Internet Protocol, Version 6 (IPv6)

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- July 1st, 2009.

Not every flower can represent love, but roses did it
Not every tree can stand thirst, but cactus did it
Not every protocol can fit the future, but IPv6 did it.

IPv6, the standard of the Internet Future.

Outline

- Introduction
- Why IPv6
  - IPv4 Address Exhaustion
- History of IPv6
- IPv6 Features
- IPv6 Header
- IPv6 Addressing Model
- Lab
- Tunnel Broker
- Conclusion & Reference

Introduction

- Why IPv6?
  - IPv4 Address Exhaustion

Why IPv6?

- IPv4 Address Exhaustion

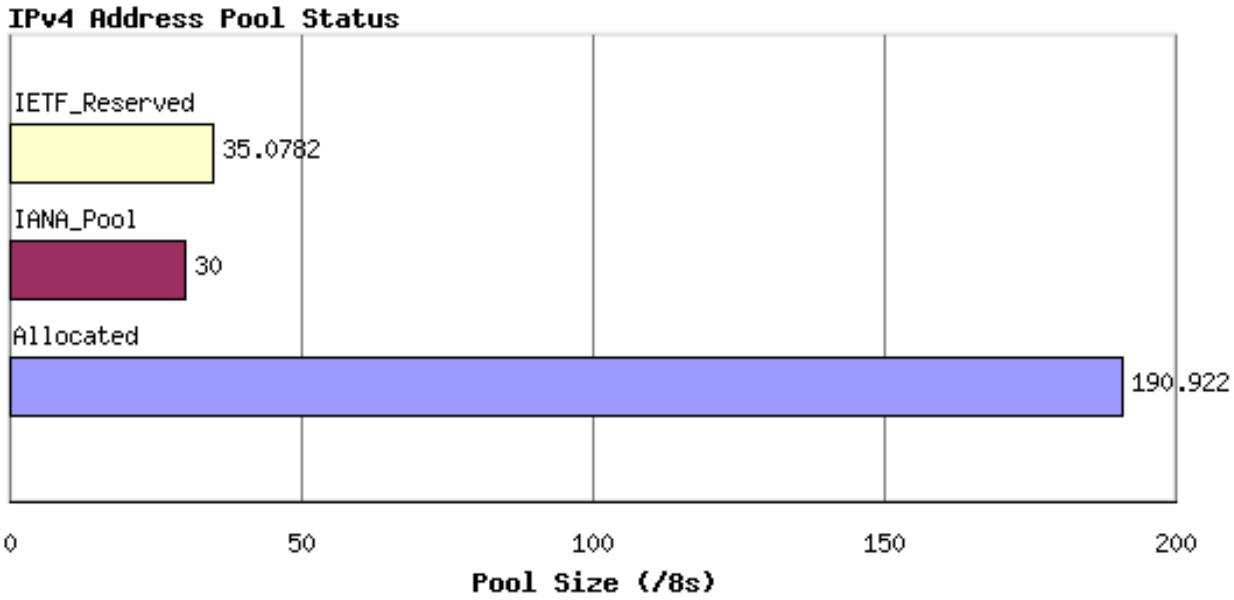


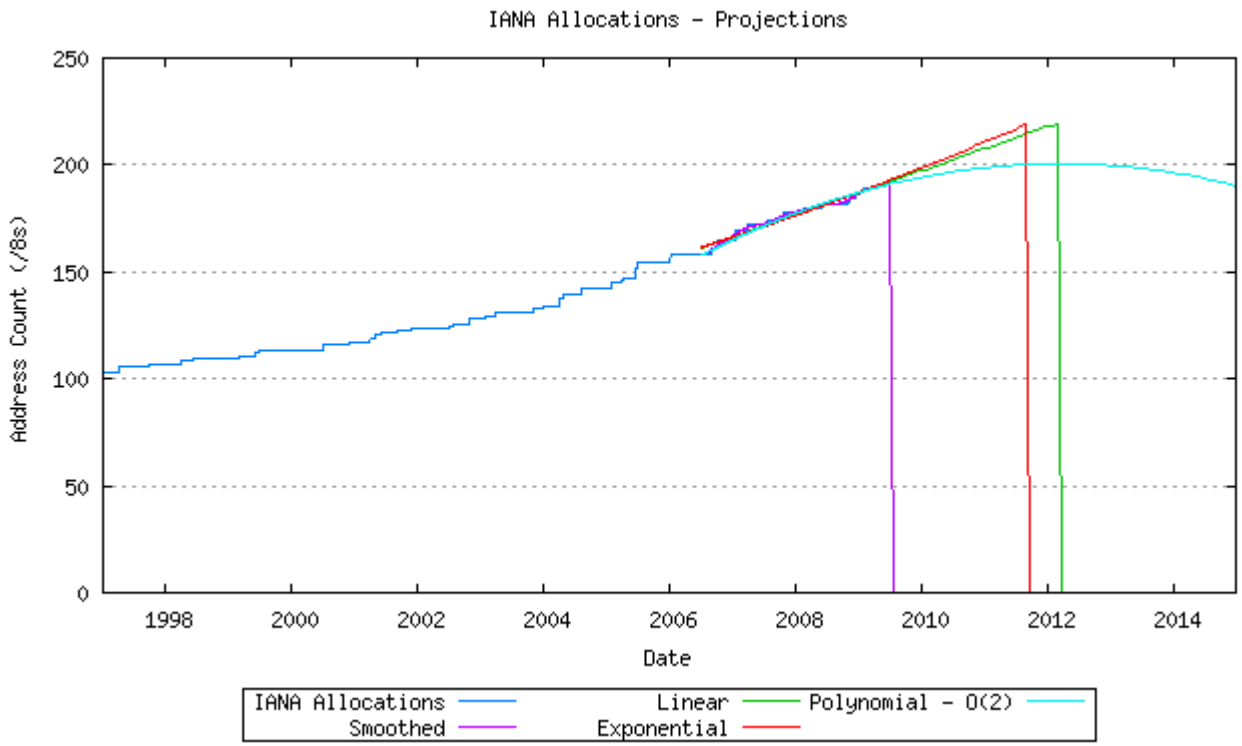
Figure 1 - Address Pool Status from IPv4 Address Report, 30-Jun-2009.

IPv4 Address Exhaustion

- Projected Unallocated Address Pool Exhaustion
  - IANA: 08-Jul-2011
  - RIRs: 10-Apr-2012

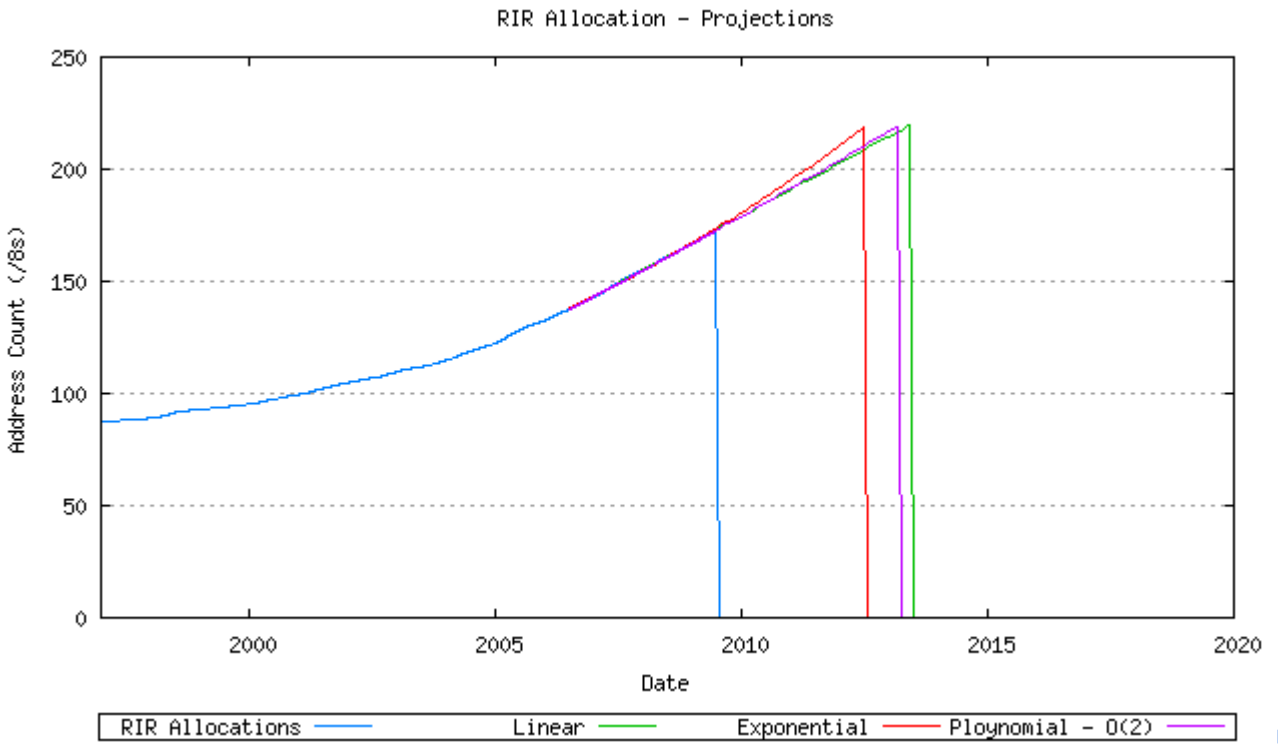
IPv4 Address Exhaustion

- Projected Unallocated Address Pool Exhaustion



IPv4 Address Exhaustion

- Projected Unallocated Address Pool Exhaustion



History of IPv6

- 1992年，IETF之IPv4的Address空間不足的問題開始被檢討
- 1994年，下一代的網際網路協定開始被提案，CATNIP (Common Architecture for the Internet)，TUBA (TCP/IP with Bigger Addresses)，SIPP (Simple Internet Protocol Plus)三個提案中出線。
- 1995年，SIPP被更名為IPv6，IPv6的規範將被RFC1752(The Recommendation for the IP Next Generation Protocol)公開。

History of IPv6

- 1998年，IPv6之位址架構與通訊協定之規範分別在RFC2373 (IP Version 6 Addressing Architecture)與RFC2460(Internet Protocol Version 6(IPv6) Specification)公開。
- 1999年，全球第一個業界團體(共有42個單位加盟)成立了「IPv6 Forum」。ARIN 將全球第一個之IPv6 Prefix：2001:400::/35授予給ESnet。
- 2002年，全球各區域性的Internet Registry RIR(Regional Internet Registries)實施新的「IPv6 Address Allocation and Assignment Global Policy」。

IPv6 Features

- New Addressing Method
- IPv6 Header Extensions
  - Replacement of IPv4 Options
- Simplified Header

IPv6 Features

- IPv4 & IPv6 Addresses

版　本	位 元 數	位　址　數　量
IPv4	32	4, 294, 967, 296個
IPv6	128	340, 282, 366, 920, 938, 463, 463, 374, 607, 431, 768, 211, 456個(≒3.4×10^{38})

IPv6 Features

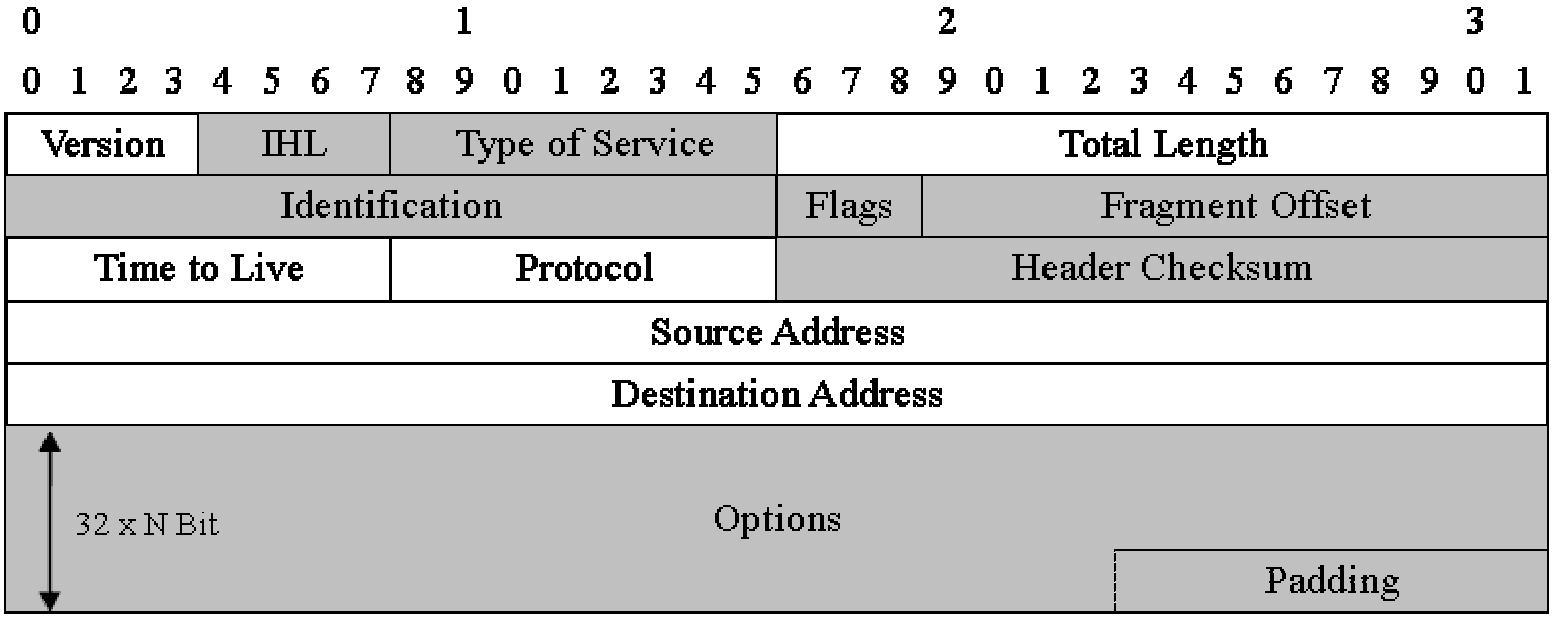
- Why not > 128bits?
  - 考慮到IP 標頭處理所造成的浪費。

協　　定	標　頭　長　度	MTU	標　頭　浪　費
IPv4	20bytes	576bytes	3.5%
IPv6	40bytes	1,280bytes	3.1%

  - 位址空間擴充了，但標頭浪費卻幾乎不變，可以判斷這樣的位址長為128bits是妥當的

Simplified Header

- IPv4 Header
  - RFC791(Internet Protocol DARPA Internet Program Protocol Specification)



於 IPv6 取消或變更的欄位

Simplified Header

- 刪除了許多IPv4的欄位
  - 標頭長度
  - 識別子(Identifier)
  - 分段位移(Fragmentation Offset)
  - 檢查碼(Checksum)
  - 服務類別(Type of Service)
- 減輕網路中路由器的負擔
  - IPv6的基本標頭從可變長度變更成固定長度
  - 取消路由器對封包的分割處理
  - 刪除Checksum 機制

IPv6 Header

Octet Offset		0								1								2								3							
	Bit Offset	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Version				Traffic Class								Flow Label																			
4	32	Payload Length																Next Header								Hop Limit							
8	64	Source Address																															
C	96																																
10	128																																
14	160																																
18	192	Destination Address																															
1C	224																																
20	256																																
24	288																																

IPv6 Header

- Version (4 bits)
  - 表示Internet Protocol 的版本號碼。IPv6 即為0110。
- Traffic Class (8 Bits)
  - 表示封包的類別或優先度。這個欄位與IPv4之”Service Type”提供相同的功能。
- Flow Label (20 Bit)
  - 顯示封包所屬的Flow編號。在不支援Flow Label 欄位的機能的主機或路由器上，會使用其預設值0。
- Payload Length (16 Bit)
  - 以無號整數表示在IPv6基本標頭之後剩下的封包長度，以Byte為單位計算。

IPv6 Header

- Next Header (8 bits)

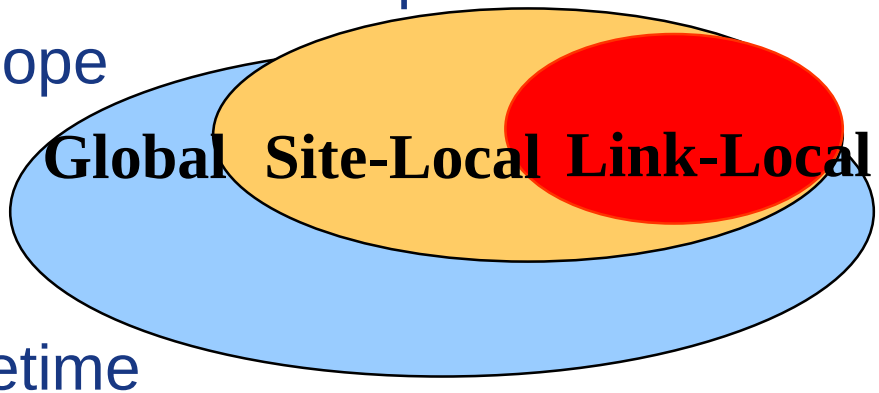
值(10進位)	下一個標頭的種類
0	Hop By Hop Option Header
6	TCP
17	UDP
41	Capsule IPv6 Header
43	Routing Header
44	Fragment Header
46	Resource Reservation Protocol
50	Security Payload Capsule Header (RFC2406)
51	Authentication Header (RFC2402)
58	ICMPv6
59	No Next Header
60	Destination Option Header

IPv6 Header

- Hop Limit (8 bits)
  - 以無號數表示IPv6 封包被捨棄之前最多可經過的節點數。
- Source Address (128 bits)
  - 封包來源的IPv6 位址。
- Destination Address (128 bits)
  - 封包目的地的IPv6 位址。一般來說，會設定為最終目的地的位址，但若延伸標頭中有Routing Header存在時，則不設定最終目的地，而是設定於Source Routing List所記錄的下一個Route Interface的位址。

IPv6 - Addressing Model

- Addresses are assigned to interfaces, not hosts
  - No change from IPv4 Model
- Interface ‘expected’ to have multiple addresses
- Addresses have scope
  - Link Local
  - Site Local
  - Global
- Addresses have lifetime
  - Valid and Preferred lifetime

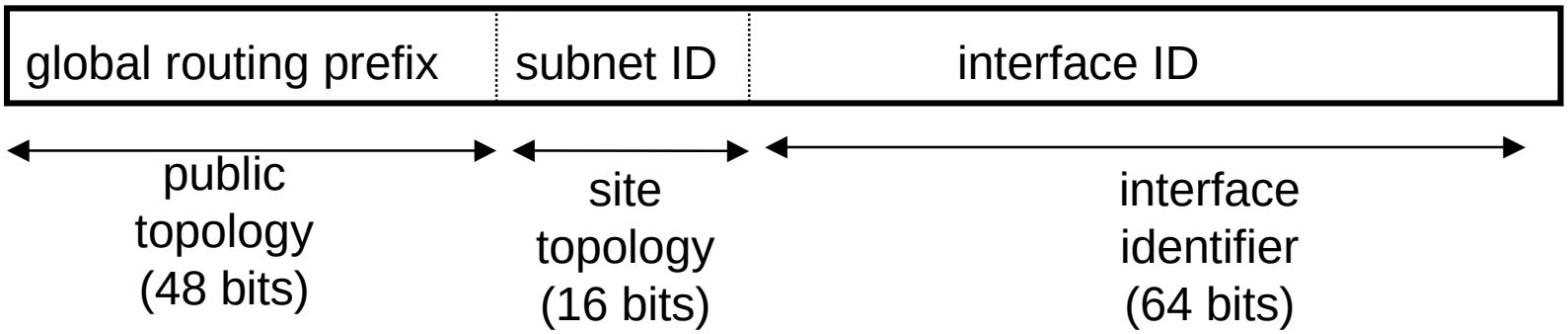


Text Representation of Addresses

- Colon-Hex
  - 3ffe:3600:2000:0800:0248:54ff:fe5c:8868
- Compressed Format:
  - 3ffe:0b00:0c18:0001:0000:0000:0000:0010
    becomes
    3ffe:b00:c18:1::10
- IPv4-compatible:
  - 0:0:0:0:0:0:140.110.60.46
  - or ::140.110.60.46
- 6to4 Address
  - 2002:8C6E:3C2E::8C6E:3C2E
    - 140.110.60.46 = 8C6E:3C2E

Text Representation of Addresses

- RFC 3587 - IPv6 Global Unicast Address Format



- Global routing prefix
  - a (typically hierarchically-structured) value assigned to a site (a cluster of subnets/links)
- Subnet ID
  - an identifier of a subnet within the site
- Interface ID
  - constructed in Modified EUI-64 format

IPv6 Address

- Difference between IPv4 and IPv6 addresses

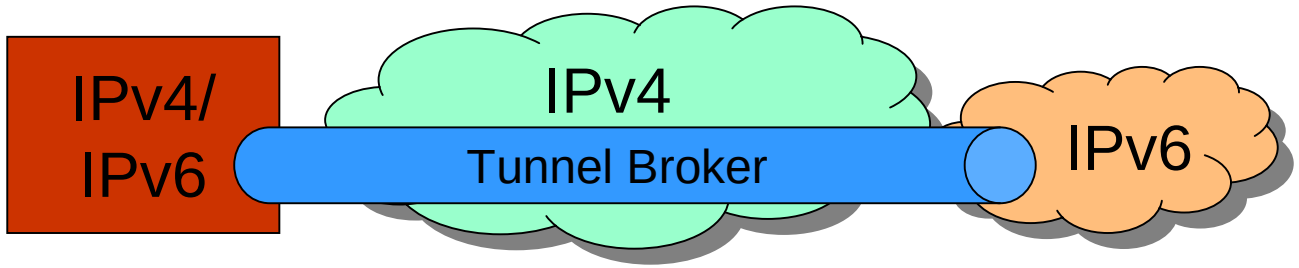
Feature	IPv4	IPv6
Multicast address	224.0.0.0/4	FF00::/8
Unspecified address	0.0.0.0	::
Loopback address	127.0.0.1	::1
address	Public IP	Aggregatable global unicast
Broadcast address	Yes	No

Feature	IPv4	IPv6
Private IP address	10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16	Site-local(FEC0::/48)
DNS reverse resolution	IN-ADDR.ARPA domain	IP6.ARPA domain
DNS name resolution	IPv4 host address(A) resource record	IPv6 host address(AAAA) resource record
Text representation	Dotted decimal notation	Colon hexadecimal format with suppression of leading zero and zero compression. IPv4-compatible are expressed in Dotted decimal notation
Network bits representation	Subnet mask in dotted decimal notation or prefix length	Prefix length notation only
Autoconfigured addresses	169.254.0.0/16 (RFC 3927)	Link-local(FE80::/64)

Lab

- Windows XP: ipv6 install
- http://www.kame.net/
- ping6
- tracert6
- More IPv6-enabled Websites
  - http://www.ipv6.hinet.net/
  - ftp.ncnu.edu.tw

IPv6 Tunnel Broker



- HiNet IPv6 Tunnel Broker
  - http://www.ipv6.hinet.net/installGuide.htm
- ASCC (Academia Sinica) Tunnel Broker
  - http://tb2.ipv6.ascc.net
- Freenet6
  - http://go6.net

Conclusion

- Solve the problem of IPv4 Address Exhaustion
- Possibility to extend more various topic research (Mobility, etc.)

Reference

- 張瑞雄 等, IPv6 新世代網際網路協定暨整合技術.
- Geoff Huston, IPv6 Address Report (30-Jun-2009) http://ipv4.potaroo.net/
- More resources on NCNU IPv6 Course page http://solomon.ipv6.club.tw/Course/IPv6.972/index.html

Q&A

Thanks!

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