Outline

- Introduction
- IP Address & MAC Address
- TCP / UDP / ICMP
- IP Gateway, Network Mask, TTL
- Routing Protocol
- Network Address Translation (NAT)
- Domain Name System (DNS)
- Dynamic Host Configuration Protocol (DHCP) / Asymmetric Digital Subscriber Line (ADSL)
- HyperText Transfer Protocol (HTTP) Protocol
- Virtual Private Network (VPN)

Gateway

- **LAN 對 WAN 之出入口**
  - 一般而言，Gateway就如同區域網路的出口，若有資料要傳送到Internet上，均需透過它，再經過中間的Router轉送到其他Router上，最後再到達目的端。
- 主要的功能是連接不同的網路架構，而且必須視架構不同而轉換不同的通訊網路協定層級
- 用來連接不同的通訊協定網路，例如：**TCP/IP**，**X.25**，**Systems Network Architecture (SNA)**等，**Gateway**必須將所接收的 **Packet**，轉換成目的位址之網路所能瞭解的資料格式(訊息格式轉換，位址轉換，以及協定轉換等)

X.25

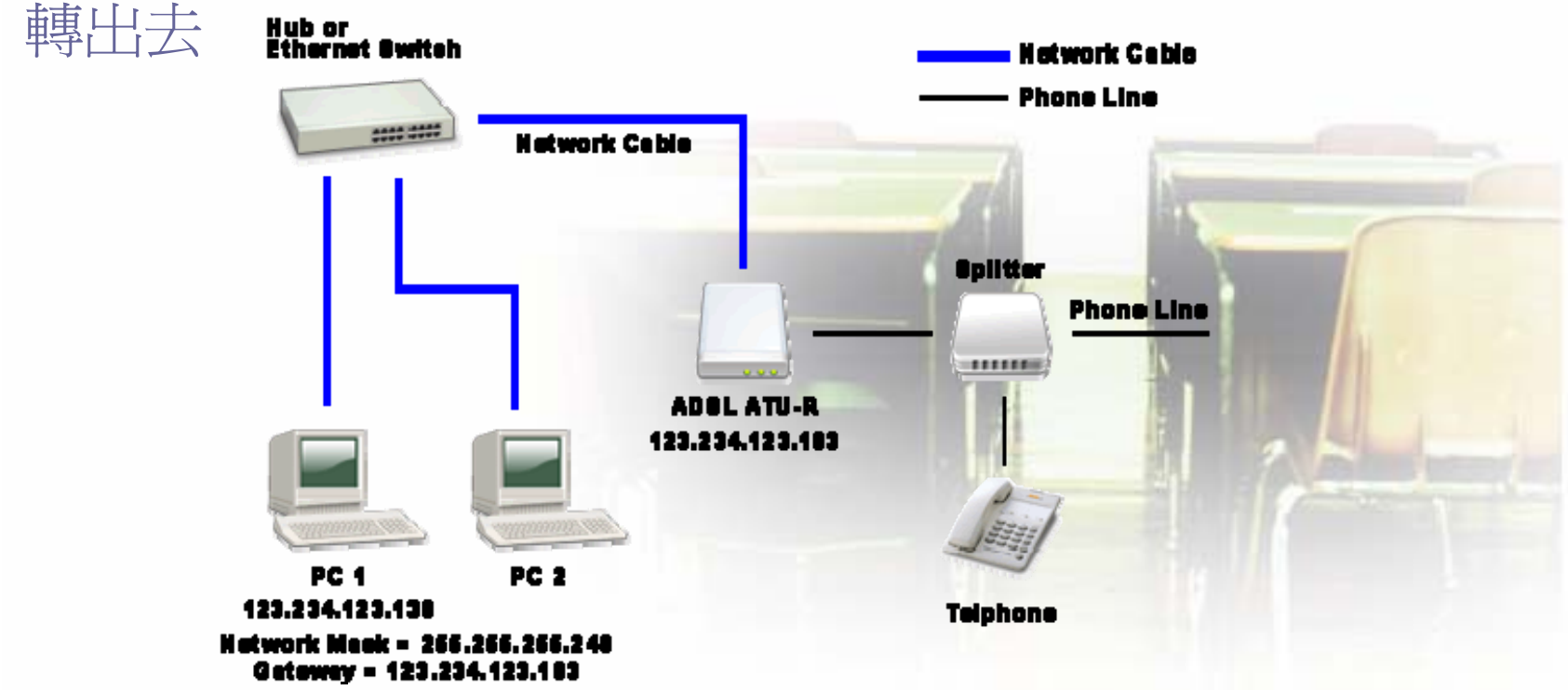
- 一種專用於資料終端設備與封包交換網路間的CCITT協定
- CCITT: Consultative Committee for International Telegraph and Telephone 國際電報電話諮詢委員會

SNA

- IBM 主機系統所使用的通信協定

舉例說明

- 如下圖，**ADSL ATU-R**做爲其他電腦上網的**Gateway**
- 假設**PC1**要傳送**Packet**到**Gateway**之流程：
  - 藉由PC1上Gateway的設定：藉ARP 找到Gateway 之MAC Address
  - 由PC1 之Netmask，決定哪些目的IP 需要送到Gateway轉出去




簡單驗證實驗
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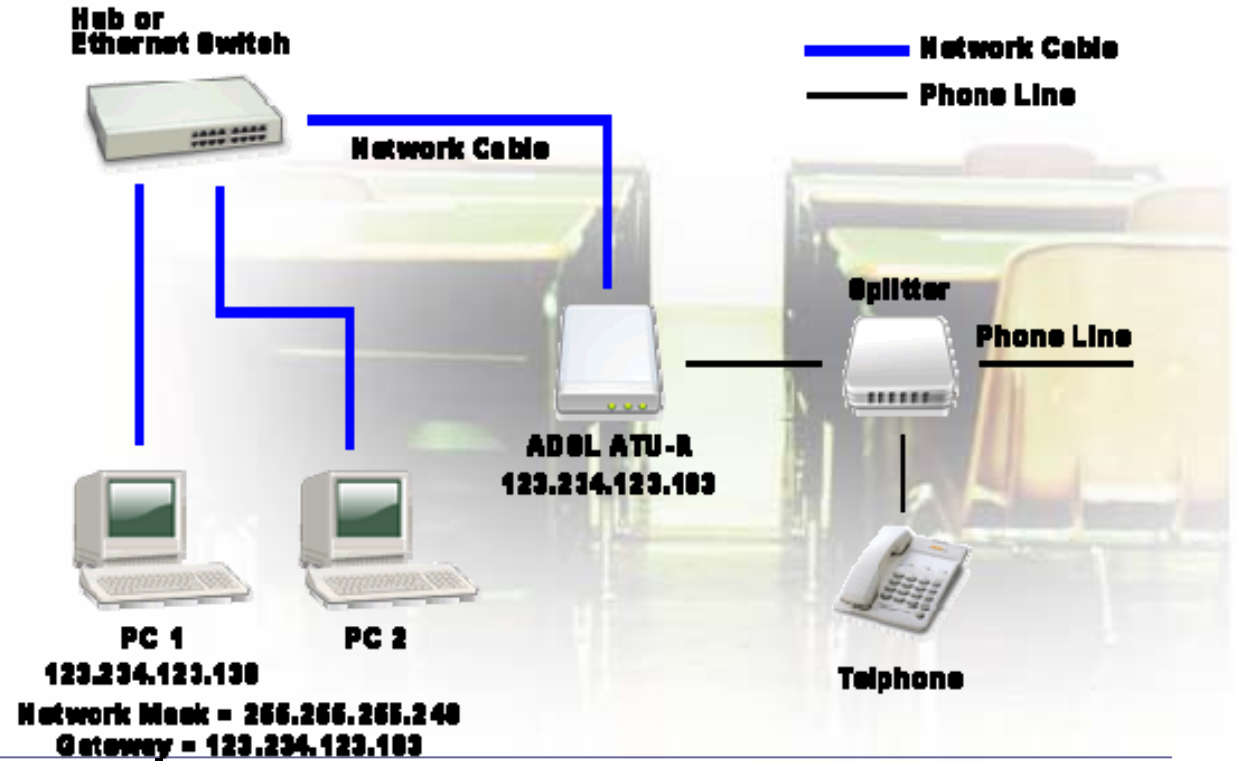
ADSL ATU-R 當Gateway

- **PC 1 是使用Windows2000作業系統執行以下的指令步驟：**
  1. arp –a
  2. ping 168.95.1.1
  3. arp –a
  4. route print



執行結果說明

- arp -a

```
Microsoft Windows 2000 [版本 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.

C:\>arp -a
No ARP Entries Found

C:\>
```

The ARP table does not have any information prior to an Internet connection

執行結果說明

- ping 168.95.1.1

```
Microsoft Windows 2000 [版本 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.

C:\>arp -a
No ARP Entries Found

C:\>

Pinging 168.95.1.1 with 32 bytes of data:

Reply from 168.95.1.1: bytes=32 time=40ms TTL=249
Reply from 168.95.1.1: bytes=32 time=30ms TTL=249
Reply from 168.95.1.1: bytes=32 time=30ms TTL=249
Reply from 168.95.1.1: bytes=32 time=30ms TTL=249

Ping statistics for 168.95.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 30ms, Maximum =  40ms, Average =  32ms

C:\>_
```

TTL value is related to the routers which have been passed through

執行結果說明

arp -a

```
C:\>arp -a
No ARP Entries Found

C:\>

Pinging 168.95.1.1 with 32 bytes of data:

Reply from 168.95.1.1: bytes=32 time=40ms TTL=249
Reply from 168.95.1.1: bytes=32 time=30ms TTL=249
Reply from 168.95.1.1: bytes=32 time=30ms TTL=249
Reply from 168.95.1.1: bytes=32 time=30ms TTL=249

Ping statistics for 168.95.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 30ms, Maximum =  40ms, Average =  32ms

C:\>arp -a

Interface: 123.234.123.203 on Interface 0x1000004
  Internet Address      Physical Address      Type
  123.234.123.193       00-d0-59-a5-d1-76     dynamic
```

The MAC Address of the gateway network interface

執行結果說明

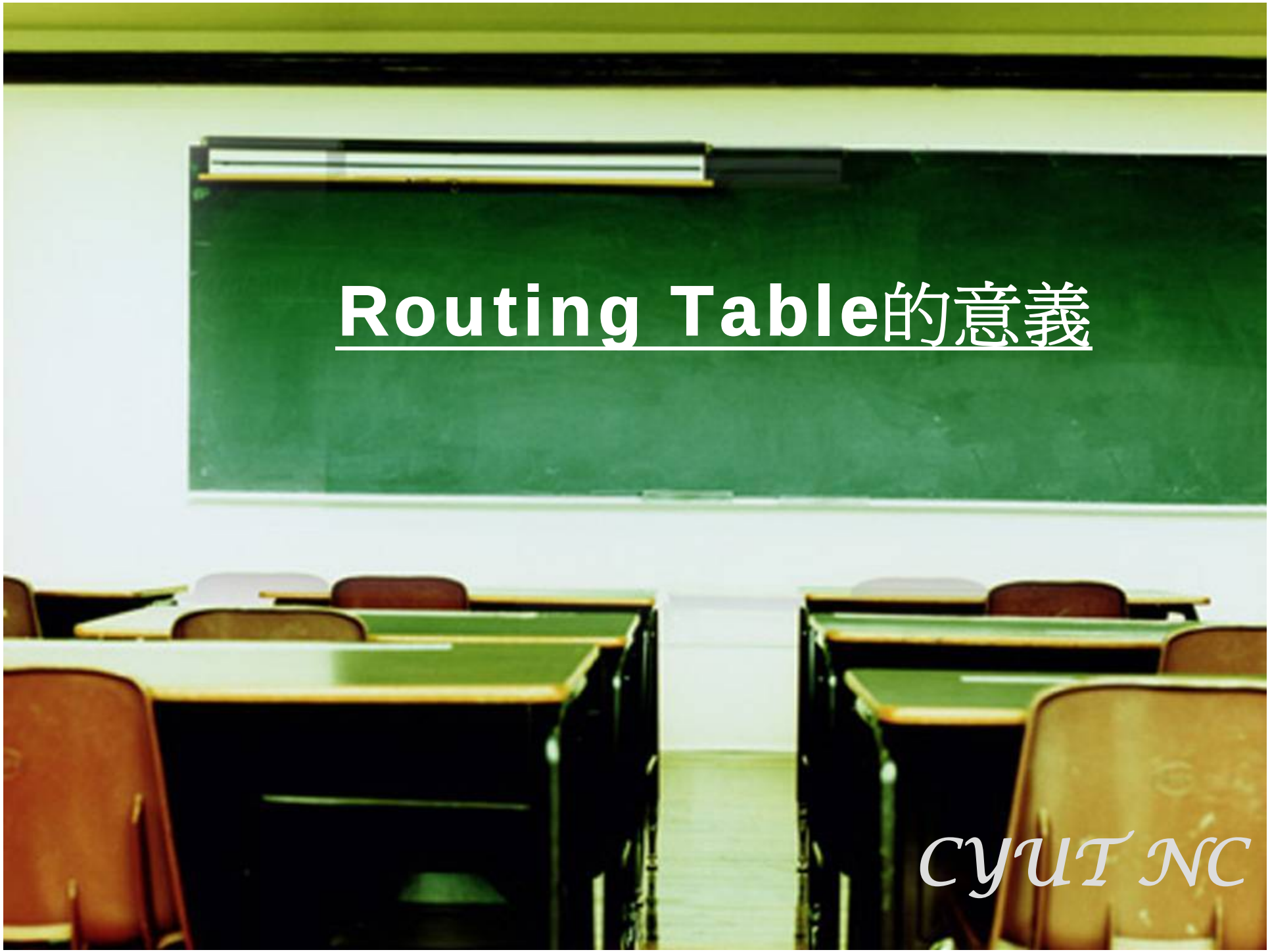
❖ route print

```
  123.234.123.193       00-d0-59-a5-d1-76     dynamic

C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2 ...44 45 53 54 77 77 ...... NTS PPPoE Adapter #1
0x1000004 ...00 e0 98 81 16 0d ...... Fast Ethernet PC Card
===========================================================================
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0  123.234.123.193 123.234.123.203       1
  123.234.123.192  255.255.255.240  123.234.123.203 123.234.123.203       1
  123.234.123.203  255.255.255.255        127.0.0.1       127.0.0.1       1
  123.255.255.255  255.255.255.255  123.234.123.203 123.234.123.203       1
        127.0.0.0        255.0.0.0        127.0.0.1       127.0.0.1       1
        224.0.0.0        224.0.0.0  123.234.123.203 123.234.123.203       1
  255.255.255.255  255.255.255.255  123.234.123.203                 2     1
Default Gateway:     123.234.123.193
===========================================================================
Persistent Routes:
  None

C:\>
```

All the packets' destination IP which is not listed in routing table will be sent to 123.234.123.193


Routing Table的意義
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Routing Table

- 當**Router** 設備接收到 **Packet** 之後，它會依照 **Packet** 的目的地 **IP**（**Destination IP Address**）決定要對 **Packet** 做怎樣的動作
  - 諸如從某個網路介面轉送、忽略或是傳回不予轉送的訊息；而做這些決策的依據，就是 Routing Table。
- **Routing Table**可能以不同資料結構存在於所有具有**Layer 3**網路以上功能的設備中，包含**PC**、**Firewall**、**Router**，甚至有網路功能的**PDA**。

Linux Host Routing Table範例 (ip route)

- 例如以下是一 **Linux Host 的 Routing Table**，使用 **/sbin/ip route (使用mask bit方式列)** 命令，或使用 **/sbin/route**命令如下頁。

```
[root@gr /]# /sbin/ip route

61.218.155.224/28      dev eth1    scope link  src 61.218.155.226
192.168.2.0/24         dev eth0    scope link  src 192.168.2.254
192.168.0.0/24         dev eth0    scope link  src 192.168.0.10
192.168.254.0/24       dev eth0    scope link  src 192.168.254.254
10.0.0.0/16            dev eth0    scope link  src 10.0.0.10
172.16.0.0/16          dev eth0    scope link  src 172.16.0.10
127.0.0.0/8            dev lo      scope link
default via 61.218.155.225 dev eth1
```

Linux Host Routing Table範例(route)

[root@gr /]# /sbin/route

Kernel IP routing table

Destination	Gateway	Genmask	Metric	Iface
NAT				
61.218.155.224	*	**255.255.255.240**	**0**	**eth1**
192.168.2.0	*	255.255.255.0	0	eth0
192.168.0.0	*	**255.255.255.0**	**0**	**eth0**
192.168.254.0	*	255.255.255.0	0	eth0
10.0.0.0	*	255.255.0.0	**0**	**eth1**
172.16.0.0	*	255.255.0.0	0	eth0
127.0.0.0	*	255.0.0.0	0	lo
default	**61.218.155.225**	**0.0.0.0**	**0**	**eth1**

Routing Table Entry

- 一般Routing Table Entry 搜尋規則是根據IP Packet之目的地IP (Destination IP) ，於Routing Table中以**Longest Prefix Length Match** 爲原則進行查詢
  - 即當比對時從最前面比對過來符合長度最長的選擇法
- Default爲**0.0.0.0 / 0**，即任意 IP 皆符合條件。若合乎該Entry 的條件，則依照其指定的規則轉送 Packet

Routing Table Entry

- 若一Packet 進入其網路核心之 Destination IP 爲 61.218.155.236 ，與第一個 Entry 的 61.218.155.224/28 從頭開始比對有28 bits相同，因此符合條件。

目的地IP 61.218.155.236 與以下 Routing Table entry 比對，決定從何介面送出	目的地 IP 二進位 00111101 11011010 10011011 1110 1100

Longest Prefix Length Match

Routing Table Entry

61.218.155.236 **00111101 11011010 10011011 1110** 1100

	Routing Table Entry	Binary Format	Interface
√ 1	61.218.155.224/28 Longest Prefix Length Match	**00111101 11011010 10011011 1110** 0000 |---------- 28 bits ----------| **00111101 11011010 10011011 1110** 1100 **28 prefix bits matched**	eth1
√ 2	Suppose there is another entry with 61.218.0.0/16	**00111101 11011010** 00000000 0000 0000 |--------16 bits--------| **00111101 11011010** 10011011 1110 1100 16 **prefix bits matched**	eth2
3	Suppose there is another entry with 61.218.155.224/30	**00111101 11011010 10011011 1110** 0000 |---------- 30 bits ----------| **00111101 11011010 10011011 1110 11**00 ***Not matched***	eth3
4	192.168.2.0/24	**11000000 10101000 00000010** 00000000 ***00111101 11011010 10011011*** 1110 1100 ***Not matched***	eth0
√ 5	Default 0.0.0.0/0 matches 0 bits	00000000 00000000 00000000 00000000 00111101 11011010 10101101 1110 1100 **Considered 0 bit matched**	eth1

Routing Table Entry

- 此Routing Table Entry 告訴當網路核心進行 Routing Decision 時，目的地IP的前 28 bits 若是與 61.218.155.224 前面的28 bits 相同，則經由介面 eth1 送出
- scope link 是說明符合條件的 IP，與其直接相連，其 Destination MAC 可藉由 ARP 得知，src 61.218.155.226 則是說明 eth1 介面使用IP 爲 61.218.155.226
- 結論：合乎條件共有 1,2,5 等三個，但是 Entry 1 是 match 最長的第一筆記錄 28 bits，因此由 Entry 1 的網路介面即 eth1 送出

Static & Dynamic Routing

Static Routing

- 由系統管理員因網路所需，設置固定的路徑表，稱爲靜態（static）路徑表
- 一般在系統安裝時就根據網路的配置情況預先設定

Dynamic Routing

- Router根據網絡系統的運行情況而自動調整的路徑表
- 路由器根據Routing Protocol提供的功能，自動學習和記憶網路運行情況，在需要時自動計算數據傳輸的最佳路徑。

TCP / IP中重要的routing protocol

- Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Border Gateway Protocol (BGP) (Chapter 5)

ifconfig 與Static Route Entry

- ifconfig指令除了設定ip及netmask之外，還會自動新增一筆對應的static route entry

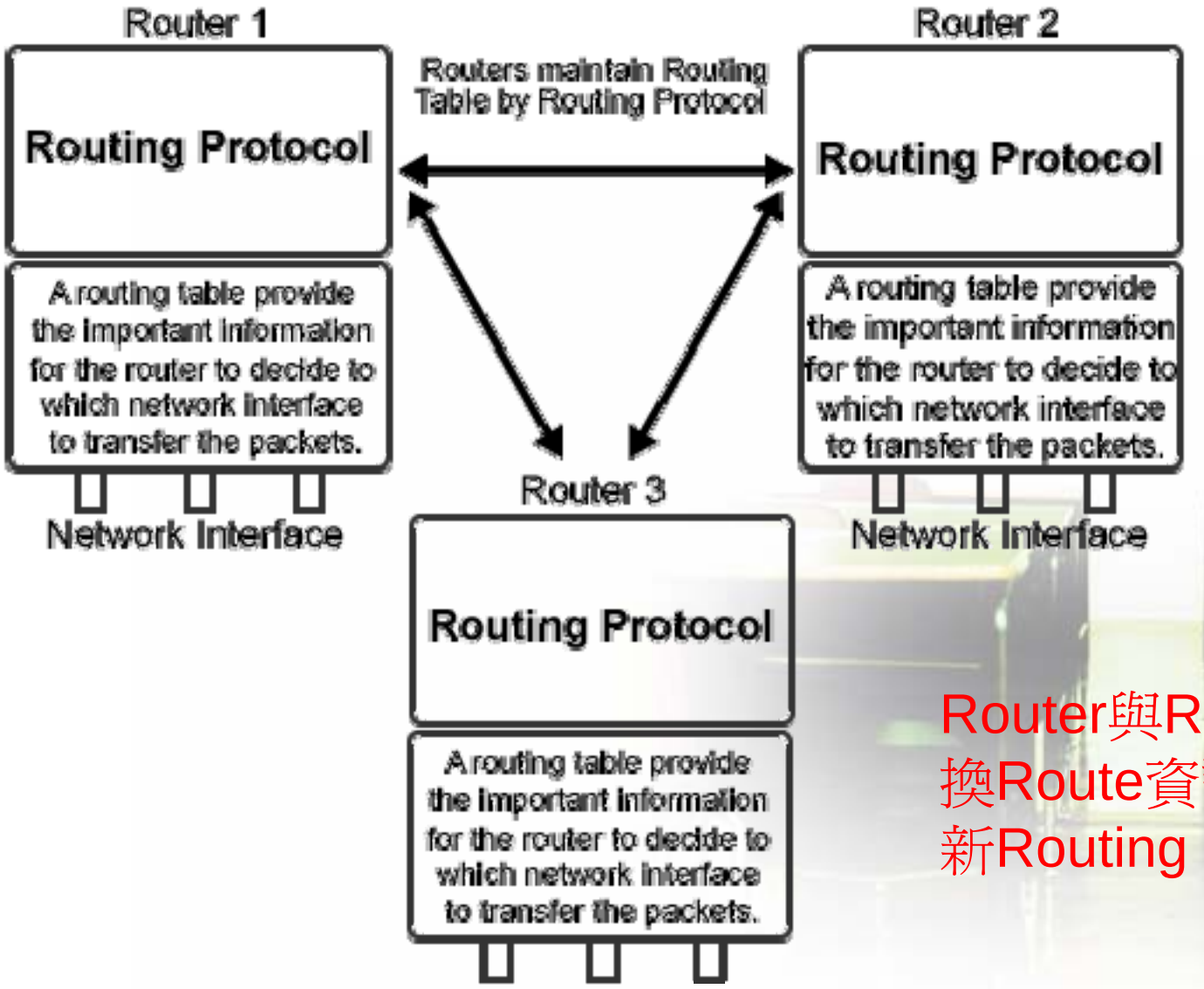
```
bash# ip route
192.168.2.0/24 dev eth2  proto kernel  scope link  src 192.168.2.1
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.1
192.168.0.0/24 dev eth0  proto kernel  scope link  src 192.168.0.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
bash#
bash#
bash# ifconfig eth0:1 192.168.4.1 netmask 255.255.255.0
bash#
bash#
bash# ip route
192.168.4.0/24 dev eth0  proto kernel  scope link  src 192.168.4.1
192.168.2.0/24 dev eth2  proto kernel  scope link  src 192.168.2.1
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.1
192.168.0.0/24 dev eth0  proto kernel  scope link  src 192.168.0.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
bash#
```

Routing的選擇

```
bash# ip route
192.168.2.0/24 dev eth2  proto kernel  scope link  src 192.168.2.1
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.1
192.168.0.0/24 dev eth0  proto kernel  scope link  src 192.168.0.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
bash#
bash# ping -c3 192.168.2.2
PING 192.168.2.2 (192.168.2.2) from 192.168.2.1 : 56(84) bytes of data.
64 bytes from 192.168.2.2: icmp_seq=1 ttl=64 time=0.319 ms
64 bytes from 192.168.2.2: icmp_seq=2 ttl=64 time=0.156 ms
64 bytes from 192.168.2.2: icmp_seq=3 ttl=64 time=0.152 ms

--- 192.168.2.2 ping statistics ---
3 packets transmitted, 3 received, 0% loss, time 2010ms
rtt min/avg/max/mdev = 0.152/0.209/0.319/0.077 ms
bash#
bash# arp -an
? (192.168.2.2) at 00:30:C7:81:44:21 [ether] on eth2
? (192.168.251.254) at 00:10:F3:03:16:B3 [ether] on eth3
? (192.168.251.22) at 00:E0:98:81:16:0D [ether] on eth3
bash#
bash# ip route del 192.168.2.0/24
bash#
bash# ip route
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.1
192.168.0.0/24 dev eth0  proto kernel  scope link  src 192.168.0.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
bash#
bash# ping 192.168.2.2
connect: Network is unreachable
bash#
```

Routing Table 與 Routing Protocol



Router與Router之間交換Route資訊，進而更新Routing Table

❖ Router的設計可分爲

- Fast Path: 需要快速查詢Routing Table並決策Packet如何轉送，故需使用硬體晶片或Network Procerssor設計加速Routing Table查詢。
- Slow Path: 速度不需太快，可用一般CPU處理Routing Protocol。

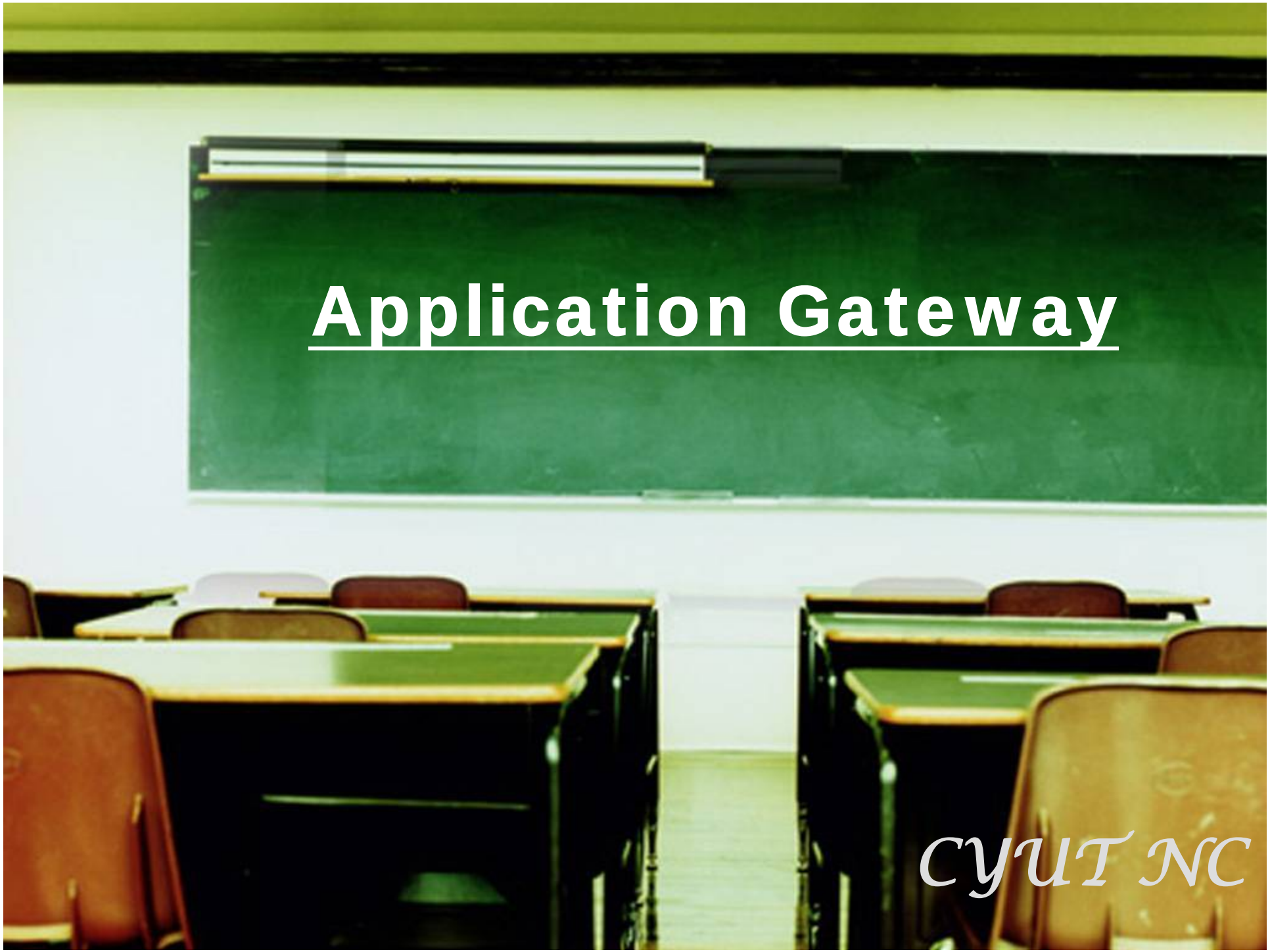
Gateway 和Router

Gateway

- 較廣義的名詞，用來連接不同的網路，甚至不同的通訊協定，從第三層到第七層OSI皆有可能
- Gateway可以是Router、防火牆、Proxy，所以說Gateway 不一定是指Router

Router

- 是指尋找、決定最佳的傳輸路徑，並根據這些路徑建立Routing Table轉送 Packet或者是過濾 Packet的網路裝置


Application Gateway
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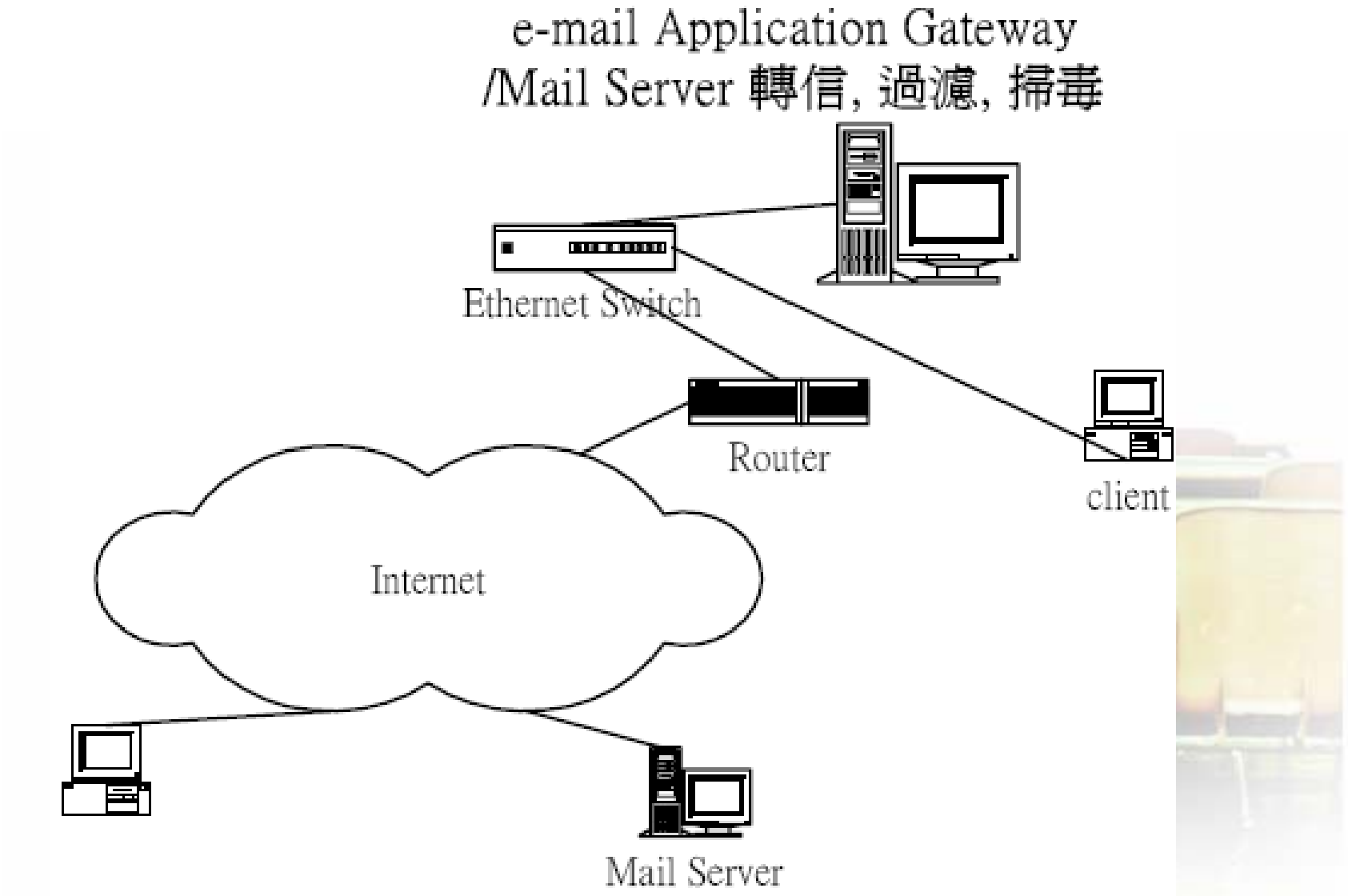
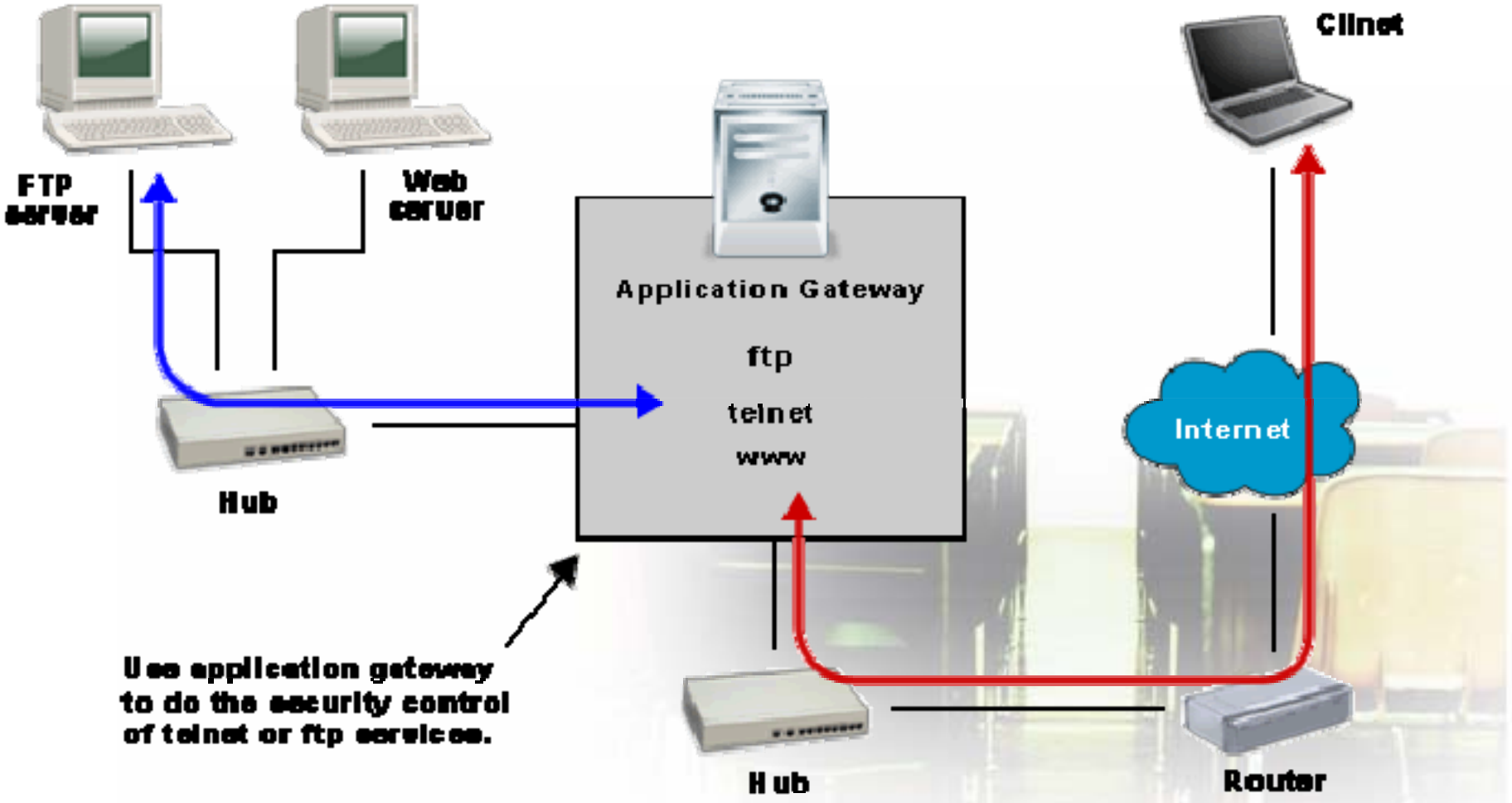
VoIP Gateway連接PSTN與Internet

- 可轉換應用層的應用稱爲 **Application Gateway**，有些則稱爲**Application Level Gateway (ALG)**

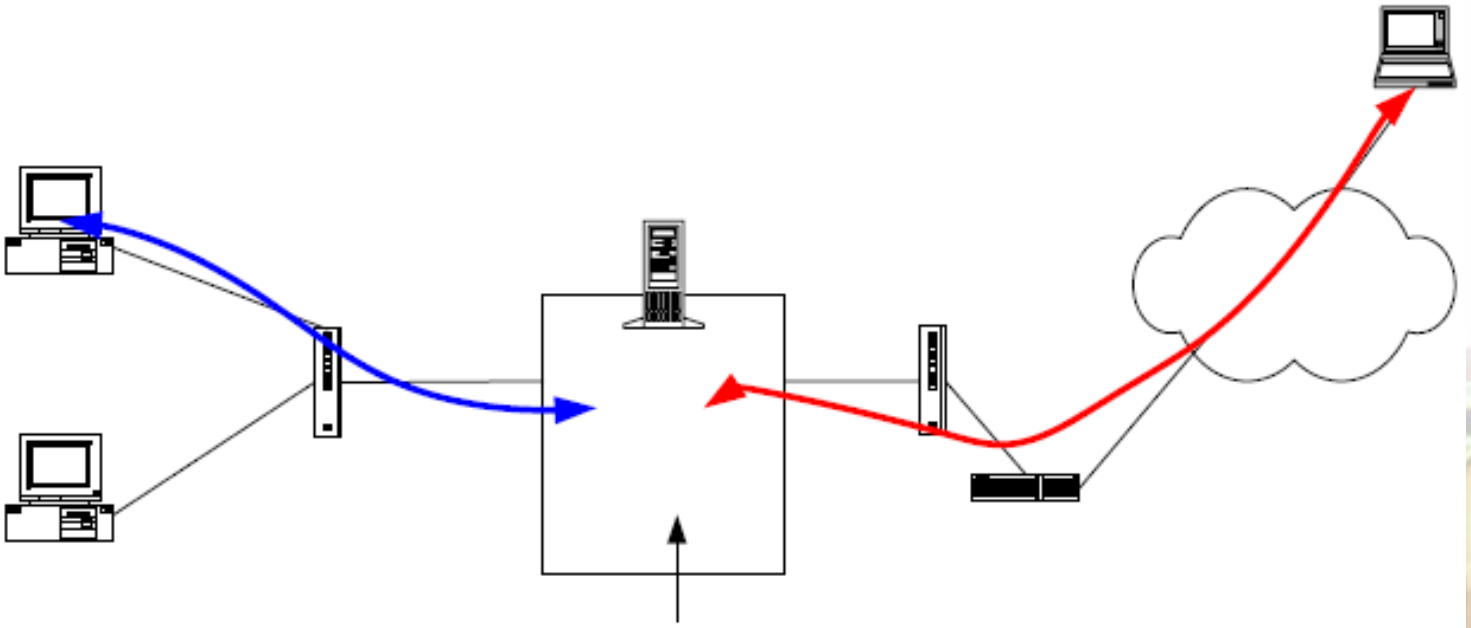
e-mail Application Gateway



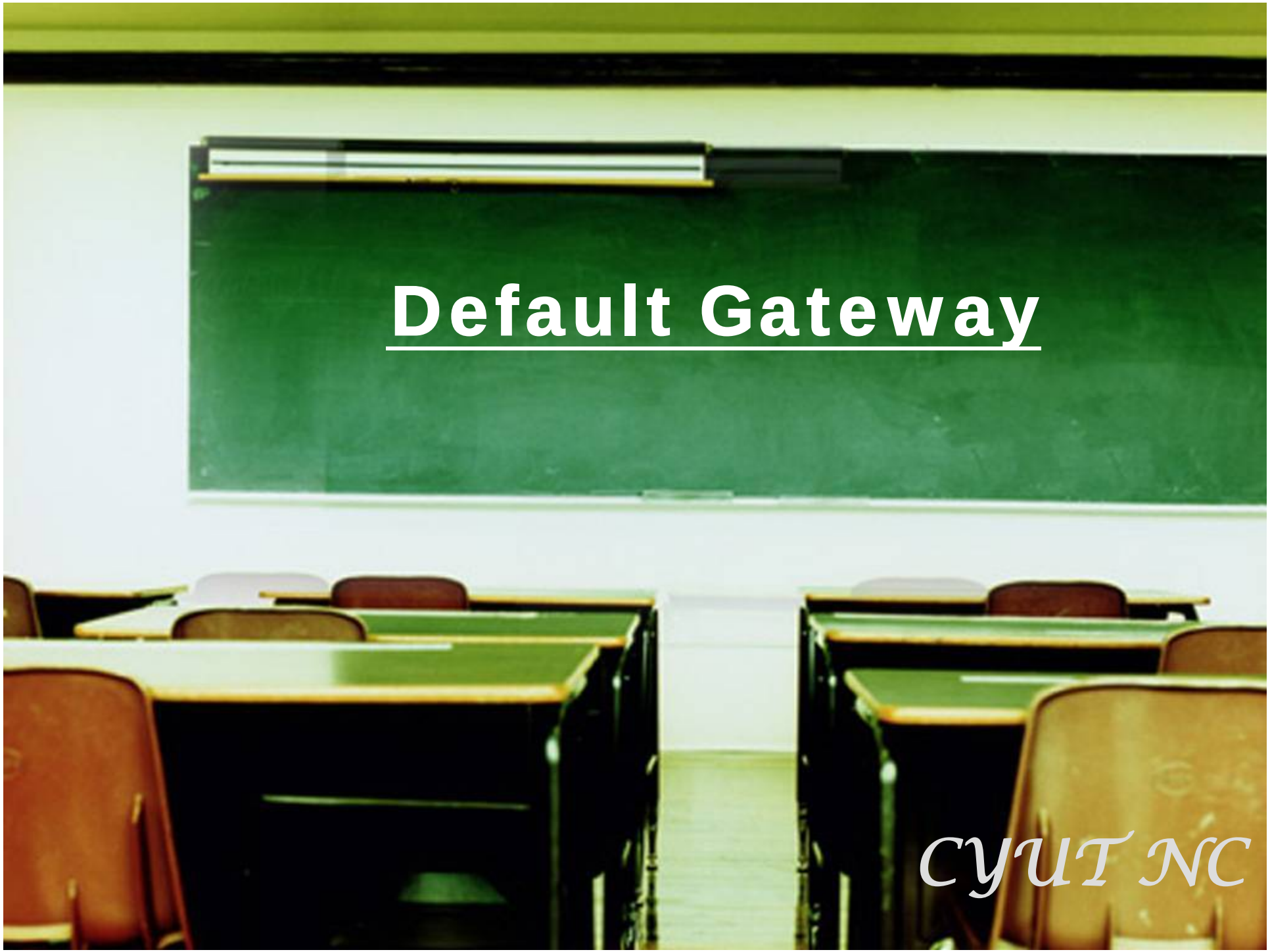
Application Gateway代理telnet與ftp



Application Gateway代理telnet與ftp



可設計成分散伺服器的負擔平衡的設備


Default Gateway
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Default Gateway

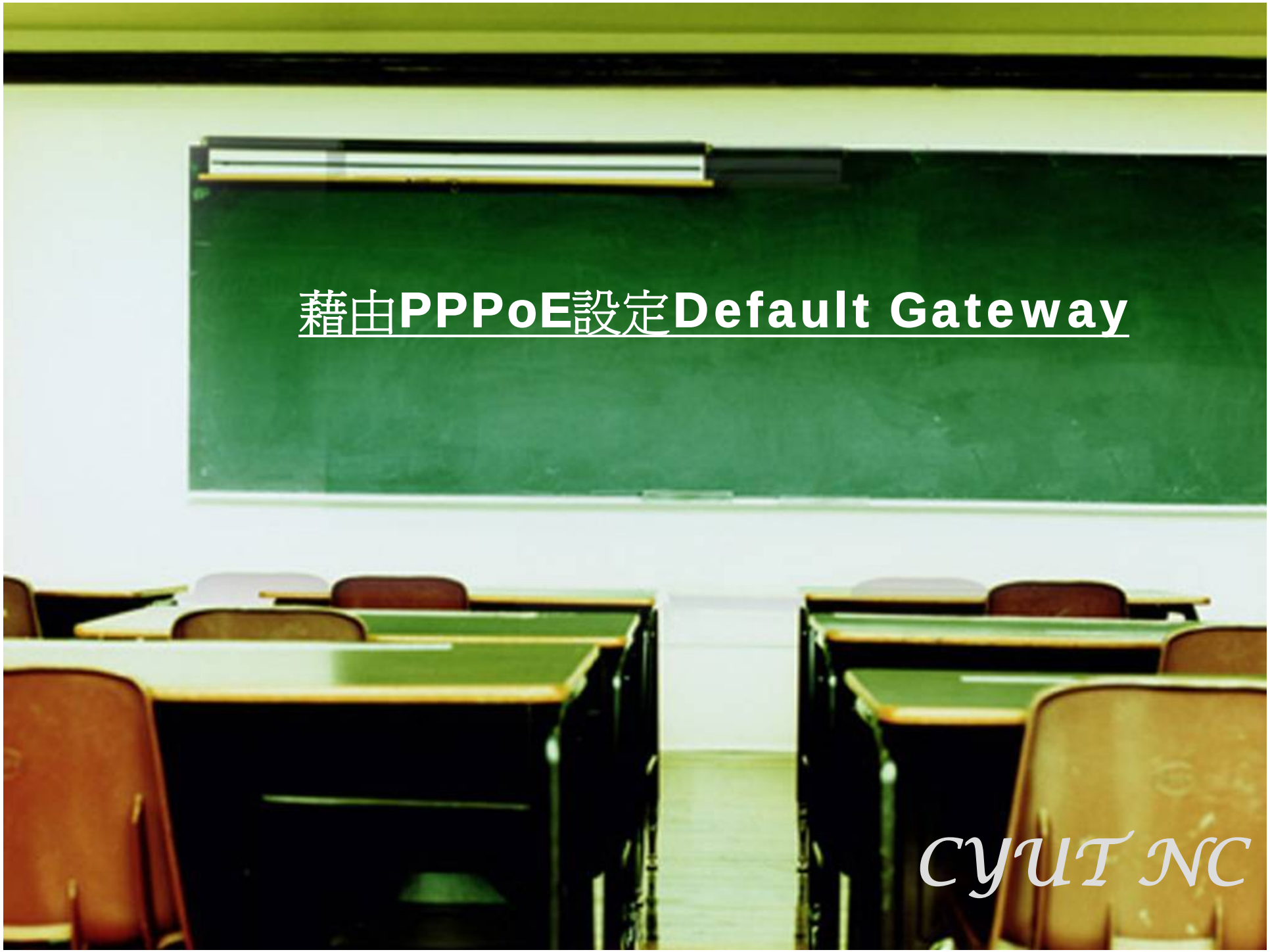
- 當兩台電腦在不同網域互傳 **Packet** 時
  - 電腦會先查詢自己的Routing Table，找出往另一台電腦的路由
  - 如果另一台電腦的網域不在自己的Routing Table內，就會送往Default Gateway，由Default Gateway負責轉送 Packet
- 一般固接式的**ADSL**都是設定**ADSL ATU-R** 做爲**Default Gateway**

Default Gateway的三種設定

- 由ISP 配發，指定Default Gateway，如固接專線或固接ADSL，用戶端必須自行設定 Default Gateway
- 使用DHCP (Dynamic Host Configuration Protocol, RFC 1541, RFC 2131) 自動取得 Default Gateway，如Cable Modem
- 使用PPP (The Point-to-Point Protocol, RFC 1661) 取得Default Gateway，例如：Modem 撥接；或撥接計時制ADSL使用PPPoE (PPP over Ethernet)取得 (事實上也使用 PPP)

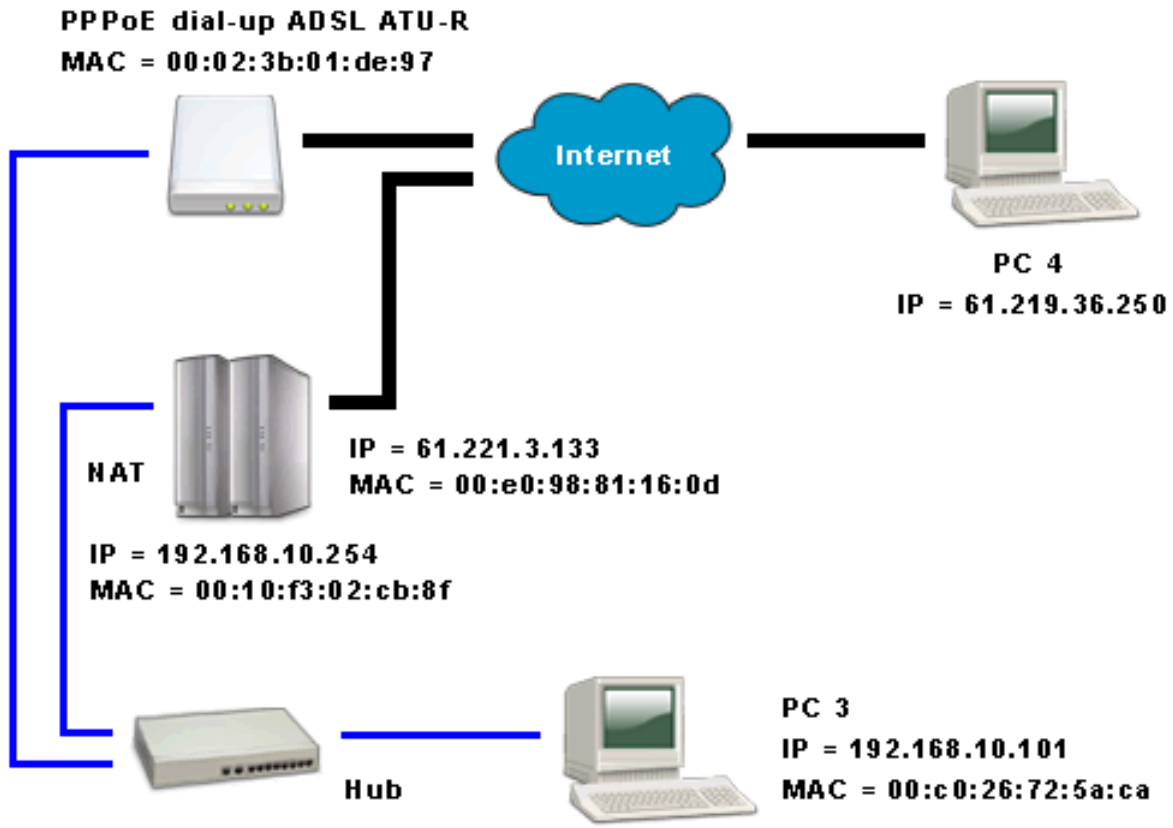
藉由 ip route 設定default gateway

```
bash# ip route
192.168.2.0/24 dev eth2  proto kernel  scope link  src 192.168.2.1
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.1
192.168.0.0/24 dev eth0  proto kernel  scope link  src 192.168.0.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
bash#
bash#
bash# ip route add default via 192.168.2.2
bash#
bash#
bash# ip route
192.168.2.0/24 dev eth2  proto kernel  scope link  src 192.168.2.1
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.1
192.168.0.0/24 dev eth0  proto kernel  scope link  src 192.168.0.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
default via 192.168.2.2 dev eth2
bash#
```


藉由PPPoE設定Default Gateway
CYUT NC

實驗架構圖

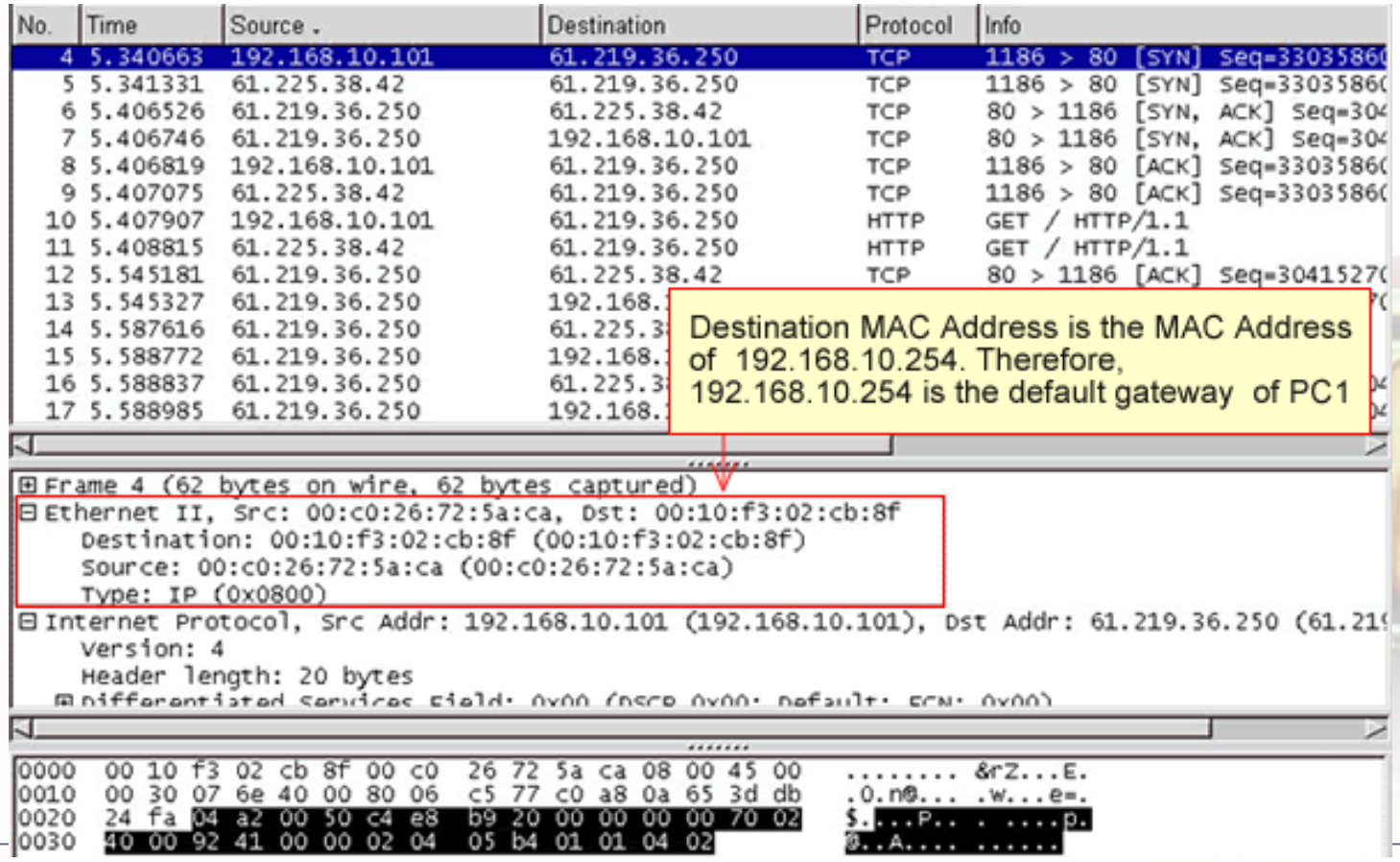
- PC3原Default Gateway為192.168.10.254



PC1還沒有執行PPPoE上網撥接程式

抓取封包觀察

- **192.168.10.101 連線遠端的 61.219.36.250**



PC1還沒有執行PPPoE上網撥接程式

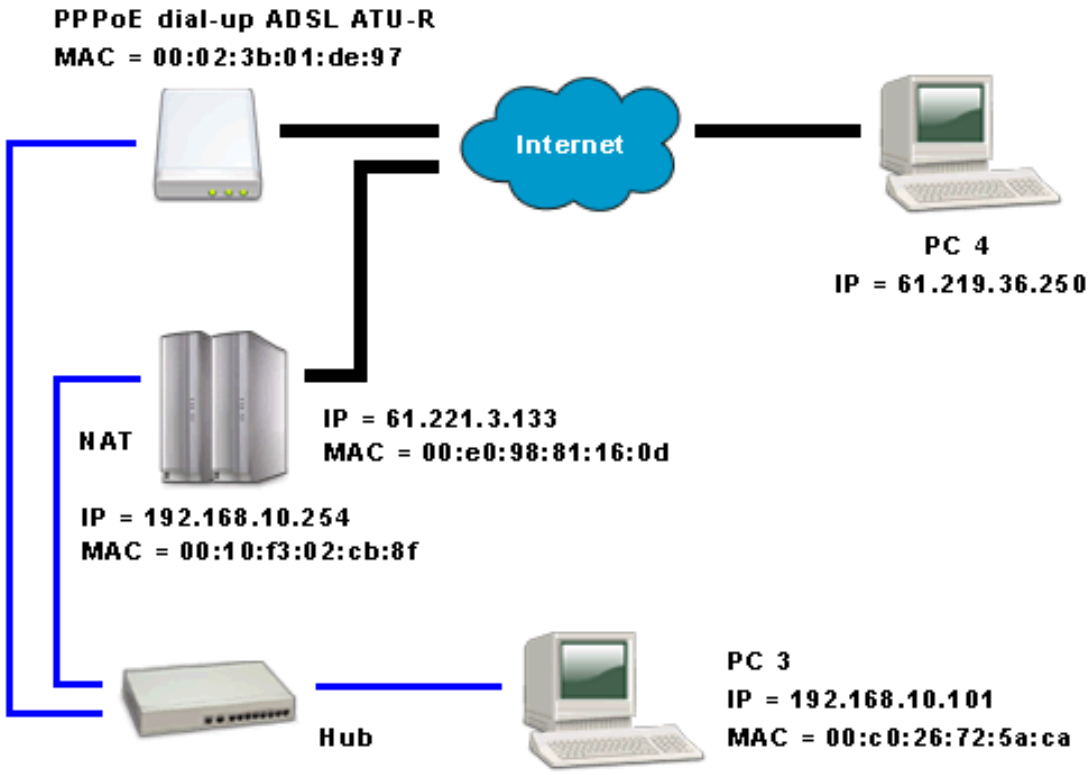
查詢Routing Table

- 原始的 **Default Gateway**為 **192.168.10.254**

```
C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2 ...44 45 53 54 77 77 ...... NTS PPPoE Adapter #1
0x1000004 ...00 c0 26 72 5a ca ...... NDIS 5.0 driver

===========================================================================
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0   192.168.10.254  192.168.10.101       1
        127.0.0.0        255.0.0.0        127.0.0.1       127.0.0.1       1
    192.168.10.0    255.255.255.0   192.168.10.101  192.168.10.101       1
  192.168.10.101  255.255.255.255        127.0.0.1       127.0.0.1       1
  192.168.10.255  255.255.255.255   192.168.10.101  192.168.10.101       1
        224.0.0.0        224.0.0.0   192.168.10.101  192.168.10.101       1
  255.255.255.255  255.255.255.255   192.168.10.101               2       1
Default Gateway:    192.168.10.254
===========================================================================
```

PC1執行PPPoE上網撥接程式後

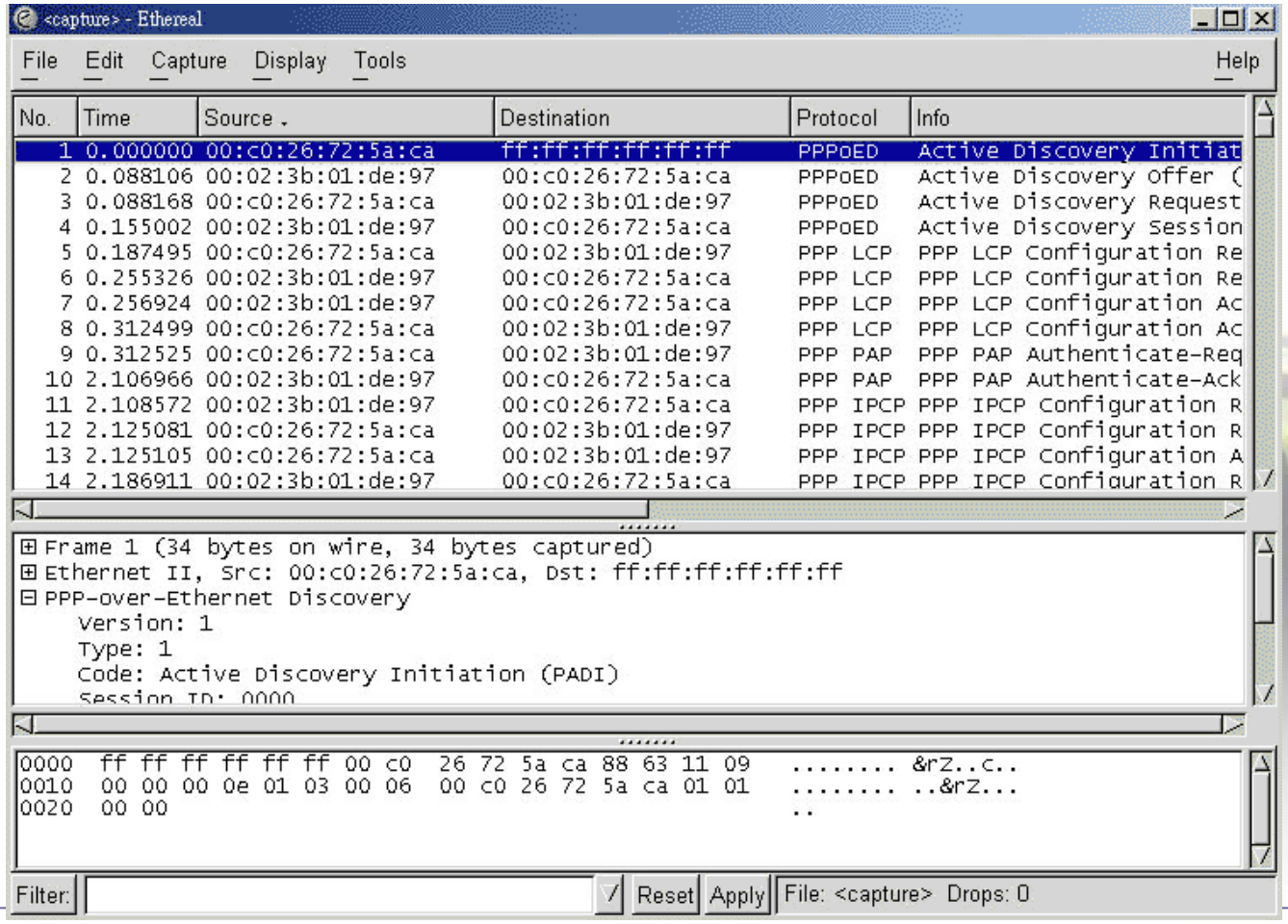
- 經由 PPP 取得網路IP、Gateway與DNS 等設定後，並更動 Routing Table，將Default Gateway 設爲由 PPP取得的 Gateway IP



PC1執行PPPoE上網撥接程式後

抓取封包觀察

上網撥接程式，同時使用**Ethereal** 擷取 **Packet**

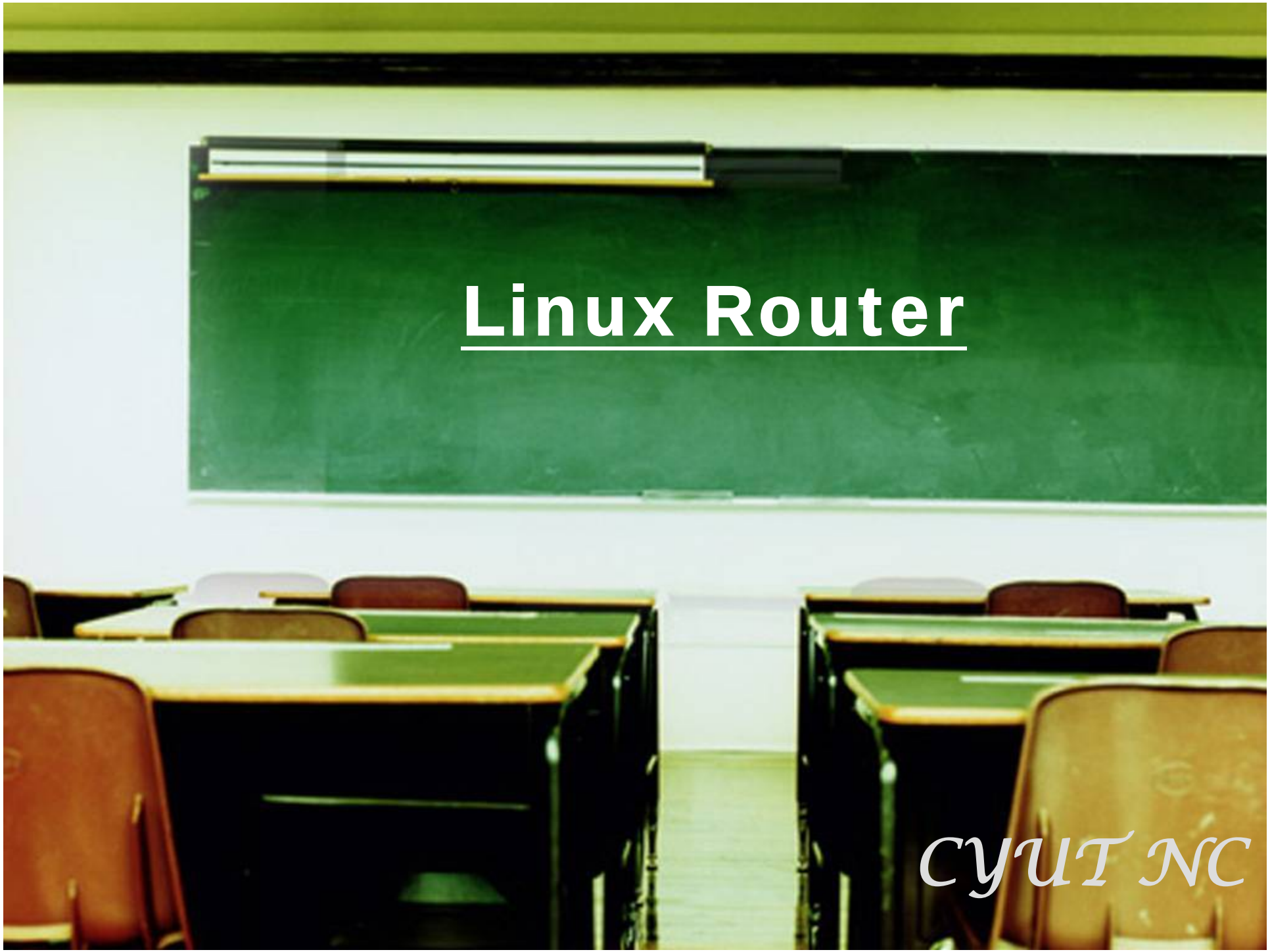


PC1執行PPPoE上網撥接程式後

查詢Routing Table

Default Gateway 已改變為PPP取得之Gateway IP

```
C:\>route print
===========================================================================
Interface List
0x1 ........................... MS TCP Loopback interface
0x2 ...44 45 53 54 77 77 ...... NTS PPPoE Adapter #1
0x1000004 ...00 c0 26 72 5a ca ...... NDIS 5.0 driver

===========================================================================
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0    192.168.10.254  192.168.10.101       2
          0.0.0.0          0.0.0.0     61.225.34.50    61.225.34.50       1
      61.225.34.0    255.255.255.0     61.225.34.50    61.225.34.50       1
     61.225.34.50  255.255.255.255        127.0.0.1       127.0.0.1       1
   61.255.255.255  255.255.255.255     61.225.34.50    61.225.34.50       1
        127.0.0.0        255.0.0.0        127.0.0.1       127.0.0.1       1
     192.168.10.0    255.255.255.0   192.168.10.101  192.168.10.101       2
   192.168.10.101  255.255.255.255        127.0.0.1       127.0.0.1       1
   192.168.10.255  255.255.255.255   192.168.10.101  192.168.10.101       1
        224.0.0.0        224.0.0.0     61.225.34.50    61.225.34.50       1
        224.0.0.0        224.0.0.0   192.168.10.101  192.168.10.101       1
  255.255.255.255  255.255.255.255     61.225.34.50    61.225.34.50       1
Default Gateway:       61.225.34.50
===========================================================================
```


Linux Router
CYUT NC

Linux Router

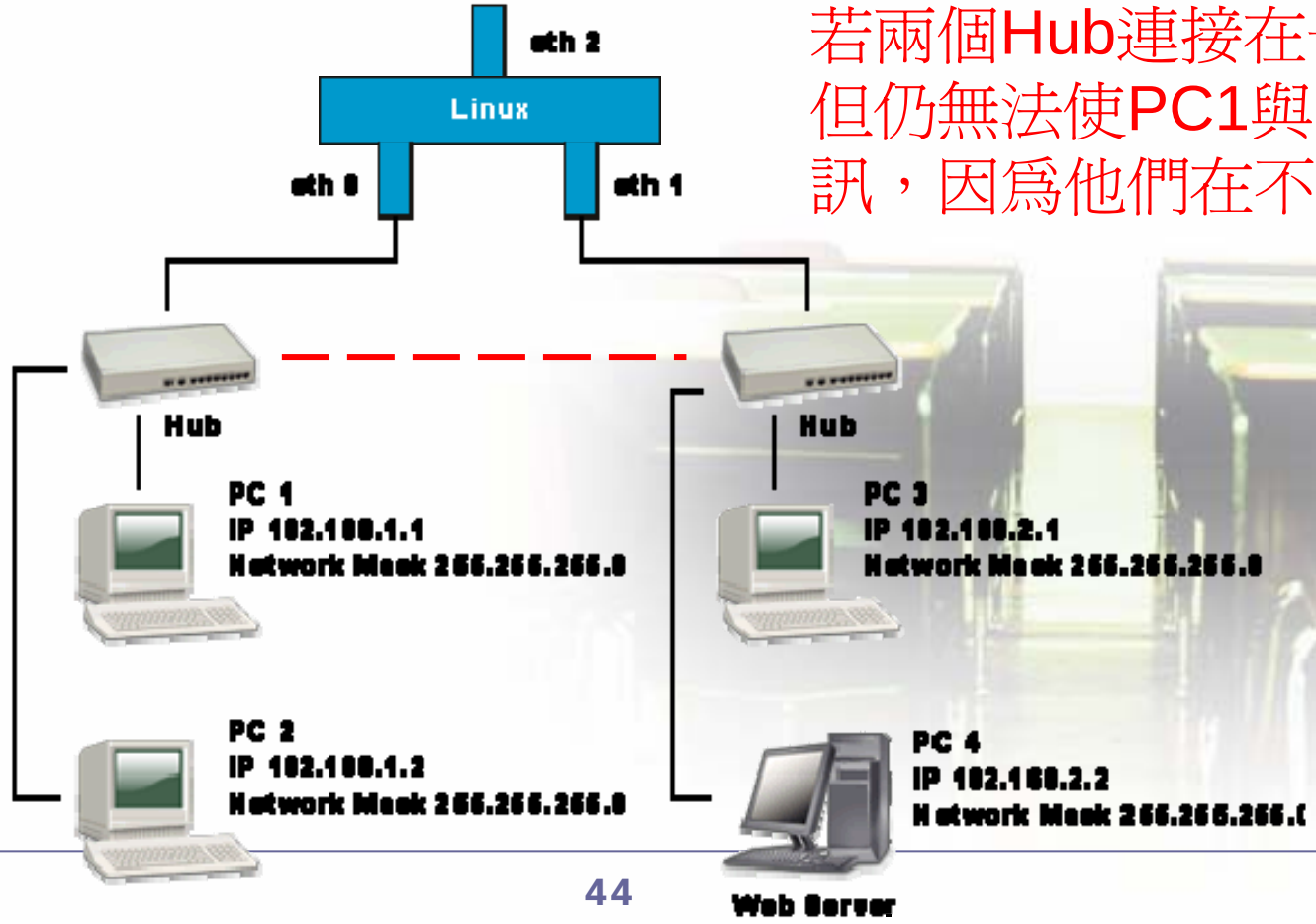
- 使用一般PC加上 Linux，經過適當的設定並結合Routing Protocol 即可成爲一小型的Router使用
- 若更進一步於硬體Routing與Packet處理方面加強，如使用Intel IXP系列 Network Processor 或 IBM PowerNP系列，這些硬體結合 Linux 可以設計爲一商業用之Router

Linux router open Source

- 網路上有許多的**Open Source**程式碼，但是當使用時，多少需要加以修正與增加功能，甚至改變原始程式以配合硬體
  - [1] Linux Router Project, http://www.linuxrouter.org/
  - [2] Free Cisco, http://www.freesco.org/
  - [3] IBM PowerNP, http://www.ibm.com
  - [4] Intel IXP系列 Network Processor, http://www.intel.com
  - [5] Linux Routing Protocol, http://www.zebra.org

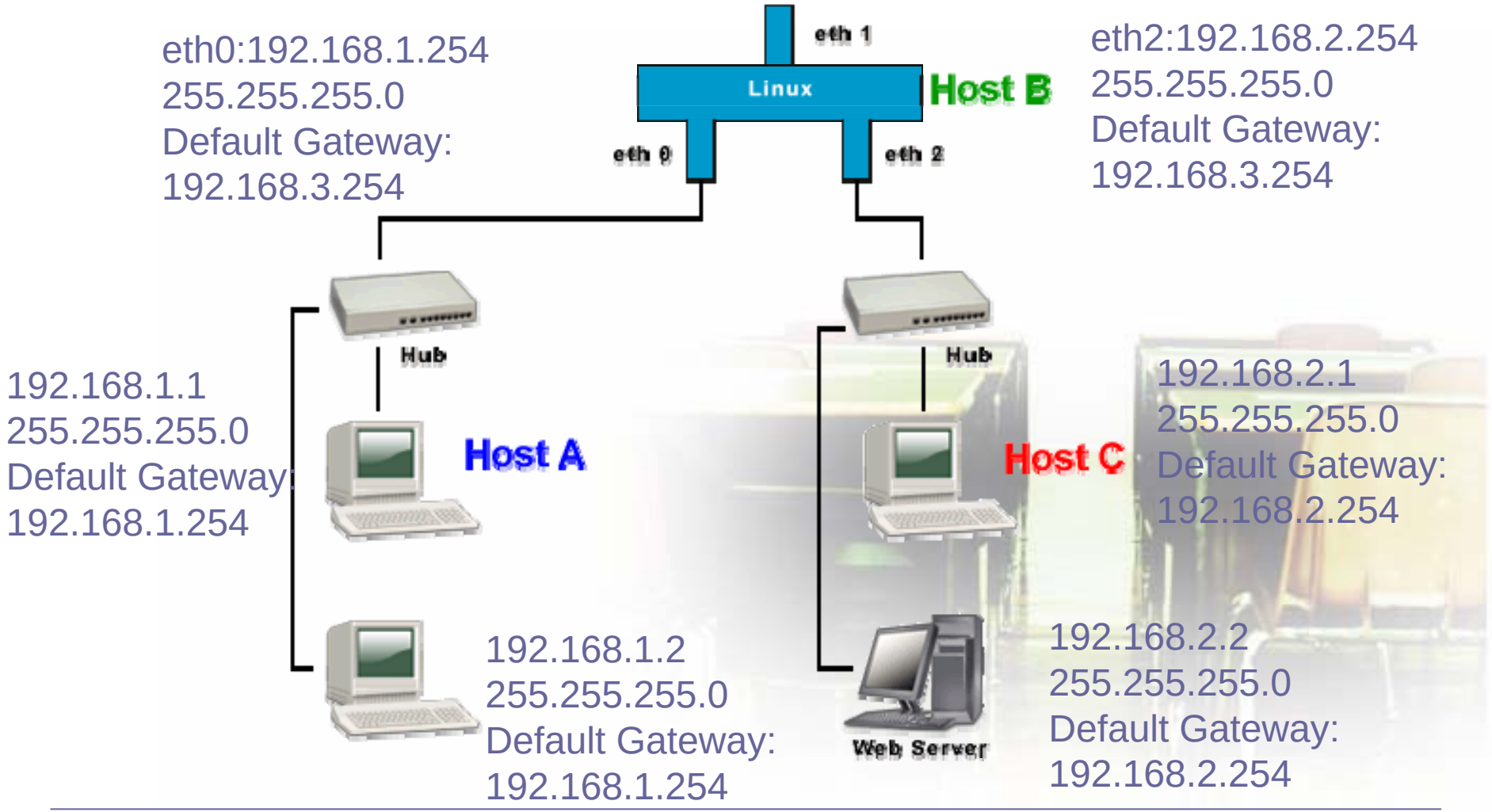
Linux Router實例

- 原本PC 1 與 PC 4 之間無法使用HTTP溝通
- 經由Linux 遞送使PC 1 與 PC 4 之間可經HTTP溝通

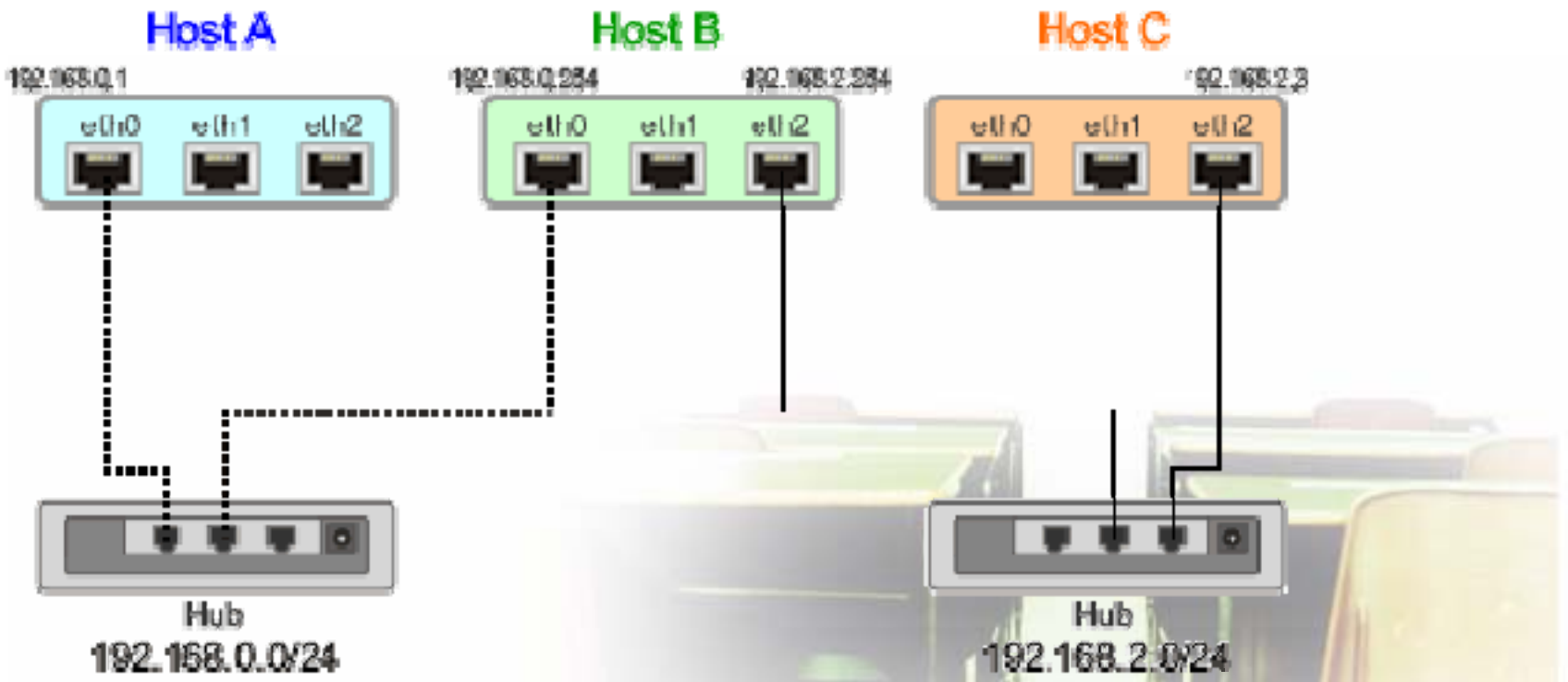


若兩個Hub連接在一起，但仍無法使PC1與PC4通訊，因爲他們在不同網域

利用NetGuru實作



NetGuru架構圖



設定 Host A eth0

- ifconfig eth0 192.168.0.1 netmask 255.255.255.0
- ip route add default via 192.168.0.254

設定Host B eth0

- **ifconfig eth0 192.168.0.254 netmask 255.255.255.0**

完成此命令除了設定介面 IP 與Network Mask 外，
ifconfig 還幫您**自動**設了一靜態Route 的Entry

192.168.0.0/24 dev eth0 scope link src 192.168.1.254

相當於執行了
ip route add 192.168.1.254/24 dev eth0

設定Host B eth2

- **ifconfig eth2 192.168.2.254 netmask 255.255.255.0**

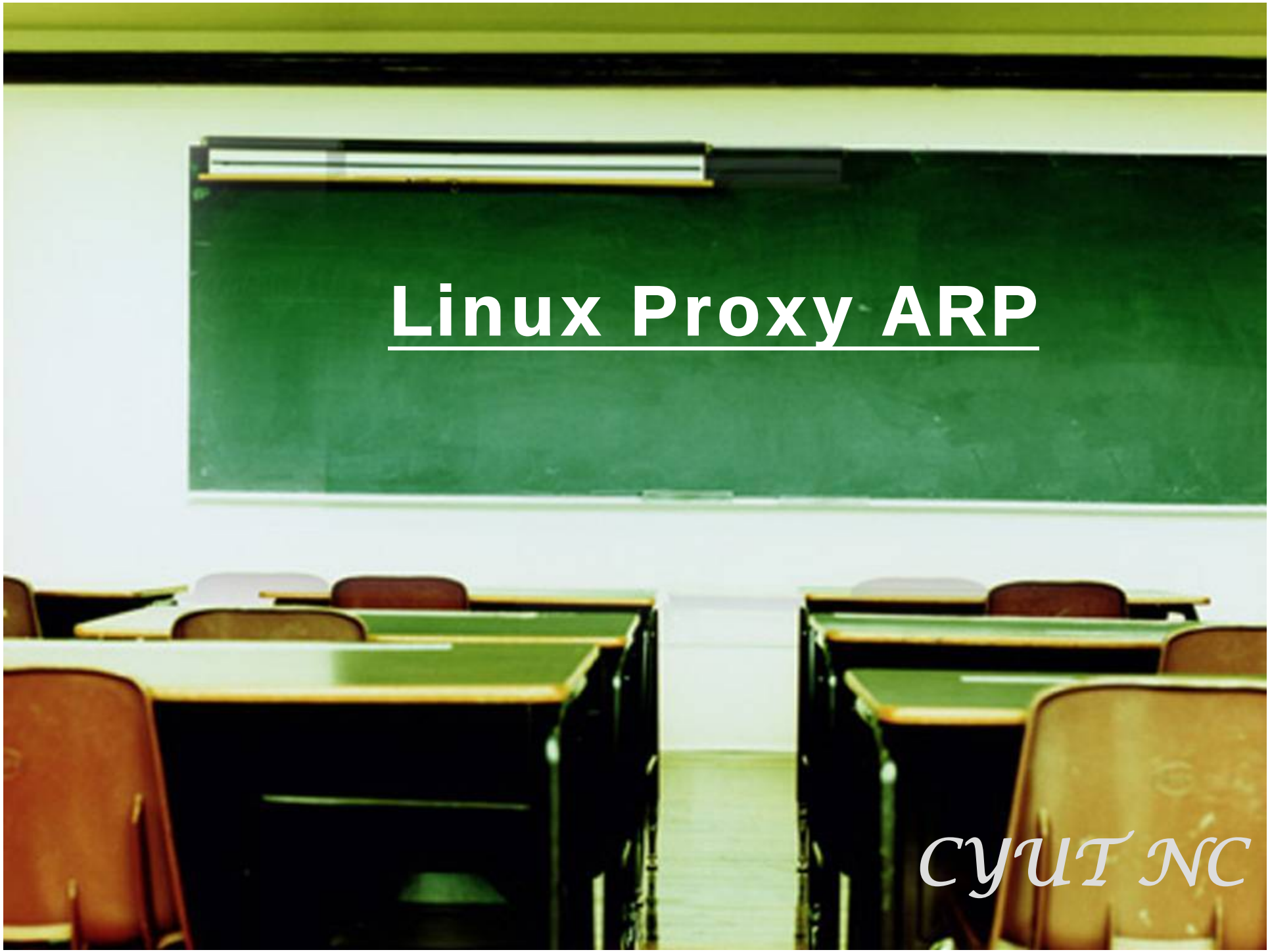
完成此命令除了設定eth1介面 IP 與Network Mask 外，ifconfig 也還幫您**自動**設了一靜態Route 的Entry

192.168.2.0/24 dev eth2 scope link src 192.168.2.254

相當於執行了
ip route add 192.168.2.254/24 dev eth2

設定Host C eth2

- ifconfig eth2 192.168.2.3 netmask 255.255.255.0
- ip route add default via 192.168.2.254


Linux Proxy ARP
CYUT NC

概說

- Proxy 一詞可以用在各種場合，我們可想像其爲代理人，當您想與某方完成一任務時，可以透過代理人間接幫您完成，但除了完成任務之外，此代理人還可以幫助加速、掃毒或紀錄等
- 如最常用的即是WEB Proxy，也就是常用的瀏覽器Proxy 設定中使用的Proxy Server。最有名的 WEB Proxy 即爲 squid（http://www.squid-cache.org/）

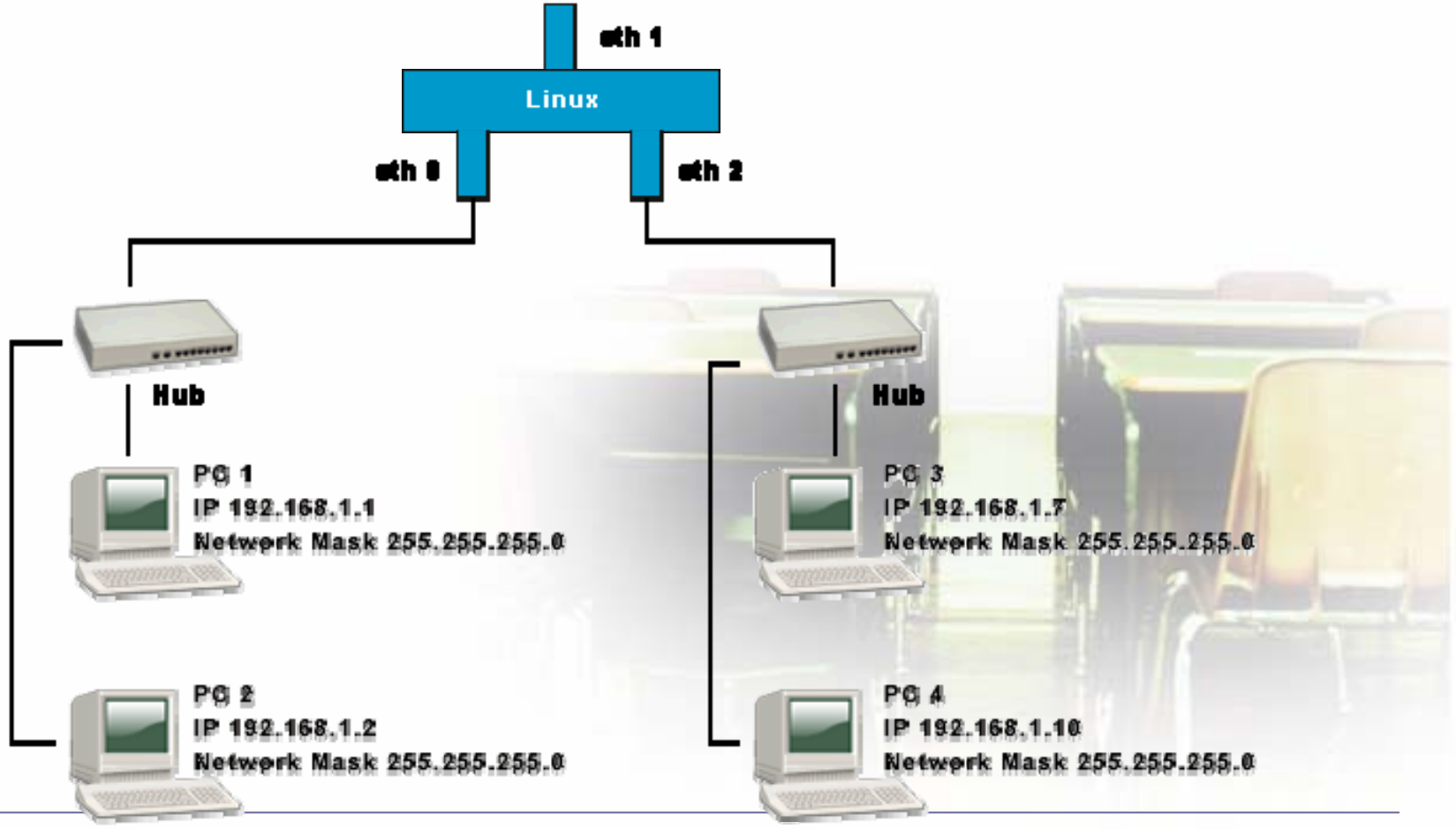
Proxy ARP

- Proxy是代理來源端向目的端提出請求，對於來源端而言，所面對的是Proxy，而目的端所回應的，也是以爲來自Proxy ，但事實的來源主機卻是在Proxy後面。
- Proxy ARP主要是針爲ARP的協定，來源端送出ARP的廣播時，Proxy ARP必須知道(記錄)它另一端的主機情形，而代理回應，並將該MAC Address的資料轉送至另一端。例如：撥接伺服器便代理兩端電腦的功能Proxy ARP 。

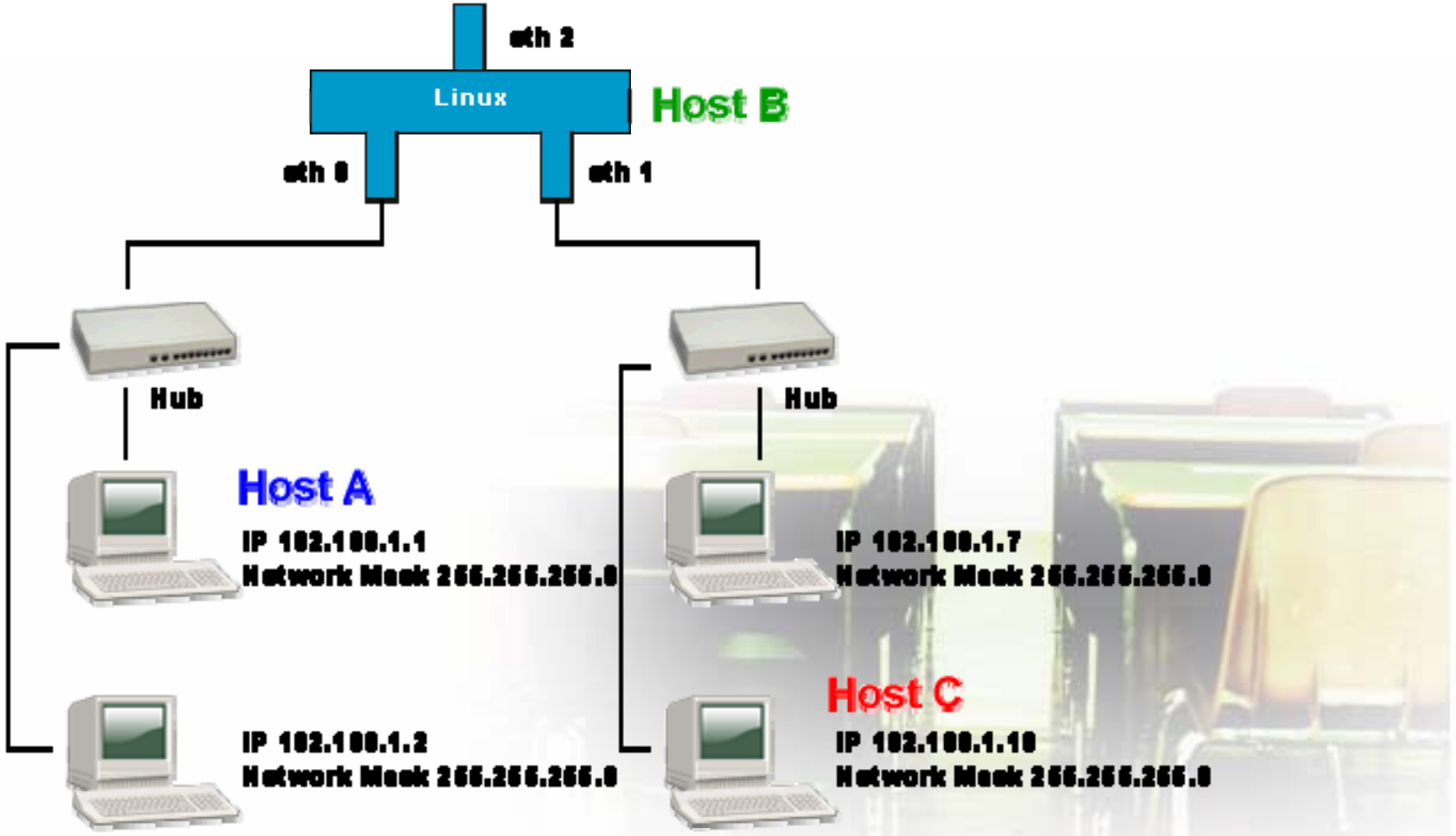
範例說明

PC 1 與 PC 4 必須透過 Proxy ARP 才能溝通

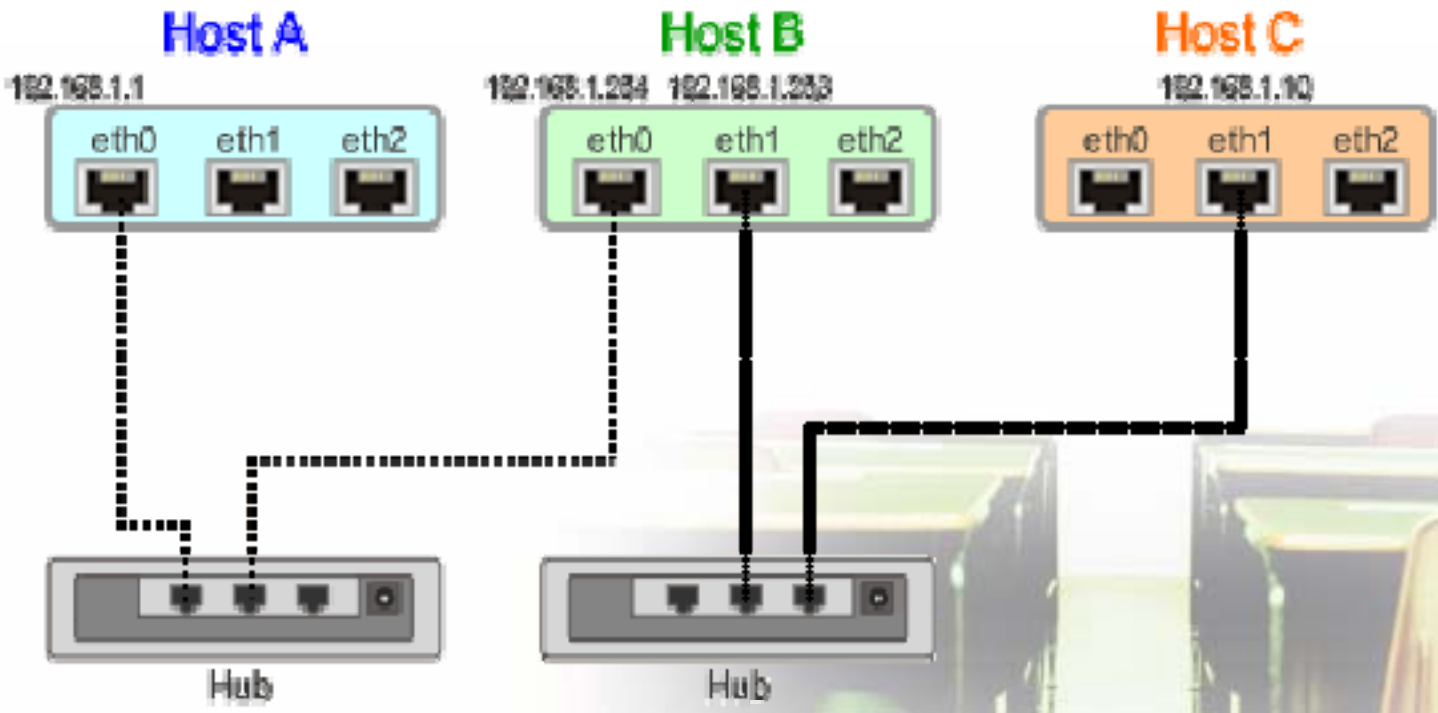
PC 4 的 MAC Address 為 Linux eth0 的 MAC Address， 而對PC 4的 ARP Request回應 PC 1 的 MAC Address 為 Linux eth2



利用NetGuru實作



NetGuru架構圖


Host A
192.168.1.1
eth0
eth1
eth2
Host B
192.168.1.254
192.168.1.253
eth0
eth1
eth2
Host C
192.168.1.10
eth0
eth1
eth2
Hub
Hub

NetGuru内部 Host B

```
bash# ip route
192.168.1.0/24 dev eth0  proto kernel  scope link  src 192.168. .254
192.168.1.0/24 dev eth1  proto kernel  scope link  src 192.168.1.253
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.252
bash# ifconfig
eth0      Link encap:Ethernet  HWaddr 00:30:C7:81:44:23
          inet addr:192.168.1.254  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:72 errors:0 dropped:0 overruns:0 frame:0
          TX packets:81 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          Interrupt:10 Base address:0xa000

eth1      Link encap:Ethernet  HWaddr 00:30:C7:81:44:22
          inet addr:192.168.1.253  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:75 errors:0 dropped:0 overruns:0 frame:0
          TX packets:75 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          Interrupt:11 Base address:0xc000

eth3      Link encap:Ethernet  HWaddr 00:30:C7:81:44:20
          inet addr:192.168.251.252  Bcast:192.168.251.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:9347 errors:1 dropped:0 overruns:0 frame:0
          TX packets:7329 errors:0 dropped:0 overruns:0 carrier:0
          collisions:6 txqueuelen:100
          Interrupt:12
```

NetGuru內部 Host B 下達 Proxy ARP 指令

- arp –i eth1 –Ds 192.168.1.1 eth1 netmask 255.255.255.255 pub
- arp –i eth0 –Ds 192.168.1.10 eth0 netmask 255.255.255.255 pub

```
bash# arp -an
? (192.168.1.1) at 00:30:C7:81:43:65 [ether] on eth0
? (192.168.251.254) at 00:10:F3:03:16:B3 [ether] on eth3
? (192.168.1.10) at 00:30:C7:81:41:98 [ether] on eth1
? (192.168.251.22) at 00:E0:98:81:16:0D [ether] on eth3
? (192.168.1.10) at * PERM PUP on eth0
? (192.168.1.1) at * PERM PUP on eth1
```

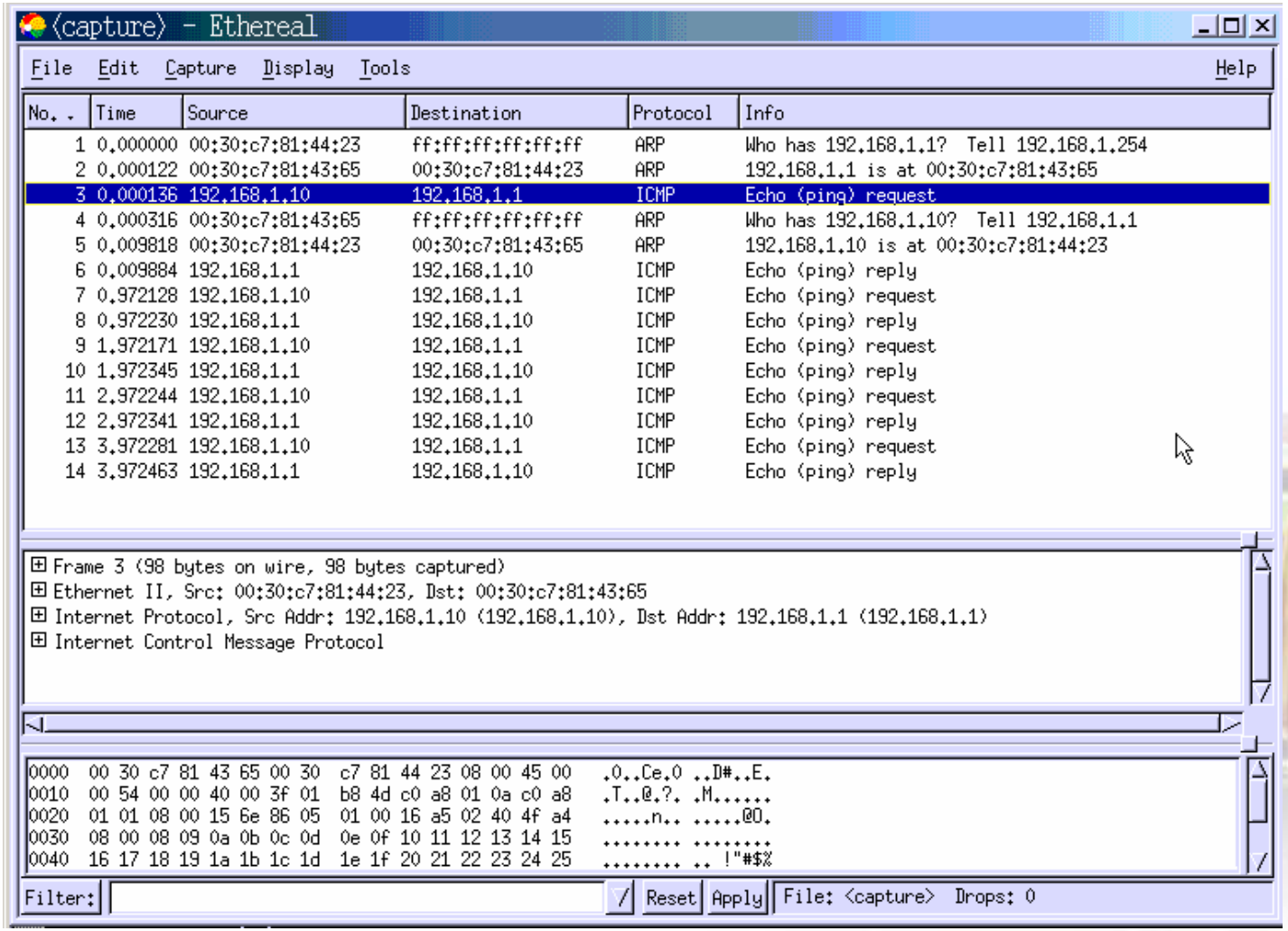
NetGuru內部 Host A

```
bash#
bash# arp -an
? (192.168.251.254) at 00:10:F3:03:16:B3 [ether] on eth3
? (192.168.251.22) at 00:E0:98:81:16:0D [ether] on eth3
bash# ping 192.168.1.10
PING 192.168.1.10 (192.168.1.10) from 192.168.1.1 : 56(84) bytes of data.
64 bytes from 192.168.1.10: icmp_seq=1 ttl=63 time=837 ms
64 bytes from 192.168.1.10: icmp_seq=2 ttl=63 time=0.238 ms
64 bytes from 192.168.1.10: icmp_seq=3 ttl=63 time=0.345 ms

[3]+  Stopped                 ping 192.168.1.10
bash# arp -an
? (192.168.251.254) at 00:10:F3:03:16:B3 [ether] on eth3
? (192.168.1.10) at 00:30:C7:81:44:23 [ether] on eth0
? (192.168.251.22) at 00:E0:98:81:16:0D [ether] on eth3
bash# ip route
192.168.1.0/24 dev eth0  proto kernel  scope link  src 192.168.1.1
192.168.251.0/24 dev eth3  proto kernel  scope link  src 192.168.251.251
bash#
```

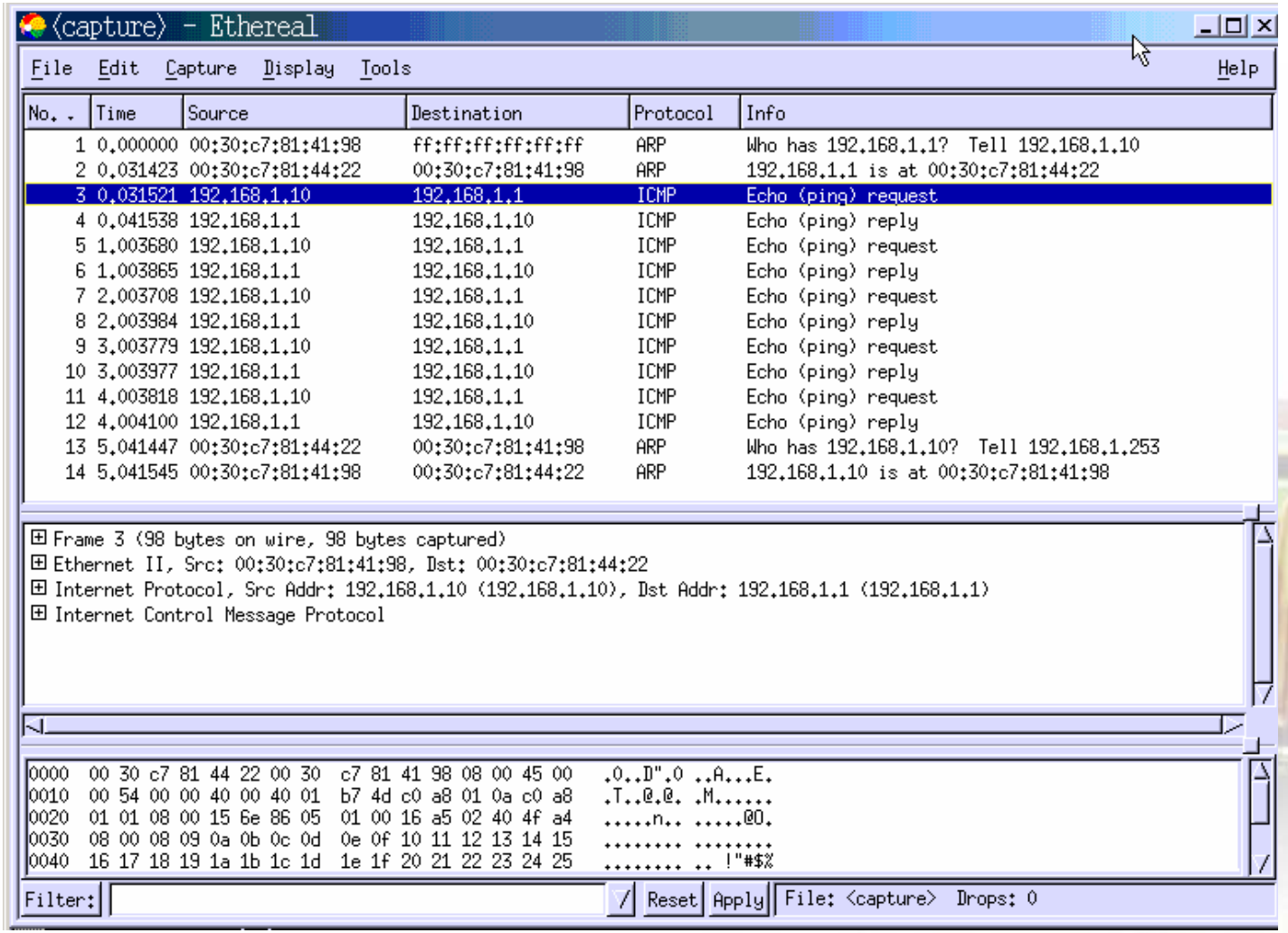
NetGuru內部 Host C

```
bash# arp -an
? (192.168.1.1) at 00:30:C7:81:44:22 [ether] on eth1
? (192.168.251.254) at 00:10:F3:03:16:B3 [ether] on eth3
? (192.168.251.22) at 00:E0:98:81:16:0D [ether] on eth3
bash# ping 192.168.1.253
PING 192.168.1.253 (192.168.1.253) from 192.168.1.10 : 56(84) bytes of data.
64 bytes from 192.168.1.253: icmp_seq=1 ttl=64 time=0.322 ms
64 bytes from 192.168.1.253: icmp_seq=2 ttl=64 time=0.158 ms

[7]+  Stopped                 ping 192.168.1.253
bash# arp -an
? (192.168.1.253) at 00:30:C7:81:44:22 [ether] on eth1
? (192.168.1.1) at 00:30:C7:81:44:22 [ether] on eth1
? (192.168.251.254) at 00:10:F3:03:16:B3 [ether] on eth3
? (192.168.251.22) at 00:E0:98:81:16:0D [ether] on eth3
bash#
```

NetGuru内部 Host B 抓取eth0的封包



NetGuru內部 Host B 抓取eth1的封包



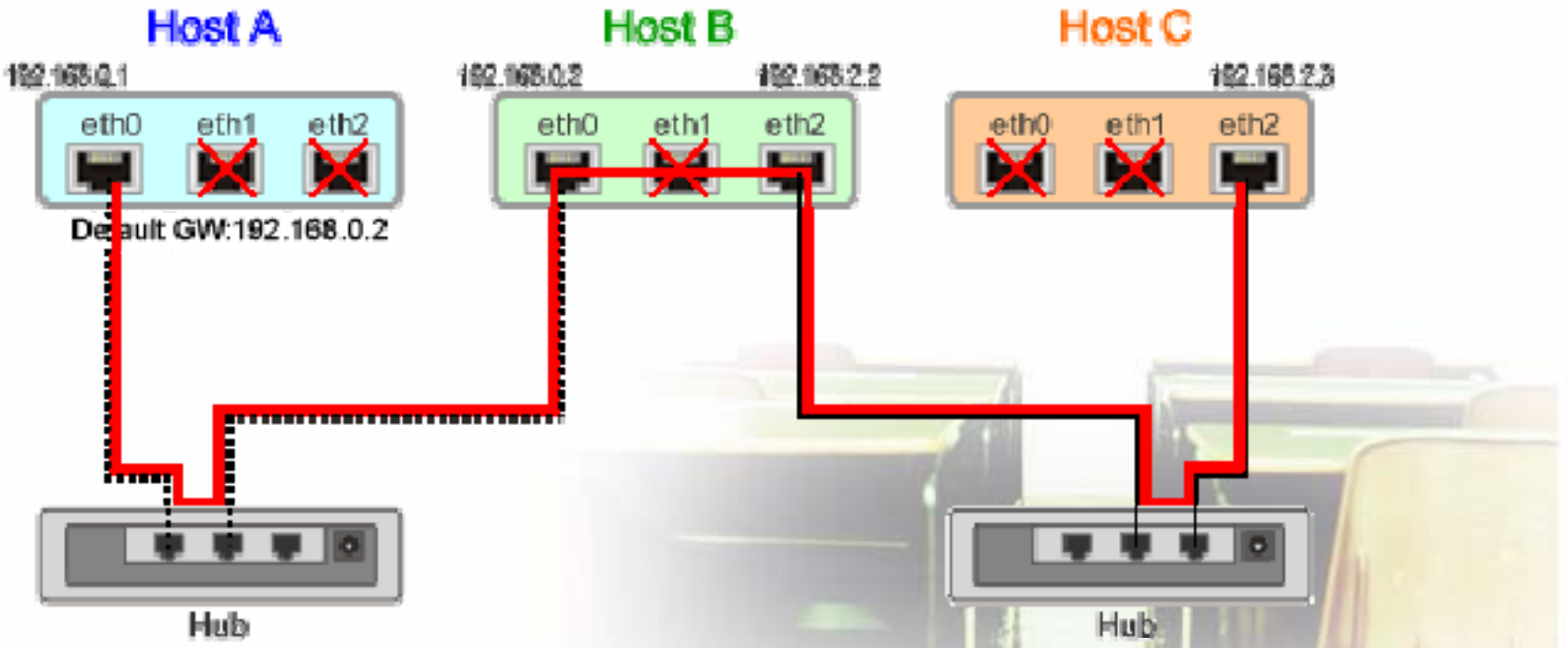

實驗導引
實驗 5.1 Routing設定與TTL觀察
CYUT NC

實驗 5.1 Routing設定與TTL觀察

實驗目的

- 了解如何設定Gateway
- 了解routing相關概念
- 了解default route的意義
- 了解TTL相關概念
- 觀察route與TTL的變化

第一次routing架構圖

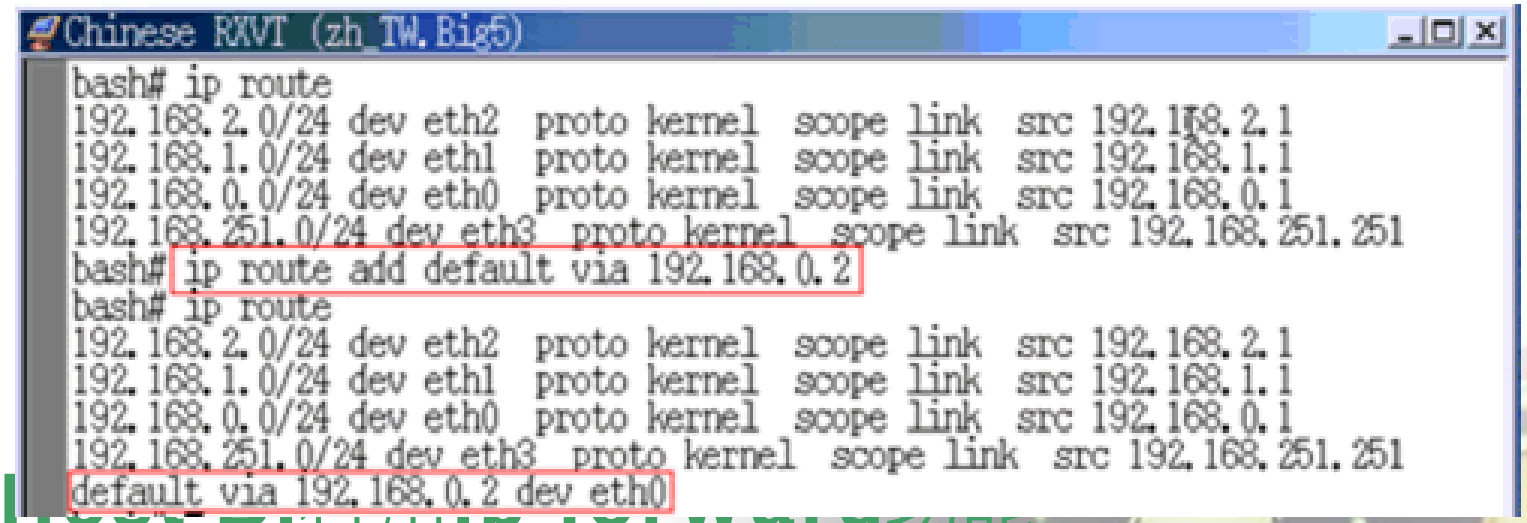


Step 1: 實驗環境設定

- 停用與實驗無關的網卡
- **Host A:**
  - ifconfig eth1 down
  - ifconfig eth2 down
- **Host B:**
  - ifconfig eth1 down
- **Host C:**
  - ifconfig eth0 down
  - ifconfig eth1 down

Step 2:設定Host B爲Host A的default gateway

- Host A:



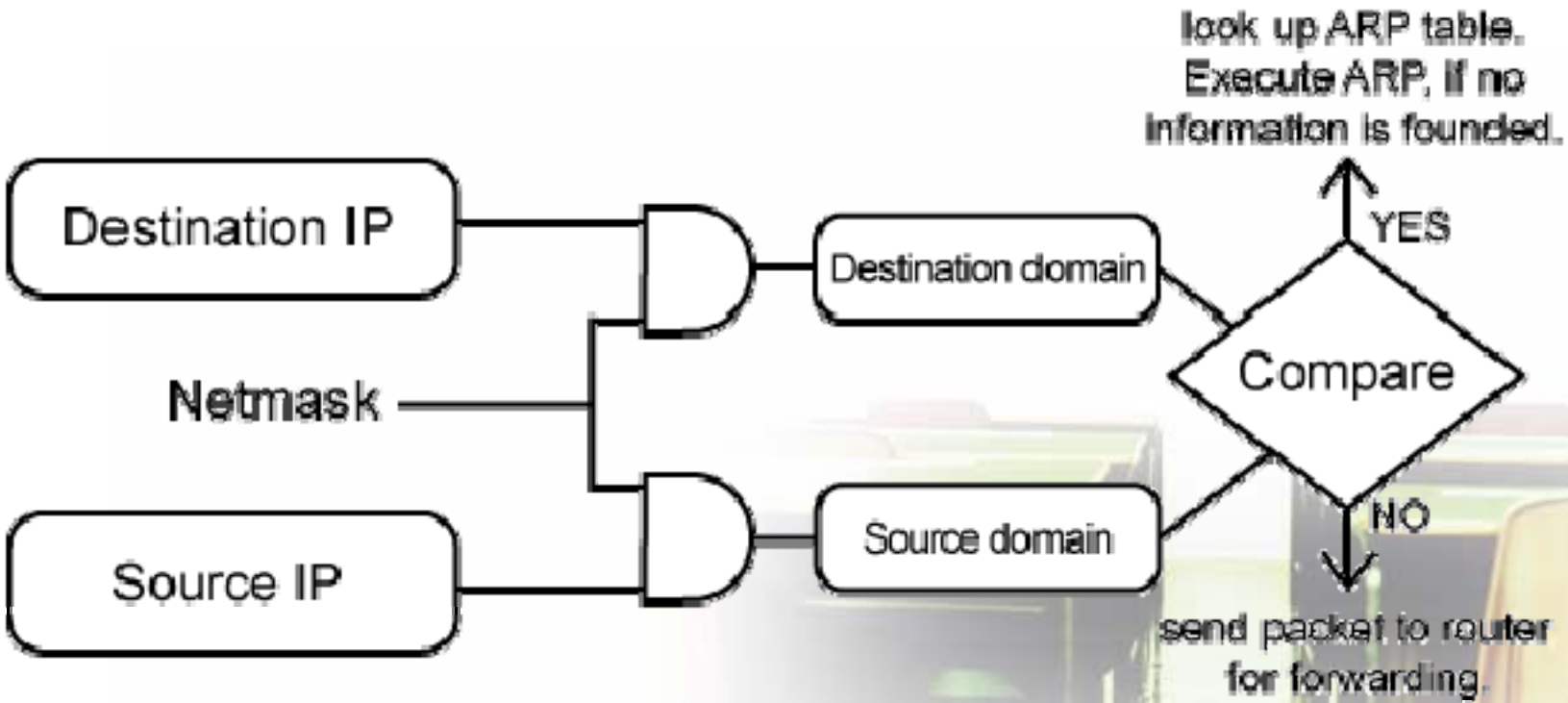
- Host B:啓用ip forward功能
  - echo “1” > /proc/sys/net/ipv4/ip_forward

- 復習：何謂default gateway

Step 3: 連線測試

- **Host B:**
  - 開啓Ethereal，interface選eth0，以觀察連線測試之封包
- **Host C:**
  - 開啓Ethereal，interface選eth2，以觀察連線測試之封包
- **Host A:**
  - ping 192.168.2.3
  - 觀察是否有回應，並探討其原因
  - 如無法連線，該如何進行問題排除
- **問題與討論：**
  - 比較Host B與Host C Ethereal所抓到的ICMP封包的

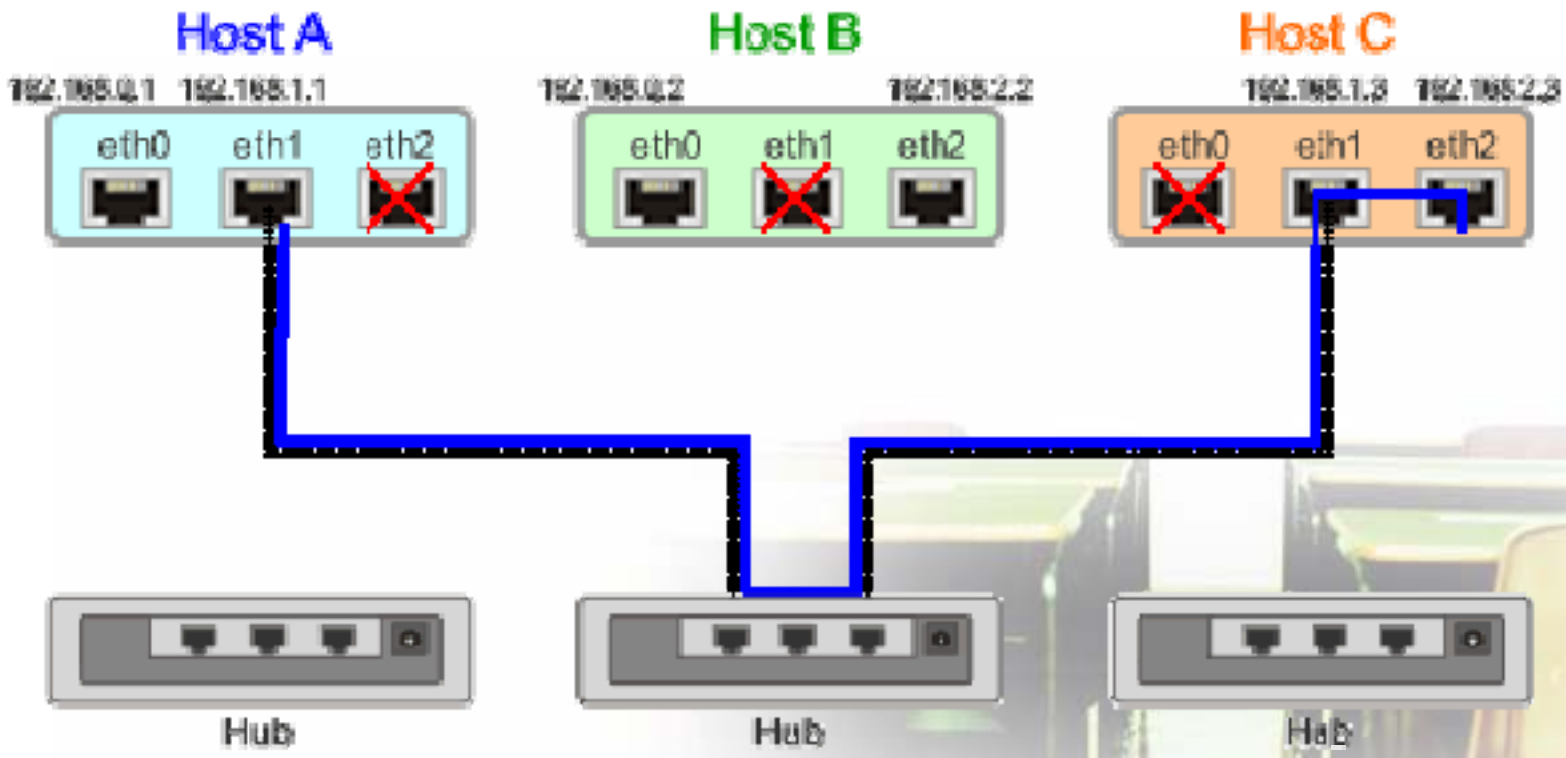
復習


look up ARP table.
Execute ARP, if no
information is founded.
YES
Destination IP
Destination domain
Compare
Netmask
Source domain
NO
Source IP
send packet to router
for forwarding.

Step 4: 問題排除

- 設定Host C回到192.168.0.0/24的路徑
  - ip route add default via 192.168.2.2
- 上面做法是使ICMP request和reply的路徑相同，然而ICMP request和reply的路徑不一定相同，如接下來的步驟所示

第二次routing架構圖



Step 5: 實驗環境設定

- **Host A的eth1回復預設值:**
  - ifconfig eth1 192.168.1.1 netmask 255.255.255.0
- **Host B:**
  - 沿用之前步驟的設定值不需更改
- **Host C的eth1回復預設值:**
  - ifconfig eth1 192.168.1.3 netmask 255.255.255.0

Step 6:設定路徑

- 設定Host C往192.168.0.0/24的路徑
- Host C:
  - ip route add 192.168.0.0/24 via 192.168.1.1
  - 使Host C藉由192.168.1.1直接到達Host A(不經Host B轉送封包)

Step 7: 連線測試

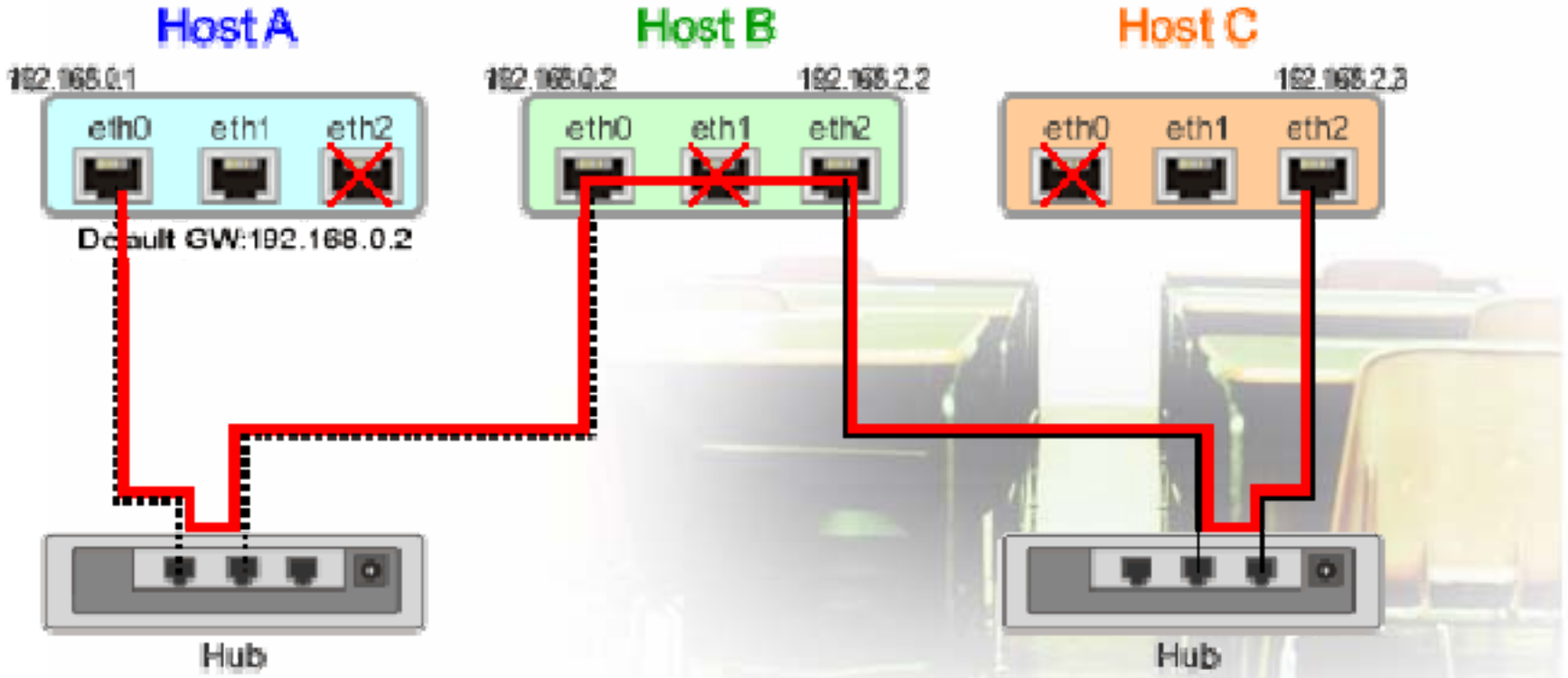
- **Host C:**
  - 開啓Ethereal，interface選eth2，以觀察連線測試之封包
- **Host A:**
  - 開啓Ethereal，interface選eth1，以觀察連線測試之封包
- **Host A:**
  - ping 192.168.2.3，觀察TTL值並探討其原因
  - traceroute 192.168.2.3

問題與討論

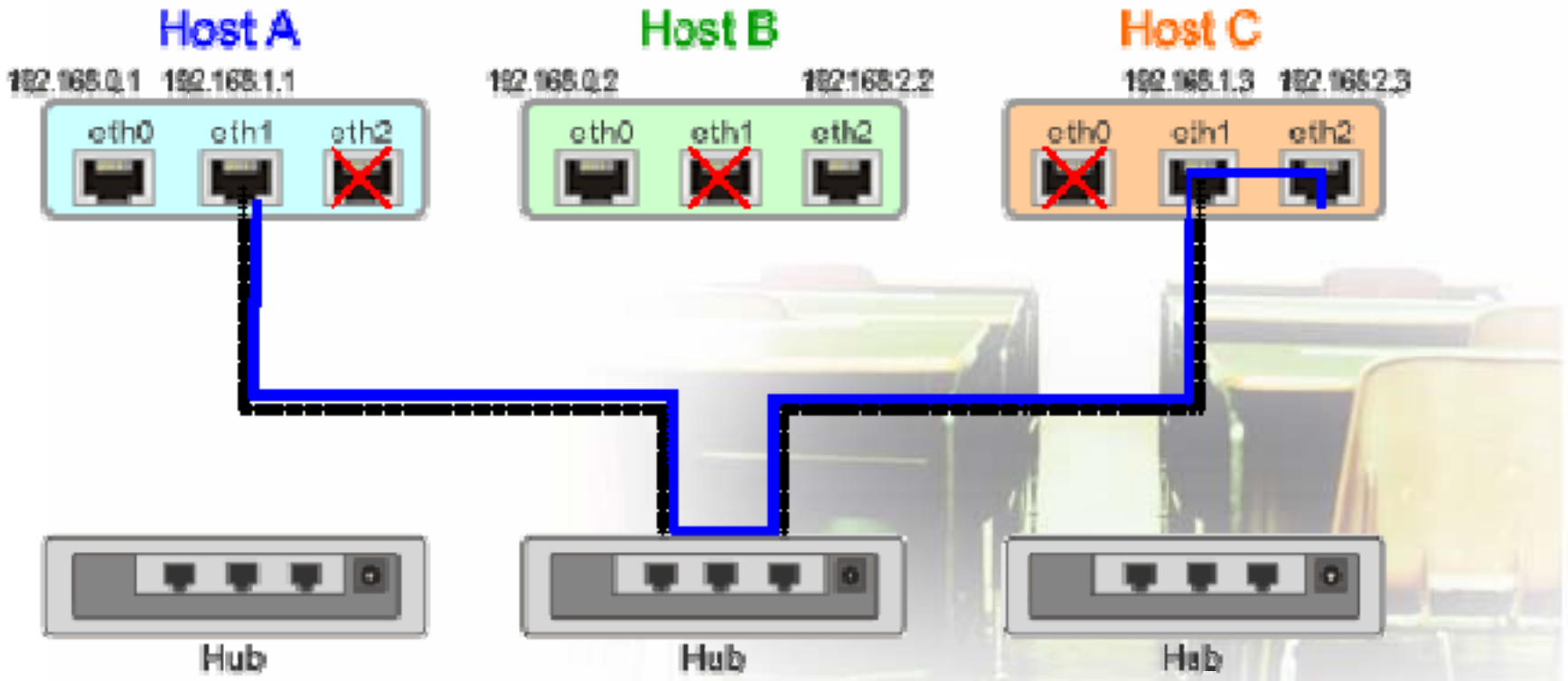
- 爲何在Host C Ethereal所觀察到的ICMP封包其TTL值爲63?
- 爲何在Host A Ethereal所觀察到的ICMP封包其TTL值爲64?
- 爲何ping 192.168.2.3的TTL值爲64?ping回復的TTL值是由哪一主機所決定?
- 爲何Step 4(p.69)所設定Host C到192.168.0.0/24的路徑(default route)在上步驟(Step 7)的連線測試沒有生效?
- 發出ICMP request封包的interface是否必須與接收ICMP reply的interface相同?

分析封包行經路徑

- ICMP request



❖ ICMP reply


Host A
192.168.0.1
192.168.1.1
eth0
eth1
eth2
Host B
192.168.0.2
192.168.2.2
eth0
eth1
eth2
Host C
192.168.1.3
192.168.2.3
eth0
eth1
eth2
Hub
Hub
Hub

Step 8:更改TTL預設值

- **Host C:**
  - echo “260”> /proc/sys/net/ipv4/ip_default_ttl
  - ping 192.168.0.1
  - 討論其TTL=64的意義，並分析封包行經路徑
- **Host A:**
  - ping 192.168.2.3
  - 討論其TTL=4的意義，並分析封包行經路徑

Hint: TTL的極大值爲255