

第二章

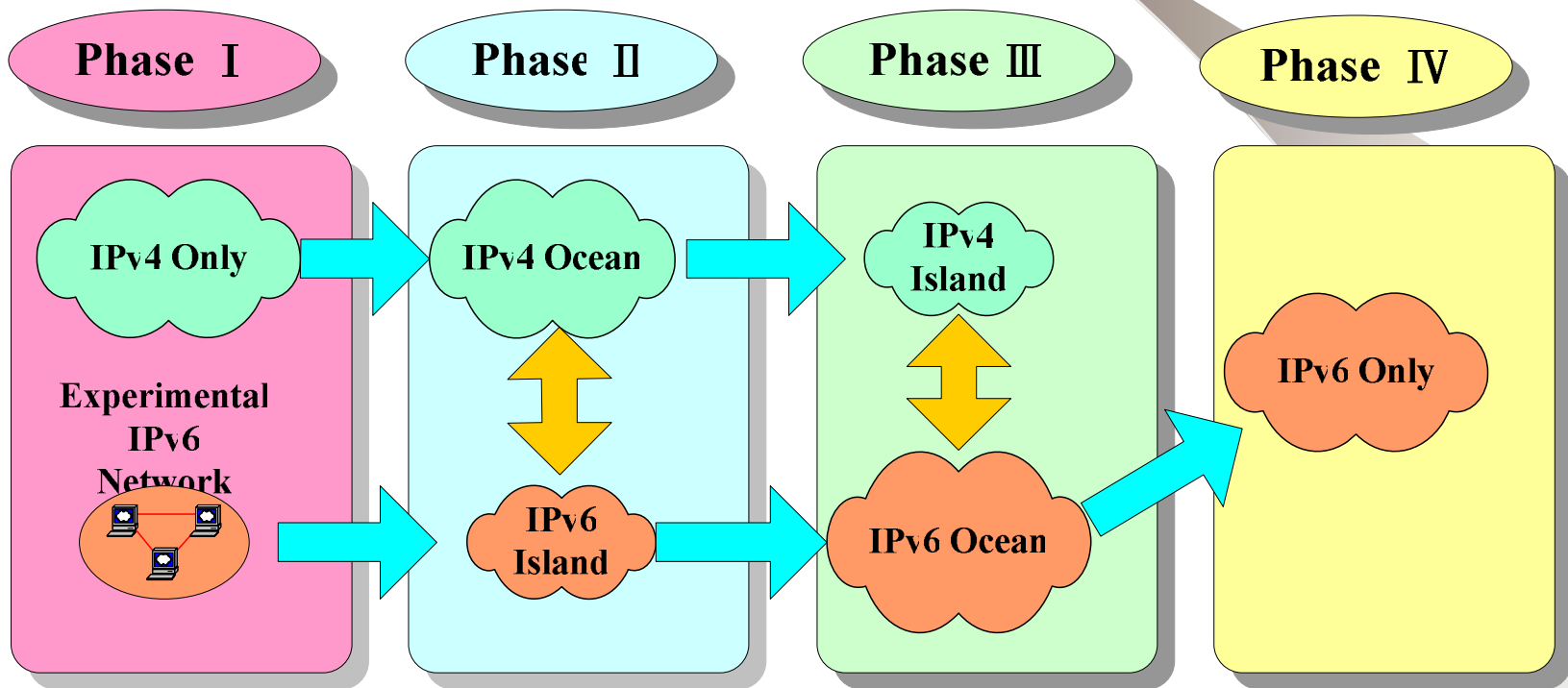
IPv6/IPv4轉換技術



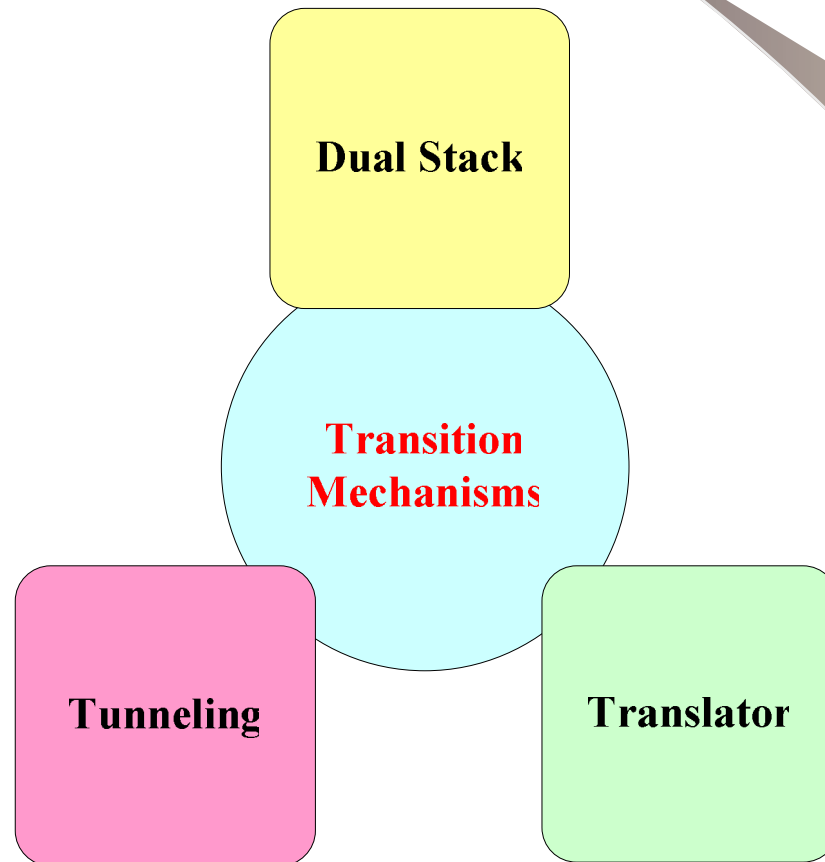
章節目錄

- 簡介
- IPv4/IPv6 雙重架構機制(Dual Stack)
- 通道機制(Tunnel)
- 位址協定轉換機制(Translator)
- 參考文獻

簡介



NGtrans 規劃之轉換機制



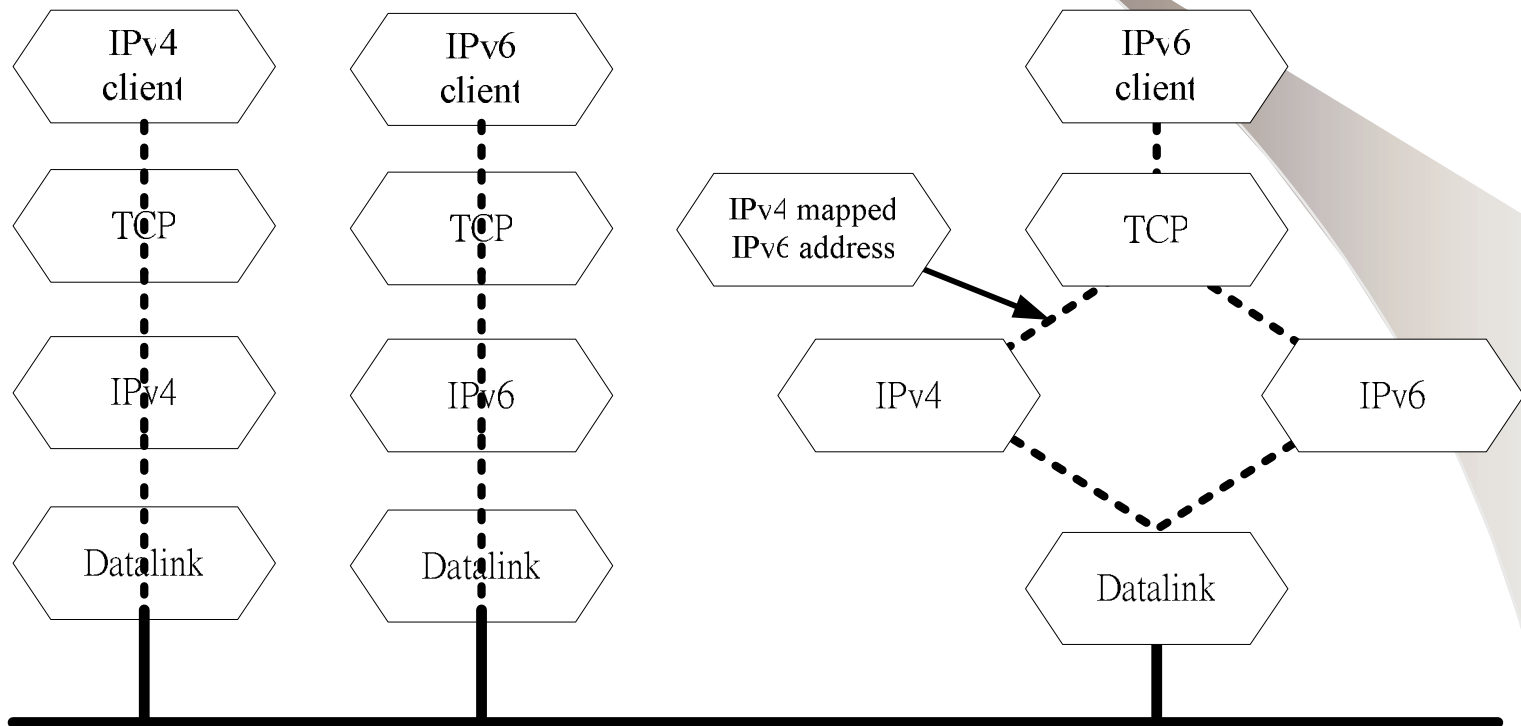
轉換機制比較

Name	Connectivity	Type	Location
Dual stack	4-to-4 over 4, 6-to-6 over 6	Dual stack	In single ES or ND
SIIT	6-to-4, 4-to-6	Translator	In single ES or ND
Bump-in-Stack (BIS)	4-to-6	Translator	In single ES
Bump-in-API (BIA)	4-to-6	Translator	In single ES
NAT-PT	6-to-4, 4-to-6	Translator	In single ND
MTP	4-to-6,4-to-6 (multicast)	Translator	In single ND
TRT	6-to-4	Translator	In single ND
SOCKS64	4-to-6, 4-to-6	Translator	Between ES and ND
6over4	6-to-6 over 4	Tunnel	Between ES and ND
ISATAP	6-to-6 over 4	Tunnel	Between ES and ND
DSTM	4-to-4 over 6	Tunnel	Between ES and ND
Configured IP-in-IP	6-to-6 over 4, 4-to-4 over 6	Tunnel	Between ES and ND, two NDs or two ESs
6to4	6-to-6 over 4	Tunnel	Between two NDs

IPv4/IPv6 雙重架構 機制 (Dual Stack)

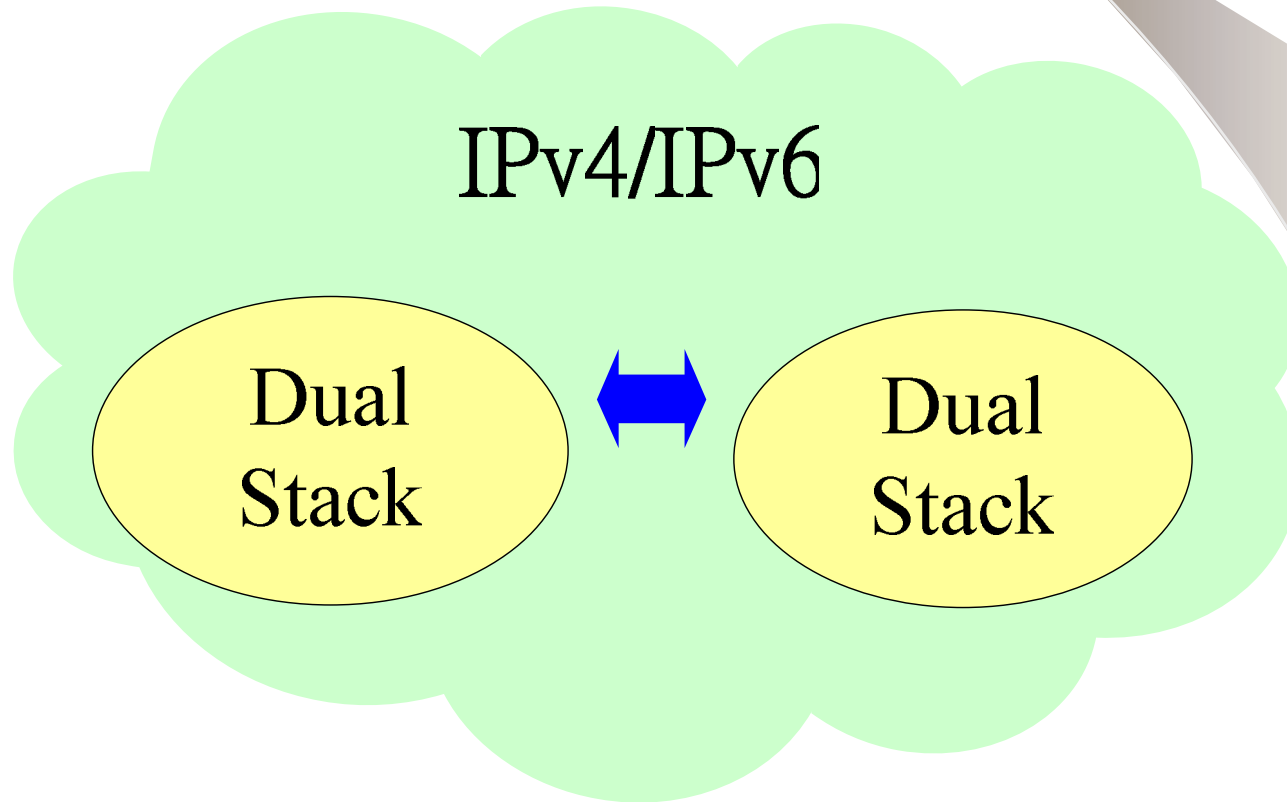


IPv4/IPv6 雙重架構機制



簡易雙重架構機制

- RFC1933->RFC2893(Standard)

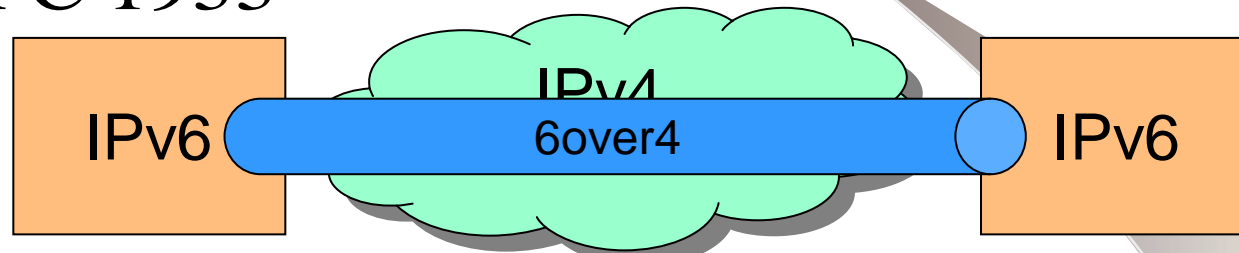


簡易雙重架構機制

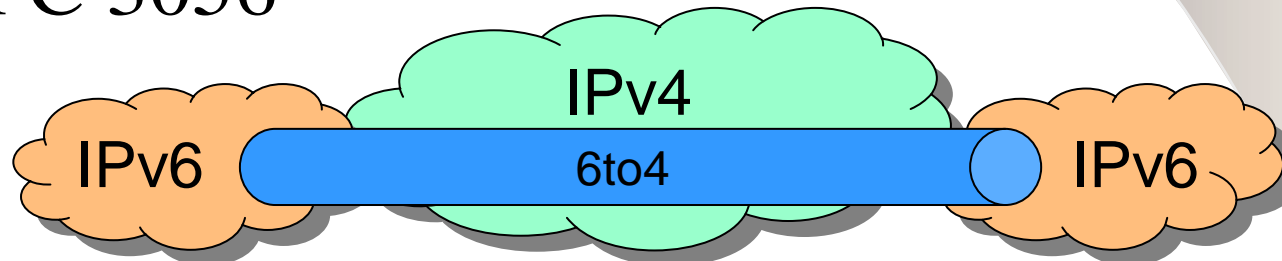
- IPv4 Stack功能啟動，而IPv6功能關閉
(即IPv4-only node)
- IPv6 Stack功能啟動，而IPv4功能關閉
(即IPv6-only node)
- IPv4 Stack及IPv6 Stack功能皆啟動
(node具組態切換功能)

簡易雙重架構機制+Tunneling

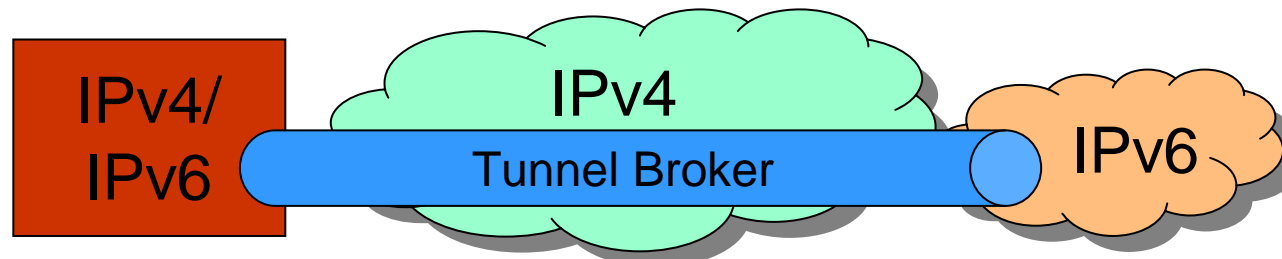
- RFC 1933



- RFC 3056



- RFC 3053



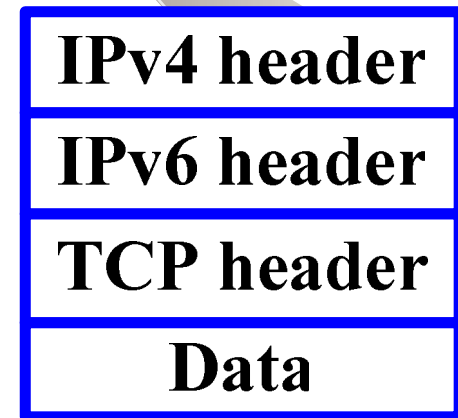
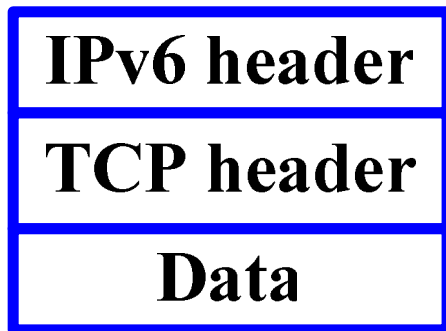
通道機制 (Tunnel)



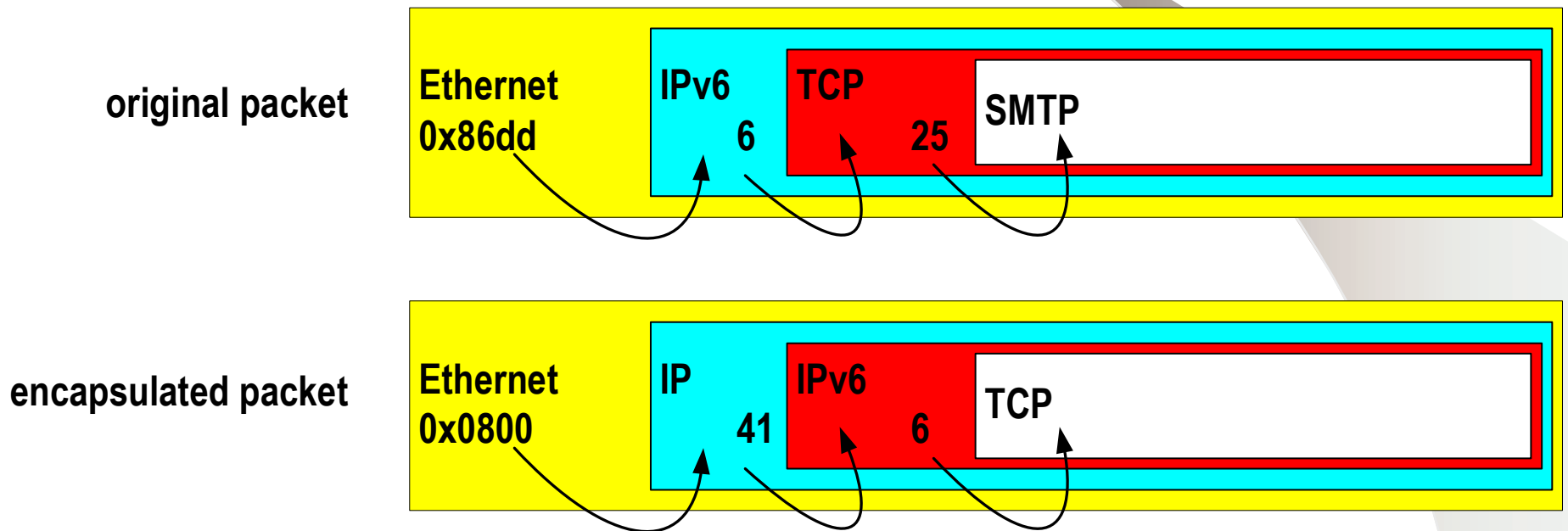
通道機制



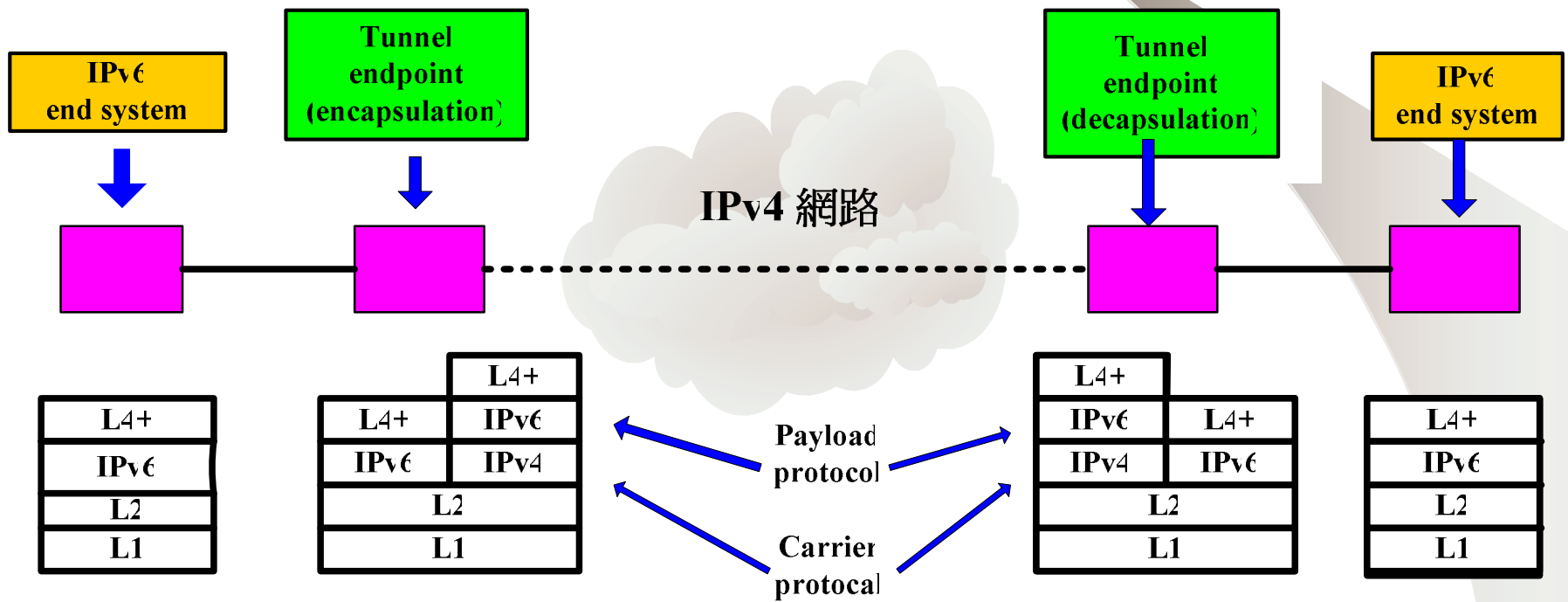
6over4通道機制封包格式



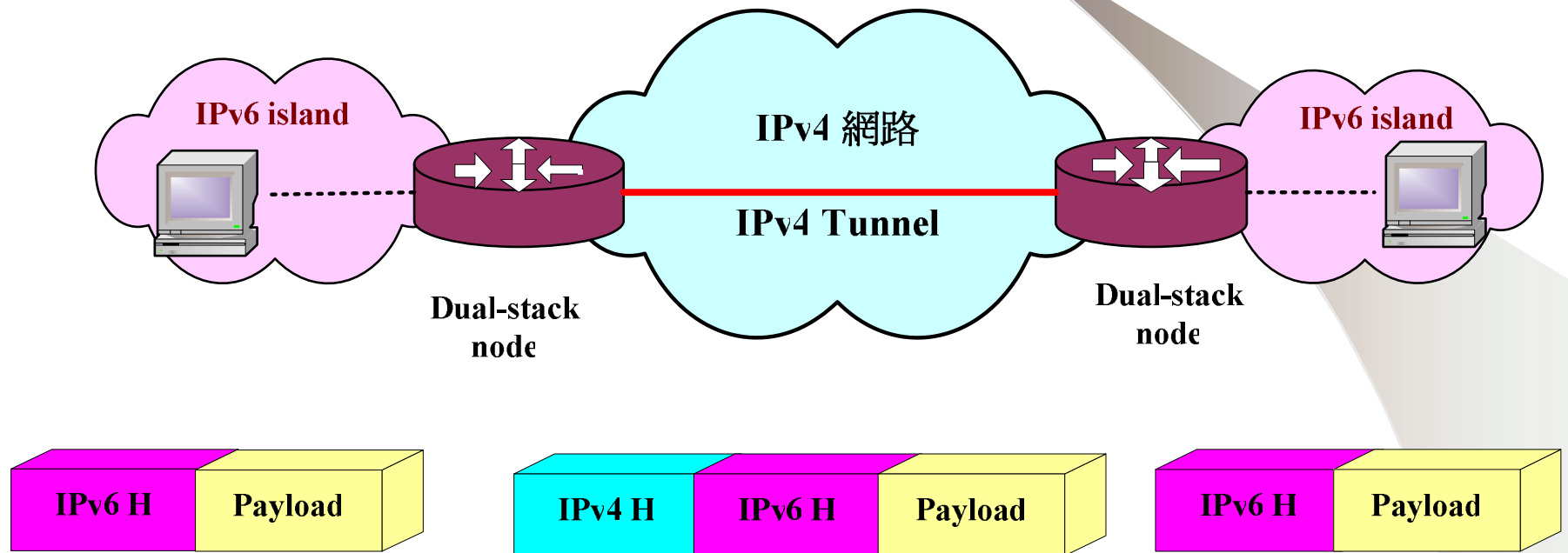
通道機制封包格式



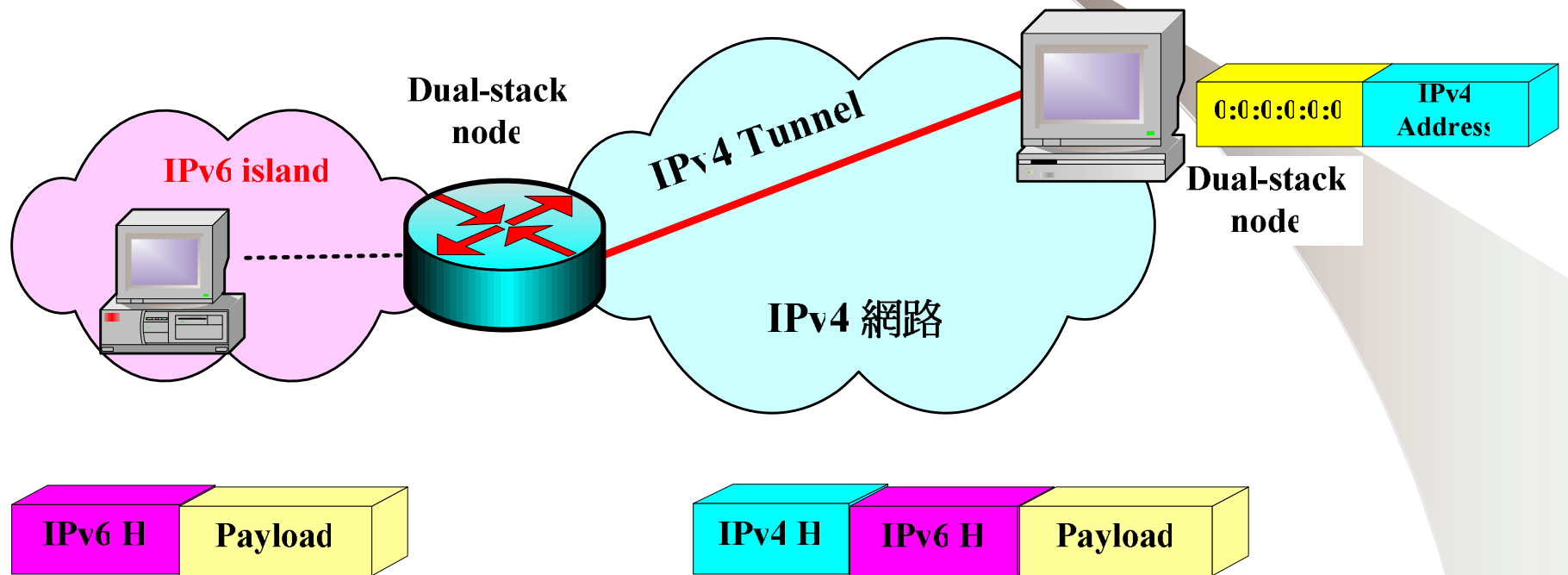
通道之協定運作



通道端點- Dual Stack Router



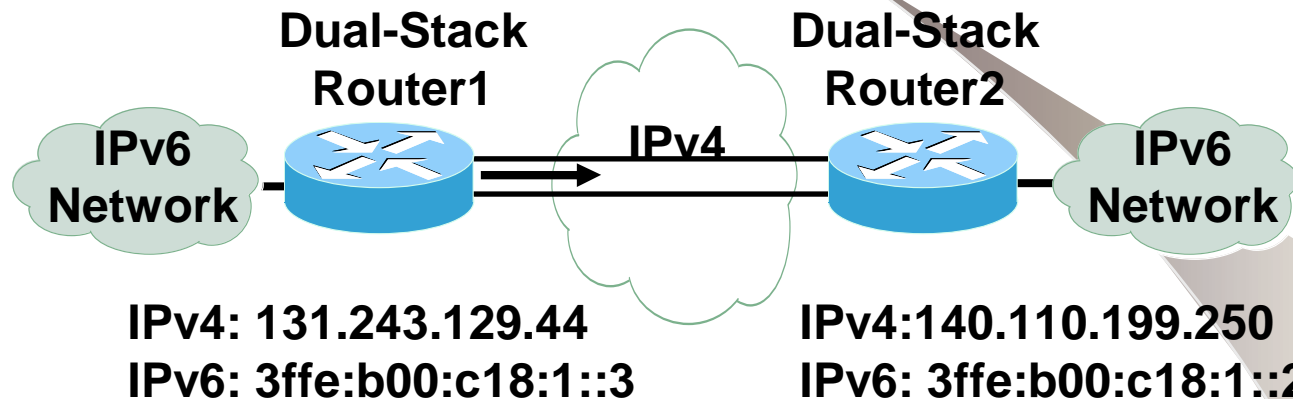
通道端點- Dual Stack Host



通道建立機制

- 手動建置(Manually Configured)
- 半自動建置(Semi-automated)
- 全自動建置(Automated)

Manually Configured Tunnel (RFC 2893)

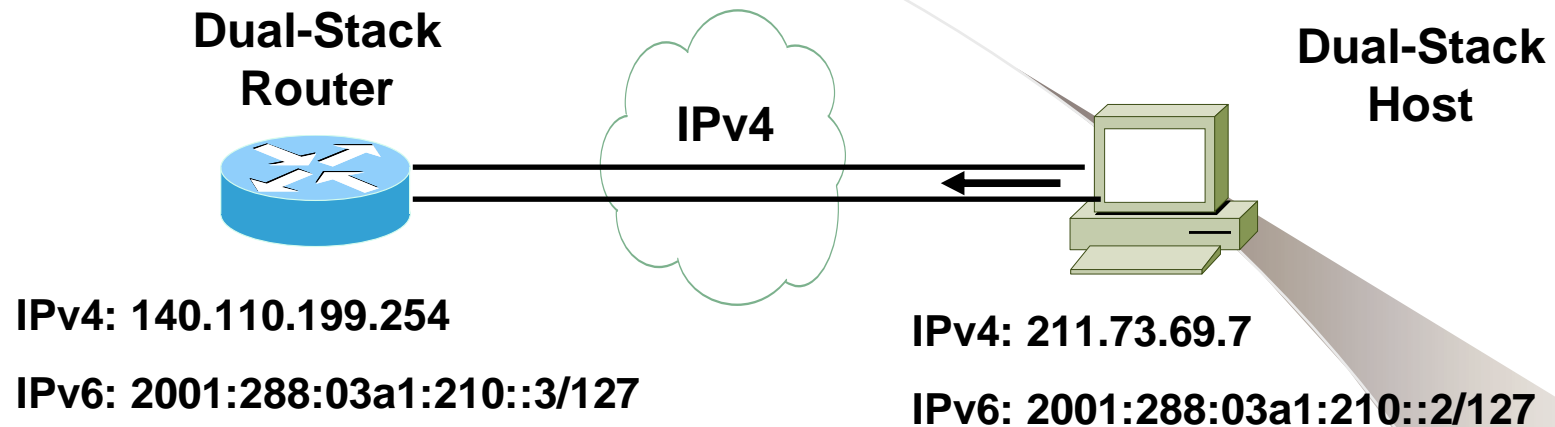


```
router1#  
  
interface Tunnel0  
  ipv6 address 3ffe:b00:c18:1::3/64  
  tunnel source 131.243.129.44  
  tunnel destination 140.110.199.250  
  tunnel mode ipv6ip
```

```
router2#  
  
interface Tunnel0  
  ipv6 address 3ffe:b00:c18:1::2/64  
  tunnel source 140.110.199.250  
  tunnel destination 131.243.129.44  
  tunnel mode ipv6ip
```

- **Manually Configured tunnels require:**
 - Dual stack end points**
 - Both IPv4 and IPv6 addresses configured at each end**

Manually Configured Tunnel



```
FreeBSD4.7#  
gifconfig gif0 211.73.69.7 140.110.199.254  
ifconfig gif0 inet6 2001:288:03a1:210::2 2001:288:3a1:210::3 prefixlen 128
```

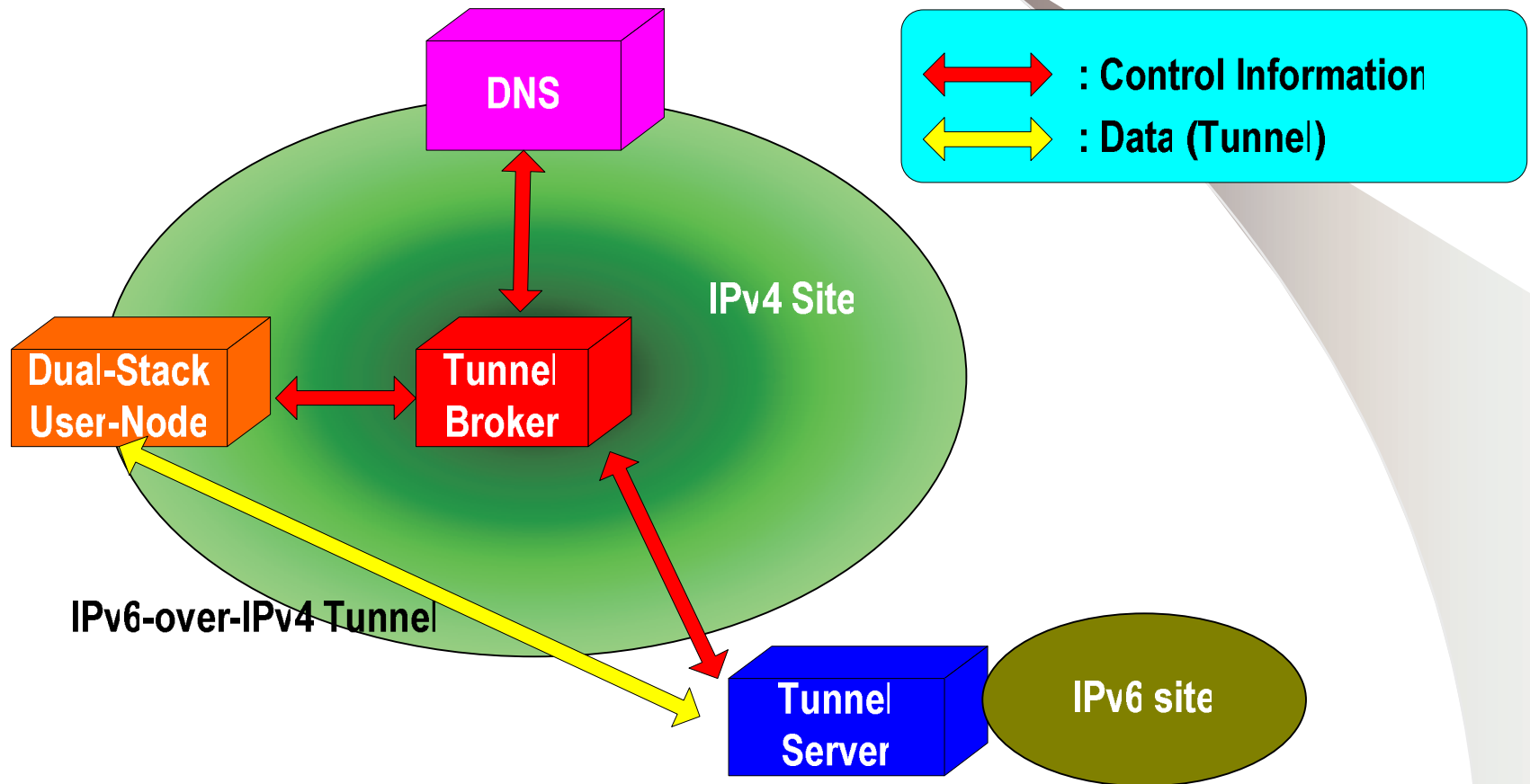
Linux Tunnel

```
/etc/sysconfig/network-scripts/ifcfg-sit1
```

```
DEVICE=sit1  
BOOTPROTO=none  
ONBOOT=yes  
IPV6INIT=yes  
#Remote end-ISP IPv4 addr  
IPV6TUNNELIPV4=140.110.199.250  
#Yourself IPv6 tunnel addr from ISP  
IPV6ADDR=2001:288:3A1:210::2/127
```

```
ifup sit1
```

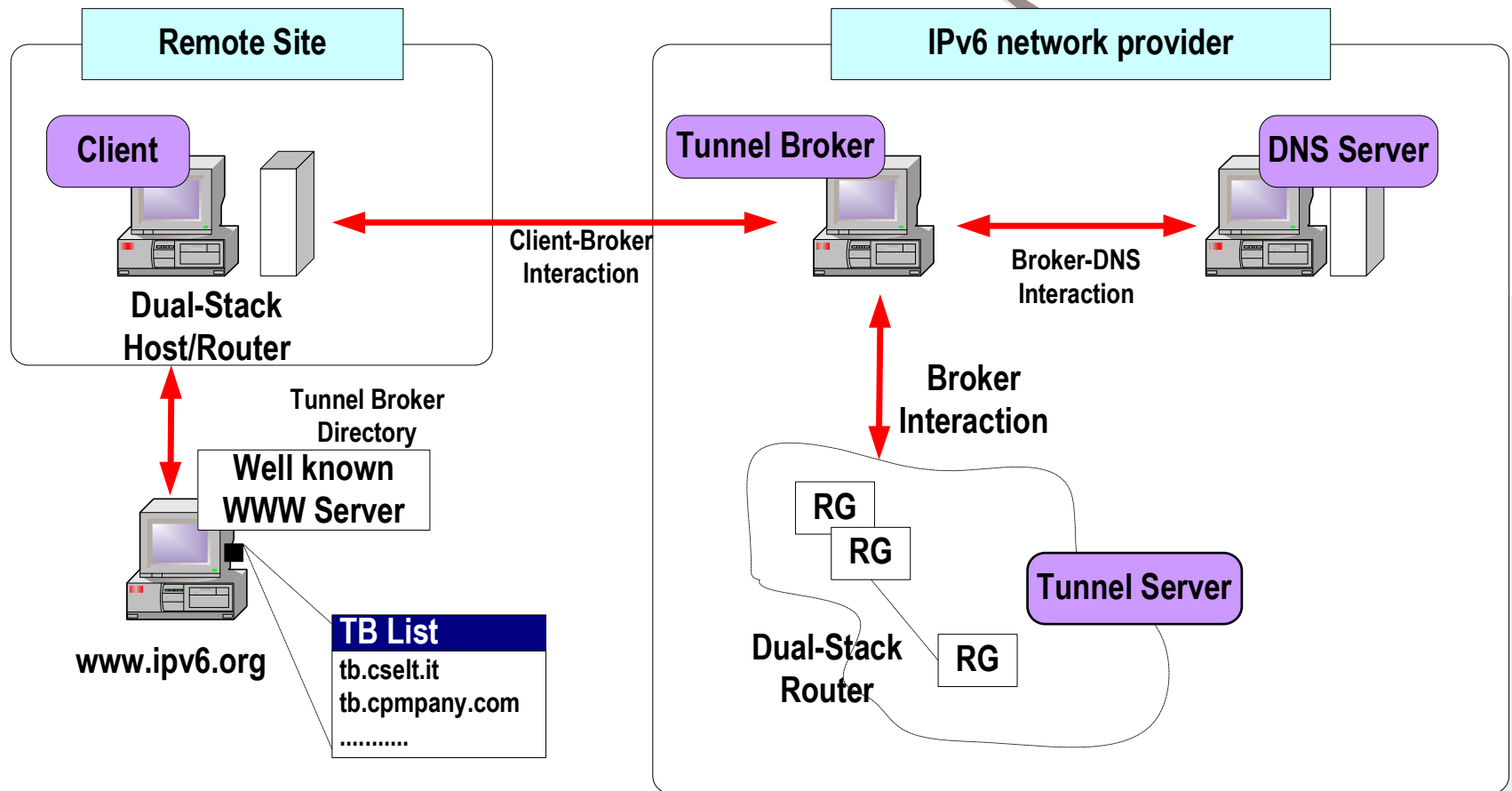
通道代理者(Tunnel Broker)機制



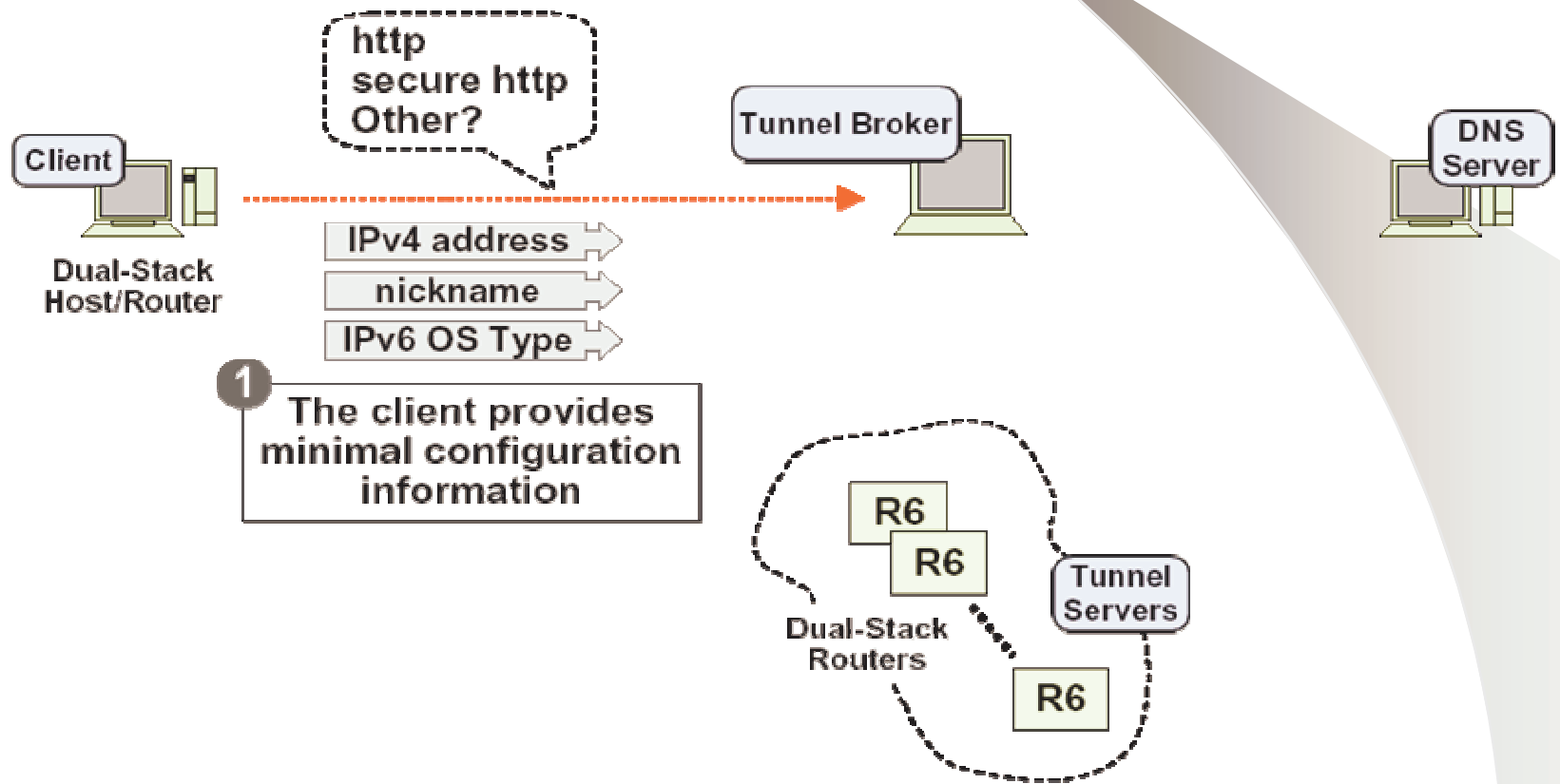
通道代理者機制運作

- 1) 使用者聯結 Tunnel Broker 進行註冊事宜 (registration procedure)
- 2) 使用者再次聯結 Tunnel Broker，提供使用者端點資訊(包括：IP位址、作業系統、IPv6支援軟體等)
- 3) Tunnel Broker建置網路端點、DNS伺服器及使用者端點組態
- 4) 通道建置完成，使用者可以直接連至IPv6網路

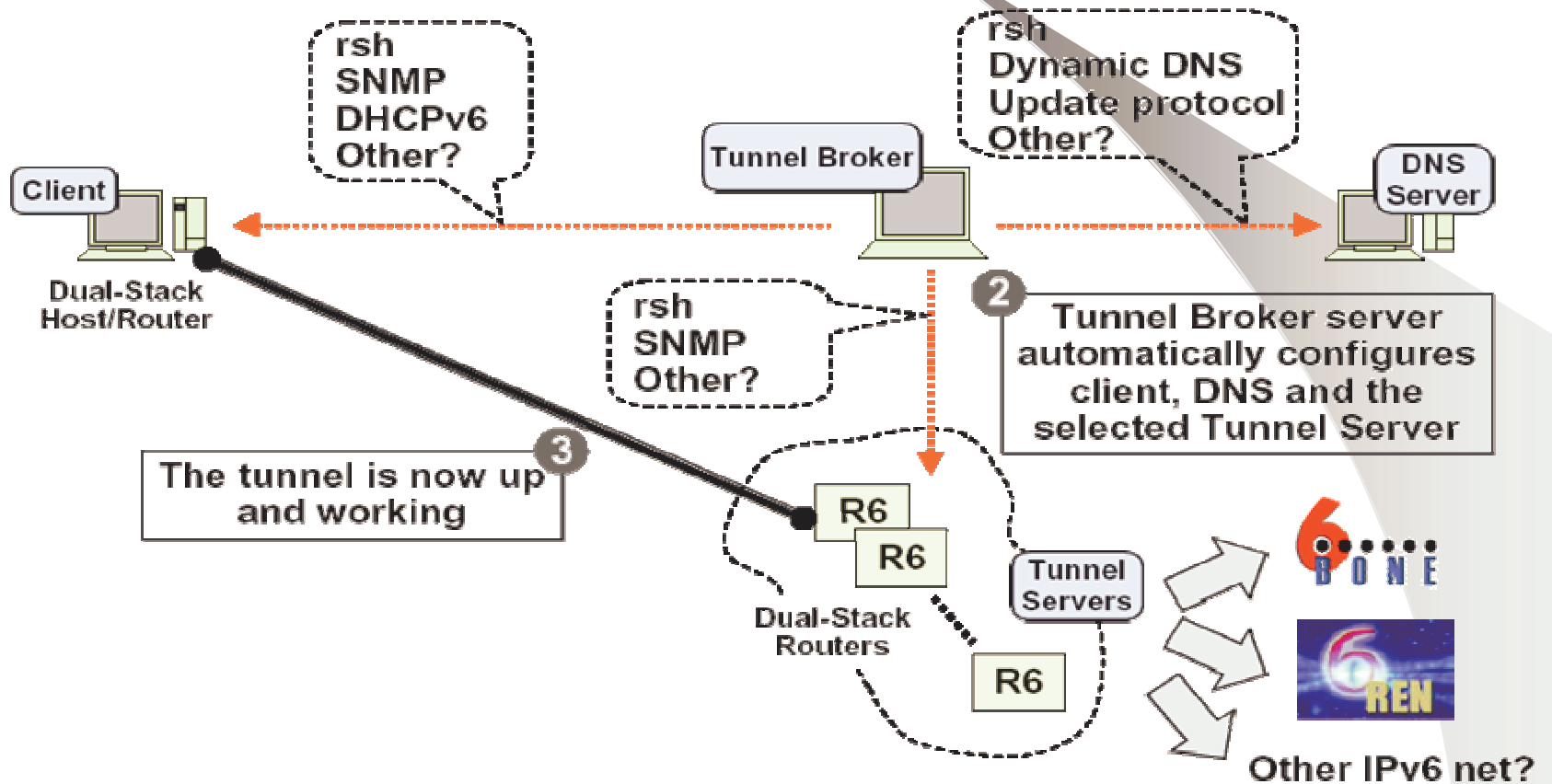
通道代理者機制運作



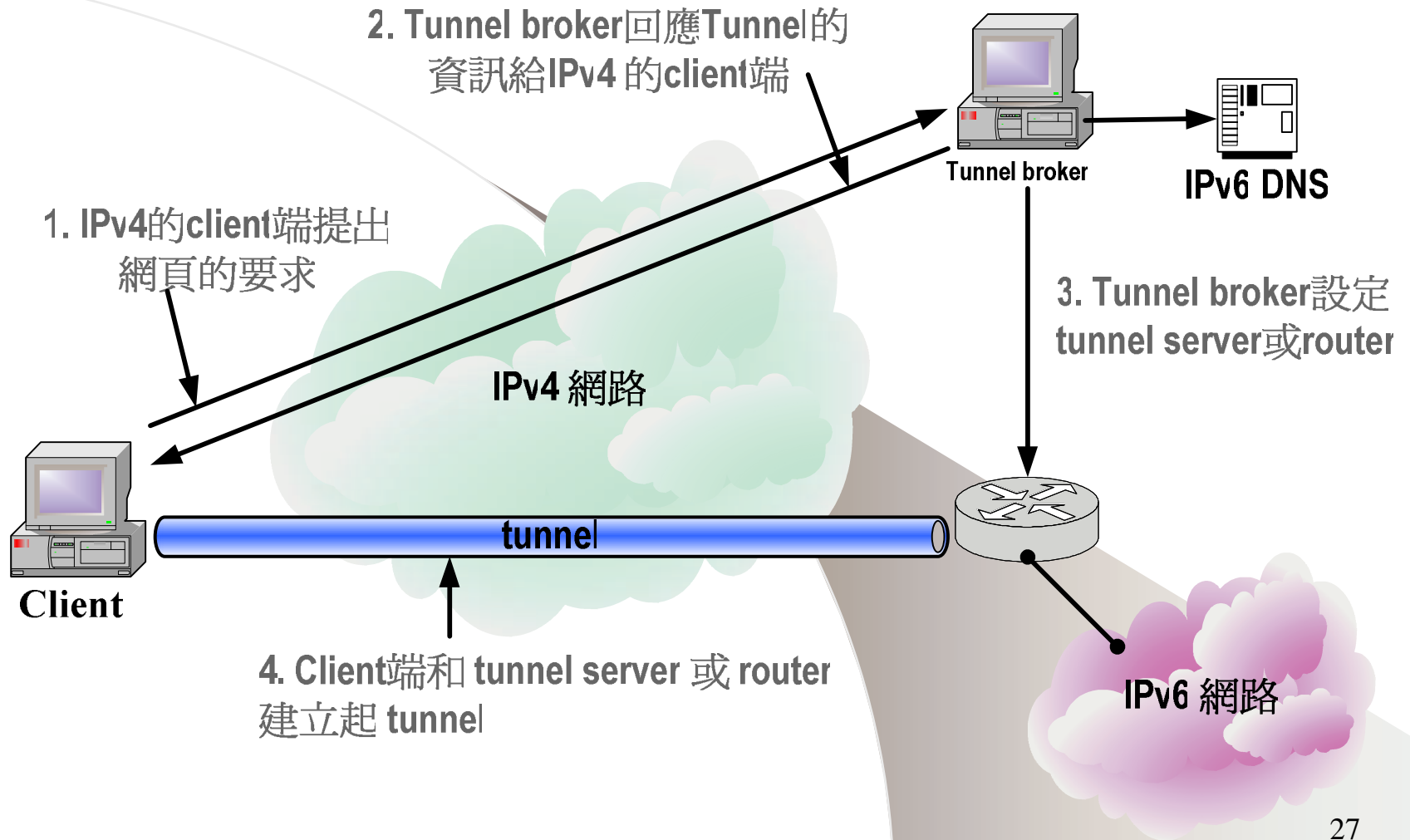
通道代理者機制運作 (1)



通道代理者機制運作(2)



通道代理者(Tunnel Broker)機制 Implementation



通道代理者機制服務

The screenshot shows a Microsoft Internet Explorer browser window displaying the BTexact IPv6 Tunnel Broker Service website. The browser's address bar shows the URL <http://tb.ipv6.btexact.com/>. The website features a purple header with the BTexact Technologies logo. The main heading is "Tunnel Broker Service". Below the heading, there is a welcome message and a login form. The login form has two input fields: "Login:" with the text "beng" and "Password:" with masked characters "*****". There are "Submit" and "Reset" buttons below the form. To the left of the main content, there is a "TB NEWS" section with a news item dated 2005/02. At the bottom of the page, there is a "NOTE" section. The browser's status bar at the bottom shows the page title "BTexact IPv6 Tunnel Broker" and the system tray area.

BTexact
TECHNOLOGIES

Tunnel Broker Service

Welcome to the BTexact IPv6 Tunnel Broker Service.

On this site you are able to setup and manage IPv6 tunnels through our network. If you are already registered, please start by logging in below, otherwise please [register](#) first.

Login:

Password:

NOTE: In order to successfully use the site, please have javascript and cookies enabled on your browser. Please also note that this website is still under development, so any [feedback and reports](#) on bugs or script type mistakes from you would be greatly appreciated.

TB NEWS

2005/02: The linking mechanism for migrating allocations from the old TB to the new one is no longer available. A new mechanism which allows static users to carry their address block allocations with them in case their IPv4 endpoint changes has replaced that function. [Feedback](#) is much appreciated as always.

[Cycle through news \(11 items\)](#)


BTexact IPv6 Tunnel Broker

通道代理者機制服務

BTexact IPv6 Tunnel Broker - Microsoft Internet Explorer

檔案(F) 編輯(E) 檢視(V) 我的最愛(A) 工具(T) 說明(H)

網址: https://bt.ipv6.btexact.com/



Tunnel Broker Service

Please provide the necessary information to setup the IPv6 tunnel. The IP address displayed is your current IPv4 address. If you want the tunnel to be terminated at an end-point with another IPv4 address (eg. a route) please specify it in the address field below. After the creation of the tunnel end-point on the network side, you will be emailed the script files, specific to your operating system, which will setup the tunnel end-point on your side. This will allow your machine to have a semi-permanent IPv6 address on the Internet.

NOTE: The tunnel creation process might take up to a minute (during peak hours), so please be patient after clicking on the create button...

Tunnel Type	<input checked="" type="radio"/> Host <input type="radio"/> Subnet <input type="radio"/> Network
Tunnel Name	BTexact
Your IPv4 address	61 216 95 55
Operating System	Windows NT/2000
Router	Artemis

NOTE: If you don't see the Create button above these lines, please enable javascript on your browser...

[BACK](#)

BTexact IPv6 Tunnel Broker

通道代理者(Tunnel Broker)機制

Scripts and Parameters

Your request for a tunnel has been accepted

To configure you machine 203.75.43.148, you will need to run the attached configuration script to start using your tunnel.

As with all scripts you should review its contents to make sure that it behaves as you expect. You should consult your vendor's documentation to determine how to make this configuration stable across a machine reboot

attached configuration

```
ipv6.exe rtu ::/0 2/::203.74.21.3
```

```
ipv6.exe adu 2/2001:238:888::1
```

通道代理者(Tunnel Broker)機制 Interface

```
C:\ Select Command Prompt
C:\Documents and Settings\Administrator>netsh interface ipv6 show address
Querying active state...

Interface 6: Teredo Tunneling Pseudo-Interface
-----
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Link       Preferred  infinite   infinite    fe80::1481:3e2b:6379:fd0

Interface 5: Local Area Connection 3
-----
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Link       Preferred  infinite   infinite    fe80::4645:53ff:fe54:7777

Interface 4: Local Area Connection 2
-----
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Link       Preferred  infinite   infinite    fe80::240:5ff:fea7:82b6

Interface 3: 6to4 Pseudo-Interface
-----
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Manual     Preferred  infinite   infinite    2002:cb4b:2b94::cb4b:2b94

Interface 2: Automatic Tunneling Pseudo-Interface
-----
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Manual     Preferred  infinite   infinite    2001:238:888::1

Interface 1: Loopback Pseudo-Interface
-----
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Loopback   Preferred  infinite   infinite    ::1
Link       Preferred  infinite   infinite    fe80::1
```

通道代理者(Tunnel Broker)機制

Routing Table

```
C:\Documents and Settings\Administrator>netsh interface ipv6 show routes
Querying active state...

Publish  Type      Met  Prefix                               Idx  Gateway/Interface Name
-----  -
yes      Manual  1002 2002::/16                             3    6to4 Pseudo-Interface
yes      Manual  1393 ::/0                                    3    2002:c058:6301::
yes      Manual  1222 ::/0                                    3    2002:836b:213c:1:e0:8f08:f020:8
yes      Manual   1    ::/0                                    2    ::203.74.21.3

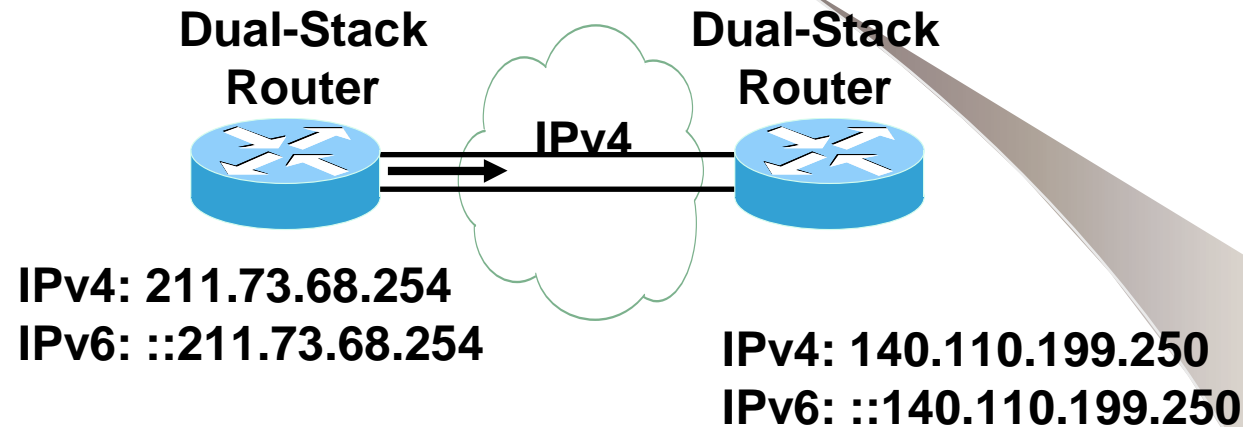
C:\Documents and Settings\Administrator>tracert www.6bone.net

Tracing route to 6bone.net [3ffe:b00:c18:1::10]
over a maximum of 30 hops:

 1  63 ms  *      62 ms  2001:238:888::2
 2  65 ms  *      63 ms  2001:238:800:0:260:70ff:fe0c:b040
 3  65 ms  *      64 ms  2001:238::250:73ff:fe10:d0d0
 4  70 ms  *      72 ms  2001:238:0:24::2
 5  302 ms *      114 ms 2001:238:e80::14
 6  335 ms 339 ms 440 ms rap.ipv6.viagenie.qc.ca [3ffe:b00:c18:1:290:27ff:fe17:fc0f]
 7  330 ms 325 ms 328 ms www.6bone.net [3ffe:b00:c18:1::10]

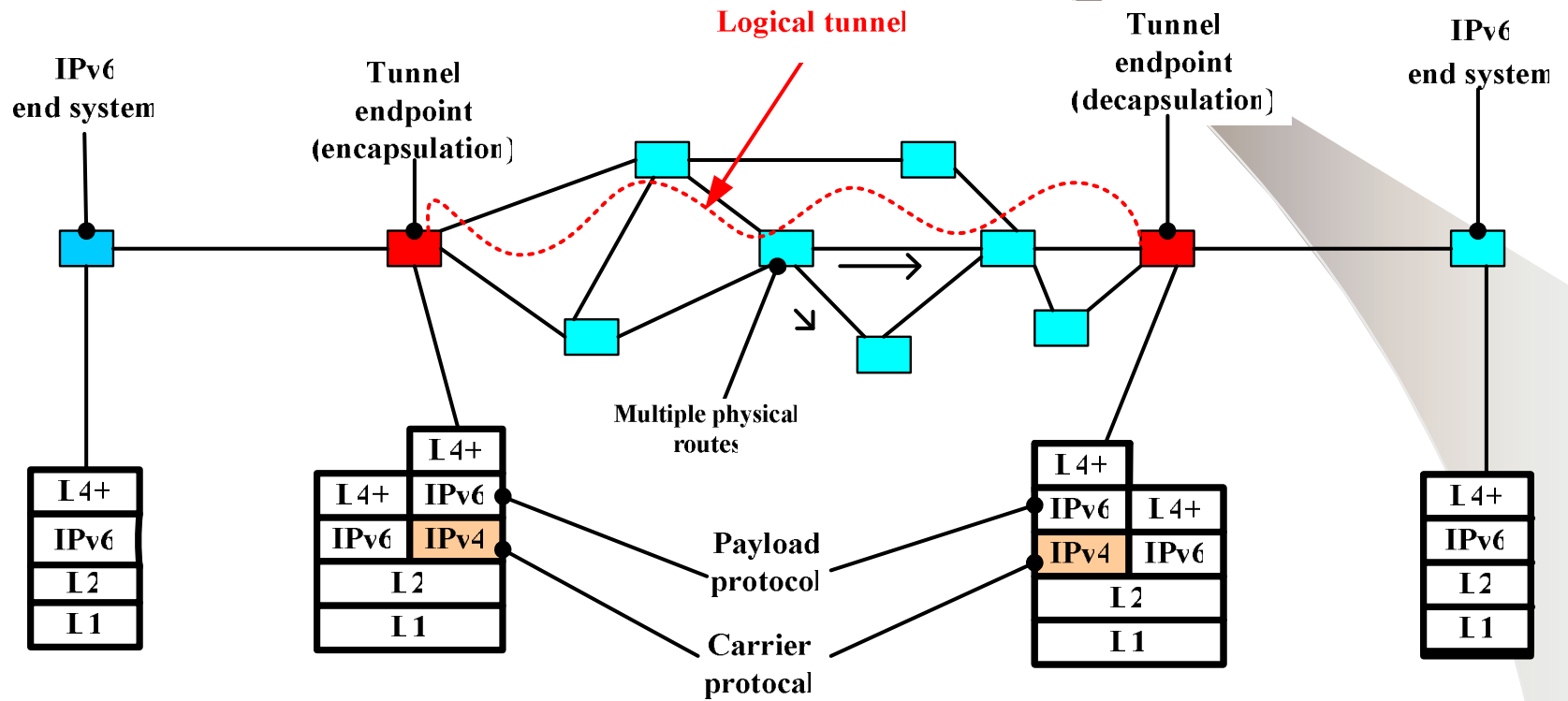
Trace complete.
```


IPv4 Compatible Tunnel (RFC 2893)



- IPv4-compatible addresses are easy way to autotunnel, but it:
 - May be deprecated soon

6over4通道機制



6over4通道機制

```
c:\>ip6 if
```

```
Interface 7 (site 1): 6-over-4 Virtual Interface
```

```
uses Neighbor Discovery
```

```
link-level address: 134.208.27.231
```

```
preferred address fe80::86d0:1be7, infinite/infinite
```

```
mcast address ff02::1, 1 refs, not reportable
```

```
mcast address ff02::1::ff00:1be7, 1 refs, last reporter
```

```
link MTU 1280 (true link MTU 65515)
```

```
current hop limit 128
```

```
reachable time 42000ms (base 30000ms)
```

```
retransmission interval 1000ms
```

```
DAD transmits 1
```

```
Interface 4 (site 1): 區域連線
```

```
uses Neighbor Discovery
```

```
link-level address: 00-02-44-0b-48-98
```

```
preferred address fe80::202:44ff:fe0b:4898, infinite/infinite
```

```
mcast address ff02::1, 1 refs, not reportable
```

```
mcast address ff02::1::ff0b:4898, 1 refs, last reporter
```

```
link MTU 1500 (true link MTU 1500)
```

```
current hop limit 128
```

```
reachable time 23000ms (base 30000ms)
```

```
retransmission interval 1000ms
```

```
DAD transmits 1
```

```
Interface 2 (site 0): Tunnel Pseudo-Interface
```

```
does not use Neighbor Discovery
```

```
link-level address: 0.0.0.0
```

```
preferred address ::134.208.27.231, infinite/infinite
```

```
link MTU 1280 (true link MTU 65515)
```

```
current hop limit 128
```

```
reachable time 0ms (base 0ms)
```

```
retransmission interval 0ms
```

```
DAD transmits 0
```

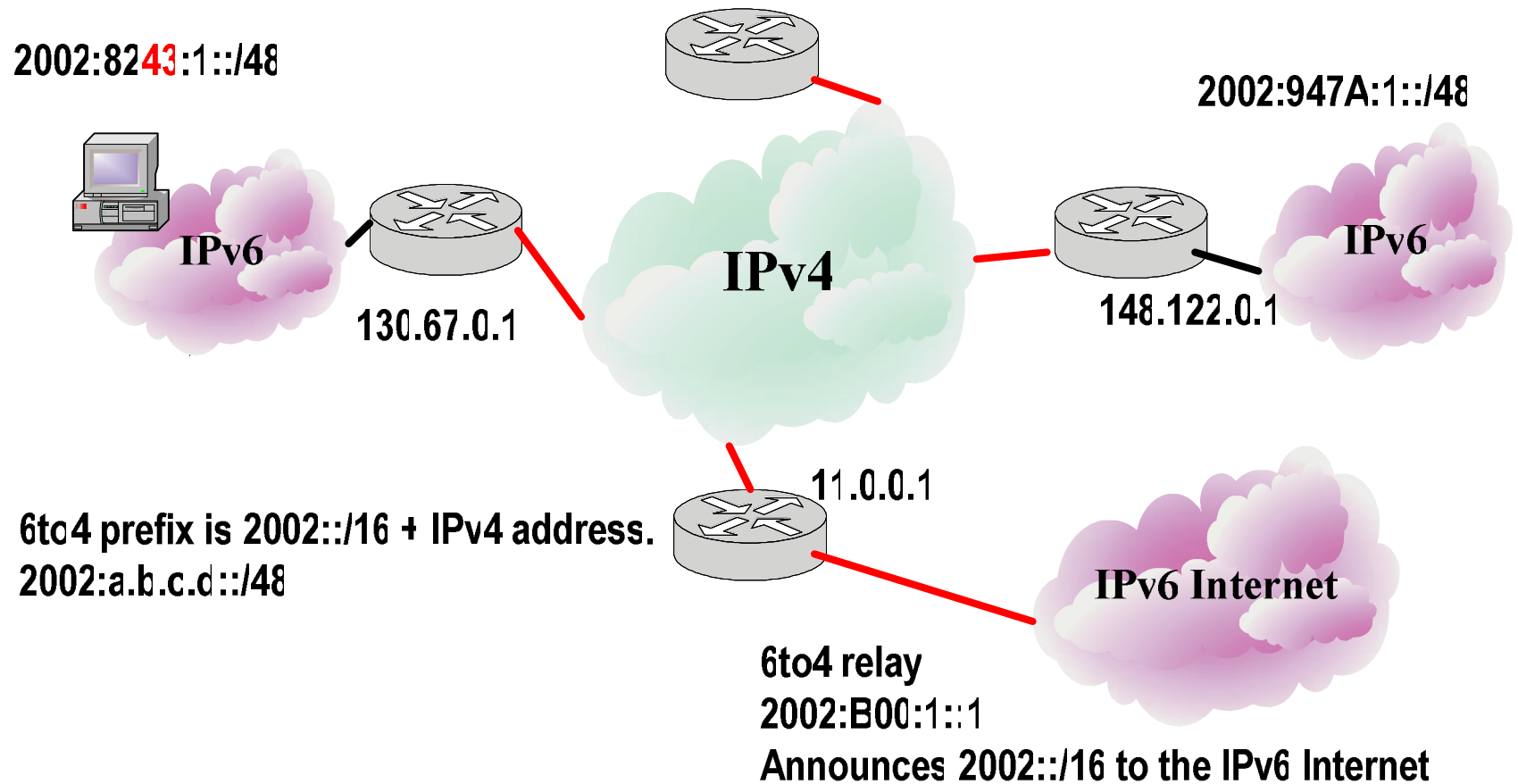
```
Interface 1 (site 0): Loopback Pseudo-Interface
```

```
does not use Neighbor Discovery
```

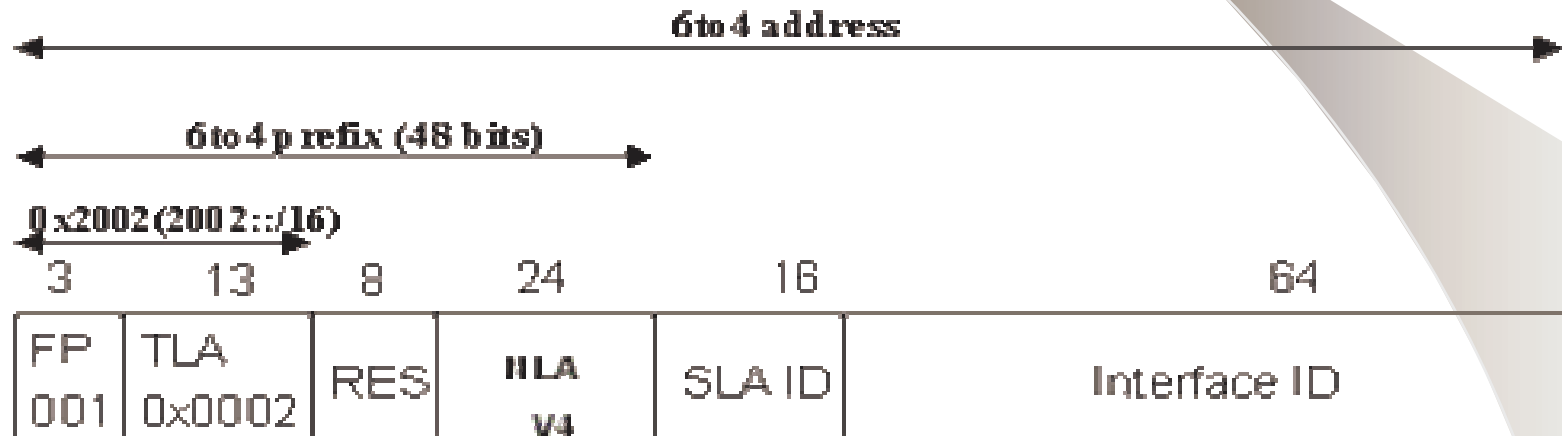
```
link-level address:
```

6to4自動通道機制

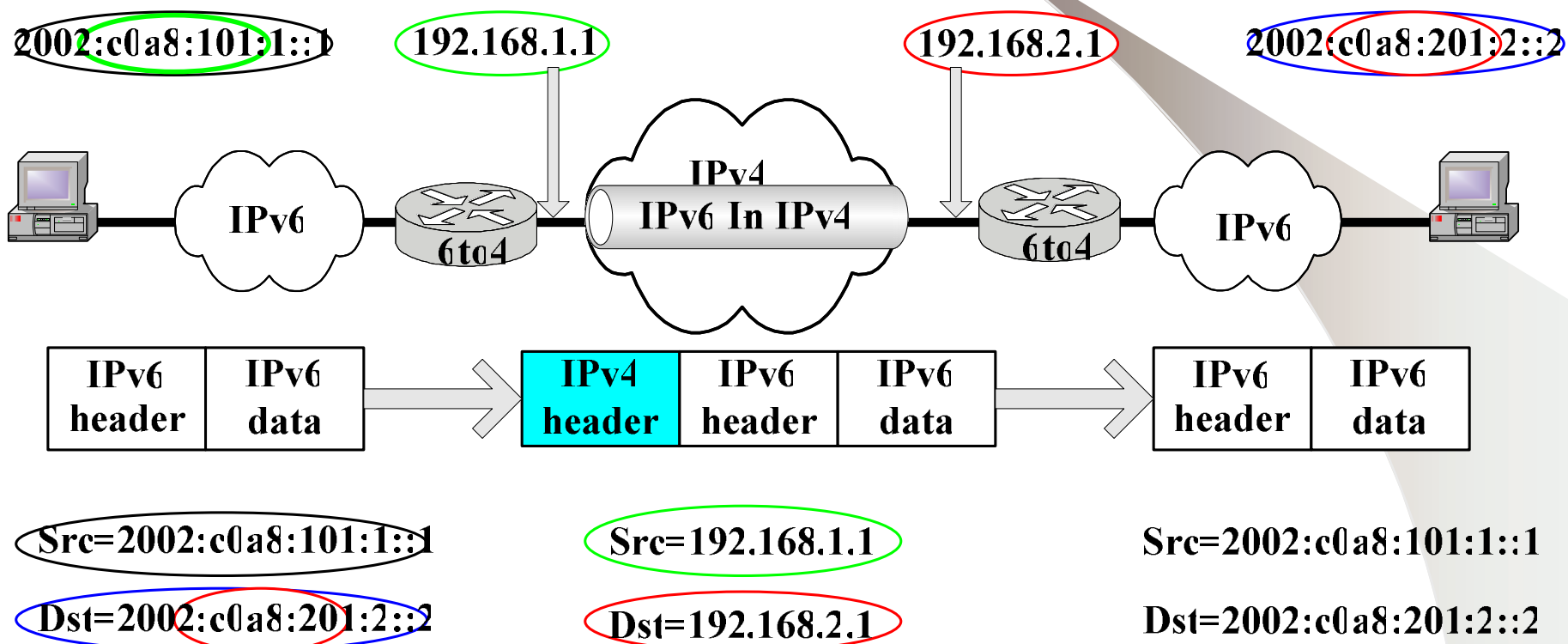
PP(3bits)	TLA(13bits)	IPv4 Address (32bits)	SLA ID (16bits)	Interface ID (64bits)
001	0x0002	ISP assigned	Local Administered	Auto configured



6to4封包格式



6to4自動通道機制



6to4自動通道機制-Interface

```

C:\Documents and Settings\Administrator.CHTD-IPU6>netsh inter ipv6 show address
Querying active state...

Interface 6: Local Area Connection
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Link       Preferred  infinite   infinite   fe80::207:e9ff:fe07:7364

Interface 4: Local Area Connection 2
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Link       Tentative  infinite   infinite   fe80::220:edff:fe4d:cb65

Interface 3: 6to4 Tunneling Pseudo-Interface
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Other      Preferred  infinite   infinite   2002:d247:cf1d::d247:cf1d

Interface 2: Automatic Tunneling Pseudo-Interface
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Link       Preferred  infinite   infinite   fe80::5efe:210.71.207.29

Interface 1: Loopback Pseudo-Interface
Addr Type  DAD State  Valid Life  Pref. Life  Address
-----
Loopback   Preferred  infinite   infinite   ::1
Link       Preferred  infinite   infinite   fe80::1

```

6to4自動通道機制

Routing Table

```
C:\Documents and Settings\Administrator.CHTD-IPU6>netsh inter ipv6 show routes
Querying active state...

Publish  Type      Met  Prefix                                Idx  Gateway/Interface Name
-----  -
yes      Manual  1329  ::/0                                  3    2002:c058:6301::
yes      Manual  1173  ::/0                                  3    2002:836b:213c:1:e0:8f08:f020:8
yes      Manual  1001  2002::/16                             3    6to4 Tunneling Pseudo-Interface

C:\Documents and Settings\Administrator.CHTD-IPU6>tracert www.6bone.net

Tracing route to 6bone.net [3ffe:b00:c18:1::10]
over a maximum of 30 hops:

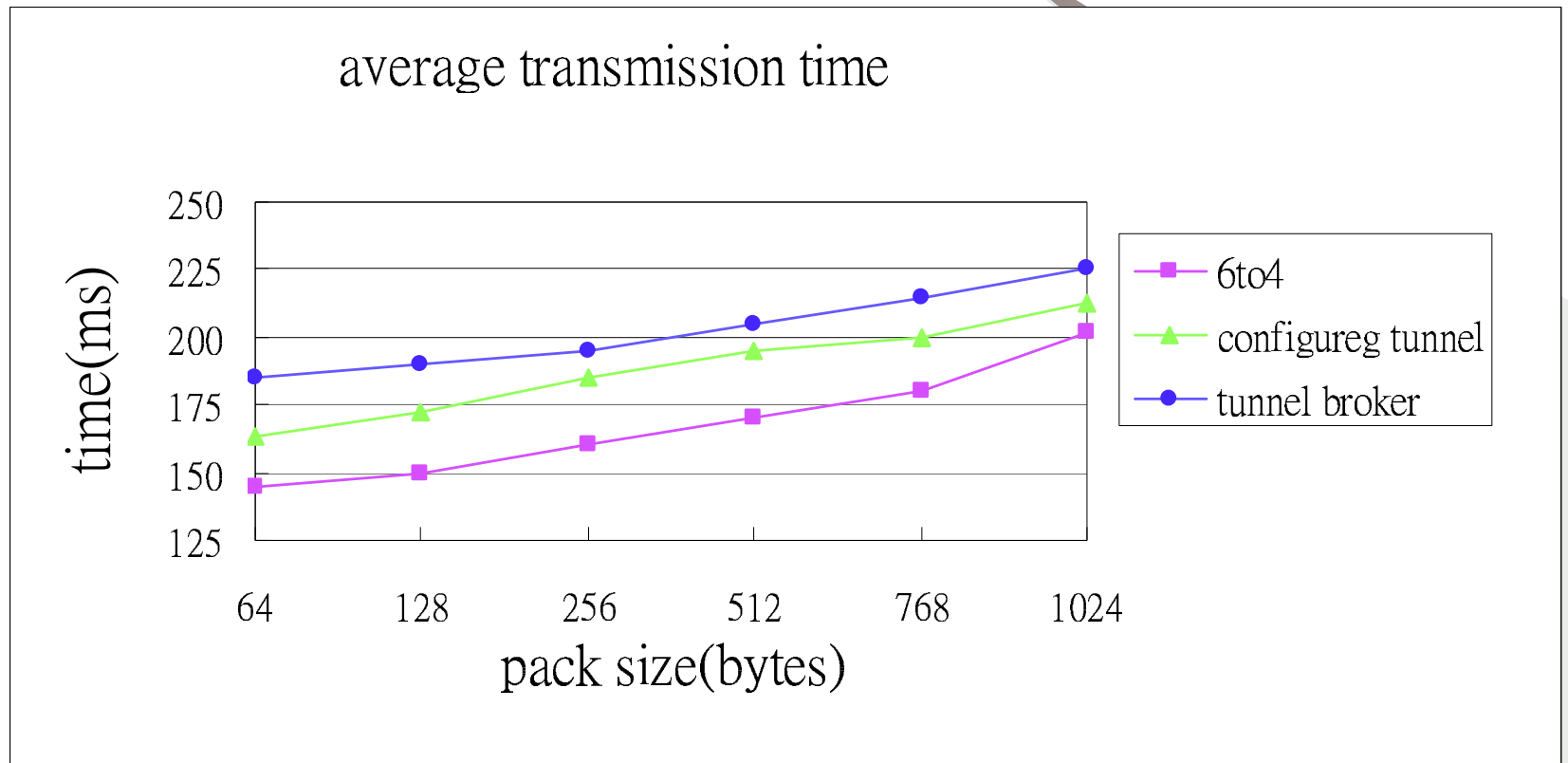
 1  176 ms  176 ms  175 ms  2002:836b:213c:1:e0:8f08:f020:8
 2  229 ms  228 ms  228 ms  3ffe:2900:1010:1::1
 3  228 ms  228 ms  228 ms  sl-bb1v6-rly-t-1004.sprintv6.net [2001:440:1239:1009::2]
 4  392 ms  547 ms  392 ms  3ffe:b00:c18:1:290:27ff:fe17:fc0f
 5  394 ms  393 ms  391 ms  3ffe:b00:c18:1::10

Trace complete.
```

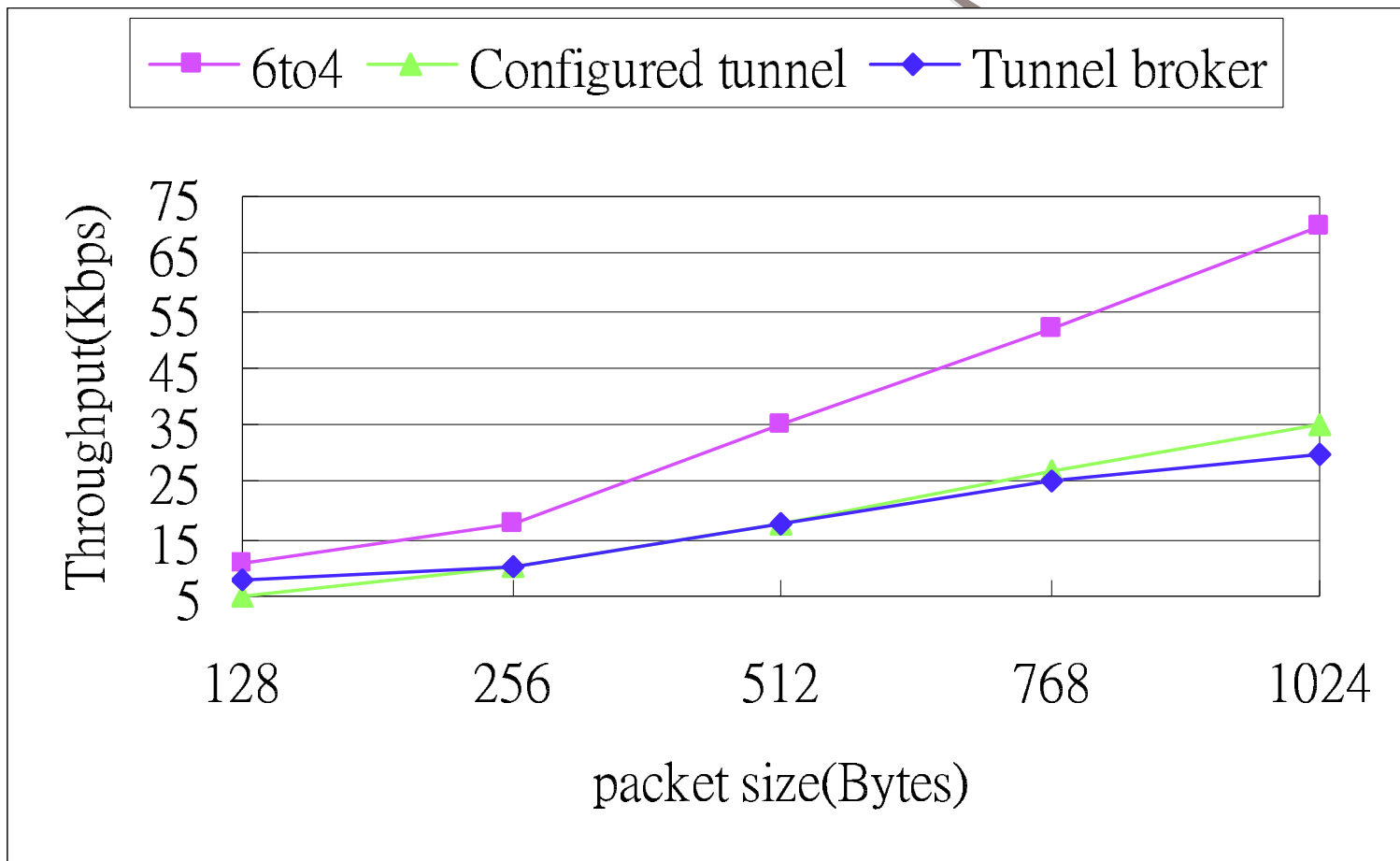

應用特性

Tunnel Mechanism	Primary Use	Limitation	Requirements
Configured Tunnel	Stable and secure links for regular communication	Tunnel between two points only Large management overhead No independently managed NAT	ISP-registered IPv6 address Dual-stack router
6to4 Tunnel	Connection of multiple remote IPv6 domains Frequent communication	Limitation of the number of tunnels supported by the 6to4 router	IPv6 prefix (2002::/16) Dual-stack router
Tunnel Broker	Standalone isolated IPv6 end systems	Potential security implication	Tunnel broker service must know how to create and set a script

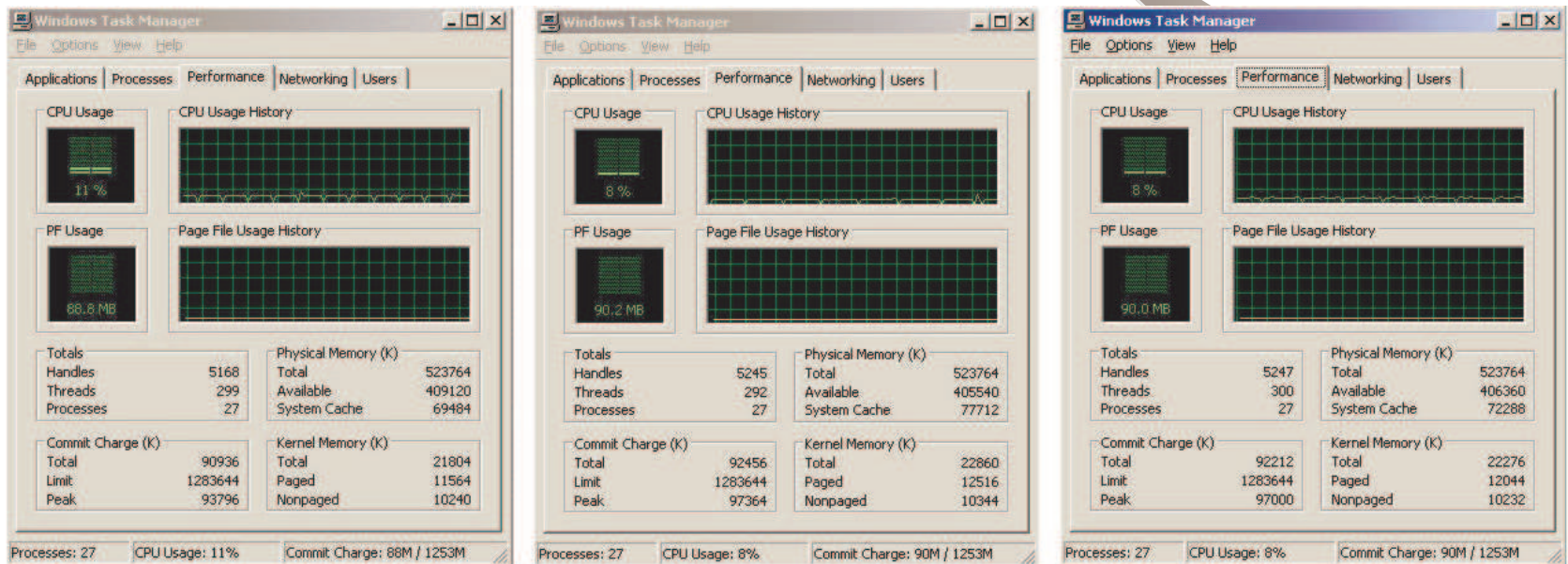
通道機制之延遲時間分析



通道機制之通過率分析



通道機制之CPU利用率分析

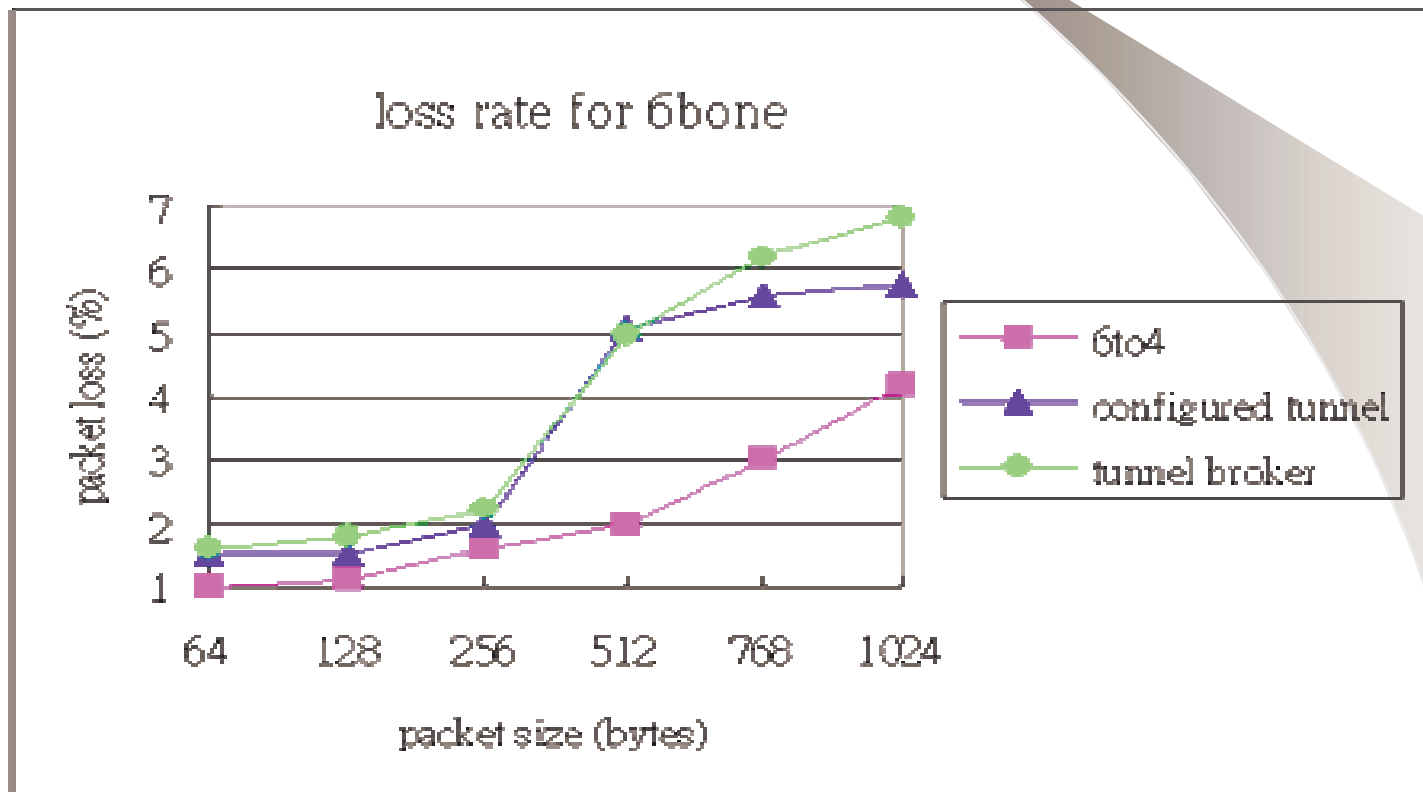


6to4 tunnel

configured tunnel

tunnel broker

通道機制之資料遺失率分析

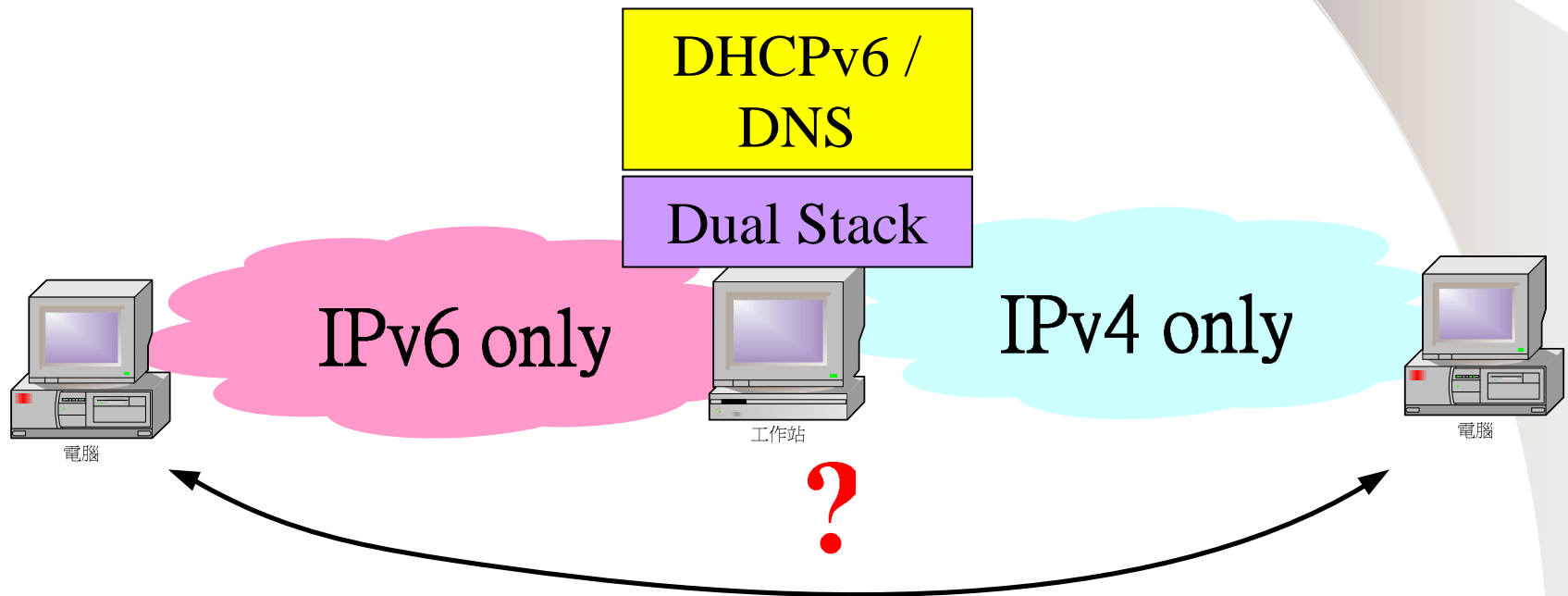


通道為主之機制的效能指標

6bone Site	6to4 Tunnel		Configured Tunnel		Tunnel Broker	
	Small packet size	Large packet size	Small packet size	Large packet size	Small packet size	Large packet size
Latency	1	1	2	2	3	3
Throughput	1	1	3	2	2	3
CPU Utilization	2	2	1	1	1	1
Loss Rate	1	1	2	2	3	3

DSTM 雙重架構機制

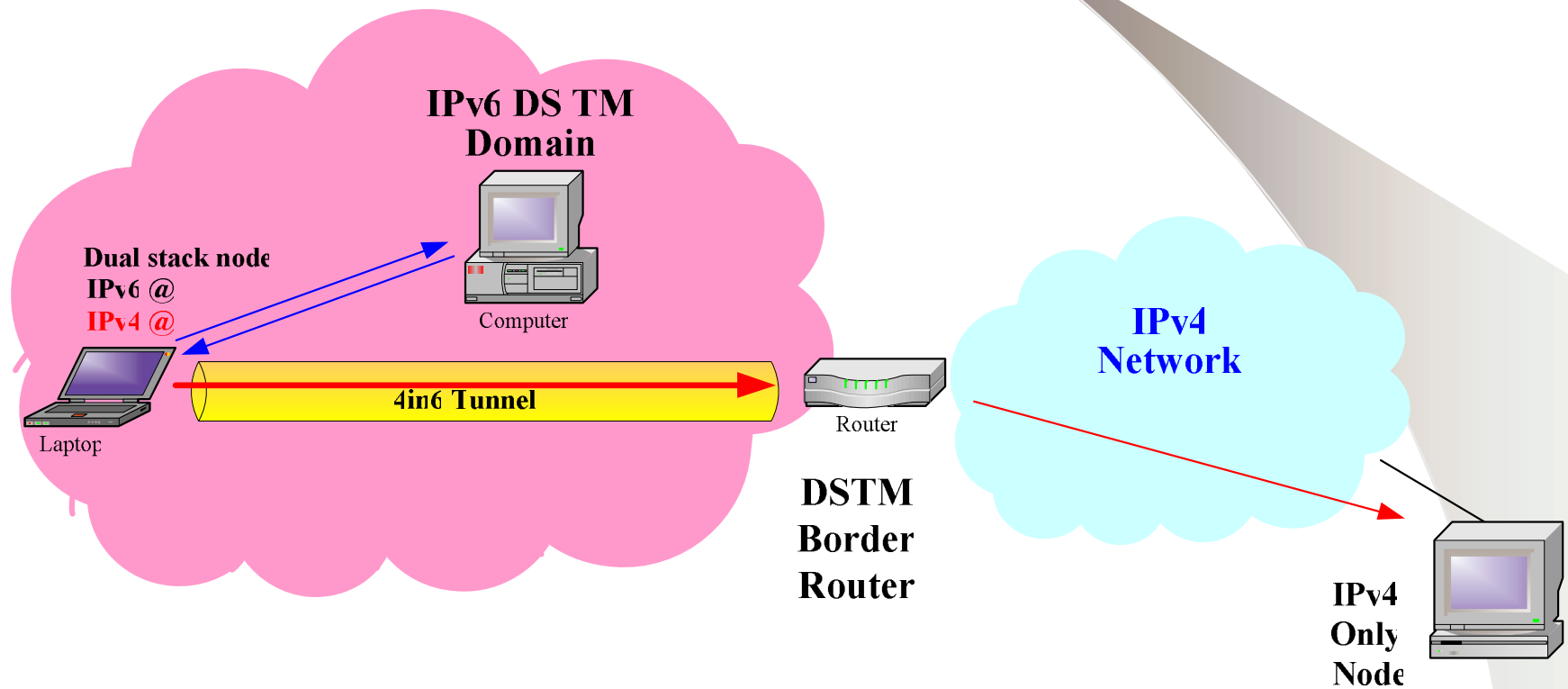
- DSTM 雙重架構機制係確保 IPv4 之應用能於 IPv6 網路上運作
 - Draft-ietf-ngtrans-dstm-08.txt



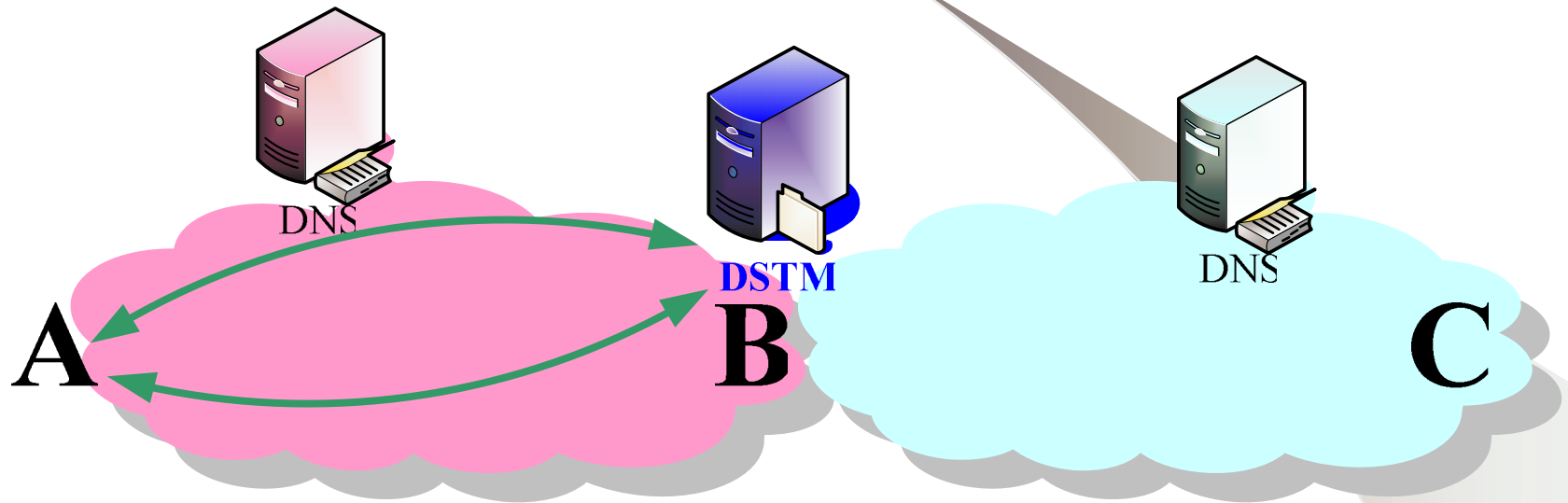
DSTM雙重架構機制

- ❖ 一IPv6 node與一IPv4 node互通時,其先取得一暫用之IPv4位址(DSTM伺服器提供)
- ❖ 此暫用之IPv4位址係由DNS及DHCPv6協調產生
- ❖ 傳送時藉由動態通道技術包裝IPv4封包

DSTM 雙重架構機制



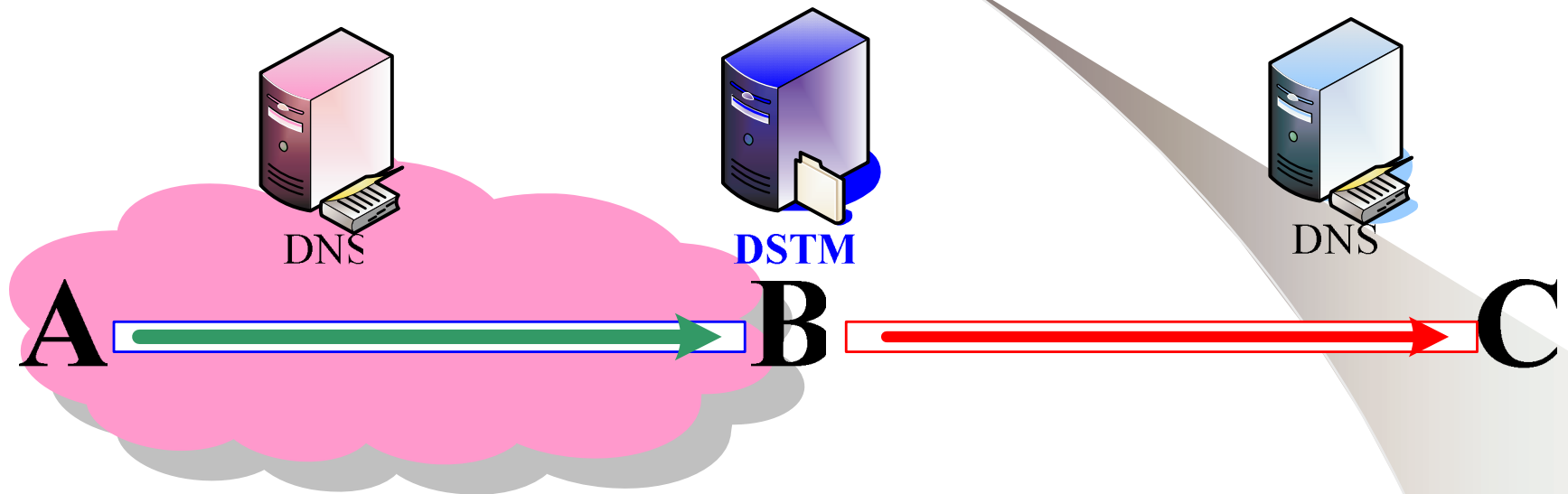
DSTM雙重架構機制運作(v6 → v4)



一個應用之封包傳送由A node(IPv6)至C node(IPv4)

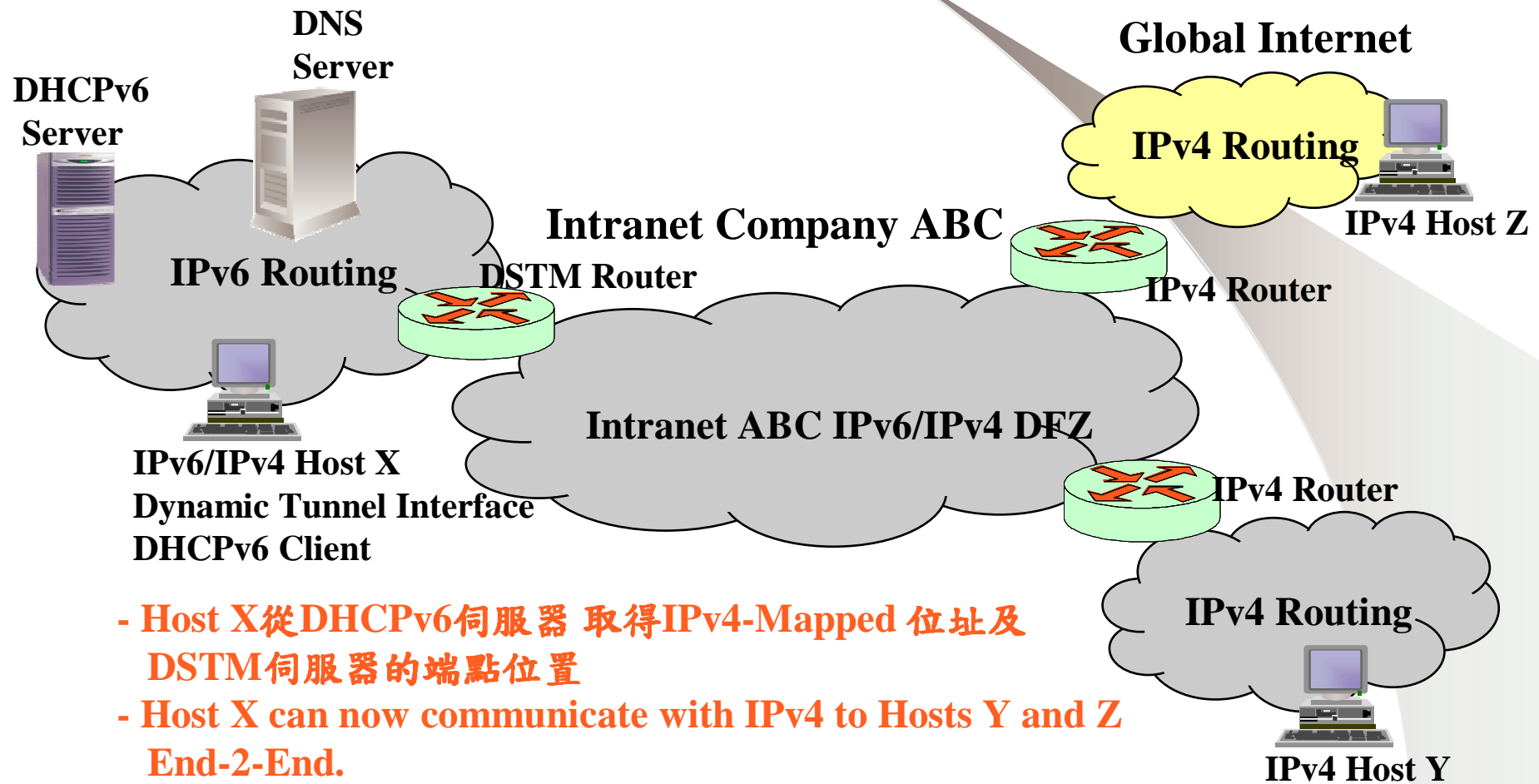
1. A node要求DSTM伺服器給予一IPv4 Source位址
2. DSTM伺服器回覆A node暫用之IPv4 address位址及DSTM Gateway的IPv6位址
3. A node 產生IPv4封包

DSTM雙重架構機制運作(v6 → v4)



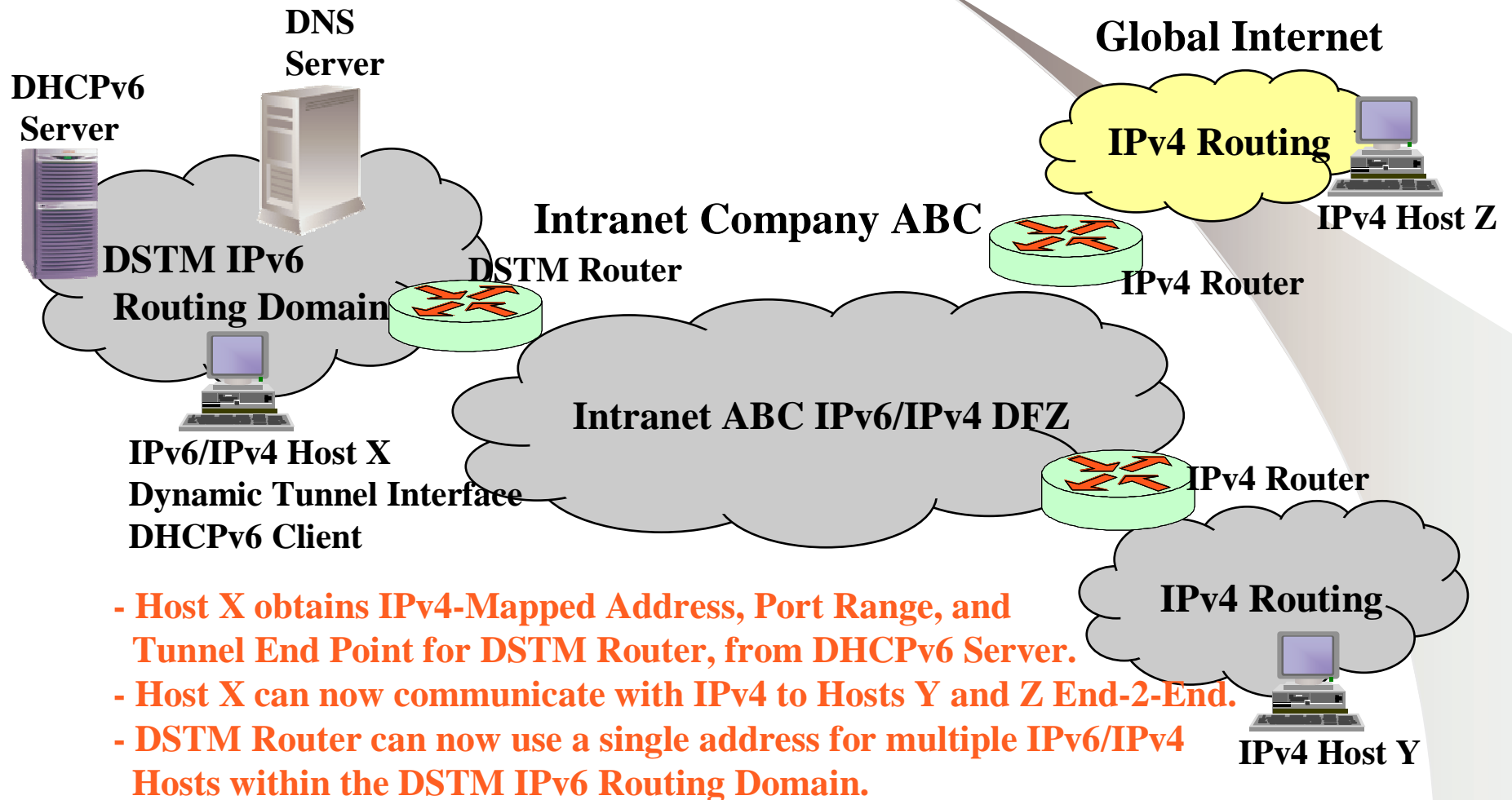
1. 一個A node至B node的通道建立(送IPv6封包)。
2. B node拆除IPv6封包頭，然後將此IPv4封包送給C node。
3. B node記錄A node的IPv4與IPv6位址，然後Mapping在它的 Routing Table中。

DSTM雙重架構機制



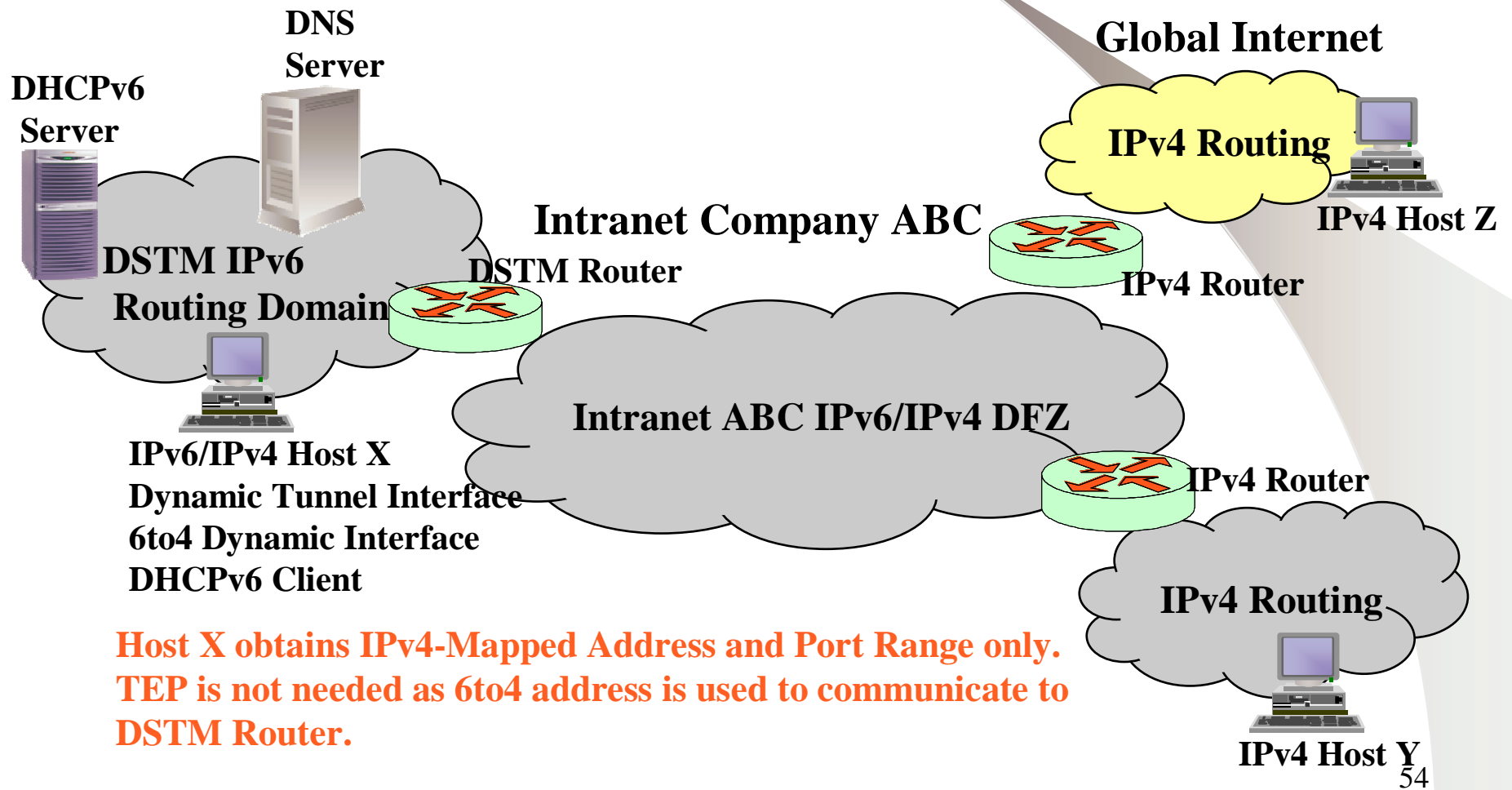
- Host X從DHCPv6伺服器取得IPv4-Mapped位址及DSTM伺服器的端點位置
- Host X can now communicate with IPv4 to Hosts Y and Z End-2-End.

DSTM 雙重架構機制 + Port Range

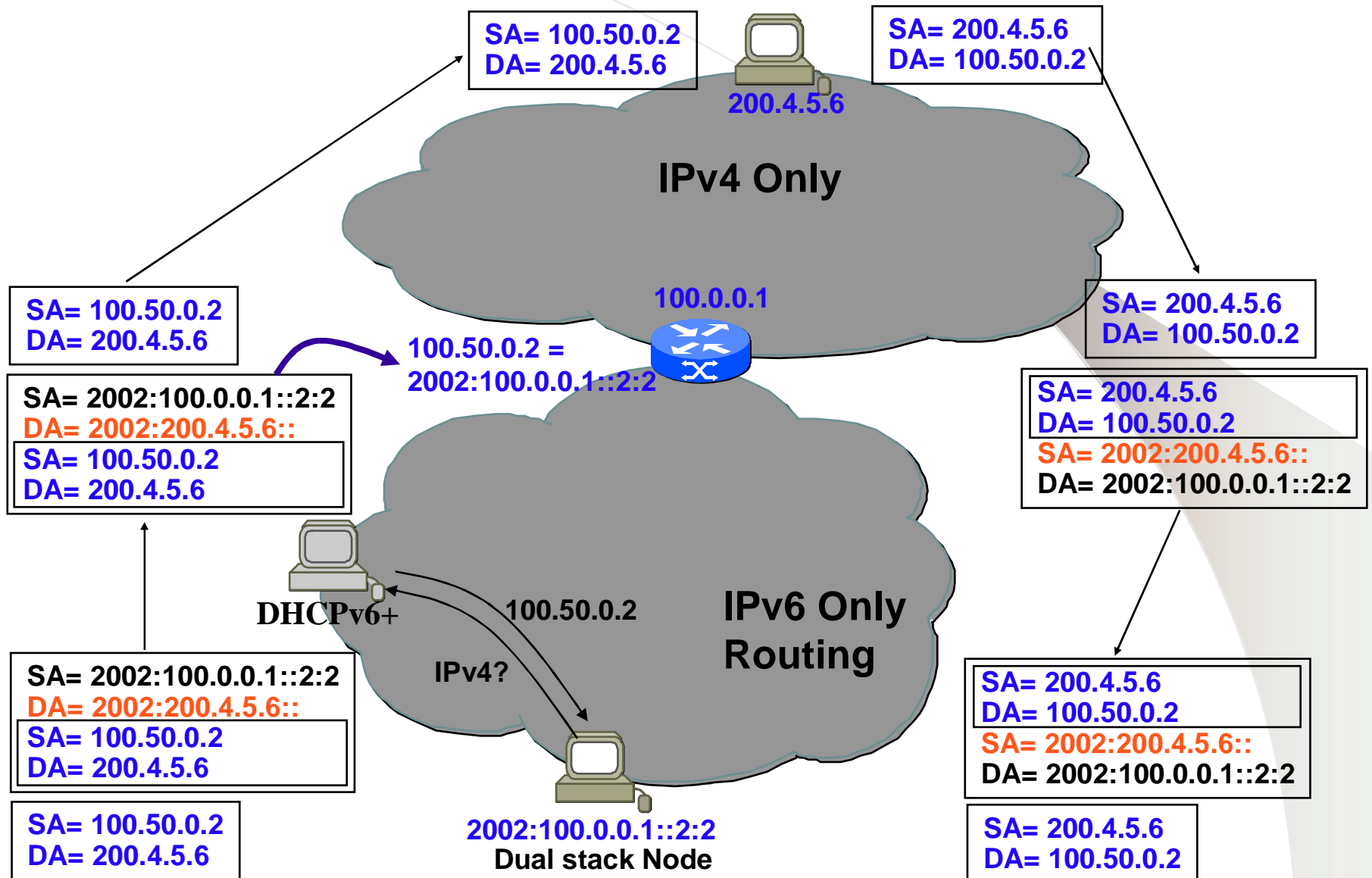


DSTM 雙重架構機制

6to4

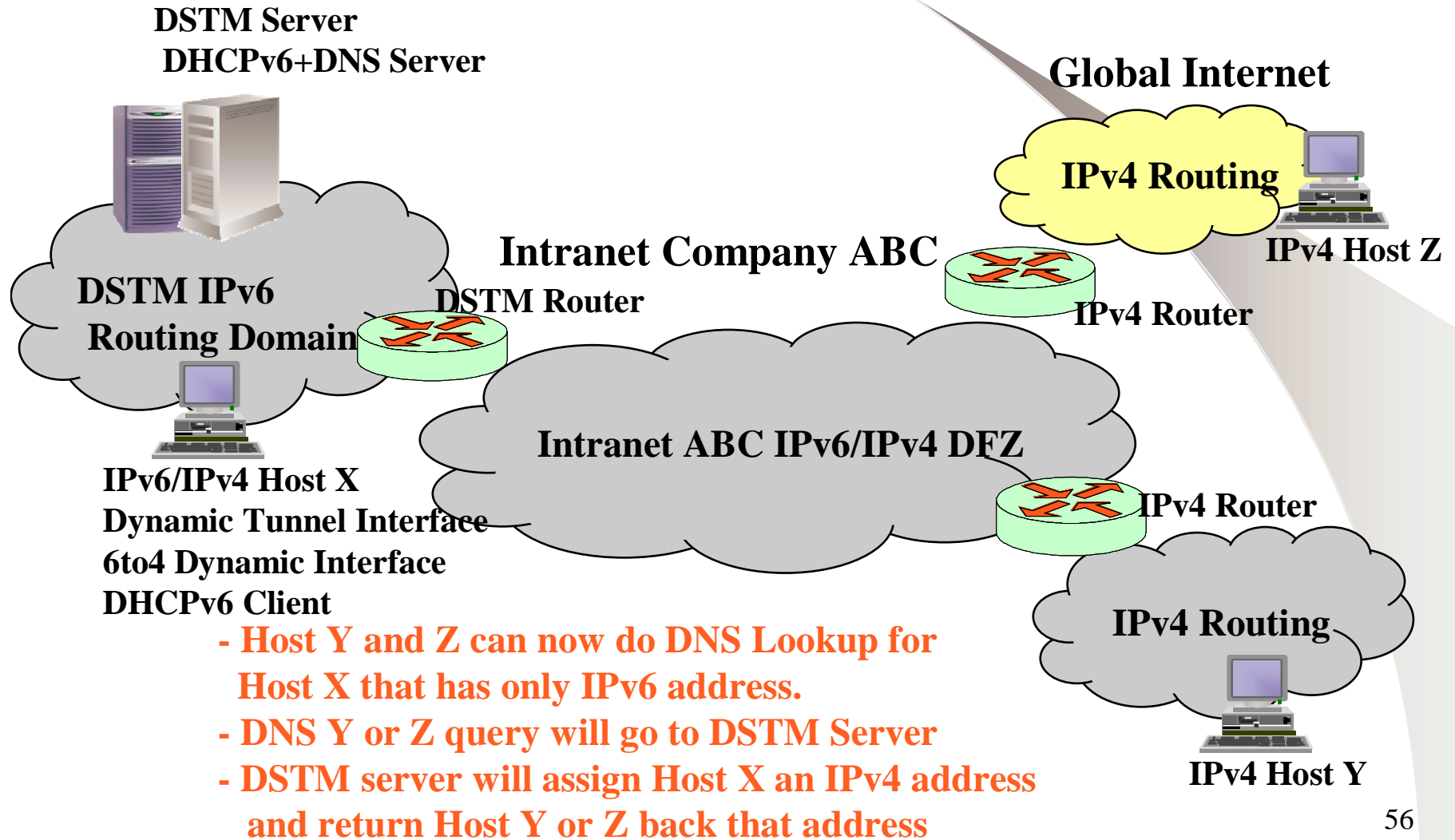


DSTM雙重架構機制+ 6to4



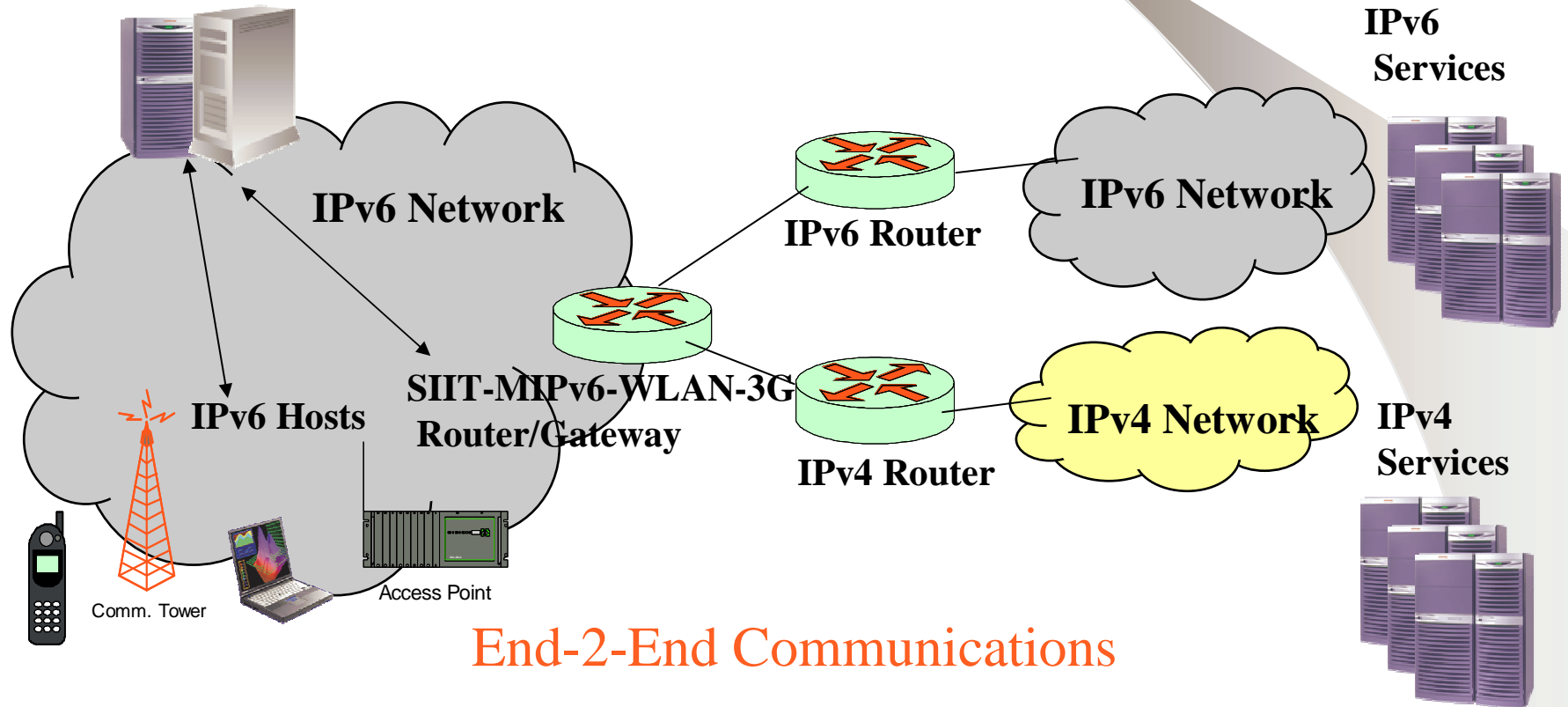
DSTM雙重架構機制

IPv4 Query to IPv6 Address



DSTM 雙重架構機制 3G and WLAN Network

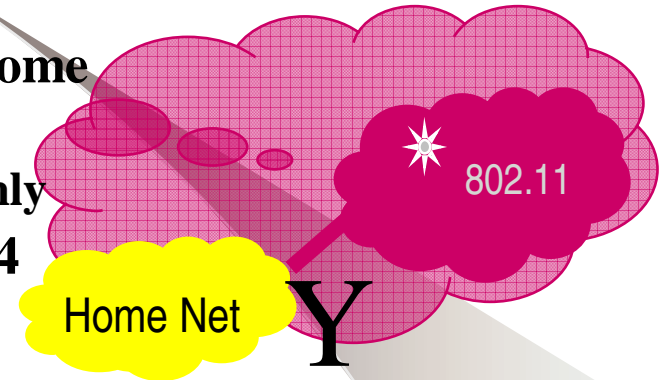
DSTM Server Mechanisms and Extensions



DSTM 雙重架構機制應用

Roaming Scenario

- ❖ **Giving IPv4 addresses to visitors can become expensive:**
 - Visited Network offers IPv6 connectivity **only**
- ❖ **Home network offers connection to the v4 world via DSTM**
 - to Corporate Intranet
 - to Global Internet



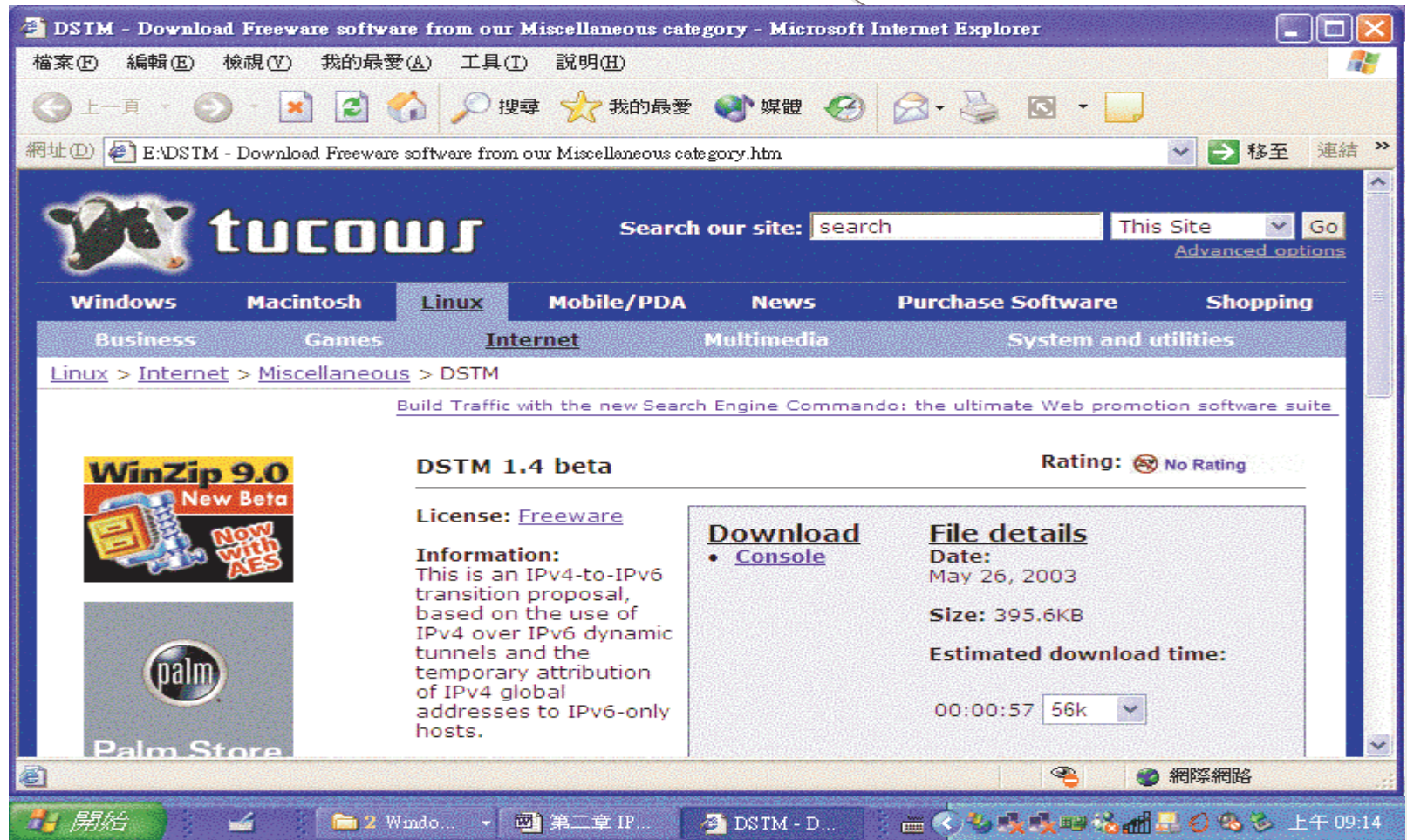
```
ed0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    inet6 fe80::200:c0ff:fe11:cba0%ed0 prefixlen 64 scopeid 0x1
    inet6 3ffe:305:1002:4:200:c0ff:fe11:cba0 prefixlen 64
    inet6 2001:660:282:4:200:c0ff:fe11:cba0 prefixlen 64
    ether 00:00:c0:11:cb:a0

gif0: flags=8011<UP,POINTOPOINT,MULTICAST> mtu 1280
    inet6 fe80::200:c0ff:fe11:cba0%gif0 --> :: prefixlen 64
    inet 192.108.119.197 --> 192.108.119.199 netmask 0xffffffff
    physical address inet6 3ffe:305:1002:4:200:c0ff:fe11:cba0 -
-> 3ffe:305:1002:1:200:c0ff:fe85:cba0
```

Implementation of DSTM

- ❖ BSD « INRIA »
 - DSTM gateway
 - DSTM server (RPC)
 - Client: manual conf, dynamic conf
- ❖ BSD Kame
 - Client: Manual Configuration
- ❖ Linux
 - Client: Manual Configuration
- ❖ Windows : ?

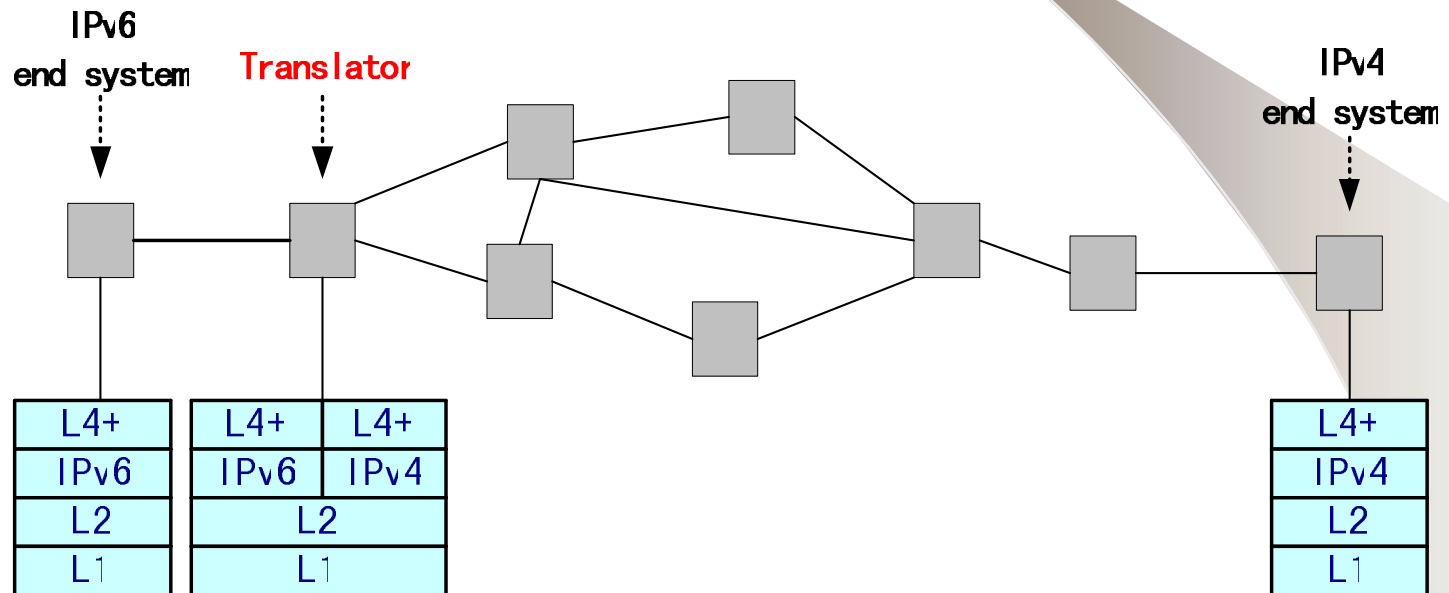
DSTM機制之freeware軟體



位址協定轉換機制 (Translator)



位址協定轉換機制之網路端協定轉換

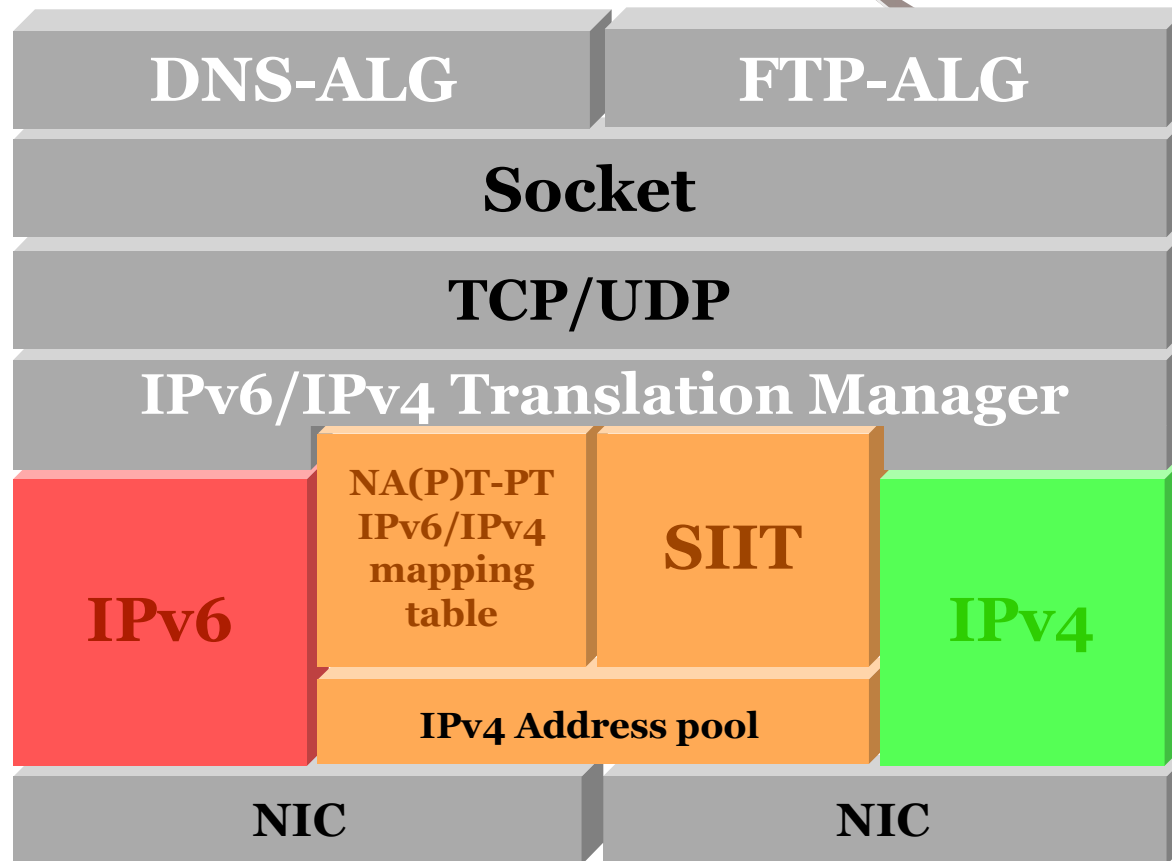


位址協定轉換機制

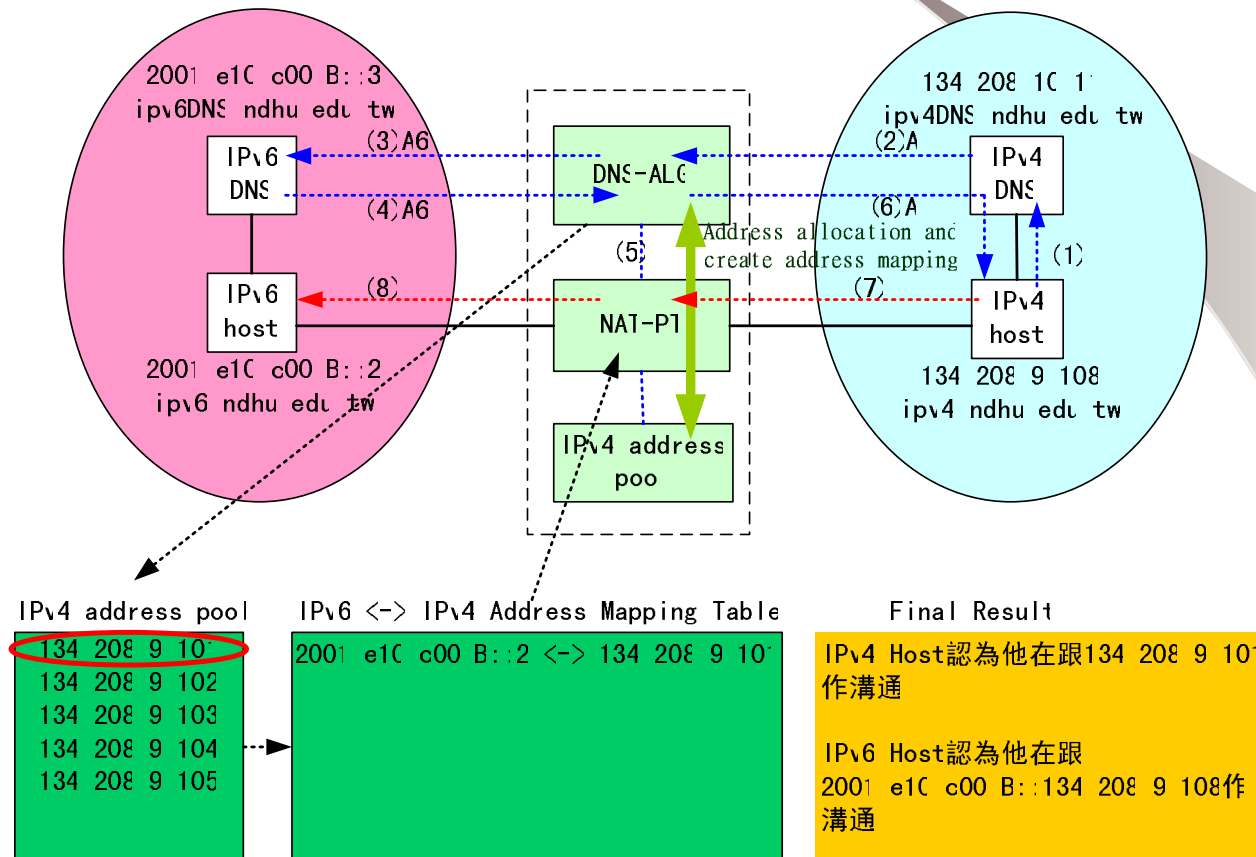
- 網路位址與通訊協定之轉換(Network Address Translation-Protocol Translation; NAT-PT)
- TCP-UDP 中繼機制(TCP-UDP Relay)
- Bump-in-the-Stack (BIS)機制
- SOCKS 為基礎的IPv6/IPv4閘道器機制

無縫IP/ICMP轉換演算法

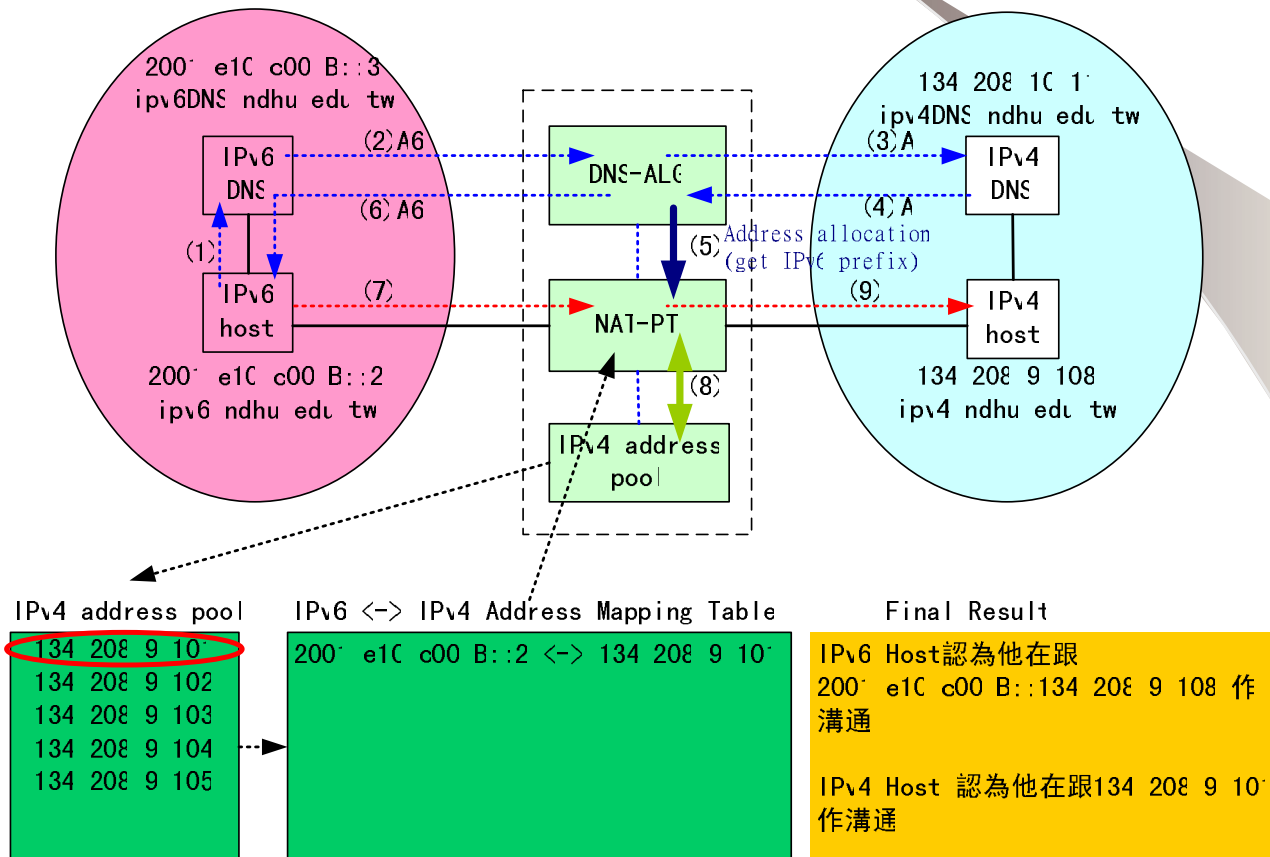
SIIT 演算法



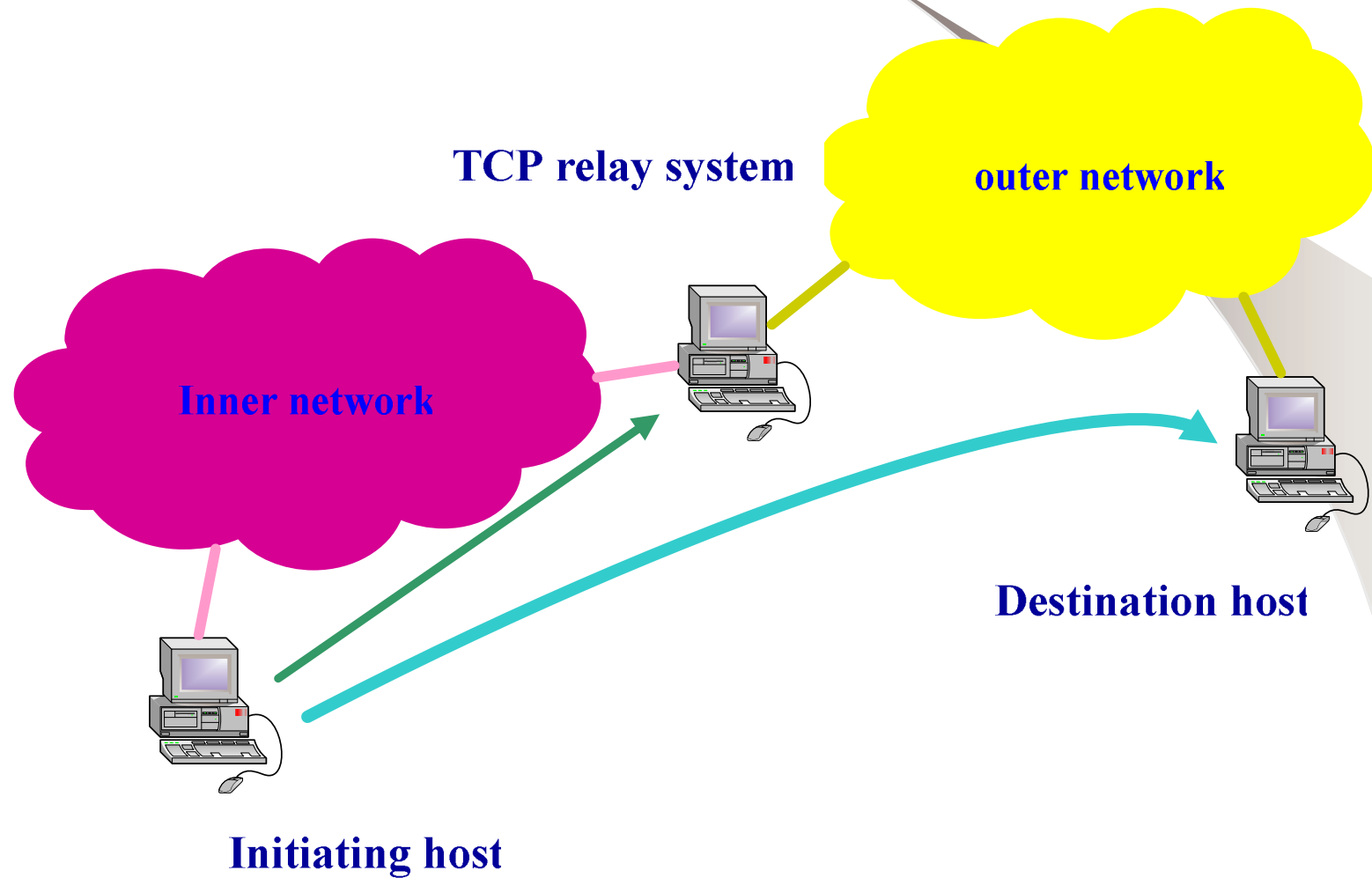
網路位址與通訊協定之轉換機制(4-6)



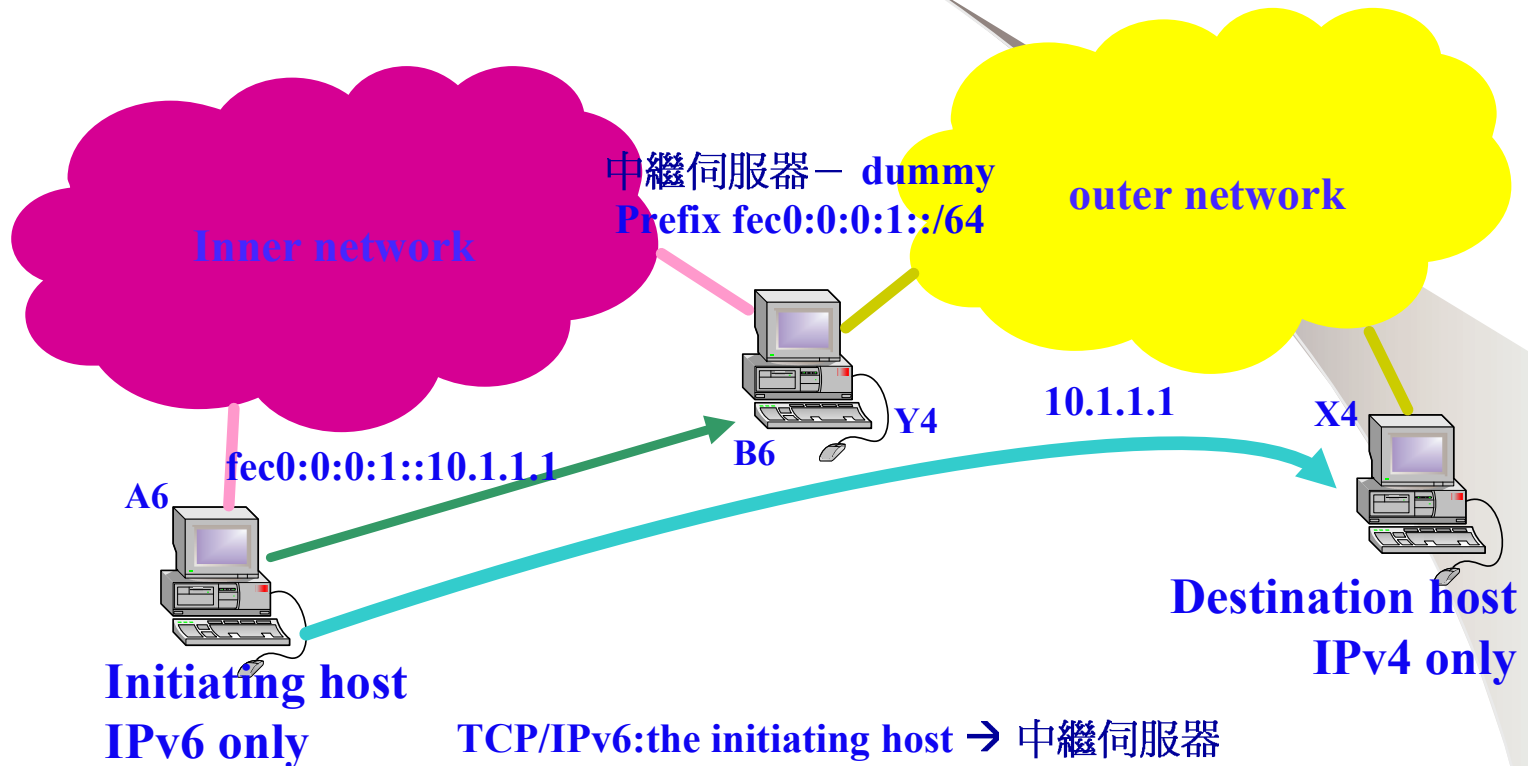
網路位址與通訊協定之轉換機制(6-4)



TCP-UDP 中繼機制(TCP-UDP Relay)



TCP-UDP 中繼機制運作



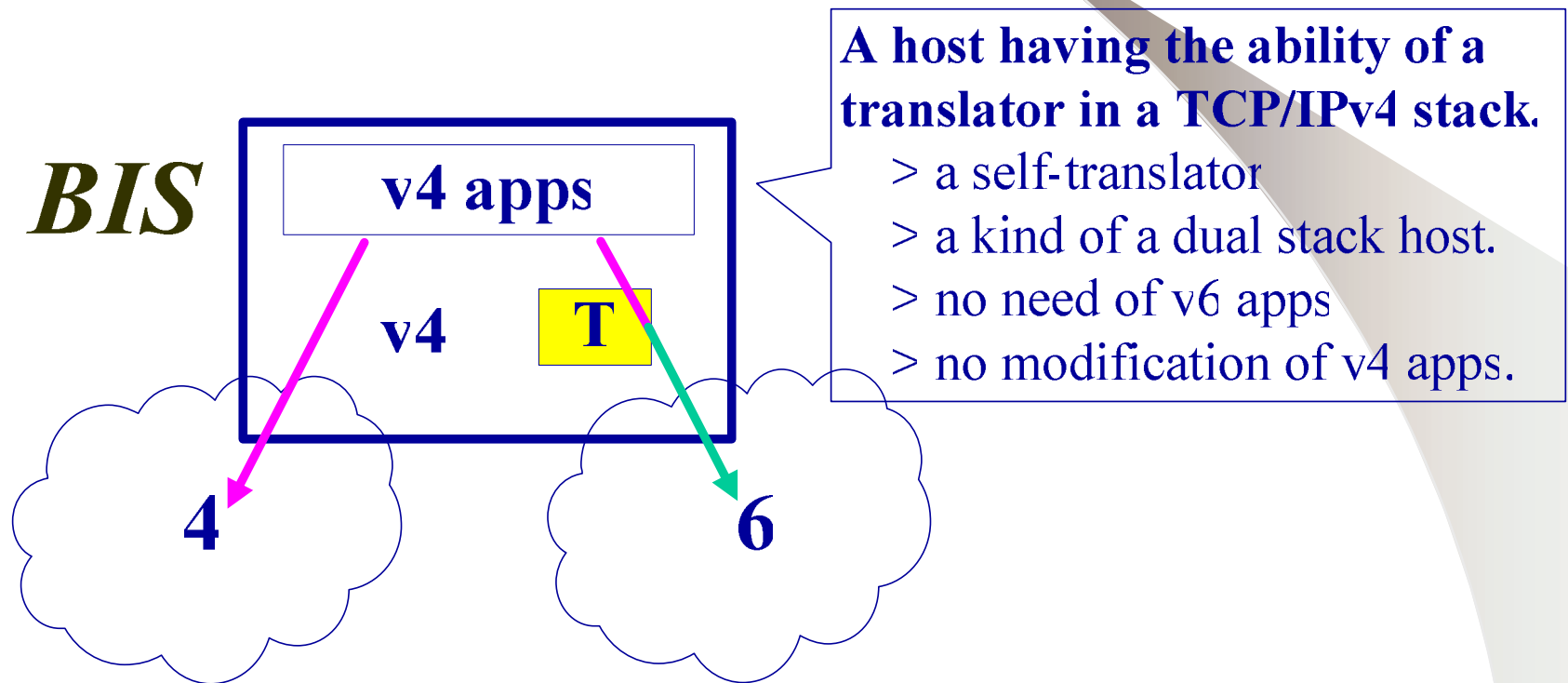
TCP/IP_{v6}: the initiating host → 中繼伺服器

address on IPv6 header: A6 → A6::X4

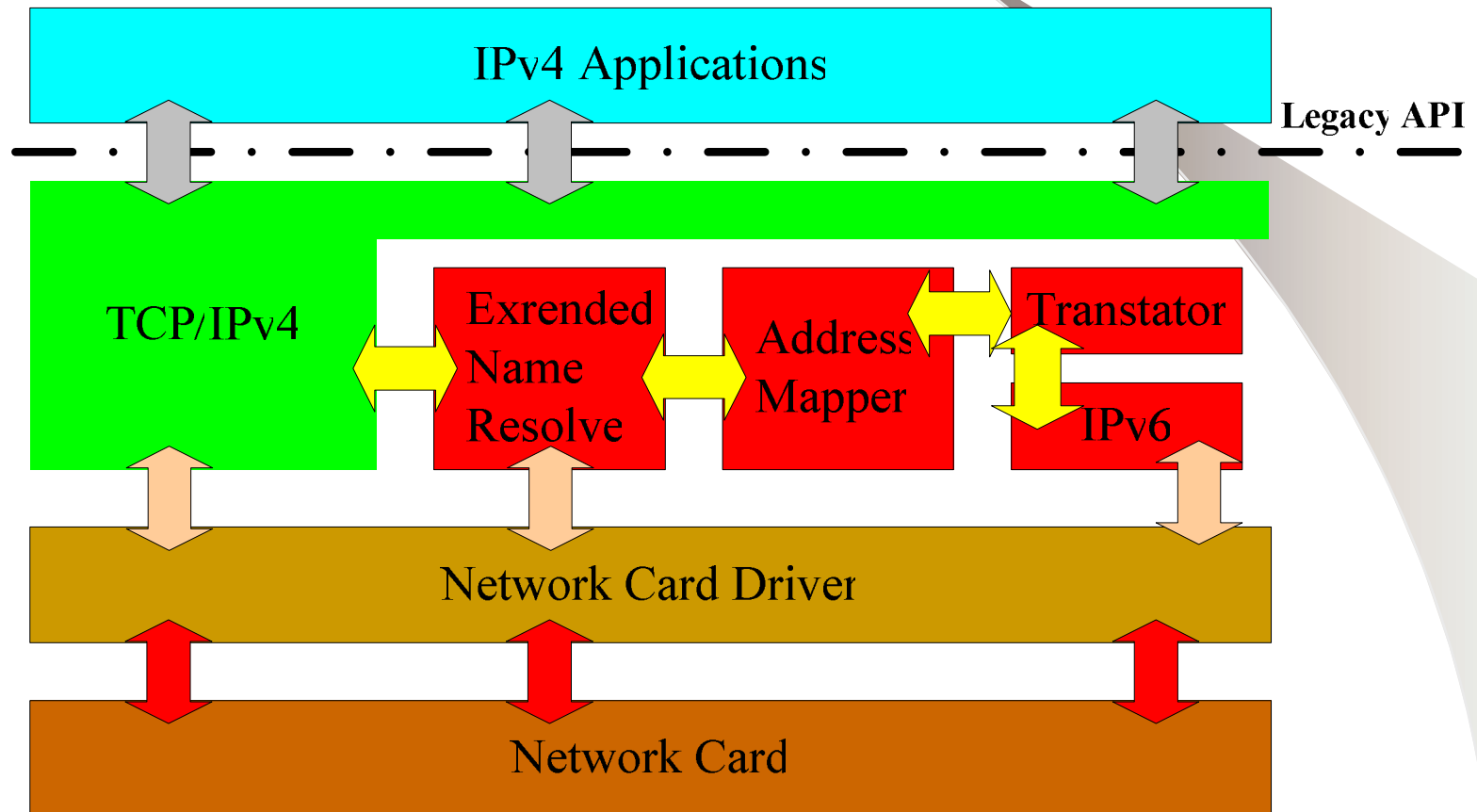
TCP/IP_{v4}: 中繼伺服器 → the destination host

address on IPv4 header: Y4 → X4

BIS機制



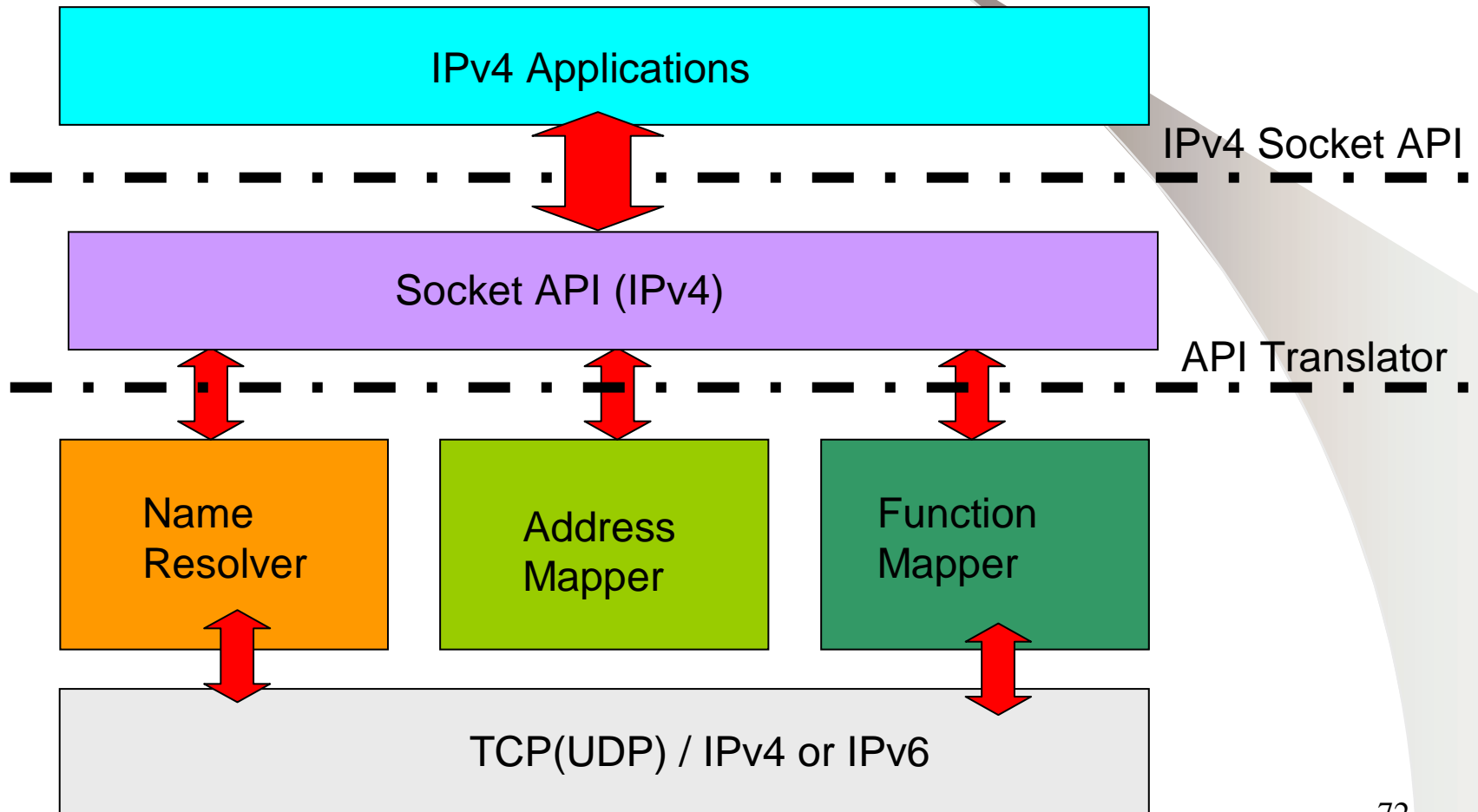
BIS機制協定模組



RFC 3338 – Bump-In-the-API

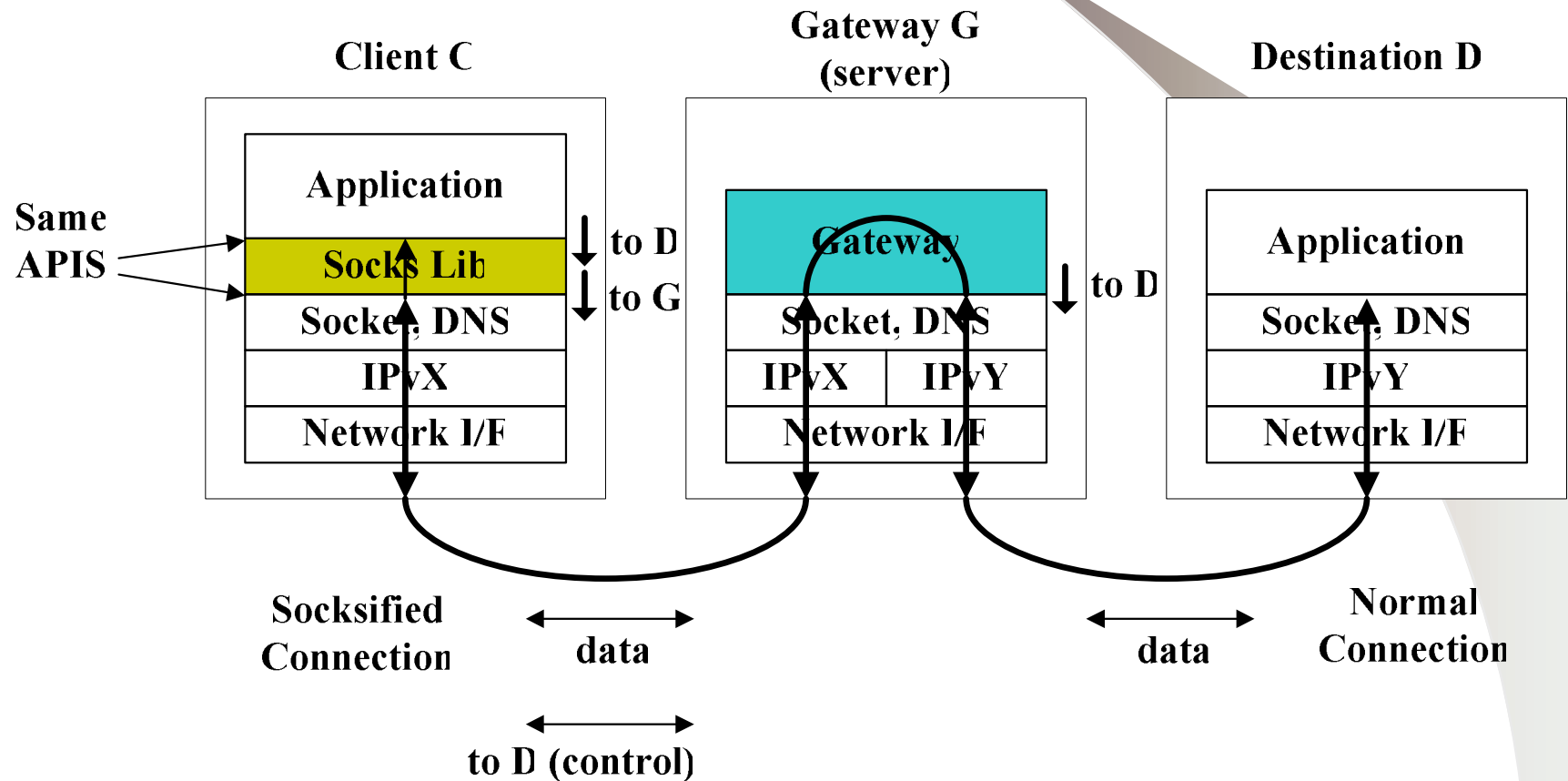
- The main purposes of BIA are the same as BIS.
 - It makes **IPv4 applications** communicate with IPv6 hosts without any modification of those IPv4 applications.
- BIS is for systems with no IPv6 stack, BIA is for systems with an IPv6 stack.
- BIA SHOULD NOT be used for an IPv4 application for which **source code** is available.

Architecture of BIA



SOCKS為基礎的IPv6/IPv4

閘道器機制運作



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