南華大學資訊工程學系 九十七學年度 高速網路

組別：3、4
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一、實驗名稱

實驗　3　–　An IP Network - Dynamic Routing

二、實驗目的

1. 學習設定 PC Routers 和 PCs 的 IP Address、Default Gateway
2. 瞭解 RIP、OSPF 運作原理規則
3. 學會使用 Quagga 架設 Dynamic Routing Network 中的 RIP 和 OSPF
4. 學會想辦法提升路徑學習的速度

三、實驗原理

透過多台PCs模擬PCs和PC Routers並串接起來架起一個Network，了解Linux的各介面設定IP Address指令、default-gateway指令、Routing Table指令等，再經由所Quagga所架設的Dynamic Routing Network來了解RIP和OSPF的運作及路徑學習反應時間，再想辦法提升其路徑學習速度，來改善網路效能。

四、實驗項目

1. 架設一個 Network Topology
2. 安裝 Quagga 軟體並把轉送功能開啟
3. 使用 RIP routing
   - i　啟動每台 PC Routers 的 RIP routing 並觀看其 RoutingTable
   - ii　當 R1 和 R2 間的連線中斷後多久時間能學到新的路徑(ping from PC1 to PC2)
   - iii　當 R1 和 R2 間的連線恢復後多久時間能回復到原先的路徑
4. 使用 OSPF routing
   - i　啟動每台 PC Routers 的 OSPF routing 並觀看其 RoutingTable
   - ii　當 R1 和 R2 間的連線中斷後多久時間能學到新的路徑(ping from PC1 to PC2)
   - iii　當 R1 和 R2 間的連線恢復後多久時間能回復到原先的路徑
   - iv　如何提升路徑學習的速度

五、實驗設備

- 硬體
  1. PC x6
  2. 有線網路卡 x6
  3. Crossover 線 x6

- 軟體
  1. Linux-Ubuntu operation system
  2. ping、tracepath 指令
  3. quagga 軟體
  4. wireshark 軟體

六、實驗步驟

Part 0. 進入superuser

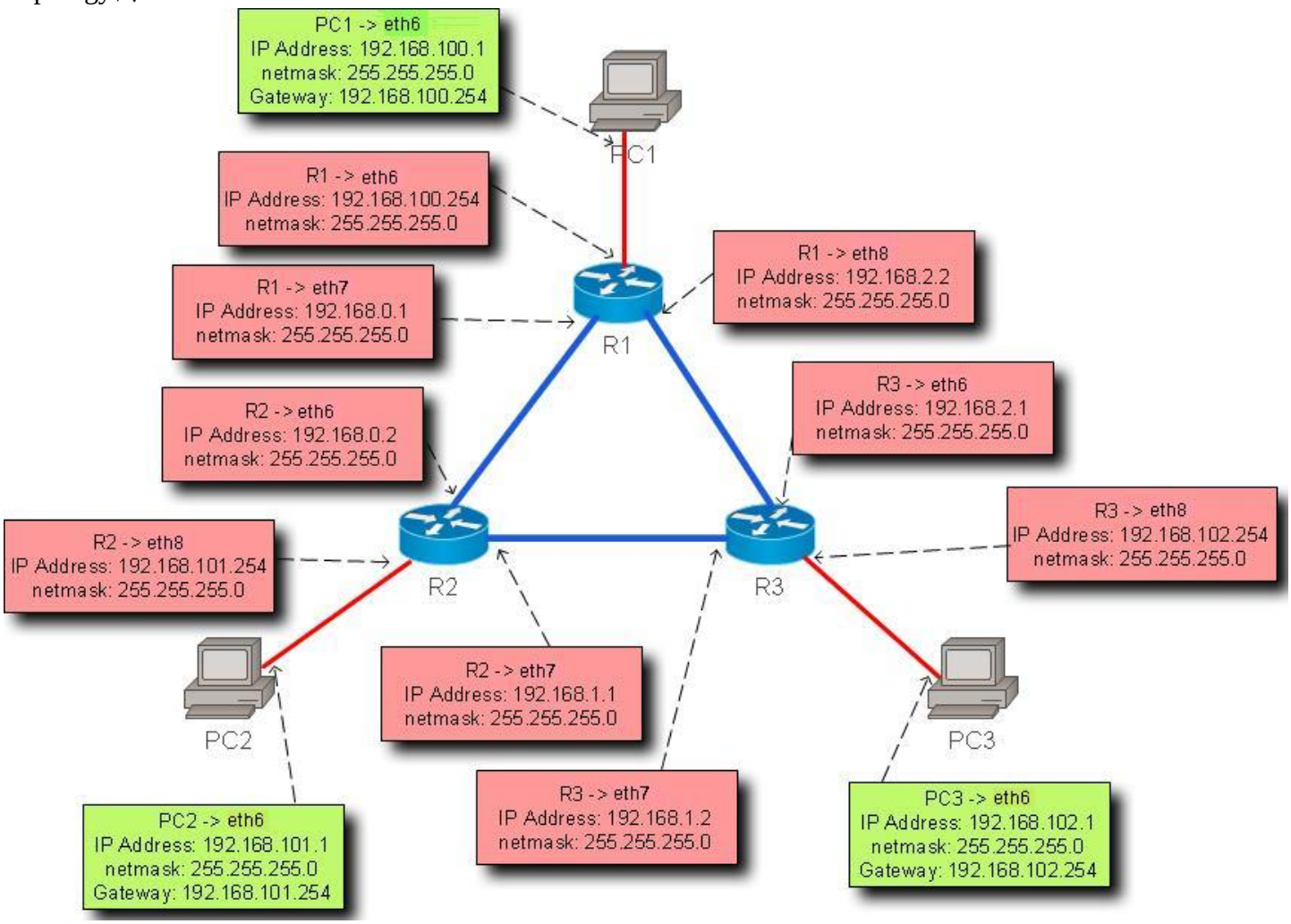
因涉汲介面設定請先進入superuser，才有權限操作。

```
$ sudo su –
[sudo] password for csie :
#
```

Part 1.架設Network Topology

因為要測試Dynamic Routing，所以最少要架設一個三角的Routing Topology。

Topology圖



1. 先確定PCs和PC Routers的分配，再把所有網路線接上。

2. 先把所有PCs和PC Routers的全部網路介面關閉。

```
PC1:~#ifconfig eth6 down
PC1:~#ifconfig eth7 down
PC1:~#ifconfig eth8 down
```

其它依此類推。

3. 依照Topology圖設定各電腦網路介面的IP Address和default-gateway。

方法 1：使用終端機直接下指令設定

```
PC1:~#ifconfig eth6 192.168.100.1 netmask 255.255.255.0
PC1:~#route add default gw 192.168.100.254
PC2:~#ifconfig eth6 192.168.101.1 netmask 255.255.255.0
```

```
PC2:~#route add default gw 192.168.101.254
PC3:~#ifconfig eth6 192.168.102.1 netmask 255.255.255.0
PC3:~#route add default gw 192.168.102.254
R1:~#ifconfig eth6 192.168.100.254 netmask 255.255.255.0
R1:~#ifconfig eth7 192.168.0.1 netmask 255.255.255.0
R1:~#ifconfig eth8 192.168.2.2 netmask 255.255.255.0
R2:~#ifconfig eth6 192.168.0.2 netmask 255.255.255.0
R2:~#ifconfig eth7 192.168.1.1 netmask 255.255.255.0
R2:~#ifconfig eth8 192.168.101.254 netmask 255.255.255.0
R3:~#ifconfig eth6 192.168.2.1 netmask 255.255.255.0
R3:~#ifconfig eth7 192.168.1.2 netmask 255.255.255.0
R3:~#ifconfig eth8 192.168.102.254 netmask 255.255.255.0
```

PC Routers不用設default-gateway。

檢查各PCs與PC Routers的網路介面設定

```
#ifconfig
```

方法 2：使用圖形化網路連線介面設定

i. 桌面右上角點選網路的圖像，選擇手動設定，開啟網路設定介面。

ii. 解除鎖定。

解鎖前

解鎖後

iii. 選擇介面並設定，記得改成固定IP地址。

iv. eth6 設定完成。

其它依此類推。

v. 全部介面設好後重新開機，以完成介面設定。

Part 2. 在PC Routers上安裝Quagga並把轉送功能開啟

此為在PC Routers上使用quagga軟體模擬Dynamic routing功能。

1. 在所有PC Routers安裝quagga。

```
R1:~#apt-get install quagga
```

其它PC Routers依此類推。

2. 從/usr/share/doc/quagga/examples/複製RIP和OSPF的設定檔範例到/etc/quagga，並改變其副檔名為.conf。

```
R1:~#cp /usr/share/doc/quagga/examples/ripd.conf.example /etc/quagga/ripd.conf
R1:~#cp /usr/share/doc/quagga/examples/ospfd.conf.example /etc/quagga/ospfd.conf
```

其它PC Routers依此類推。

3. 啟動所有PC Routers轉送功能。(0 為關閉、1 為開啟)

```
#cd /proc/sys/net/ipv4
#cat ip_forward
0
#echo 1 > ip_forward
#cat ip_forward
1
```

Part 3. 使用RIP routing

此為測試RIP routing Network的運作和學習路徑的時間反應。

1. 啟動每台PC Routers的RIP routing並觀看其RoutingTable

i 修改/etc/quagga/daemons.conf。(開啟想要的功能，yes開啟、no關閉)

R1:/etc/quagga#vi daemons.conf

```
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no
isisd=no
```

ii 修改/etc/quagga/zebra.conf。(telnet密碼為 1234，無enable密碼)

R1:/etc/quagga#vi zebra.conf

```
! Zebra configuration saved from vty
!   2008/11/26 16:50:51
!
hostname zebra
password 1234
!enable password 1234
!
interface eth6
 ipv6 nd suppress-ra

!
interface eth7
 ipv6 nd suppress-ra

!
interface eth8
 ipv6 nd suppress-ra

!
interface lo
!
interface vty
 ipv6 nd suppress-ra
!
ip forwarding
!
!
line vty
!
```

iii 修改/etc/quagga/ripd.conf。(telnet密碼為 1234，無enable密碼)

R1:/etc/quagga#vi ripd.conf

```
router rip
 network 192.168.0.0/16
```

iv 重新啟動quagga，以執行修改過的設定。

R1:/etc/quagga#/etc/init.d/quagga restart

v 登入本機測試是否有真的啟動RIP。(port號：RIP為 2602)

R1:/etc/quagga#telnet localhost 2602

vi 可在登入本機後修改RIP相關資訊，再後下指令產生ripd.conf檔。(port號：RIP為 2602)

R1#write

vii 觀看各PC Routers的RoutingTable

R1:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.0.2     255.255.255.0   UG    2      0        0 eth7
192.168.102.0   192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

R2:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   192.168.0.1     255.255.255.0   UG    2      0        0 eth6
192.168.101.0   0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.102.0   192.168.1.2     255.255.255.0   UG    2      0        0 eth7
192.168.2.0     192.168.0.1     255.255.255.0   UG    2      0        0 eth6
192.168.1.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth6
```

R3:~#route -n

```
root@csie-desktop:/proc/sys/net/ipv4# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   192.168.2.2     255.255.255.0   UG    2      0        0 eth6
192.168.101.0   192.168.1.1     255.255.255.0   UG    2      0        0 eth7
192.168.102.0   0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.1.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
192.168.0.0     192.168.2.2     255.255.255.0   UG    2      0        0 eth6
```

結果：RIP routing確實有抓到各network。

2. 當R1 和R2 間的連線中斷後多久時間能學到新的路徑(ping from PC1 to PC2)

i 路徑變化

中斷前：PC1 -> R1 -> R2 -> PC2

PC1:~#tracepath 192.168.101.1

```
root@csie-desktop:~# tracepath 192.168.101.1
 1:  csie-desktop.local (192.168.100.1)                    0.088ms pmtu 1500
 1:  csie-desktop-3.local (192.168.100.254)                0.160ms
 1:  csie-desktop-3.local (192.168.100.254)                0.126ms
 2:  192.168.0.2 (192.168.0.2)                             0.360ms
 3:  192.168.101.1 (192.168.101.1)                         1.226ms reached
     Resume: pmtu 1500 hops 3 back 62
```

R1:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.0.2     255.255.255.0   UG    2      0        0 eth7
192.168.102.0   192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

中斷後：PC1 -> R1 -> R3 -> R2 -> PC2

PC1:~#tracepath 192.168.101.1

```
root@csie-desktop:~# tracepath 192.168.101.1
 1:  csie-desktop.local (192.168.100.1)                    0.093ms pmtu 1500
 1:  csie-desktop-3.local (192.168.100.254)                0.130ms
 1:  csie-desktop-3.local (192.168.100.254)                0.116ms
 2:  192.168.2.1 (192.168.2.1)                             3.021ms
 3:  192.168.1.1 (192.168.1.1)                             3.448ms
 4:  192.168.101.1 (192.168.101.1)                         0.985ms reached
     Resume: pmtu 1500 hops 4 back 61
```

R1:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.2.1     255.255.255.0   UG    3      0        0 eth8
192.168.102.0   192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

ii RIP學習新路徑時間：

方法 1：計算ping的icmp sequence

PC1:~#ping 192.168.101.1

```
root@csie-desktop:~# ping 192.168.101.1
PING 192.168.101.1 (192.168.101.1) 56(84) bytes of data.
64 bytes from 192.168.101.1: icmp_seq=1 ttl=62 time=1.74 ms
64 bytes from 192.168.101.1: icmp_seq=2 ttl=62 time=0.228 ms
64 bytes from 192.168.101.1: icmp_seq=3 ttl=62 time=0.264 ms
64 bytes from 192.168.101.1: icmp_seq=4 ttl=62 time=0.227 ms
From 192.168.100.254 icmp_seq=10 Destination Host Unreachable
From 192.168.100.254 icmp_seq=11 Destination Host Unreachable
From 192.168.100.254 icmp_seq=187 Destination Net Unreachable
From 192.168.100.254 icmp_seq=188 Destination 61 time=6.70 ms
64 bytes from 192.168.101.1: icmp_seq=189 ttl=61 time=0.651 ms
64 bytes from 192.168.101.1: icmp_seq=190 ttl=61 time=0.532 ms
```

路徑變換時間=189 – 4 = 185 秒

方法 2：使用wireshark監聽R1 的eth7 和eth8

R1 的eth7

17	19.972366	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
18	19.972590	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
19	20.972392	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
20	343.946718	192.168.0.2	192.168.0.255	RIPv1	Response
21	344.039939	CompaqCo_4e:95:f8	Broadcast	ARP	Who has 192.168.0.2? Tell 192.168.0.1
22	344.040037	CompaqCo_4e:98:0d	CompaqCo_4e:95:f8	ARP	192.168.0.2 is at 00:02:a5:4e:98:0d

R1 的eth8

16	197.906977	192.168.2.2	192.168.2.255	RIPv1	Response
17	206.010990	192.168.2.2	192.168.2.255	RIPv1	Response
18	220.815920	192.168.2.1	192.168.2.255	RIPv1	Response
19	223.018930	CompaqCo_4e:95:f9	Broadcast	ARP	Who has 192.168.2.1? Tell 192.168.2.2
20	223.019145	CompaqCo_4e:98:7a	CompaqCo_4e:95:f9	ARP	192.168.2.1 is at 00:02:a5:4e:98:7a
21	223.019150	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
22	223.022389	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
23	224.016983	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
24	224.017564	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply

路徑變換時間=223 – 21 = 202 秒

結果：路徑學習都在 180 秒以後，因為RIP的route invalid time和holddown time都為 180 秒 (有誤差，wireshark測出的誤差較大)

3. 當R1 和R2 間的連線恢復後多久時間能回復到原先的路徑

觀看R1 的RoutingTable

```
PC1:~#route -n
```

恢復前：

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.2.1     255.255.255.0   UG    3      0        0 eth8
192.168.102.0   192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

恢復後：

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.0.2     255.255.255.0   UG    2      0        0 eth7
192.168.102.0   192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    2      0        0 eth8
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

恢復時間在 1 秒以內

結果：路徑恢復在 1 秒以內。

Part 4. 使用OSPF routing

此為測試OSPF routing Network的運作和學習路徑的時間反應。

1. 啟動每台PC Routers的OSPF routing並觀看其RoutingTable

   i 修改/etc/quagga/daemons.conf。(開啟想要的功能，yes開啟、no關閉)

   R1:/etc/quagga#vi daemons.conf

```
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no
isisd=no
```

   ii 修改/etc/quagga/zebra.conf。(telnet密碼為 1234，無enable密碼)

   R1:/etc/quagga#vi zebra.conf

```
! Zebra configuration saved from vty
!   2008/11/26 16:50:51
!
hostname zebra
password 1234
!enable password 1234
!
interface eth6
 ipv6 nd suppress-ra

!
interface eth7
 ipv6 nd suppress-ra

!
interface eth8
 ipv6 nd suppress-ra

!
interface lo
!
interface vty
 ipv6 nd suppress-ra
!
ip forwarding
!
!
line vty
!
```

   iii 修改/etc/quagga/ospfd.conf。(telnet密碼為 1234，無enable密碼)

   R1:/etc/quagga#vi ospfd.conf

```
router ospf
 network 192.168.0.0/16 area 0.0.0.0
```

   iv 重新啟動quagga，以執行修改過的設定。

   R1:/etc/quagga#/etc/init.d/quagga restart

   v 登入本機測試是否有真的啟動OSPF。(port號：OSPF為 2604)

   R1:/etc/quagga#telnet localhost 2604

   vi 可在登入本機後修改OSPF相關資訊，再後下指令產生ospfd.conf檔。(port號：OSPF為 2604)

   R1#write

vii 觀看各PC Routers的RoutingTable

R1:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.0.2     255.255.255.0   UG    20     0        0 eth7
192.168.102.0   192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.0.2     255.255.255.0   UG    20     0        0 eth7
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

R2:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   192.168.0.1     255.255.255.0   UG    20     0        0 eth6
192.168.101.0   0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.102.0   192.168.1.2     255.255.255.0   UG    20     0        0 eth7
192.168.2.0     192.168.0.1     255.255.255.0   UG    20     0        0 eth6
192.168.1.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth6
```

R3:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   192.168.2.2     255.255.255.0   UG    20     0        0 eth6
192.168.101.0   192.168.1.1     255.255.255.0   UG    20     0        0 eth7
192.168.102.0   0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.1.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
192.168.0.0     192.168.2.2     255.255.255.0   UG    20     0        0 eth6
```

結果：OSPF routing確實有抓到各network

2. 當R1 和R2 間的連線中斷後多久時間能學到新的路徑(ping from PC1 to PC2)

i 路徑變化

中斷前：PC1 -> R1 -> R2 -> PC2

PC1:~#tracepath 192.168.101.1

```
root@csie-desktop:~# tracepath 192.168.101.1
 1:  csie-desktop.local (192.168.100.1)                    0.088ms pmtu 1500
 1:  csie-desktop-3.local (192.168.100.254)                0.160ms
 1:  csie-desktop-3.local (192.168.100.254)                0.126ms
 2:  192.168.0.2 (192.168.0.2)                             0.360ms
 3:  192.168.101.1 (192.168.101.1)                         1.226ms reached
     Resume: pmtu 1500 hops 3 back 62
```

R1:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.0.2     255.255.255.0   UG    20     0        0 eth7
192.168.102.0   192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.0.2     255.255.255.0   UG    20     0        0 eth7
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

中斷後：PC1 -> R1 -> R3 -> R2 -> PC2

PC1:~#tracepath 192.168.101.1

```
root@csie-desktop:~# tracepath 192.168.101.1
 1:  csie-desktop.local (192.168.100.1)                    0.093ms pmtu 1500
 1:  csie-desktop-3.local (192.168.100.254)                0.130ms
 1:  csie-desktop-3.local (192.168.100.254)                0.116ms
 2:  192.168.2.1 (192.168.2.1)                             3.021ms
 3:  192.168.1.1 (192.168.1.1)                             3.448ms
 4:  192.168.101.1 (192.168.101.1)                         0.985ms reached
     Resume: pmtu 1500 hops 4 back 61
```

R1:~#route -n

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.2.1     255.255.255.0   UG    30     0        0 eth8
192.168.102.0   192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.0.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
```

ii OSPF學習新路徑時間：

方法 1：計算ping的icmp sequence

PC1:~#ping 192.168.101.1

```
root@csie-desktop:~# ping 192.168.101.1
PING 192.168.101.1 (192.168.101.1) 56(84) bytes of data.
64 bytes from 192.168.101.1: icmp_seq=1 ttl=62 time=2.00 ms
64 bytes from 192.168.101.1: icmp_seq=2 ttl=62 time=0.267 ms
64 bytes from 192.168.101.1: icmp_seq=3 ttl=62 time=0.320 ms
64 bytes from 192.168.101.1: icmp_seq=4 ttl=62 time=0.371 ms
64 bytes from 192.168.101.1: icmp_seq=5 ttl=62 time=0.326 ms
64 bytes from 192.168.101.1: icmp_seq=6 ttl=62 time=0.328 ms
From 192.168.100.254 icmp_seq=30 Destination Host Unreachable
From 192.168.100.254 icmp_seq=31 Destination Host Unreachable
From 192.168.100.254 icmp_seq=46 Destination Host Unreachable
From 192.168.100.254 icmp_seq=47 Destination Host Unreachable
64 bytes from 192.168.101.1: icmp_seq=48 ttl=61 time=0.543 ms
64 bytes from 192.168.101.1: icmp_seq=49 ttl=61 time=0.447 ms
```

路徑變換時間=48 – 6 = 42 秒

方法 2：使用wireshark監聽R2 的eth6 和eth7

R2 的eth6

40	139.145283	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
41	140.012642	192.168.0.1	224.0.0.5	OSPF	Hello Packet
42	140.038240	192.168.0.2	224.0.0.5	OSPF	Hello Packet
43	140.145077	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
44	140.145186	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
45	141.145042	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
46	141.145146	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
47	141.146188	CompaqCo_4e:98:0d	CompaqCo_4e:95:f8	ARP	Who has 192.168.0.1? Tell 192.168.0.2
48	141.146289	CompaqCo_4e:95:f8	CompaqCo_4e:98:0d	ARP	192.168.0.1 is at 00:02:a5:4e:95:f8

R2 的eth7

41	180.045196	192.168.1.1	224.0.0.5	OSPF	Hello Packet
42	181.689335	192.168.1.1	224.0.0.5	OSPF	LS Update
43	181.689347	192.168.1.1	224.0.0.5	OSPF	LS Update
44	181.713081	192.168.1.2	224.0.0.5	OSPF	LS Update
45	181.733196	192.168.1.1	224.0.0.5	OSPF	LS Acknowledge
46	182.578762	192.168.1.2	224.0.0.5	OSPF	LS Acknowledge
47	183.693236	192.168.1.1	224.0.0.5	OSPF	LS Update
48	183.698684	CompaqCo_4e:98:7b	Broadcast	ARP	Who has 192.168.1.1? Tell 192.168.1.2
49	183.698702	CompaqCo_4e:98:0c	CompaqCo_4e:98:7b	ARP	192.168.1.1 is at 00:02:a5:4e:98:0c
50	183.698782	192.168.1.2	192.168.1.1	OSPF	LS Acknowledge
51	184.829143	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
52	184.829292	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
53	185.828008	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request

路徑變換時間=184 – 141 = 43 秒

結果：路徑學習都在 40 秒以後，因為OSPF的dead time為 40 秒。

3. 當R1 和R2 間的連線恢復後多久時間能回復到原先的路徑

使用wireshark監聽R2 的eth6 和eth7

R2 的eth7

267	631.406272	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
268	632.409074	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
269	632.409184	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
270	633.408939	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
271	633.409009	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
272	634.410055	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request

R2 的eth6

53	640.102388	192.168.0.1	224.0.0.5	OSPF	Hello Packet
54	640.102437	192.168.0.1	192.168.0.2	OSPF	DB Descr.
55	640.102493	192.168.0.2	192.168.0.1	OSPF	DB Descr.
56	640.102637	192.168.0.1	192.168.0.2	OSPF	DB Descr.
57	640.102672	192.168.0.2	192.168.0.1	OSPF	DB Descr.
58	640.102738	192.168.0.1	192.168.0.2	OSPF	DB Descr.
59	640.102793	192.168.0.2	224.0.0.5	OSPF	LS Update
60	640.102800	192.168.0.2	224.0.0.5	OSPF	LS Update
61	640.567329	192.168.0.1	224.0.0.5	OSPF	LS Acknowledge
62	645.102192	CompaqCo_4e:98:0d	CompaqCo_4e:95:f8	ARP	Who has 192.168.0.1? Tell 192.168.0.2
63	645.102268	CompaqCo_4e:95:f8	CompaqCo_4e:98:0d	ARP	192.168.0.1 is at 00:02:a5:4e:95:f8
64	645.106061	192.168.0.1	224.0.0.5	OSPF	LS Update
65	645.254333	192.168.0.2	224.0.0.5	OSPF	LS Acknowledge
66	647.737112	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
67	647.737236	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
68	648.737078	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
69	648.737187	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply

路徑變換時間：647 – 633 = 14 秒

結果：路徑恢復在 10 秒以後，可能是因為hello time的原因。

4. 如何提升路徑學習的速度

- 減少hello time和dead time (在所有PC Routers修改/etc/quagga/ospfd.conf並重啟quagga)
  dead time一定要比hello time大，不然網路會不穩定

```
R1:/etc/quagga#vi ospfd.conf
R1:/etc/quagga#/etc/init.d/quagga restart
```

```
!
! Zebra configuration saved from vty
!   2008/12/11 20:41:22
!
hostname ospfd
password 1234
log stdout
!
!
!
interface eth6
 ip ospf hello-interval 1
 ip ospf dead-interval 4
!
interface eth7
 ip ospf hello-interval 1
 ip ospf dead-interval 4
!
interface eth8
 ip ospf hello-interval 1
 ip ospf dead-interval 4
!
interface lo
!
router ospf
 network 192.168.0.0/16 area 0.0.0.0
!
line vty
```

➢ 中斷R1 和R2 間的連線

測試方法 1(ping)

```
root@csie-desktop:~# ping 192.168.101.1
PING 192.168.101.1 (192.168.101.1) 56(84) bytes of data.
64 bytes from 192.168.101.1: icmp_seq=1 ttl=62 time=8.37 ms
64 bytes from 192.168.101.1: icmp_seq=2 ttl=62 time=0.296 ms
64 bytes from 192.168.101.1: icmp_seq=3 ttl=62 time=0.300 ms
64 bytes from 192.168.101.1: icmp_seq=4 ttl=62 time=0.253 ms
64 bytes from 192.168.101.1: icmp_seq=11 ttl=61 time=0.529 ms
64 bytes from 192.168.101.1: icmp_seq=12 ttl=61 time=0.481 ms
64 bytes from 192.168.101.1: icmp_seq=13 ttl=61 time=0.884 ms
```

路徑變換時間：11 – 4 = 7 秒

測試方法 2(wireshark)

R2 的eth6

743	1391.170975	192.168.0.1	224.0.0.5	OSPF	Hello Packet
744	1391.211204	192.168.0.2	224.0.0.5	OSPF	Hello Packet
745	1392.124122	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
746	1392.124191	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
747	1392.170892	192.168.0.1	224.0.0.5	OSPF	Hello Packet
748	1392.214201	192.168.0.2	224.0.0.5	OSPF	Hello Packet
749	1393.123040	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
750	1393.123111	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
751	1393.170859	192.168.0.1	224.0.0.5	OSPF	Hello Packet
752	1393.215204	192.168.0.2	224.0.0.5	OSPF	Hello Packet

R2 的eth7

717	1400.369196	192.168.1.1	224.0.0.5	OSPF	Hello Packet
718	1400.369364	192.168.1.2	224.0.0.5	OSPF	Hello Packet
719	1400.894211	192.168.1.1	224.0.0.5	OSPF	LS Update
720	1400.894458	192.168.1.2	224.0.0.5	OSPF	LS Update
721	1400.894563	192.168.1.1	192.168.1.2	OSPF	LS Acknowledge
722	1400.896053	CompaqCo_4e:98:7b	Broadcast	ARP	Who has 192.168.1.1? Tell 192.168.1.2
723	1400.896062	CompaqCo_4e:98:0c	CompaqCo_4e:98:7b	ARP	192.168.1.1 is at 00:02:a5:4e:98:0c
724	1400.896153	192.168.1.2	192.168.1.1	OSPF	LS Acknowledge
725	1401.369229	192.168.1.1	224.0.0.5	OSPF	Hello Packet
726	1401.369381	192.168.1.2	224.0.0.5	OSPF	Hello Packet
727	1401.796736	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
728	1401.796864	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
729	1402.371095	192.168.1.2	224.0.0.5	OSPF	Hello Packet
730	1402.371136	192.168.1.1	224.0.0.5	OSPF	Hello Packet

路徑變換時間：1401 – 1393 = 8 秒

結果：路徑學習在 4 秒後，因為dead time為 4 秒。

➢ 恢復R1 和R2 間的連線

測試方法(wireshark)

R2 的eth7

2029	1979.521298	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2030	1979.521352	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
2031	1979.554943	192.168.1.2	224.0.0.5	OSPF	Hello Packet
2032	1979.561195	192.168.1.1	224.0.0.5	OSPF	Hello Packet
2033	1980.521414	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2034	1980.521466	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
2035	1980.557954	192.168.1.2	224.0.0.5	OSPF	Hello Packet
2036	1980.565194	192.168.1.1	224.0.0.5	OSPF	Hello Packet
2037	1981.425638	192.168.1.2	224.0.0.5	OSPF	LS Update
2038	1981.425788	192.168.1.1	224.0.0.5	OSPF	LS Update
2039	1981.425799	192.168.1.1	224.0.0.5	OSPF	LS Update
2040	1981.521281	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2041	1981.521339	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
2042	1981.534908	192.168.1.2	224.0.0.5	OSPF	LS Acknowledge
2043	1981.561914	192.168.1.2	224.0.0.5	OSPF	Hello Packet
2044	1981.569192	192.168.1.1	224.0.0.5	OSPF	Hello Packet
2045	1982.421236	192.168.1.1	224.0.0.5	OSPF	LS Acknowledge

R2 的eth6

768	1979.750770	192.168.0.2	192.168.0.1	OSPF	LS Acknowledge
769	1980.098670	192.168.0.1	224.0.0.5	OSPF	LS Acknowledge
770	1980.751600	192.168.0.1	224.0.0.5	OSPF	Hello Packet
771	1980.751698	192.168.0.2	224.0.0.5	OSPF	Hello Packet
772	1981.755208	192.168.0.2	224.0.0.5	OSPF	Hello Packet
773	1981.755314	192.168.0.1	224.0.0.5	OSPF	Hello Packet
774	1982.758203	192.168.0.2	224.0.0.5	OSPF	Hello Packet
775	1982.758319	192.168.0.1	224.0.0.5	OSPF	Hello Packet
776	1983.758205	192.168.0.2	224.0.0.5	OSPF	Hello Packet
777	1983.758285	192.168.0.1	224.0.0.5	OSPF	Hello Packet
778	1984.746321	CompaqCo_4e:95:f8	CompaqCo_4e:98:0d	ARP	Who has 192.168.0.2? Tell 192.168.0.1
779	1984.746330	CompaqCo_4e:98:0d	CompaqCo_4e:95:f8	ARP	192.168.0.2 is at 00:02:a5:4e:98:0d
780	1984.750363	192.168.0.1	224.0.0.5	OSPF	LS Update
781	1984.755225	192.168.0.2	224.0.0.5	OSPF	LS Acknowledge
782	1984.758350	192.168.0.1	224.0.0.5	OSPF	Hello Packet
783	1984.758378	192.168.0.2	224.0.0.5	OSPF	Hello Packet
784	1985.758266	192.168.0.1	224.0.0.5	OSPF	Hello Packet
785	1985.759202	192.168.0.2	224.0.0.5	OSPF	Hello Packet
786	1986.762177	192.168.0.1	224.0.0.5	OSPF	Hello Packet
787	1986.762284	192.168.0.2	224.0.0.5	OSPF	Hello Packet
788	1987.762143	192.168.0.1	224.0.0.5	OSPF	Hello Packet
789	1987.767248	192.168.0.2	224.0.0.5	OSPF	Hello Packet
790	1987.845805	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
791	1987.845911	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
792	1988.766053	192.168.0.1	224.0.0.5	OSPF	Hello Packet
793	1988.771243	192.168.0.2	224.0.0.5	OSPF	Hello Packet
794	1988.845771	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
795	1988.845871	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply

路徑變換時間：1987 – 1980 = 8 秒

結果：路徑恢復在 4 秒後。

- 啟用link-detect (在所有PC Routers修改/etc/quagga/zebra.conf並重啟quagga)
  啟動網路卡介面偵測

```
R1:/etc/quagga#vi zebra.conf
R1:/etc/quagga#/etc/init.d/quagga restart
```

```
! Zebra configuration saved from vty
!   2008/11/26 16:50:51
!
hostname zebra
password 1234
!enable password 1234
!
interface eth6
 ipv6 nd suppress-ra
 link-detect
!
interface eth7
 ipv6 nd suppress-ra
 link-detect
!
interface eth8
 ipv6 nd suppress-ra
 link-detect
!
interface lo
!
interface vty
 ipv6 nd suppress-ra
!
ip forwarding
!
!
line vty
!
```

➢ 中斷R1 和R2 間的連線

測試方法 1(ping)

```
root@csie-desktop:~# ping 192.168.101.1
PING 192.168.101.1 (192.168.101.1) 56(84) bytes of data.
64 bytes from 192.168.101.1: icmp_seq=1 ttl=62 time=6.73 ms
64 bytes from 192.168.101.1: icmp_seq=2 ttl=62 time=0.263 ms
64 bytes from 192.168.101.1: icmp_seq=3 ttl=62 time=0.266 ms
64 bytes from 192.168.101.1: icmp_seq=4 ttl=62 time=0.267 ms
64 bytes from 192.168.101.1: icmp_seq=5 ttl=62 time=0.322 ms
64 bytes from 192.168.101.1: icmp_seq=6 ttl=62 time=0.225 ms
64 bytes from 192.168.101.1: icmp_seq=8 ttl=61 time=3.47 ms
64 bytes from 192.168.101.1: icmp_seq=9 ttl=61 time=0.683 ms
64 bytes from 192.168.101.1: icmp_seq=10 ttl=61 time=0.585 ms
64 bytes from 192.168.101.1: icmp_seq=11 ttl=61 time=0.788 ms
```

路徑變換時間：8 – 6 = 2 秒

測試方法 2(wireshark)：eth6 時間比eth7 快 4 秒

R2 的eth6

2344	4025.545617	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2345	4025.545684	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
2346	4026.545533	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2347	4026.545604	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
2348	4026.550189	CompaqCo_4e:98:0d	CompaqCo_4e:95:f8	ARP	Who has 192.168.0.1? Tell 192.168.0.2
2349	4026.550272	CompaqCo_4e:95:f8	CompaqCo_4e:98:0d	ARP	192.168.0.1 is at 00:02:a5:4e:95:f8

R2 的eth7

3572	4028.932892	192.168.1.1	224.0.0.5	OSPF	LS Update
3573	4028.932903	192.168.1.1	224.0.0.5	OSPF	LS Update
3574	4029.413442	192.168.1.2	224.0.0.5	OSPF	LS Update
3575	4029.567491	192.168.1.2	224.0.0.5	OSPF	LS Acknowledge
3576	4030.223475	CompaqCo_4e:98:7b	Broadcast	ARP	Who has 192.168.1.1? Tell 192.168.1.2
3577	4030.223498	CompaqCo_4e:98:0c	CompaqCo_4e:98:7b	ARP	192.168.1.1 is at 00:02:a5:4e:98:0c
3578	4030.223569	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
3579	4030.223642	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply

路徑變換時間：4030 – 4 – 4026 = 0 秒

結果：ping有誤差，理想中為只要介面偵測到斷線就馬上學習。

➢ 恢復R1 和R2 間的連線

測試方法(wireshark)

R2 的eth7

3799	4703.960766	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
3800	4703.960887	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
3801	4704.960683	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
3802	4704.960803	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
3803	4705.733590	192.168.1.1	224.0.0.5	OSPF	LS Update
3804	4705.754433	192.168.1.2	224.0.0.5	OSPF	LS Update
3805	4705.960795	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
3806	4705.960917	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
3807	4706.090200	192.168.1.1	224.0.0.5	OSPF	LS Acknowledge
3808	4706.396184	192.168.1.2	224.0.0.5	OSPF	LS Acknowledge
3809	4706.960667	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request

R2 的eth6

2376	4749.063247	192.168.0.2	192.168.0.1	OSPF	DB Descr.
2377	4749.063436	192.168.0.1	192.168.0.2	OSPF	DB Descr.
2378	4749.063548	192.168.0.2	192.168.0.1	OSPF	DB Descr.
2379	4749.063634	192.168.0.1	192.168.0.2	OSPF	DB Descr.
2380	4749.063698	192.168.0.2	224.0.0.5	OSPF	LS Update
2381	4749.063705	192.168.0.2	224.0.0.5	OSPF	LS Update
2382	4749.077212	CompaqCo_4e:95:f8	CompaqCo_4e:98:0d	ARP	Who has 192.168.0.2? Tell 192.168.0.1
2383	4749.077217	CompaqCo_4e:98:0d	CompaqCo_4e:95:f8	ARP	192.168.0.2 is at 00:02:a5:4e:98:0d
2384	4749.098229	192.168.0.1	224.0.0.5	OSPF	LS Acknowledge
2385	4750.065148	192.168.0.1	224.0.0.5	OSPF	LS Update
2386	4750.074202	192.168.0.2	224.0.0.5	OSPF	LS Acknowledge
2387	4752.283307	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2388	4752.283388	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply
2389	4753.283244	192.168.100.1	192.168.101.1	ICMP	Echo (ping) request
2390	4753.283367	192.168.101.1	192.168.100.1	ICMP	Echo (ping) reply

路徑變換時間：4752 – (4703 – 4) = 53 秒

結果：有很大的誤差，理想中為馬上恢復。

- 利用Static routing in shorter mask (在R1 增加)

  修改R1 的eth7 和R2 的eth6 的IP。(不使用 192.168.0.0/24)

```
R1:~#ifconfig eth7 192.168.3.1 netmask 255.255.255.0
R2:~#ifconfig eth6 192.168.3.2 netmask 255.255.255.0
```

  修改所有PC Routers的routing network。

```
R1:/etc/quagga#vi ospfd.conf
router ospf
! network 192.168.0.0/16 area 0.0.0.0
 network 192.168.3.0/24 area 0
 network 192.168.1.0/24 area 0
 network 192.168.2.0/24 area 0
 network 192.168.100.0/24 area 0
 network 192.168.101.0/24 area 0
 network 192.168.102.0/24 area 0
```

  在R1 增加一條Static routing (192.168.0.0/16 往R3 送)

```
R1:/etc/quagga#route add –net 192.168.0.0 netmask 255.255.0.0 gw 192.168.2.1
R1:/etc/quagga#route -n
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.3.2     255.255.255.0   UG    20     0        0 eth7
192.168.102.0   192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.3.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.0.0     192.168.2.1     255.255.0.0     UG    0      0        0 eth8
```

➢ 中斷R1 和R2 間的連線

測試方法(ping)

```
root@csie-desktop:~# ping 192.168.101.1
PING 192.168.101.1 (192.168.101.1) 56(84) bytes of data.
64 bytes from 192.168.101.1: icmp_seq=1 ttl=62 time=5.30 ms
64 bytes from 192.168.101.1: icmp_seq=2 ttl=62 time=0.268 ms
64 bytes from 192.168.101.1: icmp_seq=3 ttl=62 time=0.268 ms
64 bytes from 192.168.101.1: icmp_seq=4 ttl=62 time=0.271 ms
64 bytes from 192.168.101.1: icmp_seq=5 ttl=62 time=0.326 ms
64 bytes from 192.168.101.1: icmp_seq=6 ttl=62 time=0.328 ms
64 bytes from 192.168.101.1: icmp_seq=48 ttl=61 time=0.851 ms
From 192.168.100.254 icmp_seq=45 Destination Host Unreachable
From 192.168.100.254 icmp_seq=46 Destination Host Unreachable
From 192.168.100.254 icmp_seq=47 Destination Host Unreachable
64 bytes from 192.168.101.1: icmp_seq=49 ttl=61 time=0.552 ms
64 bytes from 192.168.101.1: icmp_seq=50 ttl=61 time=0.707 ms
```

路徑變換時間：49 – 6 = 43 秒 (和正常的相同)

RoutingTable change

```
root@csie-desktop:/etc/quagga# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.100.0   0.0.0.0         255.255.255.0   U     0      0        0 eth6
192.168.101.0   192.168.2.1     255.255.255.0   UG    30     0        0 eth8
192.168.102.0   192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.3.0     0.0.0.0         255.255.255.0   U     0      0        0 eth7
192.168.2.0     0.0.0.0         255.255.255.0   U     0      0        0 eth8
192.168.1.0     192.168.2.1     255.255.255.0   UG    20     0        0 eth8
192.168.0.0     192.168.2.1     255.255.0.0     UG    0      0        0 eth8
```

結果：Static routing沒有作用。

七、問題與討論

- 結論：
  1. OSPF路徑學習速度快於RIP。
  2. RIP路徑恢復速度快於OSPF。
  3. 加快OSPF的路徑學習速度：
     - 縮短hello time和dead time，dead time一定要大於hello time，不然網路會不穩，只要封包不小心loss掉就容易造成誤判認為無效而被砍掉。
     - 啟用網路卡介面的link-detect，隨時偵測連線。

- 問題：(每次插與拔都間隔至少 5 分鐘)
  1. 為何RIP的恢復速度很快，是如何判斷的，跟link-detect相同嗎？
  2. 用wireshark各別監聽eth6 和eth7，開始同步啟動，一直放著給它跑，幾次實驗後 (網路線插拔幾次、quagga重啟幾次後)，兩個介面接收hello封包從原本的同步變成不同步，是什麼原因造成的？這樣會影響實驗的準確度嗎？
  3. OSPF的恢復是以什麼來做判斷？是hello後發現已連線恢復就馬上回復嗎？(實驗結果正常狀態為 14 秒約與hello time相同)
  4. 在修改hello time為 1 秒、dead time為 4 秒，恢復時間為 7 秒，與hello time相差很大，為何與問題 3 不合(在 1 秒多一點)？是誤差太大？
  5. 啟用link-detect時為何恢復時間太久(53 秒)？做過三次都是如此。
  6. 為何Static routing會無效？