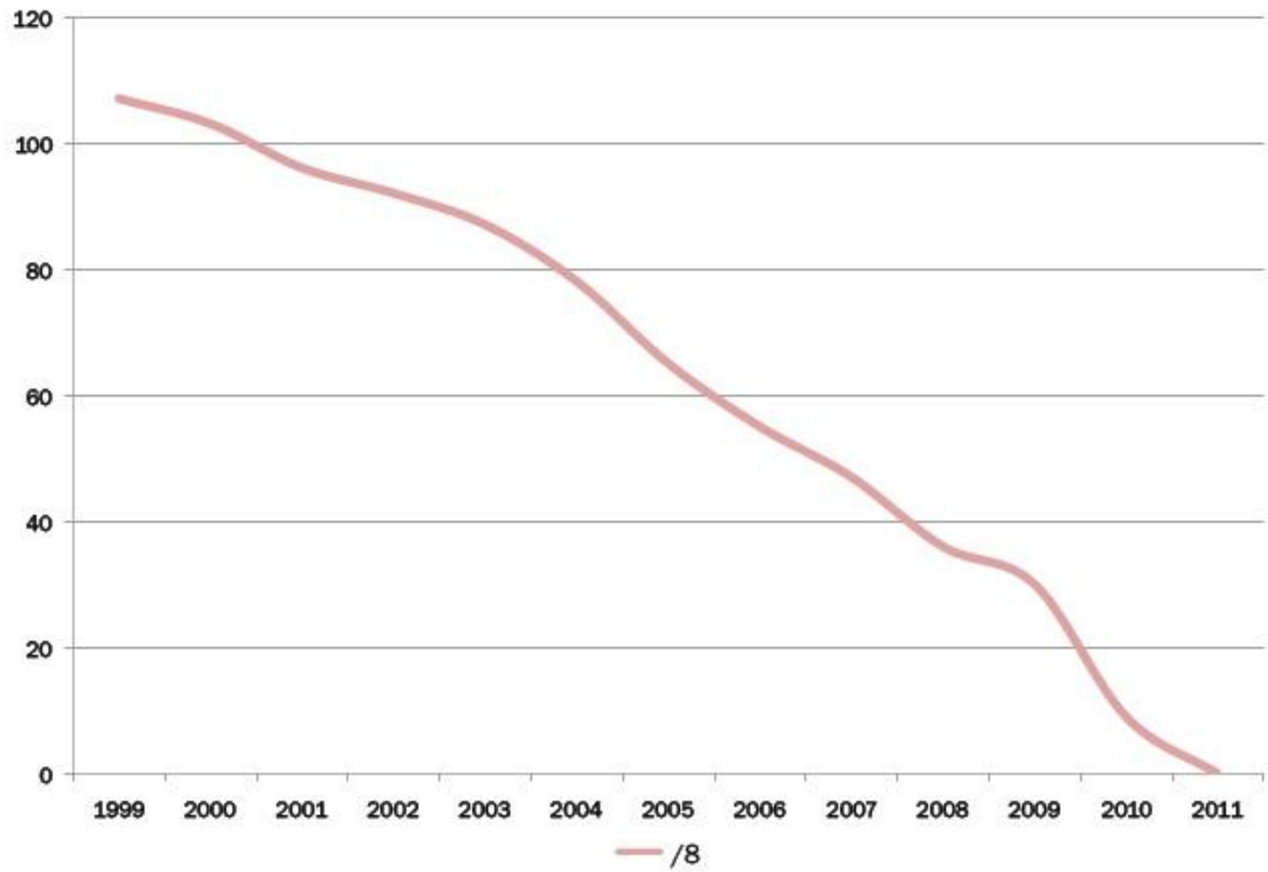
Hechos Históricos

- 1983 : Red académica con ~ 100 computadoras
- 1992 : Inernet se abre al sector comercial:
  - Crecimiento exponencial
  - El IETF llama a trabajar en una nueva generación del protocolo de IP
- 1993 :
  - Terminación del espacio de clases B
  - Predicción del colapso de la red ¡para 1994
  - Se publica RFC 1519 (CIDR)
- 1995 :
  - Se publica RFC 1883 (IPv6 specs)
  - Primer RFC acerca de IPv6

Medidas Emergentes

- CIDR (Classless Interdomain Routing)
- Direcciones Privadas (RFC1918)
- NAT (Network Address Translation)
  - Multiplexión de Direcciones IPv4
  - Translación IP - IP
  - o IP - IP+puerto (NAT-PT)
- Estas medidas dieron tiempo para el desarrollo de IPv6

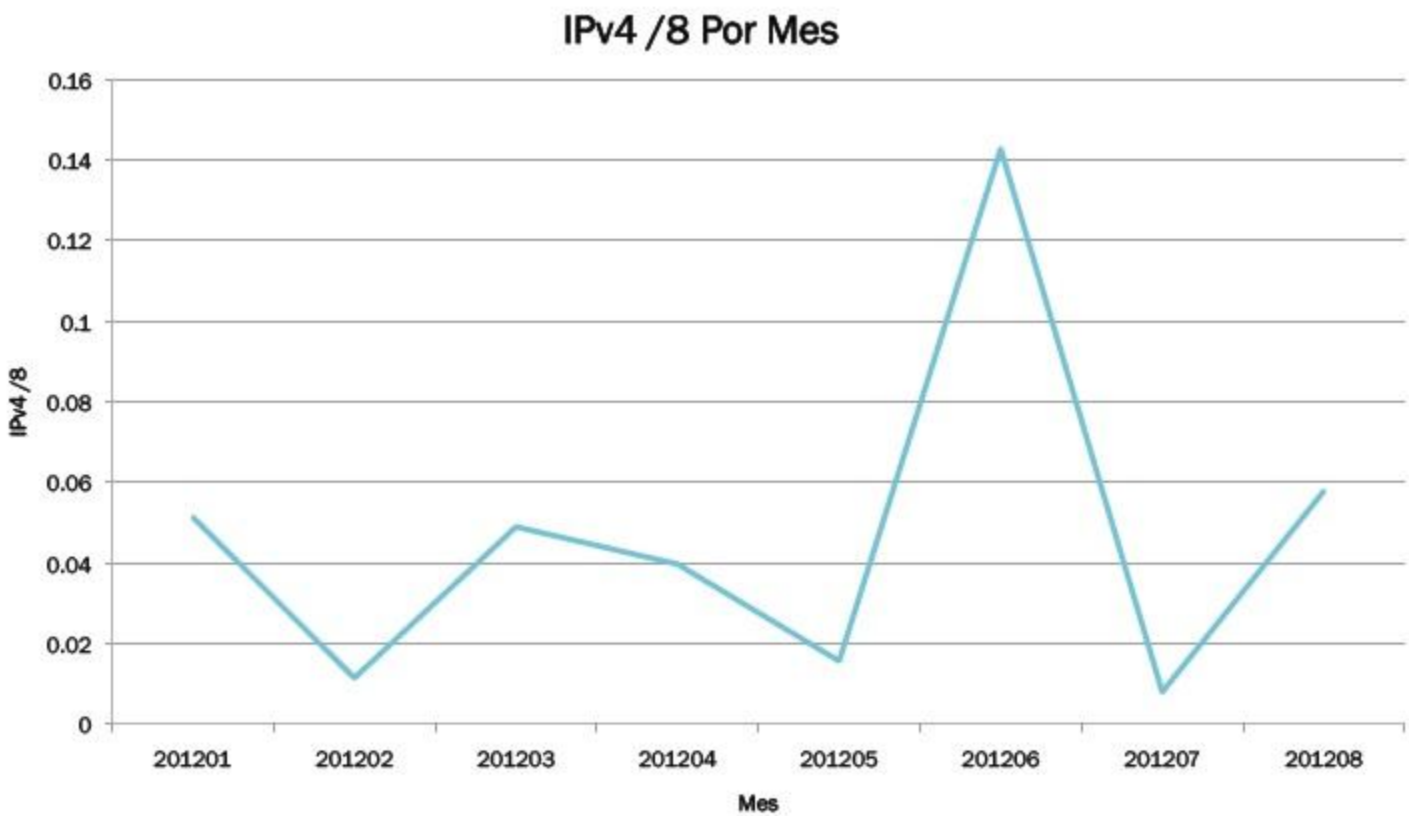
Evolución del Pool Central de IANA



Espacio disponible en LACNIC (Setiembre 2012)

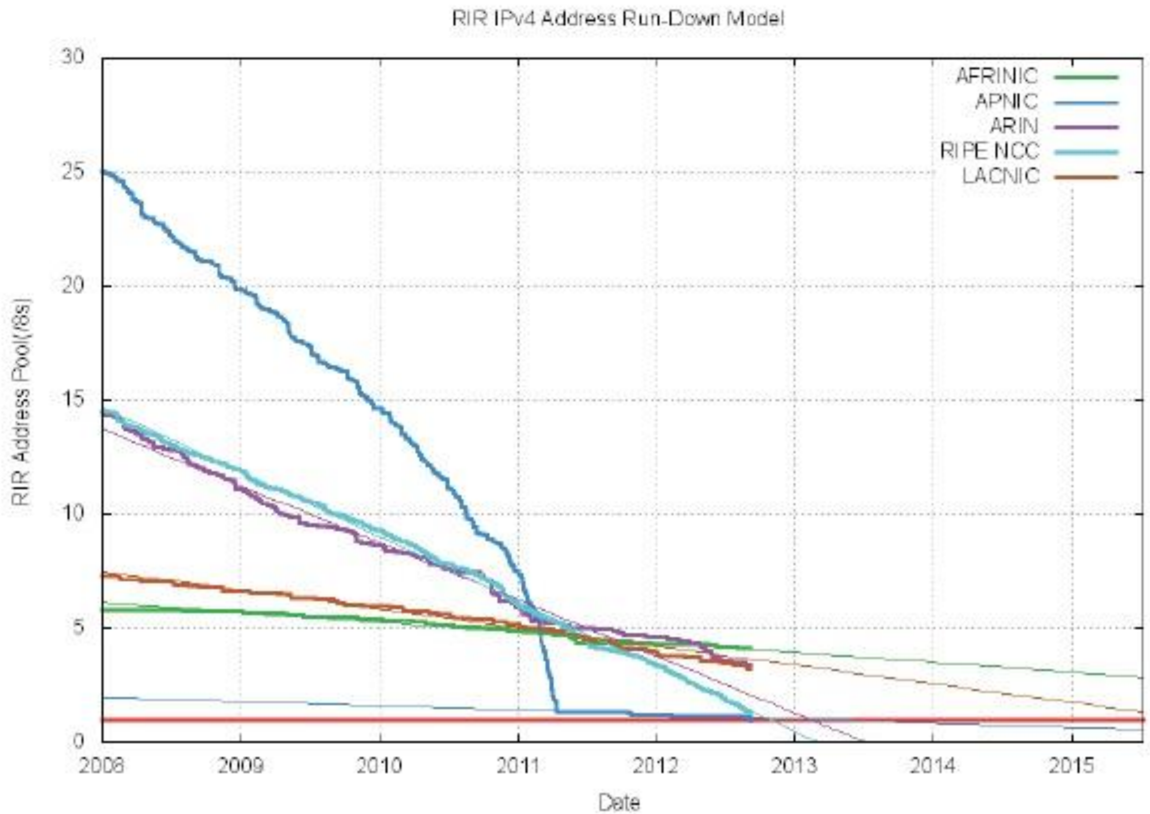
Disponible hoy /32	**54.387.200**
Disponible Hoy /8	3,242
Reserva último /10	- 25%
Total	2,431 /8 = 40.790.400 IPs

IPv4 allocation monthly



LACNIC

Terminación IPv4 en RIRs



Fuente: Geoff Huston
http://www.potaroo.net/tools/ipv4/

IPV4 admite 232 direcciones de hosts. 4.294.967.296

IPV6 admite 2^{128} direcciones de hosts

340.282.366.920.938.463.463.374.607.431.768.211.456

340 sextillones

$6.7x10^{17}$ direcciones por mm cuadrado de la sup. terrestre

Comparando IPv4 / IPv6 en un slide

- IPv4 e IPv6 tienen características similares pero han sido implementadas de forma diferente.

	IPv4	IPv6
Direccionamiento	32 bits	128 bits
Resolución de Hardware	ARP	ICMPv6 ND/NA
Auto-configuración	DHCP	ICMPv6 RS/RA & DHCPv6 (opcional)
IPsec	Opcional	Mandatoria
Fragmentación	Hosts y routers pueden fragmentar	Solo hosts pueden fragmentar

¿Sólo IPv6?

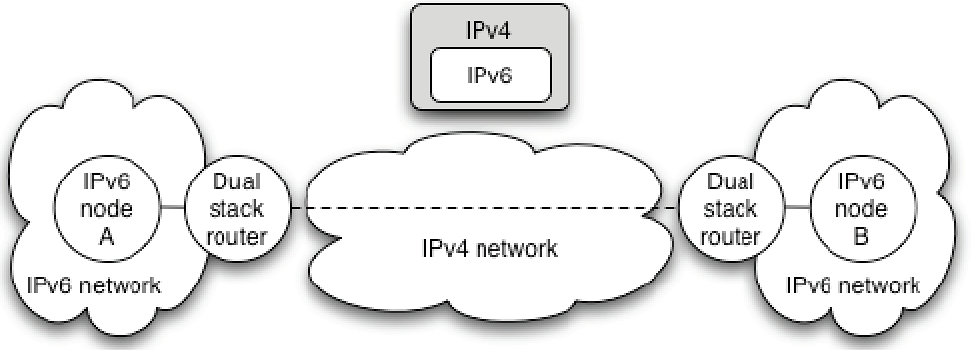
- Al desplegar IPv6, tienes 2 opciones:
  - Solo-IPv6
  - Desplegar IPv6 junto con
- IPv6 no está lo suficientemente desplegado en muchos productos, sin embargo esa soportado en muchos equipos de redes y prácticamente cualquier OS de computador
- Esto lleva a desplegar “Dual-Stack”
- Esto mejorará con el tiempo

Dual-Stack

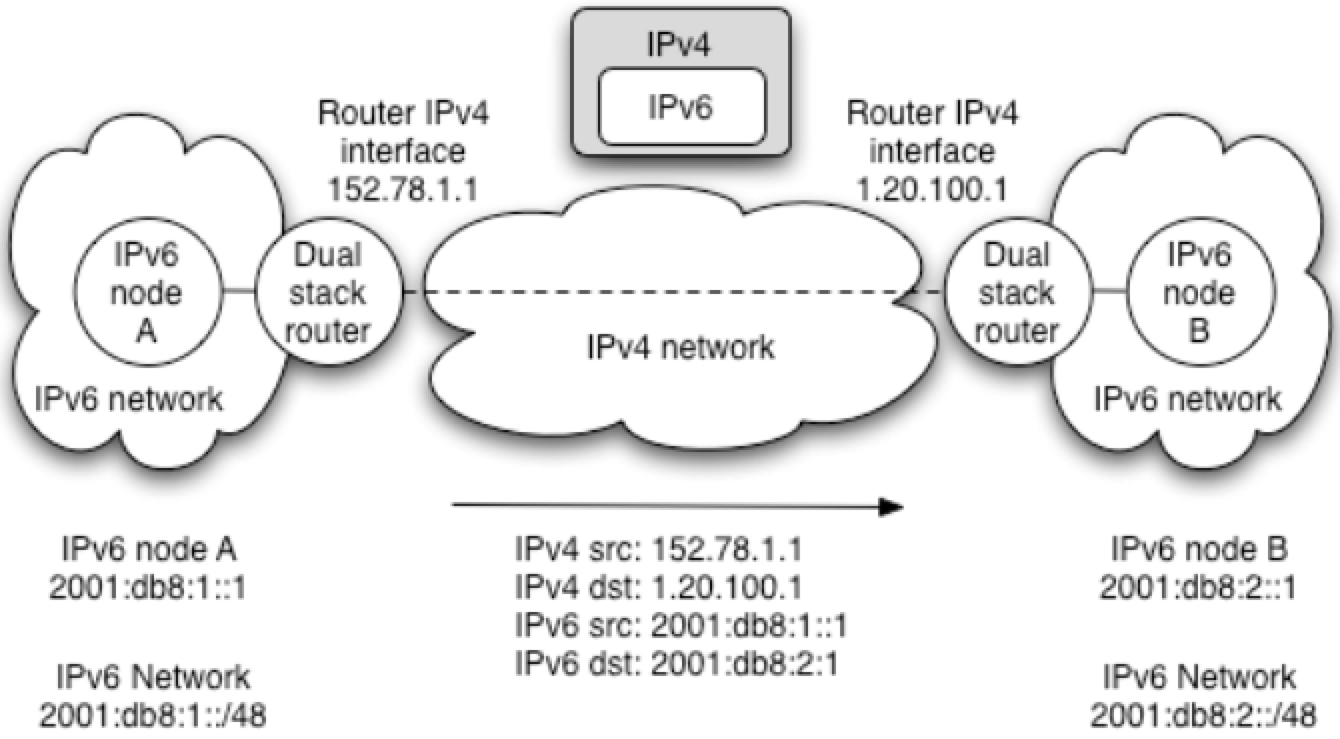
- Soporte de los dos protocolos en los enlaces y nodos seleccionados
- Requiere soporte en:
  - Hosts
  - Routers
  - Aplicaciones y servidores (e.g. web, DNS, SMTP)
- Añade consideraciones para:
  - Componentes de seguridad
  - Nuevas políticas dependientes de cualidades especificas de IPv6
- Puede correr IPv6 junto con NAT-ed IPv4

Túneles

- Paquete IPv6 dentro de paquete de IPv4
- Manuales
  - Tunnel Brokers
  - Site a Site
- Automáticos
  - 6to4
  - Teredo
- Hoy IPv6 en IPv4, en el futuro IPv4 en IPv6



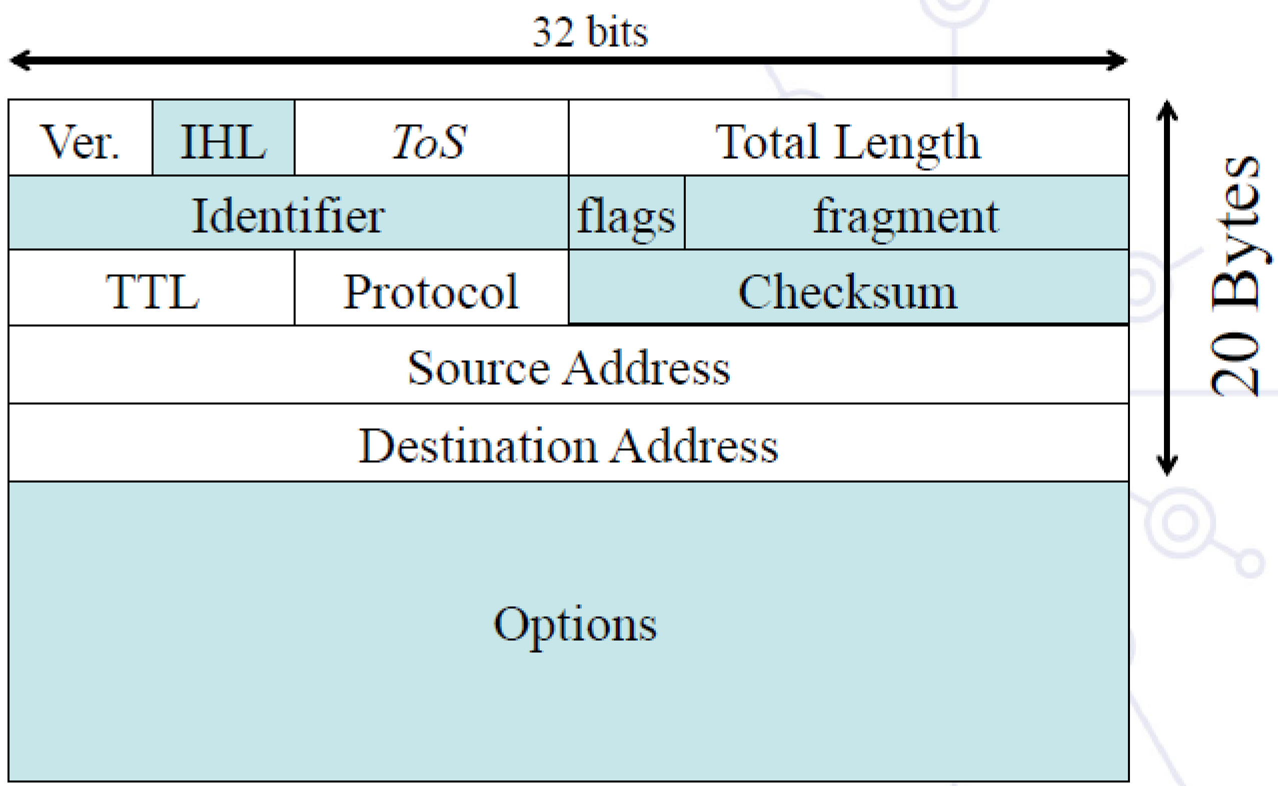
Tunnel addressing view



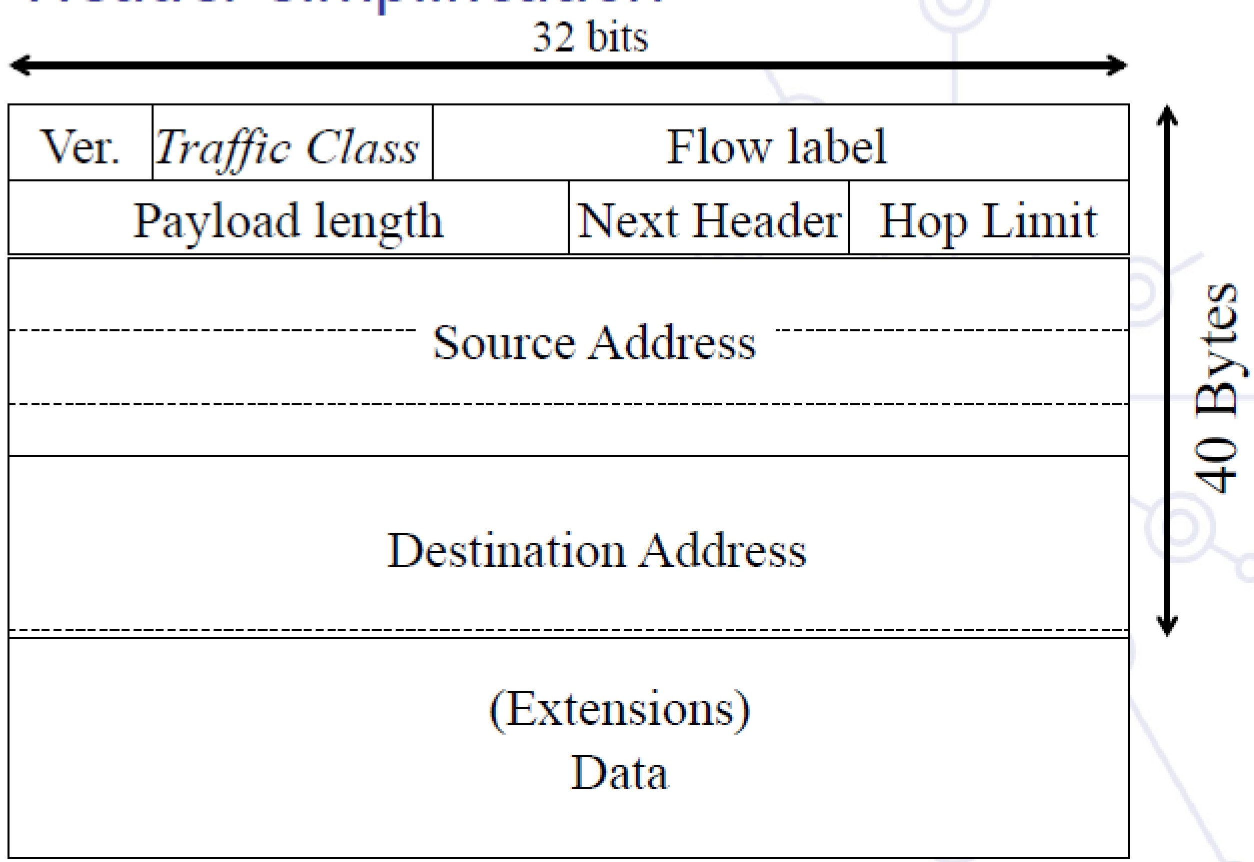
Para saber más y solicitar IPv6

- General
  - http://portalipv6.lacnic.net
  - http://www.nro.net
- Estadísticas
  - http://www.labs.lacnic.net
- Solicitud de IPv6
  - http://www.lacnic.net/sp/registro/

IPv4 Header


32 bits
Ver.
IHL
ToS
Total Length
Identifier
flags
fragment
TTL
Protocol
Checksum
Source Address
Destination Address
Options
20 Bytes

IPv6 Header simplification



IPv6: optional Extensions

New "mechanism" replacing IPv4 options

An IPv6 extension :

- Every extension has its own message format
- Is a n x 8-byte datagram
- Starts with a 1-byte 'Next Header' field
  - Pointing to either another extension or a L-4 protocol

Hop-by-hop (jumbogram, router alert)

- Always the first extension
- Analyzed by every router.

Destination

Routing (*loose source routing*)

Fragmentation

Security

- Authentication (AH)
- Encapsulating Security Payload (ESP) : confidentiality

Order is important (RFC 2460)

IPv6	
Hop by hop	Processed by every router
Destination	Processed by routers listed in *Routing extension*
Routing	List of routers to cross
Fragmentation	Processed by the destination
Authentication	After reassembling the packet
Security	Cipher the content of the remaining information
Destination	Processed **only** by the destination
Upper Layer	

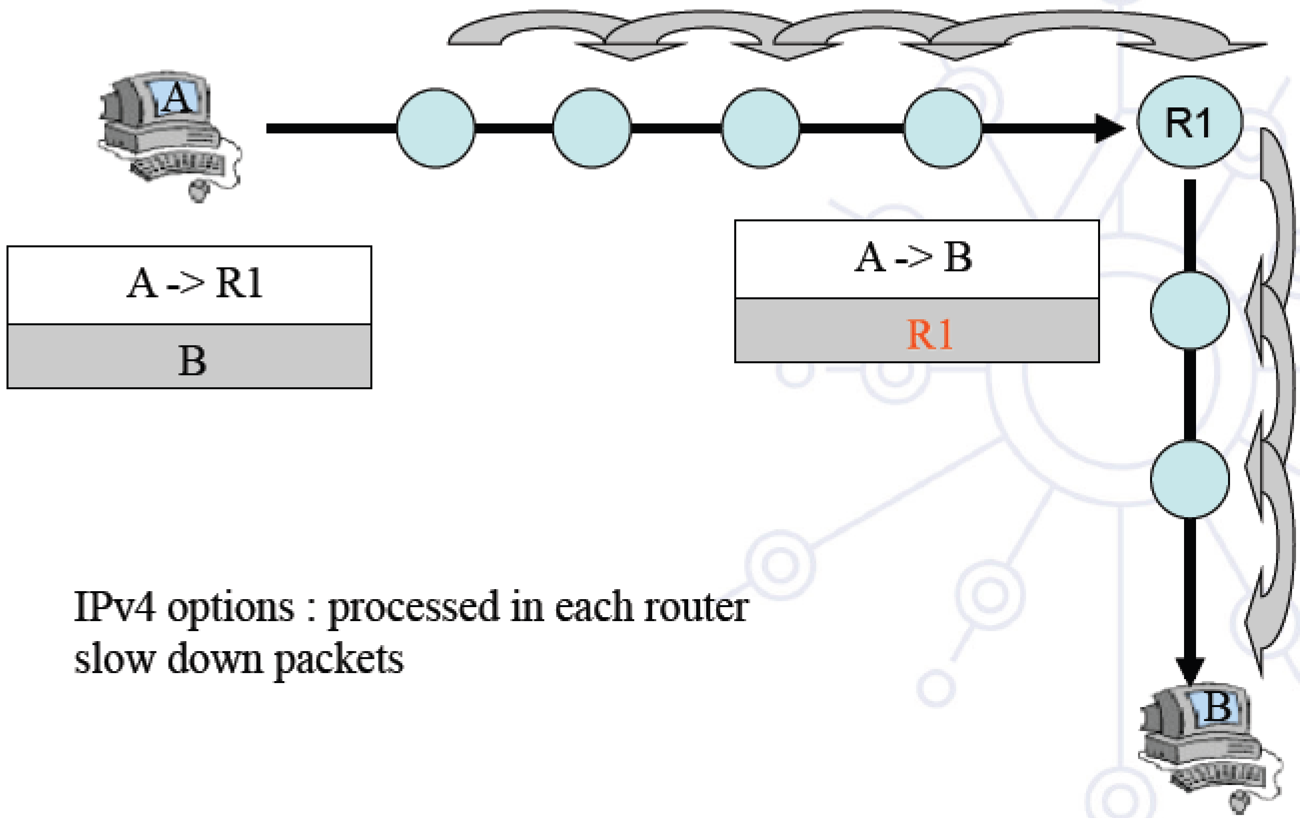
IPv6: Optional headers

IPv6 Header Next Header = TCP	TCP Header + DATA

IPv6 Header Next Header = Routing	Routing Header Next Header = TCP	TCP Header + DATA

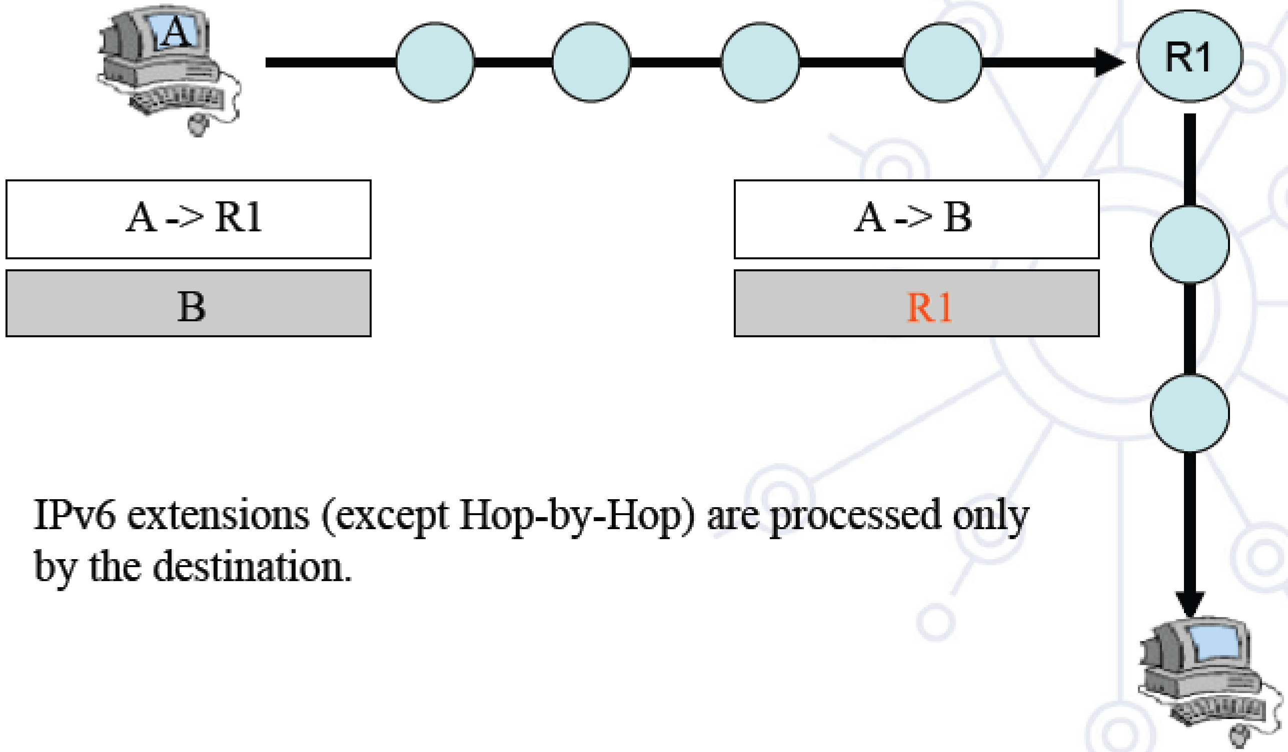
IPv6 Header Next Header = Routing	Routing Header Next Header = Fragment	Fragment Header Next Header = TCP	TCP Header + DATA

IPv4 header options processing



IPv4 options : processed in each router
slow down packets

IPv6 ext. header processing



IPv6 extensions (except Hop-by-Hop) are processed only by the destination.

Conclusion

Main changes in IPv6 protocol are within address format and datagram headers

- **A lot of fields in the IPv6 header have disappeared**
  - ⇒ More efficient processing in the (intermediate) routers
- **Optional extensions allow more functionalities (source routing, authentication, …)**
- **Optional header mechanism allows new options introduction without modifying the protocol**

IPv6 Address Types

Unicast (one-to-one)

- global
- link-local
- site-local (deprecated)
- Unique Local (ULA)
- IPv4-compatible (deprecated)
- IPv6-mapped

Multicast (one-to-many)

Anycast (one-to-nearest)

Reserved

Textual Address Format

Preferred Form (a 16-byte Global IPv6 Address):

2001:0DB8:3003:0001:0000:0000:6543:210F

Compact Format:

2001:DB8:3003:1::6543:210F

IPv4-mapped: **::FFFF:134.1.68.3**

Literal representation

- [2001:DB8:3003:2:a00:20ff:fe18:964c]
- http://[2001:DB8::43]:80/index.html

IPv6 Address Type Prefixes

Address Type	Binary Prefix	IPv6 Notation
Unspecified	00…0 (128 bits)	::/128
Loopback	00…1 (128 bits)	::1/128
Multicast	1111 1111	FF00::/8
Link-Local Unicast	1111 1110 10	FE80::/10
ULA	1111 110	FC00::/7
Global Unicast	(everything else)	
IPv4-mapped	00…0:1111 1111:IPv4	::FFFF:IPv4/128
Site-Local Unicast (deprecated)	1111 1110 11	FEC0::/10
IPv4-compatible (deprecated)	00…0 (96 bits)	::IPv4/128

Global Unicast assigments actually use 2000::/3 (001 prefix)

Anycast addresses allocated from unicast prefixes

Some Special-Purpose Unicast Addresses

Listed in RFC5156

The **unspecified address,** used as a placeholder when no address is available:

0:0:0:0:0:0:0:0 (::/128)

The **loopback address,** for sending packets to itself:

0:0:0:0:0:0:0:1 (::1/128)

The **documentation prefix [RFC3849]:**
2001:db8::/32

Interface IDs

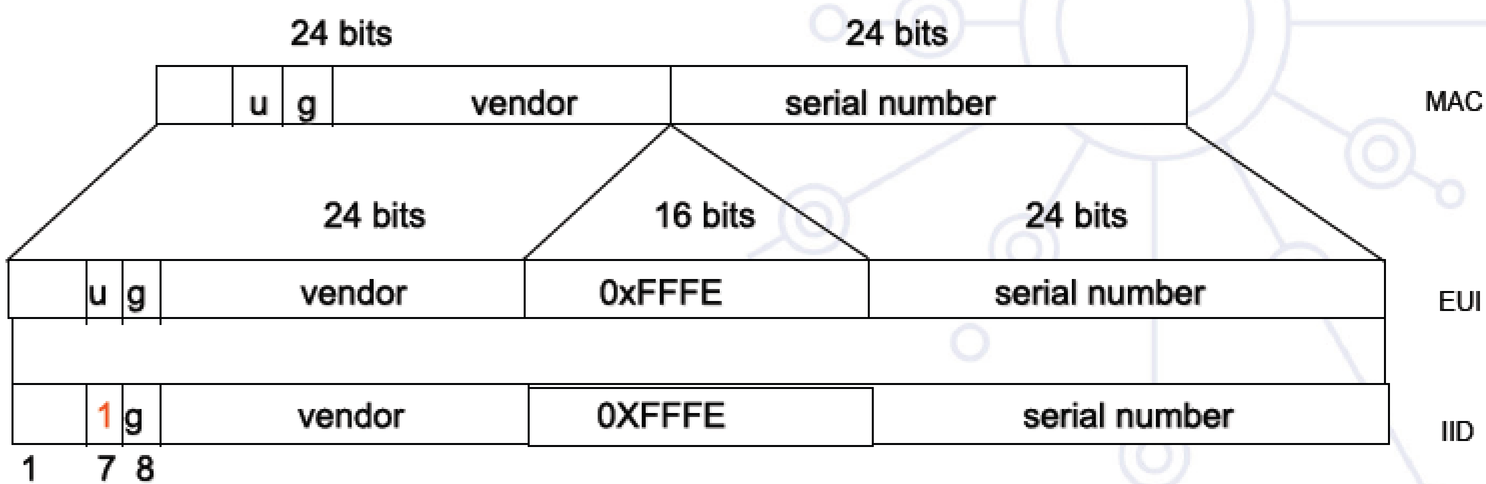
The lowest-order 64-bit field of unicast addresses may be assigned in several different ways:

- auto-configured from a 64-bit MAC address
- auto-configured from a 48-bit MAC address (e.g., Ethernet) expanded into a 64-bit EUI-64 format
- assigned via DHCP
- manually configured
- auto-generated pseudo-random number (to counter some privacy concerns)
- CGA (Cryptographically Generated Address)
- possibly other methods in the future

Network ID	Interface ID
64 bits	64 bits

Autoconfigured Interface IDs

- 64 bits to be compatible with IEEE 1394 (FireWire)
- Eases auto-configuration
- IEEE defines the mechanism to create an EUI-64 from IEEE 802 MAC addresses (Ethernet, FDDI)



Multicast Addresses

11111111	flags	scope	group ID
8	4	4	112 bits

Flags: 0RPT: The high-order flag is reserved, and must be initialized to 0.

- **T**: Transient, or not, assignment
- **P**: Assigned, or not, based on network prefix
- **R**: Rendezvous Point Address embedded, or not

Scope field:
1 - Interface-Local
2 - link-local
4 - admin-local
5 - site-local
8 - organization-local
E - global

(3,F reserved)(6,7,9,A,B,C,D unassigned)

Global Unicast Addresses

Defined in RFC3587

001	Glob. Rout. prefix	subnet ID	interface ID
	Global Routable Prefix (45 bits)	Subnet ID (16 bits)	Interface Identifier (64 bits)

The global routing prefix is a value assigned to a zone (site, a set of subnetworks/links)

- It has been designed as an hierarchical structure from the Global Routing perspective

The subnetwork ID, identifies a subnetwork within a site

- Has been designed to be an hierarchical structure from the site administrator perspective

Anycast Addresses

Identifier for a set of interfaces (typically in different nodes). A packet sent to an anycast address is delivered to the "nearest" interface (routing protocols' distance)

Taken from the unicast address space (of any scope).**Not syntactically distinguishable from unicast addresses**

A unicast address assigned to more than one interface, turning it into an anycast address, the nodes the address is assigned must be explicitly configured to know that it is an anycast address

Reserved anycast addresses are defined in **RFC2526**

The Subnet-Router anycast address is predefined (mandatory on all routers):

n bits	*128 – n bits*
Subnet Prefix	00..00

RIR Allocation Policies

AfriNIC:
http://www.afrinic.net/IPv6/index.htm
http://www.afrinic.net/docs/policies/afpol-v6200407-000.htm *

APNIC:
http://www.apnic.org/docs/index.html
http://www.apnic.org/policy/ipv6-address-policy.html *

ARIN:
http://www.arin.net/policy/index.html
http://www.arin.net/policy/nrpm.html#ipv6 *

LACNIC:
http://lacnic.net/sp/politicas/
http://lacnic.net/sp/politicas/ipv6.html *

RIPE-NCC:
http://www.ripe.net/ripe/docs/ipv6.html
http://www.ripe.net/ripe/docs/ipv6policy.html *

- *describes policies for the allocation and assignment of globally unique IPv6 address space

RIR Allocation Statistics

AfriNIC:

- http://www.afrinic.net/statistics/index.htm

APNIC:

- http://www.apnic.org/info/reports/index.html

ARIN:

- http://www.arin.net/statistics/index.html

LACNIC:

- http://lacnic.org/sp/est.html

RIPE-NCC:

- http://www.ripe.net/info/stats/index.html

See http://www.ripe.net/rs/ipv6/stats/