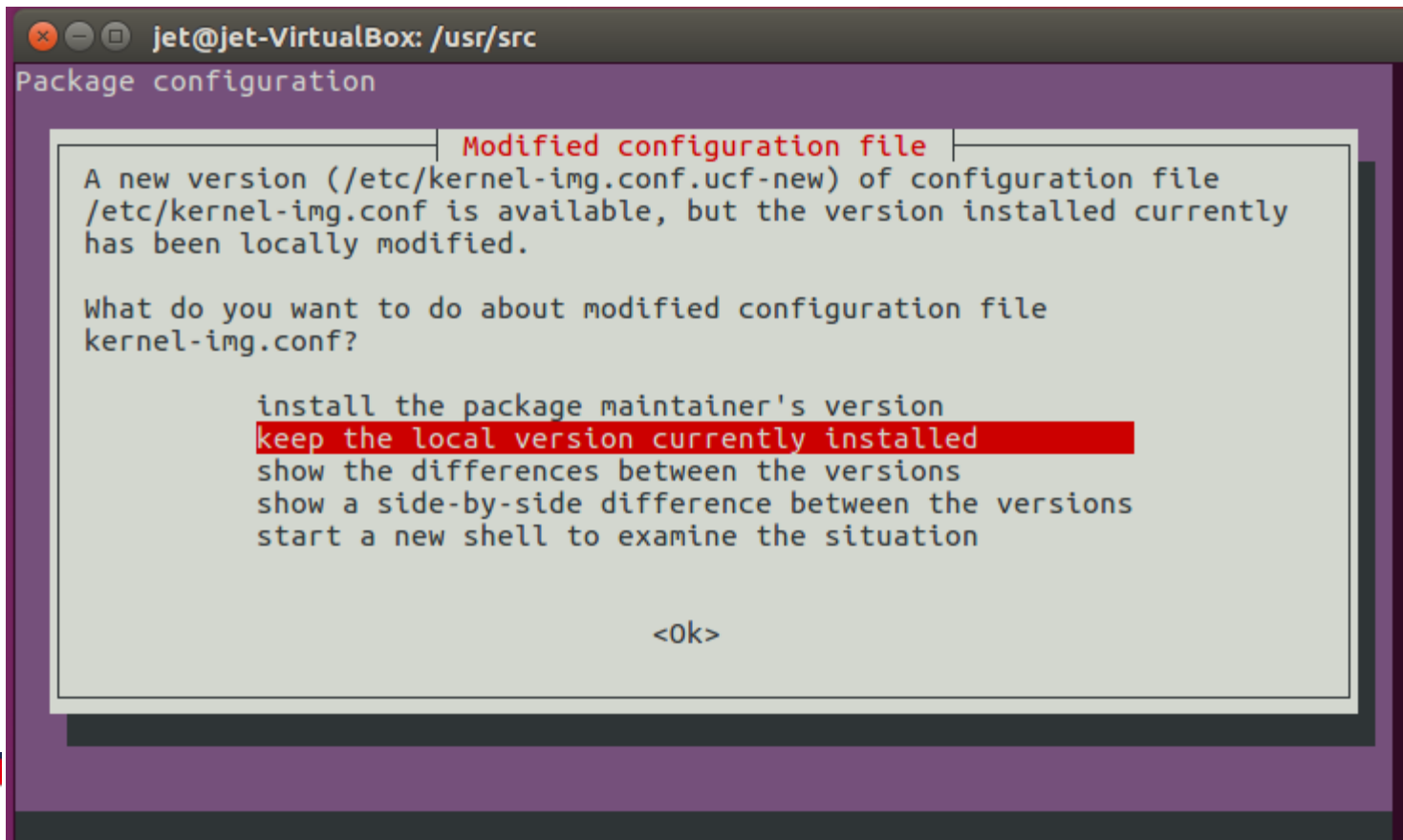
Linux 核心重編譯

- ❖ 在執行PMIPv6模組前，必須重新編譯Linux 核心。此步驟是為了將PMIPv6所需要的功能編譯至新核心中。
- ❖ 在編譯Linux 核心前必須注意與檢查Linux主機的作業系統為**Ubuntu 16.04-3 TLS**，且Linux主機已經連接上網路。
- ❖ 重新編譯Linux 核心，包含以下步驟：
 1. 向軟體伺服器更新最新的套件資訊。
 2. 下載對應作業系統核心原始檔案 (Kernel source code)
 3. 下載編譯器及編譯器模組 (Compiler and compiler module)
 4. 進入編譯核心選單，挑選PMIPV6所需功能並存檔
 5. 編譯核心 (編譯時間需**90**分鐘以上)
 6. 完成編譯核心，替換目前Linux核心並且重開機。

Linux 核心重編譯

❏ 步驟一：下載編譯器及編譯器模組 (Compiler and compiler module)

\$ sudo apt -y install build-essential libssl-dev build-essential ncurses-dev xz-utils kernel-package flex bison libelf-dev



```
jet@jet-VirtualBox: /usr/src
Package configuration

Modified configuration file

A new version (/etc/kernel-img.conf.ucf-new) of configuration file
/etc/kernel-img.conf is available, but the version installed currently
has been locally modified.

What do you want to do about modified configuration file
kernel-img.conf?

install the package maintainer's version
keep the local version currently installed
show the differences between the versions
show a side-by-side difference between the versions
start a new shell to examine the situation

<Ok>
```

Linux 核心重編譯

❏ 步驟二：更新最新的套件資訊，下載核心

```
$ sudo apt update
```

```
$ cd /usr/src/
```

```
$ sudo wget
```

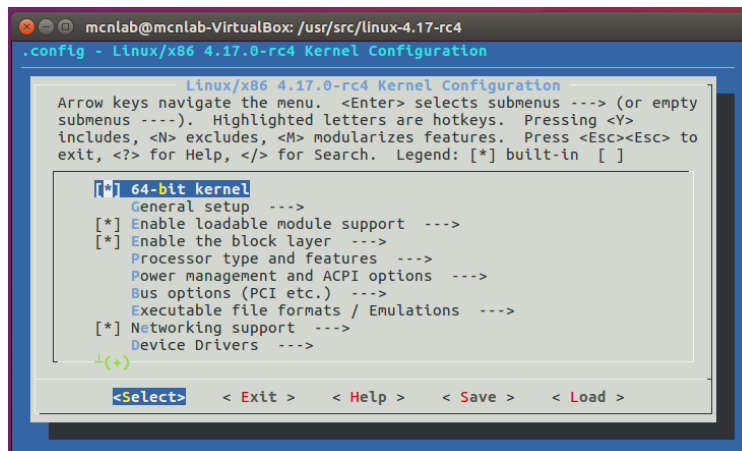
```
https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/snapshot/linux-4.17-rc4.tar.gz
```

```
$ sudo tar zxvf linux-4.17-rc4.tar.gz
```

❏ 步驟三：進入編譯核心選單，挑選MIPV6所需功能並存檔

```
$ cd /usr/src/linux-4.17-rc4/
```

```
$ sudo make menuconfig
```



Linux 核心重編譯

❏ 步驟四：進入編譯核心選單，挑選MIPV6所需功能並存檔

\$ sudo gedit /usr/src/linux-4.17-rc4/.config

更改下列數值

CONFIG_EXPERIMENTAL=y

CONFIG_ARPD=y

CONFIG_IPV6_MIP6=y

CONFIG_INET6_ESP=y

CONFIG_NET_KEY=y

CONFIG_NET_KEY_MIGRATE=y

CONFIG_XFRM_USER=y

CONFIG_XFRM_SUB_POLICY=y

CONFIG_IPV6_TUNNEL=y

CONFIG_INET6_XFRM_MODE_ROUTEOPTIMIZATION=y

CONFIG_SYSVIPC=y

CONFIG_PROC_FS=y

CONFIG_NET=y

CONFIG_INET=y

CONFIG_IPV6=y

CONFIG_IPV6_SUBTREES=y

CONFIG_XFRM=y

CONFIG_IP_ADVANCED_ROUTER=y

CONFIG_IPV6_MULTIPLE_TABLES=y

注意!!!!!!:

綠色部分需要手動加入至.config檔案中

紅色部分需要更改

黑色部分不需要更改

Linux 核心重編譯

- ❏ 檢查是否完成所需功能挑選，我們利用PMIPv6所附屬的檢驗工具進行檢測，步驟如下：

```
$ cd /usr/local/src/
```

```
$ sudo wget http://www.pcs.csie.ntu.edu.tw/views/courses/cnl/2018/PMIPv6_v0.4.1.tar.bz2
```

```
$ sudo tar xjf PMIPv6_v0.4.1.tar.bz2
```

```
$ cd PMIPv6_v0.4.1
```

```
$ sudo ./chkconf_kernel.sh /usr/src/linux-4.17-rc4/
```

```
jet@jet-VirtualBox:/usr/local/src/PMIPv6_v0.4.1$ sudo ./chkconf_kernel.sh /usr/s  
rc/linux-2.6/  
  
Checking kernel configuration...  
Using /usr/src/linux-2.6/.config  
  
All kernel options are as they should.  
  
jet@jet-VirtualBox:/usr/local/src/PMIPv6_v0.4.1$
```

Linux 核心重編譯

- 接著依照螢幕所示，進行更改。都沒有問題後，接著進行核心編譯，步驟如下：

```
$ cd /usr/src/linux-4.17-rc4/
```

```
$ sudo make -j4 && sudo make -j4 modules_install && sudo make -j4 install
```

- 編譯好核心，看到以下畫面之後，重開機。

```
run-parts: executing /etc/kernel/postinst.d/pm-utils 4.17.0-rc4 /boot/vmlinuz-4.17.0-rc4
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 4.17.0-rc4 /boot/vmlinuz-4.17.0-rc4
run-parts: executing /etc/kernel/postinst.d/update-notifier 4.17.0-rc4 /boot/vmlinuz-4.17.0-rc4
run-parts: executing /etc/kernel/postinst.d/vboxadd 4.17.0-rc4 /boot/vmlinuz-4.17.0-rc4
VirtualBox Guest Additions: Building the VirtualBox Guest Additions kernel modules.
VirtualBox Guest Additions: Look at /var/log/vboxadd-setup.log to find out what went wrong
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 4.17.0-rc4 /boot/vmlinuz-4.17.0-rc4
Generating grub configuration file ...
Warning: Setting GRUB_TIMEOUT to a non-zero value when GRUB_HIDDEN_TIMEOUT is set is no longer supported.
Found linux image: /boot/vmlinuz-4.17.0-rc4
Found initrd image: /boot/initrd.img-4.17.0-rc4
Found linux image: /boot/vmlinuz-4.10.0-28-generic
Found initrd image: /boot/initrd.img-4.10.0-28-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
mcnlab@mcnlab-VirtualBox: /usr/src/linux-4.17-rc4$
mcnlab@mcnlab-VirtualBox: /usr/src/linux-4.17-rc4$
```

- 編譯核心至少需要1.5小時
- 多核心CPU可以下 **\$ sudo make -j4** (j4 代表4核心)
- 記得Vbox tool要重安裝，才能夠雙向剪貼。

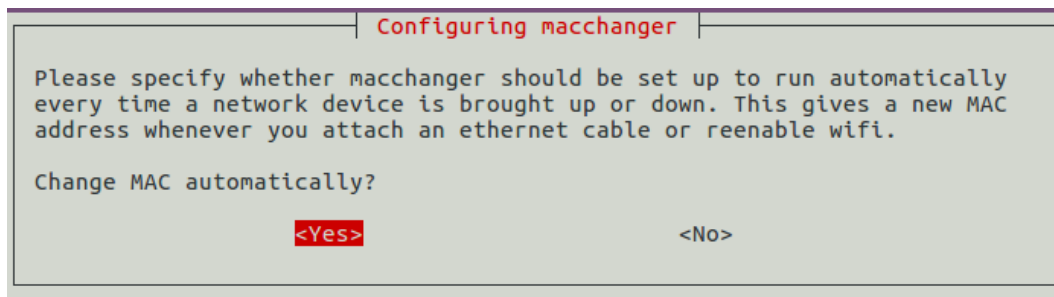
PMIPv6編譯

- LMA編譯
- MAG編譯

LMA編譯

- ❏ 先安裝，LMA所需要的套件

```
$ sudo apt -y install libpcap-dev indent bison flex libghc-iproute-dev libc6-dev libssl-dev autoconf libtool macchanger python-netaddr
```



- ❏ 接著，安裝FreeRadius client

```
$ cd /usr/local/src/PMIPv6_v0.4.1/freeradius-client-1.1.6/
```

```
$ sudo autoreconf -i
```

```
$ sudo ./configure
```

```
$ sudo make && sudo make install
```

- ❏ 接著，使PMIP6D能夠發現Freeradius libraries

```
$ sudo vi /etc/ld.so.conf 增加以下字串“include /usr/local/lib/”
```

```
$ sudo ldconfig
```

LMA編譯

- ☒ 接著，安裝FreeRadius Server

```
$ cd ..
```

```
$ sudo wget http://www.pcs.csie.ntu.edu.tw/views/courses/cnl/2018/freeradius-server-2.1.12.tar.bz2
```

```
$ sudo tar xjf freeradius-server-2.1.12.tar.bz2
```

```
$ cd freeradius-server-2.1.12
```

```
$ sudo ./configure
```

```
$ sudo make && sudo make install
```

- ☒ 接下來，將PMIPv6設定檔案，複製至下列資料夾

```
$ cd /usr/local/src/PMIPv6_v0.4.1/freeradius-client-1.1.6/examples
```

```
$ sudo cp users /usr/local/etc/raddb/
```

```
$ sudo cp radiusd.conf /usr/local/etc/raddb/
```

```
$ sudo cp clients.conf /usr/local/etc/raddb/
```

LMA編譯

☒ 接著，安裝LMA

```
$ cd /usr/local/src/PMIPv6_v0.4.1/pmipv6-daemon-umip-0.4/
```

```
$ sudo autoreconf -i
```

```
$ sudo ./configure
```

```
$ sudo make && sudo make install
```

MAG編譯

- ❏ 先安裝，MAG所需要的套件

```
$ sudo apt-get -y install libpcap-dev indent bison flex libghc-iproute-dev  
libc6-dev libssl-dev autoconf libtool macchanger python-netaddr
```

- ❏ 接著，安裝FreeRadius client

```
$ cd /usr/local/src/PMIPv6_v0.4.1/freeradius-client-1.1.6/
```

```
$ sudo autoreconf -i
```

```
$ sudo ./configure
```

```
$ sudo make && sudo make install
```

- ❏ 接著，使PMIPv6D能夠發現Freeradius libraries

```
$ sudo vi /etc/ld.so.conf ，增加“include /usr/local/lib/”
```

```
$ sudo ldconfig
```


MAG編譯

☒ 接著，安裝MAG

```
$ cd /usr/local/src/PMIPv6_v0.4.1/pmipv6-daemon-umip-0.4/
```

```
$ sudo autoreconf -i
```

```
$ sudo ./configure
```

```
$ sudo make && sudo make install
```

實驗建置流程

- ❖ 更改網路卡設定
- ❖ AP設定
- ❖ LMA伺服器設定
- ❖ MAG伺服器設定

更改網路卡設定

- 由於Ubuntu 16.04 (從15.10開始更改)將以往的網路卡名稱從**eth0**改為**enp0s3** (如圖)，將會造成pmipv6無法啟動，因此必須先更改網路名稱。

```
jet@jet-VirtualBox:~$ ifconfig
enp0s3    Link encap:Ethernet  HWaddr 08:00:27:dd:ad:ad
          inet addr:10.0.2.15  Bcast:10.0.2.255  Mask:255.255.255.0
          inet6 addr: fe80::3dfa:21c8:683b:a4f7/64  Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:4004 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1553 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:3664608 (3.6 MB)  TX bytes:103036 (103.0 KB)
```

- 步驟一：先將網卡設為DHCP。
- 步驟二：修改 /etc/default/grub
 - \$ sudo vi /etc/default/grub

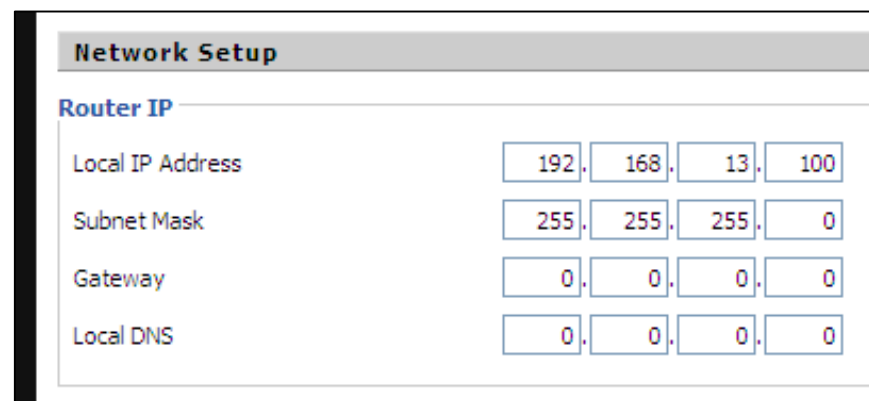
找到「GRUB_CMDLINE_LINUX=""」，加入參數「**net.ifnames=0 biosdevname=0**」₂₁

更改網路卡設定

- ❏ 步驟三，產生新的 grub.cfg 開機設定檔
 - \$ **sudo update-grub**
- ❏ 步驟四，重新開機。

AP設定

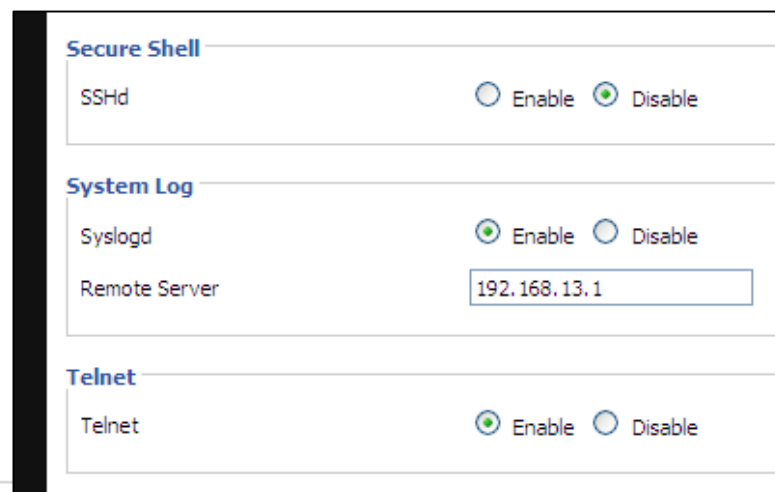
- ❏ 首先，先更改AP IP為192.168.13.100
- ❏ 接著，更改SSID為”CNL~~XX~~_MAG”
- ❏ 接著，設定service → syslog server IP為192.168.13.1
- ❏ 接著，重開AP



Network Setup

Router IP

Local IP Address	192	.	168	.	13	.	100
Subnet Mask	255	.	255	.	255	.	0
Gateway	0	.	0	.	0	.	0
Local DNS	0	.	0	.	0	.	0



Secure Shell

SShd ☐ Enable ☒ Disable

System Log

Syslogd ☒ Enable ☐ Disable

Remote Server

Telnet

Telnet ☒ Enable ☐ Disable

Network Address Server Settings (DHCP)



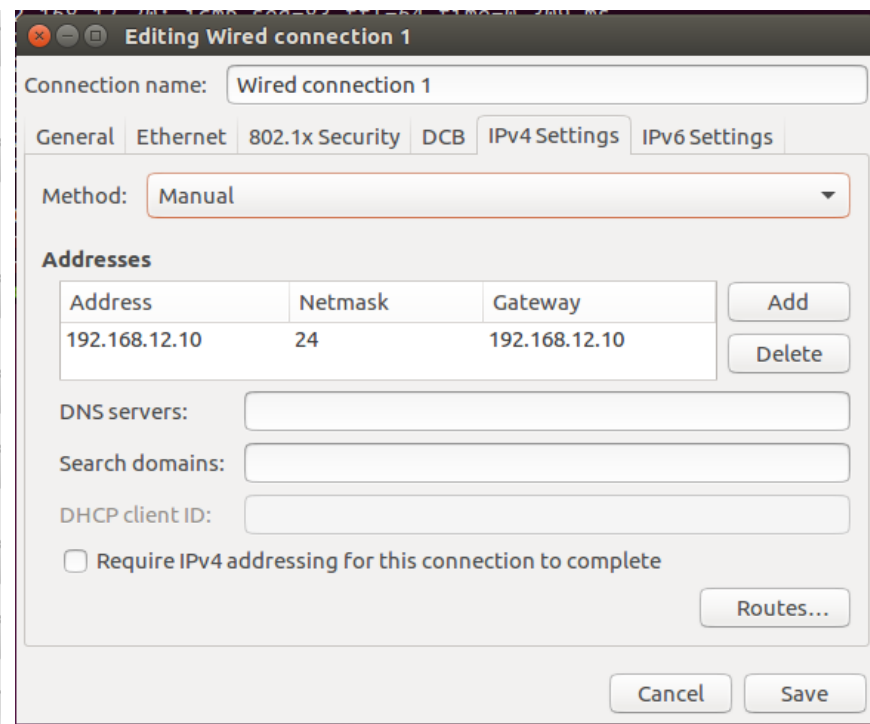
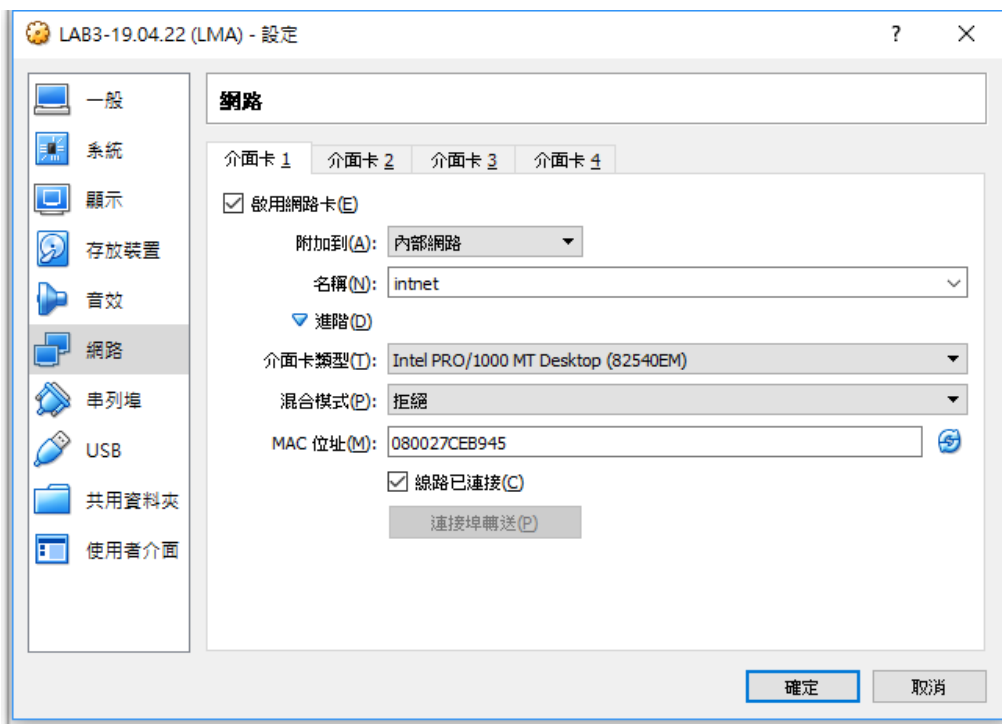
DHCP Type

DHCP Server

圖五、AP設定

LMA伺服器設定 (1/3)

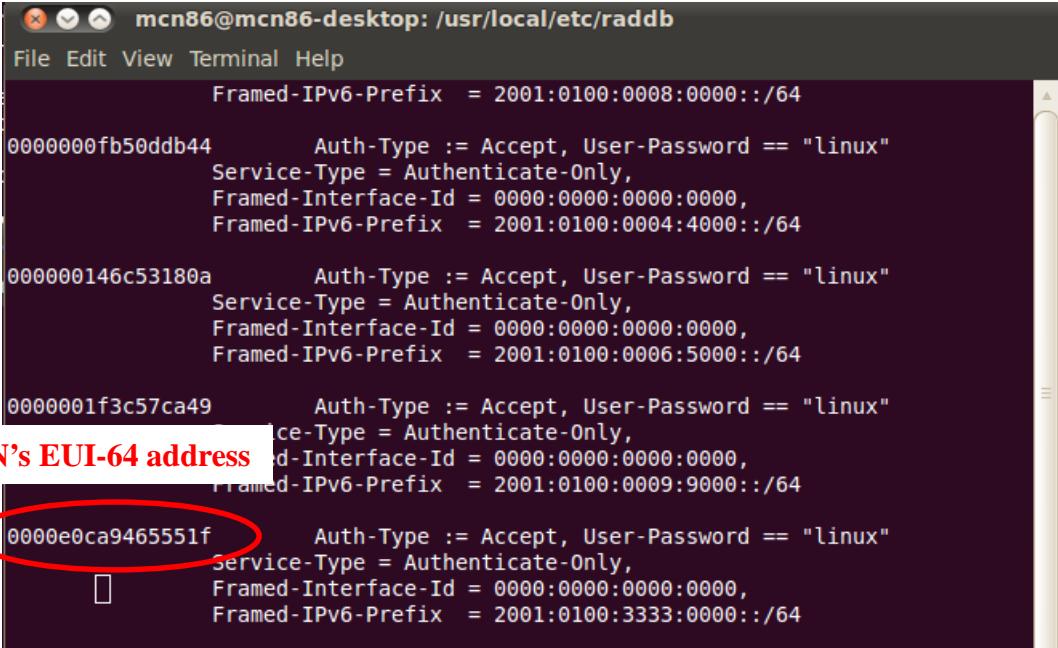
網路設定:



LMA伺服器設定 (2/3)

- 為了讓LMA得知MN資訊，所以要先在LMA FreeRadius server端設定MN資訊

\$ sudo vi /usr/local/etc/raddb/users，將MN的EUI (Extended Unique Identifier)-64 address資訊新增至文件中。



```
mcn86@mcn86-desktop: /usr/local/etc/raddb
File Edit View Terminal Help

Framed-IPv6-Prefix = 2001:0100:0008:0000::/64

0000000fb50ddb44      Auth-Type := Accept, User-Password == "linux"
Service-Type = Authenticate-Only,
Framed-Interface-Id = 0000:0000:0000:0000,
Framed-IPv6-Prefix = 2001:0100:0004:4000::/64

000000146c53180a      Auth-Type := Accept, User-Password == "linux"
Service-Type = Authenticate-Only,
Framed-Interface-Id = 0000:0000:0000:0000,
Framed-IPv6-Prefix = 2001:0100:0006:5000::/64

0000001f3c57ca49      Auth-Type := Accept, User-Password == "linux"
Service-Type = Authenticate-Only,
Framed-Interface-Id = 0000:0000:0000:0000,
Framed-IPv6-Prefix = 2001:0100:0009:9000::/64

0000e0ca946551f      Auth-Type := Accept, User-Password == "linux"
Service-Type = Authenticate-Only,
Framed-Interface-Id = 0000:0000:0000:0000,
Framed-IPv6-Prefix = 2001:0100:3333:0000::/64
```

圖四、users設定

LMA伺服器設定(3/3)

- ☒ 接著，啟動FreeRadius server

`$sudo /usr/local/sbin/radiusd -X` 或是

`$sudo radiusd -X`

P.S. radiusd 啟動有問題，請參閱problem (2)

- ☒ 接著，啟動LMA server

`$ sudo /usr/local/src/PMIPv6_v0.4.1/pmipv6-daemon-umip-0.4/extras/./UMIP0.4_LMA_UBUNTU.10.04.py`

MAG伺服器設定 (1/4)

網路設定:

LAB3-19.04.22 (MAG) - 設定

網路

介面卡 1 介面卡 2 介面卡 3 介面卡 4

☒ 啟用網路卡(E)

附加到(A): 內部網路

名稱(N): intnet

▼ 進階(D)

介面卡類型(T): Intel PRO/1000 MT Desktop (82540EM)

混合模式(P): 拒絕

MAC 位址(M): 0800274F09CA

☒ 線路已連接(C)

連接埠轉送(P)

確定

LAB3-19.04.22 (MAG) - 設定

網路

介面卡 1 介面卡 2 介面卡 3 介面卡 4

☒ 啟用網路卡(E)

附加到(A): 橋接介面卡

名稱(N): Realtek USB FE Family Controller

▼ 進階(D)

介面卡類型(T): Intel PRO/1000 MT Desktop (82540EM)

混合模式(P): 拒絕

MAC 位址(M): 08002770C7F8

☒ 線路已連接(C)

連接埠轉送(P)

確定 取消

MAG伺服器設定 (2/4)

網路設定:

Editing Wired connection 1

Connection name: Wired connection 1

General Ethernet 802.1x Security DCB IPv4 Settings IPv6 Settings

Method: Manual

Addresses

Address	Netmask	Gateway	
192.168.12.20	24	192.168.12.10	Add
			Delete

DNS servers:

Search domains:

DHCP client ID:

☐ Require IPv4 addressing for this connection to complete

Routes...

Cancel Save

Editing Wired connection 2

Connection name: Wired connection 2

General Ethernet 802.1x Security DCB IPv4 Settings IPv6 Settings

Method: Manual

Addresses

Address	Netmask	Gateway	
192.168.13.1	24	192.168.13.1	Add
			Delete

DNS servers:

Search domains:

DHCP client ID:

☐ Require IPv4 addressing for this connection to complete

Routes...

Cancel Save

MAG伺服器設定 (3/4)

- ❏ 接著，MAG需要知道FreeRadius Server的位址

`$ sudo vi /etc/hosts`，增加 `2001:100::1 radius6server`

- ❏ 接著，MAG需要安裝SYSLOG Server，使得MAG可以獲取AP所傳來的資訊

`$ sudo apt install socklog rsyslog`

`$ sudo apt purge runit`

`$ sudo apt install socklog rsyslog`

- ❏ 接著，更改SYSLOG Server 設定

`$ sudo vi /etc/rsyslog.conf`，增加「`local7.info /var/log/pmip_syslog.log`」

`$ sudo touch /var/log/pmip_syslog.log`

`$ sudo vi /etc/default/rsyslog` (將`RSYSLOGD_OPTIONS=""`更改`RSYSLOGD_OPTIONS="-r"`)

`$ sudo /etc/init.d/rsyslog restart`

MAG伺服器設定 (4/4)

- ❖ 為了讓MAG伺服器能夠正確指向LMA伺服器上的RadiusServer進行認證，需要更改FreeRadius client設定

```
$ sudo vi /usr/local/etc/radiusclient/radiusclient.conf
```

將authserver localhost 更改為 authserver radius6server

將acctserver localhost 更改為 acctserver radius6server

- ❖ 接著，啟動MAG server

```
$ sudo /usr/local/src/PMIPv6_v0.4.1/pmipv6-daemon-umip-0.4/extras/./UMIP0.4_MAG1_UBUNTU.10.04.py
```

實驗結果

- ❏ MN選擇AP : ”CNLXX_MAG
- ❏ 在Terminal輸入ifconfig
- ❏ 得到IP= 2001:100:3333:0:e2ca:94ff:fe65:551f

```
wlan0      Link encap:Ethernet  HWaddr e0:ca:94:65:55:1f
            inet6 addr: 2001:100:3333:0:e2ca:94ff:fe65:551f/64 Scope:Global
            inet6 addr: fe80::e2ca:94ff:fe65:551f/64 Scope:Link
            inet6 addr: 2001:100:3333:0:7dbf:ded:e415:db41/64 Scope:Global
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
            RX packets:1369 errors:0 dropped:0 overruns:0 frame:0
            TX packets:429 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:99048 (99.0 KB)  TX bytes:69101 (69.1 KB)
```

圖六、MN的IP address

實驗三展演要求

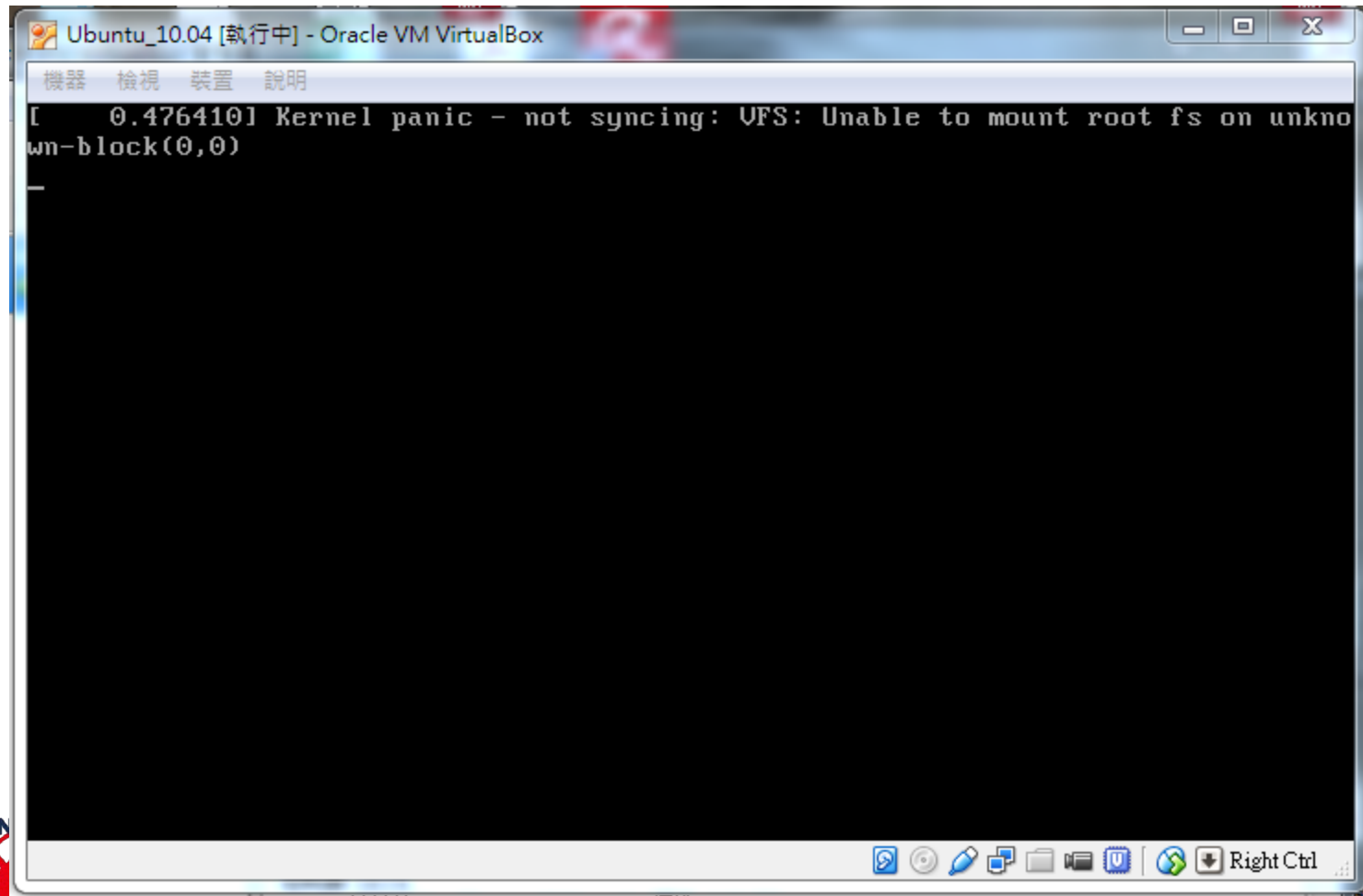
- ❖ 正常啟動LMA (10%)
- ❖ 正常啟動MAG (10%)
- ❖ MN自動取得IPv6位址 (10%)
 - MN選擇CNLXX_MAG的AP後，IPv6網路設定為自動，在Terminal輸入ifconfig，MN的IPv6位址必須為2001:100:3333:0:e2ca:94ff:fe65:551f (紅字為每個MN的EUI-64 address)
- ❖ 在MN上用wireshark秀出RA封包(10%)。

實驗三結報要求

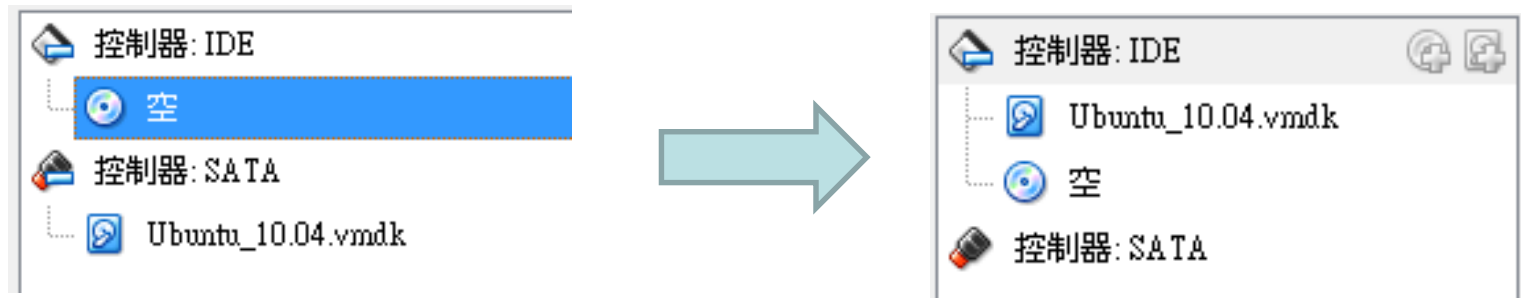
- ❑ 結報封面請記得寫上實驗名稱、組別、組員學號與姓名
- ❑ 一、IPv6 (30%)
 - 解釋IPv6的Unicast、Multicast與Anycast並舉例說明。(10%)
 - 解釋Router Solicitation與Router Advertisement的用途與功能。(5%)
 - 解釋何謂Stateful與Stateless address configuration。(10%)
 - 何謂DAD(Duplicate Address Detection)與其運作方式。(5%)
- ❑ 二、Mobile IPv6 (10%)
 - MIPv6 如何解決Triangular Routing Problem?
- ❑ 三、實驗中遇到的難題與解決方法 (10%)
- ❑ 三、實驗心得(每位同學都要) (10%)

Problem (1)

❏ If you are suffered the problem like the following picture



- ❏ Step 1: Turn down your machine, and enter the setting.
- ❏ Step 2: Change 控制器: SATA to 控制器: IDE



Problem (2)

❏ If you see the problem:

- Error while loading shared libraries:...like as follow.

```
root@lma-desktop:/usr/local/sbin# sudo radiusd -X
radiusd: error while loading shared libraries: libfreeradius-radius-2.1.12.so: c
annot open shared object file: No such file or directory
root@lma-desktop:/usr/local/sbin#
```

❏ Please type:

- \$sudo /sbin/ldconfig -v