

IPv6

Internet Protocol Version 6

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Part 1 - An Introduction

- Why?
- What do we get with IPv6?
- IPv6 Header
- Addresses
- Neighbour Discovery
- Auto-Configuration
- DNS

Part 2 - IPv4 to IPv6 Migration

- The Problems
- IPv4 <-> IPv6 Interworking - NOT!
- Dual Stack
- IPv6 in a sea of IPv4 - Tunnelling schemes
Static, 6to4, ISATAP, etc
- IPv6 Trial & Deployment Service @ Leeds

Why?

- Historic 1990's...
 - Address Exhaustion
 - Lack of Network Numbers -
IPv4 Class A/B/C not flexible enough
 - Too Many Routes for Core Routers
 - Potentially EVERY class A/B/C IPv4 Network
would have to be held in Core Routers
- But IPv4 has evolved...
 - NAT and use of private address space has eased exhaustion
 - CIDR, address aggregation + Moore's Law has eased core
router problem

What do we get? (RFC2460)

- New Header format - Better Option structure
- 128 bit addresses (but are there enough?)
<http://ispcolumn.isoc.org/2005-07/ipv6size.html>
- New ICMPv6 and Neighbour Discovery
- No Broadcasts - lots of new IPv6 MultiCast
- No fragmentation by routers - PMTUD -
min. MTU 1280
- Autoconfiguration and Router discovery
- Complexity, Big Hex Numbers and Head Aches!

Header Format (cont.)

-.../

Next Header	8-bit selector. Identifies the type of header immediately following the IPv6 header. Uses the same values as the IPv4 Protocol field [RFC-1700 et seq.].
Hop Limit	8-bit unsigned integer. Decrement by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.
Source Address	128-bit address of the originator of the packet.
Destination Address	128-bit address of the intended recipient of the packet (possibly not the ultimate recipient, if a Routing header is present).

Addresses - 1 (RFC2373)

- 128 bits long - 4 x IPv4 address length
- Written as 8 x 16 bit HexaDecimal Numbers
e.g. 2001:630:62:15A:240:63FF:FEC5:8110
A sequence of zero 16 bit words can be abbrev. "::"
e.g. ::1 localhost - equiv. to IPv4 127.0.0.1
FE80::240:63FF:FEC5:8110 link local add of above
- Network/Interface Parts
Nearly Always the lower 64 bits are the Interface Identifier
equiv. to IPv4 host address
The higher 64 bits are the network number

Addresses - 2

- Classless, Structured & Aggregatable
- Allocated in "blocks", hierarchically
- NOT owned, but merely loaned!
e.g. if you change ISP you get a new network number
- Prefixes are indicated by appending a '/' and the prefix length.

e.g. JANET is the Network 2001:630::/32

UoL is the network 2001:630:62::/48

this address space allows 65536 /64 subnets

SoC would be 2001:630:62:144::/64

Addresses - 3

- Some IETF defined top-level prefixes...
 - 2000::/3 Aggregatable Global Unicast Addresses
(Any address beginning with 2 or 3)
 - FF00::/8 Multi-Cast Addresses
 - FE80::/10 Link-Local Unicast Addresses
 - FEC0::/10 Site-Local Unicast Addresses
- A Couple of Defined addresses...
 - ::/128 THE unspecified address
 - ::1/128 loopback address

Addresses - 4

- Interface Identifiers (Host part 64 bits)...

Take 48 bit IEEE MAC Address, Insert the 16 bits "FFFE" in the middle and set the 0x02 bit (u-bit) in the first byte.

MAC 00:40:63:C5:81:10

Int. Id. 0240:63FF:FEC5:8110

If no MAC address is available, e.g. serial links, Local Interface Identifiers can be manually assigned with the u-bit set to '0'. e.g. 0:0:0:1

Neighbour Discovery (RFC2461)

- The IPv6 replacement for IPv4 ARP
- Uses MultiCast and IPv6 ICMP
 - Hosts listen on a Solicited Node MultiCast Address for each Unicast Address used
- S.N.Mc.A formed by the last 3 bytes of Unicast address appended to FF02::1:FF00:0000/104
- To find MAC add for an IPv6 add :-
 - Sender sends an ICMPv6 Neighbour Solicitation packet to the S.N.Mc.A.
 - Recipient returns an ICMPv6 Neighbour Advertisement packet.

Stateless AutoConfiguration (RFC2462)

- On Initiation a Host configures each I/F with a Link local address - FE08::(InterfaceID)/64
- Then sends a Router Solicitation message to the All Router MultiCast Add: FF02::2
- Router Responds with a Router Advertisement which gives, among other things:
 - Network Prefix(es) for the link (subnet)
 - Whether the router is the Default Router
 - Whether Hosts should use DHCPv6 for further config.

DNS

- Simple - RFC1886 :-
 - defines new DNS AAAA records
 - work like A records but return IPv6 adds
 - Reverse entries - IPv6 add. is reversed, split into each HEX digit separated by '.' and suffixed withipv6.arpa
- Complex - RFC2874 :-
 - defines new DNS A6 records
 - has facilities for handling Network Renumbering

IPv6

INTERMISSION

Migration - the Problem

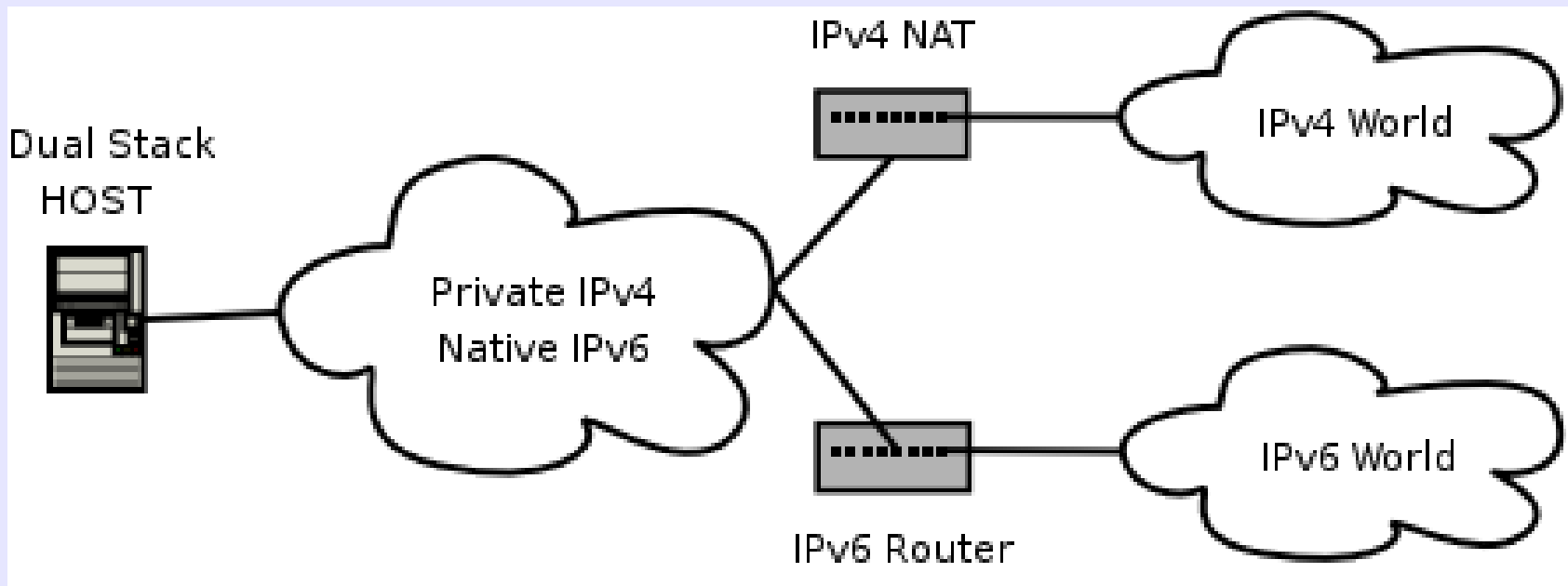
- **IPv4 shall speak unto IPv4 only**
- **IPv6 shall speak unto IPv6 only**

IPv4 <-> IPv6 Interworking

- NAT-PT RFC2766
 - Network Address Translation - Protocol Translation
 - rewrite IP headers
 - ICMPv4 <-> ICMPv6 conversion/problems
 - Has all the usual NAT problems, plus a whole lot more
- Transport Level Proxies
 - has similar problems to NAT-PT
- Application Level Proxies
 - Less Flexible - Less Problems
 - e.g. Web Proxy with IPv6 and IPv4 interfaces

Dual Stack

- Hosts Support both IPv4 and IPv6 stacks
 - Use dictated by application, DNS or configuration
- Typical scenario...

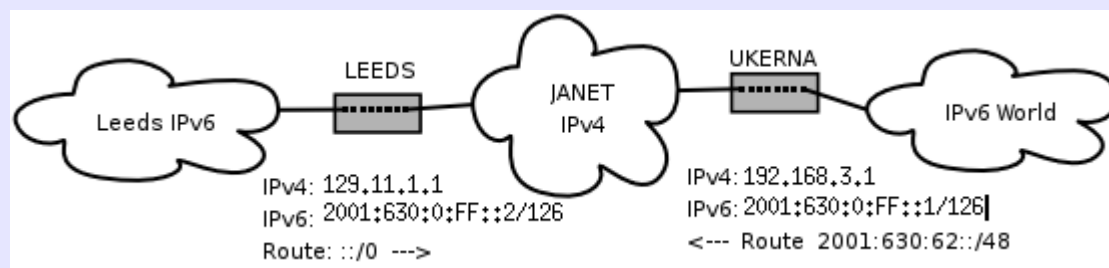


IPv6 in a Sea of IPv4

- Schemes for connecting IPv6 devices across IPv4 networks :-
 - Static Tunnels
 - Obsolete/Deprecated schemes e.g. IPv4 compatible IPv6 Addresses, 6Over4 (RFC2529), etc
 - 6to4 (RFC3056)
 - ISATAP (RFC4214), TEREDO (RFC4380)
- All schemes end up Tunnelling IPv6 packets in IPv4 frames

Static Tunnelling

- Requires Manual Configuration at each end of Tunnel of following :-
 - Remote IPv4 address
 - Local IPv6 Tunnel Interface address
 - IPv6 Routing
- IPv6 packets are the Data Payload of IPv4 protocol type 41 Datagrams

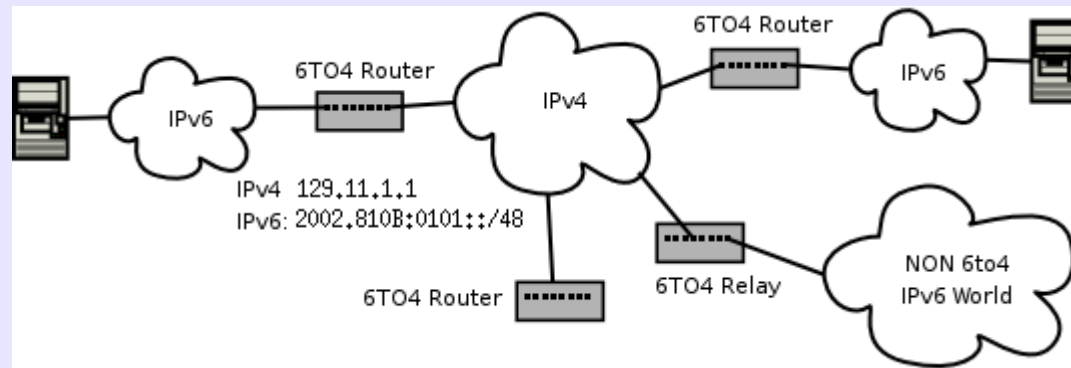


- Does not scale for general deployment

IPv6

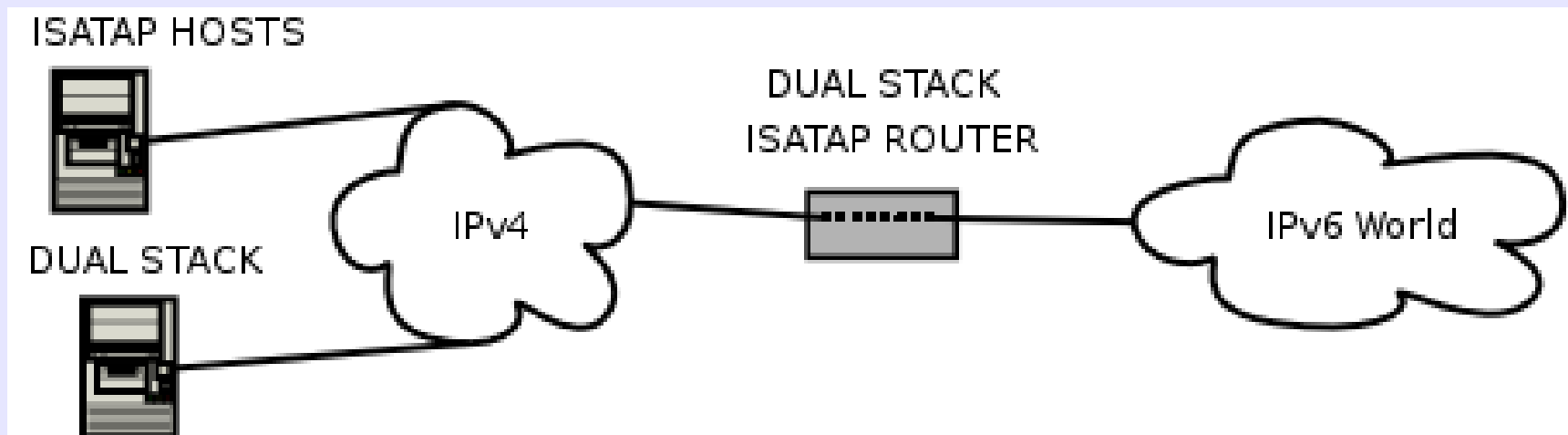
6TO4 (RFC3056)

- An IPv6 Prefix Allocation scheme based on Non-Private IPv4 addresses, and an automatic tunnelling scheme
- 6TO4 uses prefixes like: 2002:(IPv4 add)::/48
e.g. 2002:810B:0101::/48
- Tunneling uses usual IPv4 protocol 41



ISATAP (RFC4214)

- IPv6 Host add. allocation scheme and auto-tunnelling mechanism for 1st/last HOP (host <-> router) IPv6 connection across IPv4 networks



ISATAP creates Interface IDs of form `...:0200:5EFE:IPv4Add:`
These are used to create link-local and routable IPv6 Addresses
(see RFC3932 for issues)

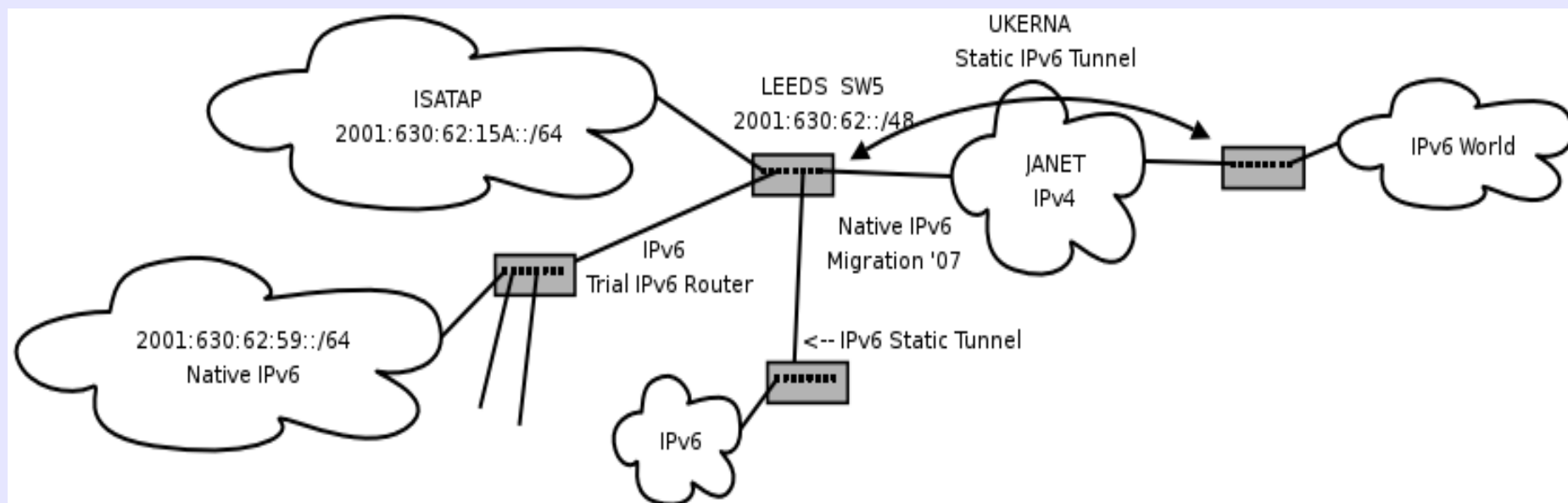
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ISATAP (cont.)

- IPv4 address of ISATAP router is either:
 - Manually Configured
 - Got by DNS lookup of well known name
e.g. isatap.site.domain.name
- Hosts send Router Solicitations over ISATAP tunnels and use the Router Advertisements to configure Routable IPv6 addresses and assign the default router

IPv6

U.o.L. IPv6 Trial & Deployment



- Trial to Service (Best Efforts) Q4/06
- Native IPv6 across Core Q3/07
- IPv6 Enabled on LANs, on request Q4/07
- IPv6 Enabled everywhere Q3/08 -->