Global IPv6 Summit – Madrid, May 2003

Routing and Addressing in IPv6

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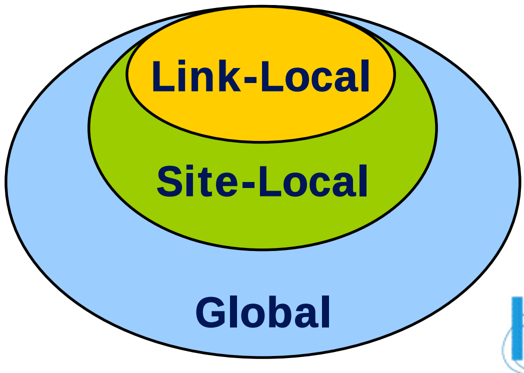
IPv6 FORUM

Contents

IPv6 Addressing Model (I)

- Defined in RFC 3513: IP Version 6 Addressing Architecture
- Addresses of 128 bits
  - more than 10^{38} possible addresses
  - more than 1500 addresses per m^2 having into account hierarchical assignment losses –and being pessimistic- (C. Huitema)
- Addresses are assigned to interfaces
  - Multiple addresses per interface
- Subnet prefix associated with one link:
  - Multiple subnet prefixes may be assigned to a link.
- Addresses have scope
  - Link-Local
  - Site-Local (being deprecated)
  - Global



IPv6 Addressing Model (II)

- Address Structure:
  - IPv6 Address = Prefix + Interface Id
- Separation of "who you are" from "where you are connected to"
  - Prefix: depends on routing topology
  - Interface Id: identifies a node
- New Anycast addresses:
  - Unicast: from one host to another
  - Multicast: from one to all belonging to a group
  - Anycast: from one to the nearest belonging to a group
- Broadcast disappears (superseded by multicast)

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Text Representation of Addresses (I)

- Preferred form:

  X:X:X:X:X:X:X:X (X = 2 bytes written in hex.)

- Example:

  3ffe:3328:4:3:250:4ff:fe5c:b3f4

- Contiguous zeros can be eliminated:

  FF01:0:0:0:0:0:0:43 = FF01::43

- IPv4-compatible IPv6 addresses:

  0:0:0:0:0:0:194.179.46.78 = ::194.179.46.78

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- Prefix representation (CIDR notation):
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- Literal Addresses in URLs (RFC 2732)
  - http://[2001::4:FEDC:BA98:7654:210]:80/index.html

IPv6 Assigned Prefixes

- Address type indicated by high-order bits of the address (formerly known as *Format Prefix):*

Type	FP	Fraction	Prefix
Link-Local	**1111 1110 10**	**1/1024**	**FE80::/10**
Site-Local	**1111 1110 11**	**1/1024**	**FEC0::/10**
Multicast	**1111 1111**	**1/256**	**FF00::/8**
Global Unicast (everything else)	**001**	**1/8**	**2000:/8**

- Anycast addresses allocated from unicast prefixes
- Future specifications may redefine sub-ranges of global unicast space for other purposes:
  - implementations must treat all addresses that do not start with any of the above-listed prefixes as global unicast addresses.

DNS Modifications for IPv6

- New DNS record types for IPv6:
  - AAAA record (quad A). Defined in RFC 1886. Equivalent to A records for IPv4 but allowing 128 bits addresses
  - PTR record: for inverse resolutions under ip6.arpa (ip6.int initially)
    - Example: to resolve 4321:0:1:2:3:4:567:89ab into a name, we ask for the PTR record of:

      b.a.9.8.7.6.5.0.4.0.0.0.3.0.0.0.2.0.0.0.1.0.0.0.0.0.0.0.1.2.3.4.ip6.arpa.
  - A6 record. Defined in 2874. Stores IPv6 address following network hierarchy to simplify renumbering.
  - DNAME and Binary Labels records: to easy renumbering for inverse resolution
- AAAA preferred to A6 (RFC3363):
  - A6, DNAME and Binary Labels need to be better understood before deployment
  - Moved to experimental standards

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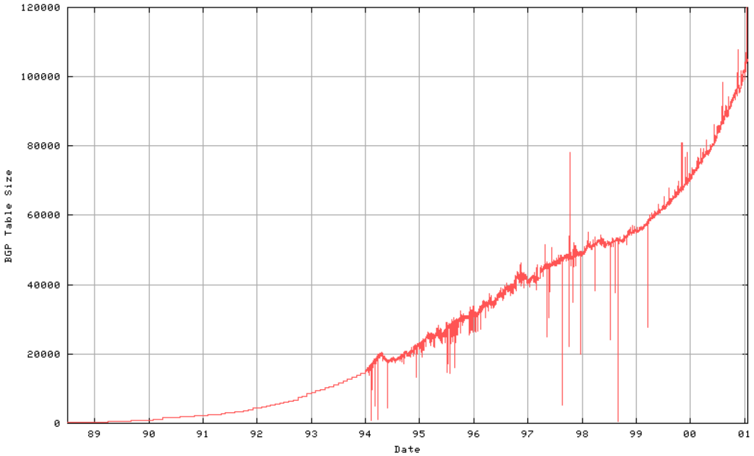

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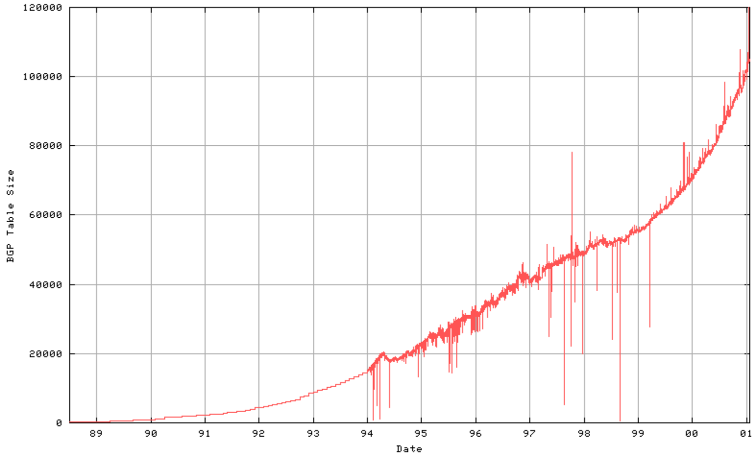

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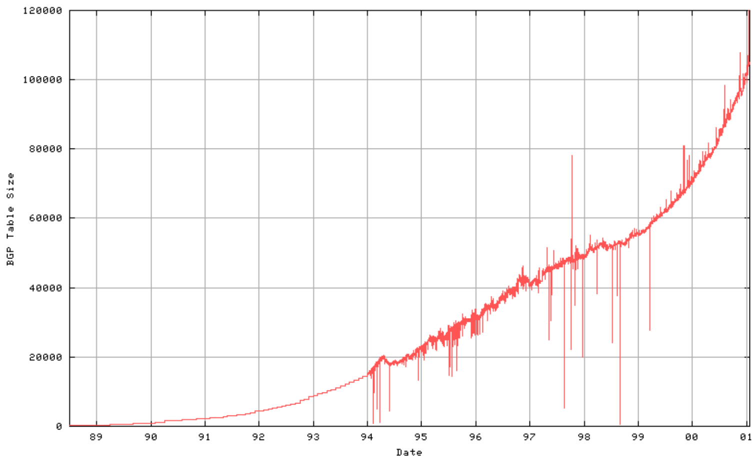

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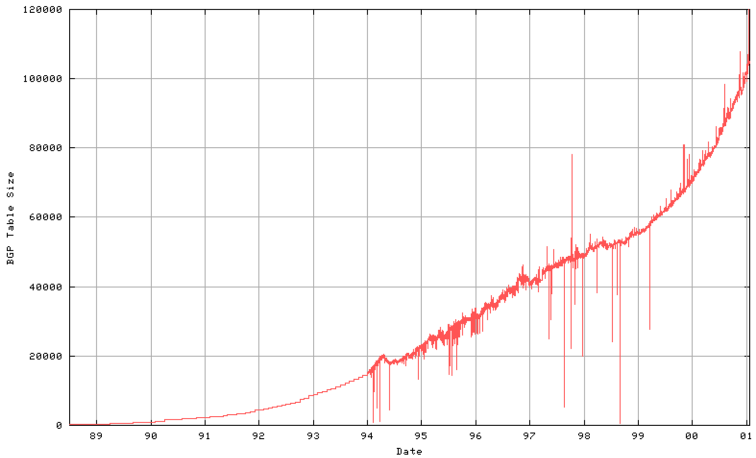

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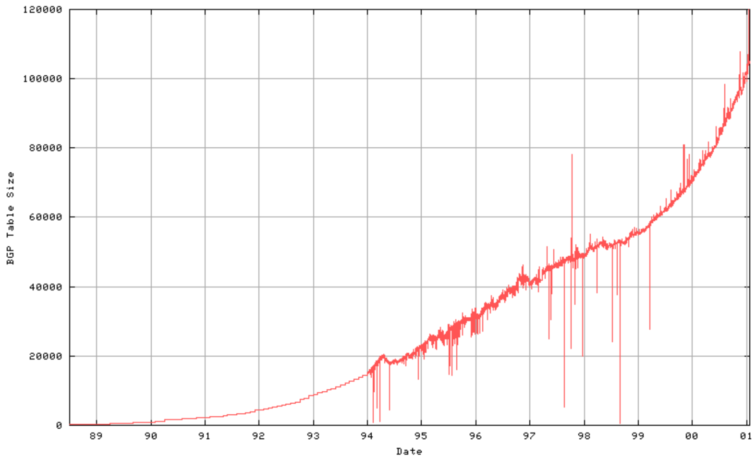

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  - Public Topology: providers and exchanges that offer Internet transit services.
  - Site Topology: local topology of a site that does not offer transit services to nodes external to its organization.
  - Interface Identifier: unique identifier assigned to any interface connected to Internet.

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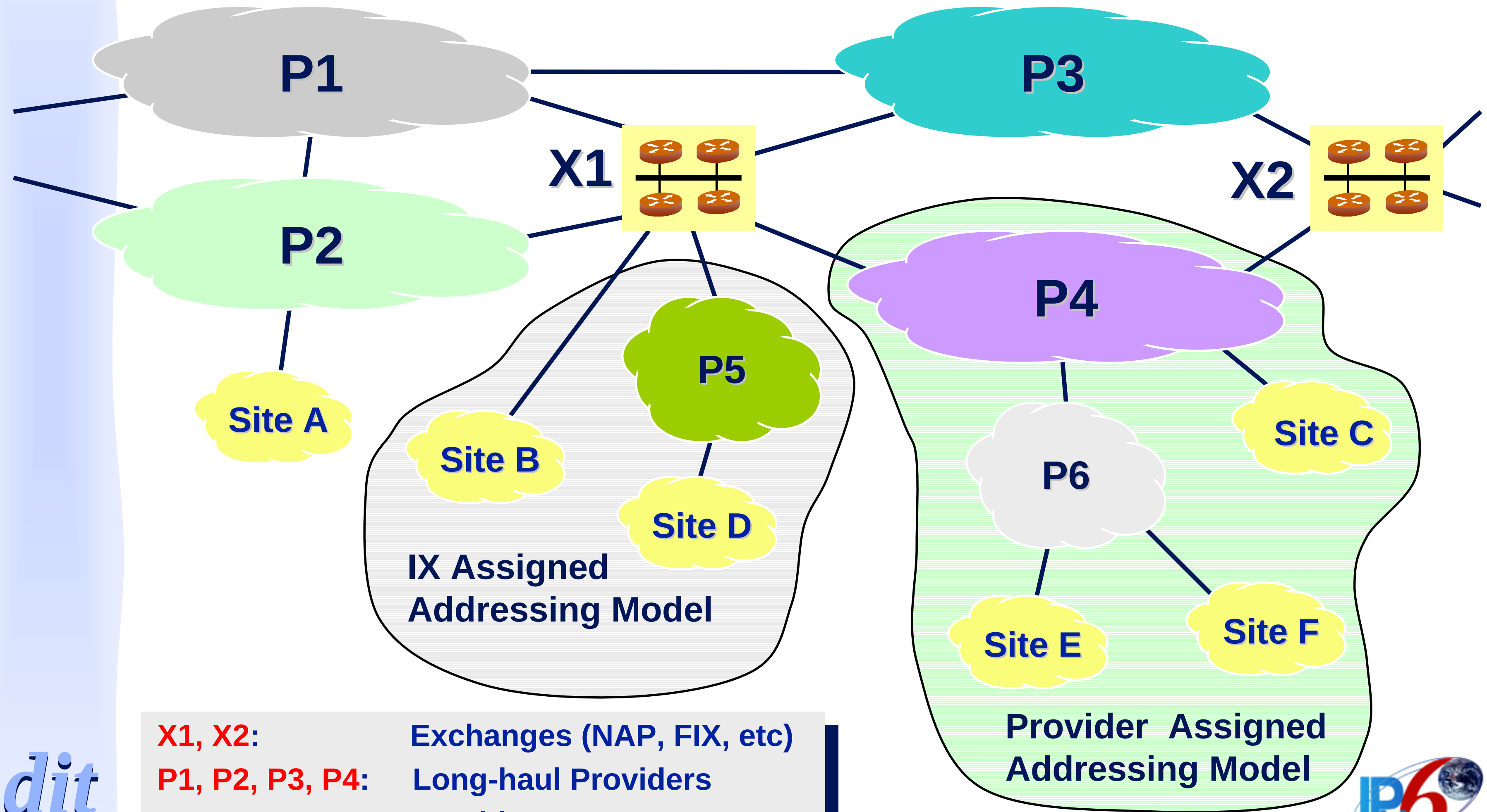
- Initially defined for prefix 2000::/3 (addresses beginning by 2XXX:... and 3XXX:...)
  - but now being extended to all Global Unicast prefixes

Public Topology



X1, X2:	Exchanges (NAP, FIX, etc)
P1, P2, P3, P4:	Long-haul Providers
P5, P6:	Providers

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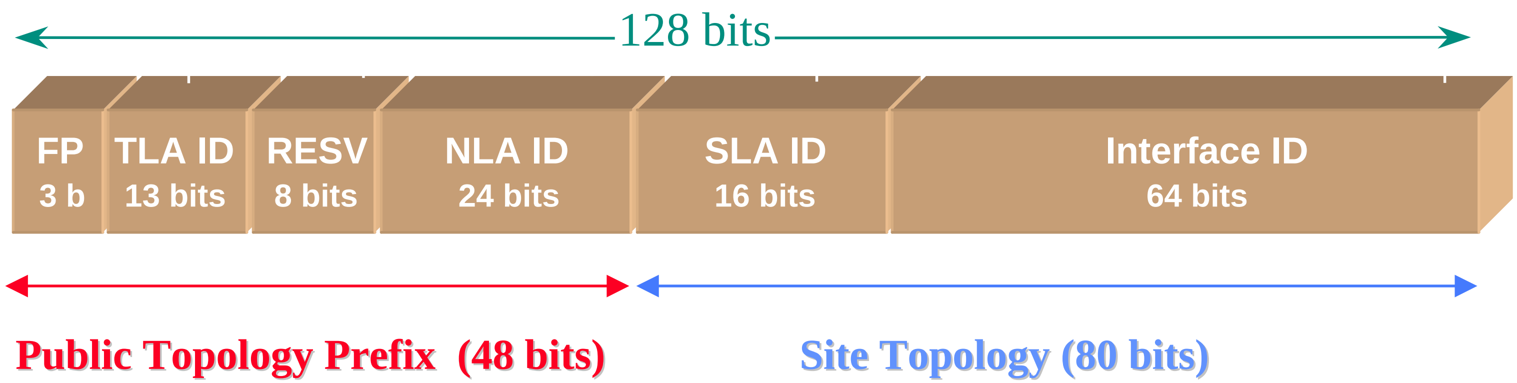
- Hierarchical model: addresses depend strictly of network topology
- Two types of Aggregation:
  - Per Provider: addresses depend on the provider we are connected to
  - Per Exchange: addresses depend on the Exchange we are connected to
- Consequences:
  - If we change Provider or Exchange, we need to *RENUMBER* our network. (The same happens if the provider of our provider changes)
  - IPv4 *multihomming* techniques not allowed

NLA/TLA Addressing Scheme

- Global Aggregatable Unicast Addresses (RFC2374):



FP	Format Prefix (001)
TLA ID	Top-Level Aggregation Identifier
RESV	Reserved (to enlarge TLA o NLA)
NLA ID	Next-Level Aggregation Identifier
SLA ID	Site-Level Aggregation Identifier
Interface ID	Interface Identifier (EUI-64)

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OBSOLETED

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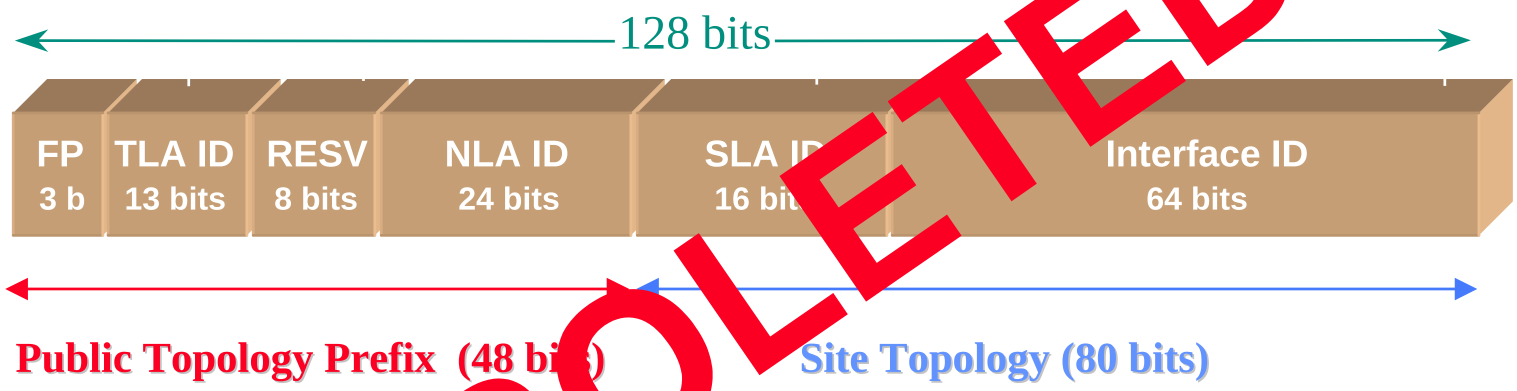

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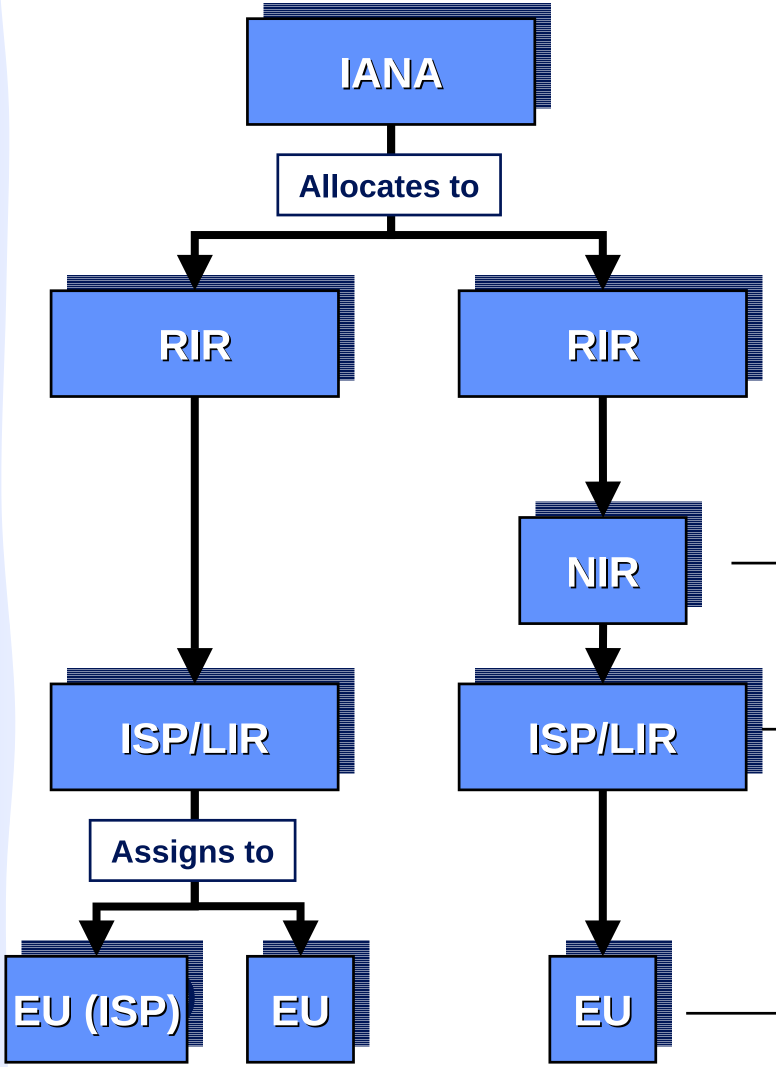
New Addressing Scheme

- Basic unicast address format defined in “IPv6 Global Unicast Address” <draft-ietf-ipv6-unicast-aggr-v2-02.txt>, Feb 2003

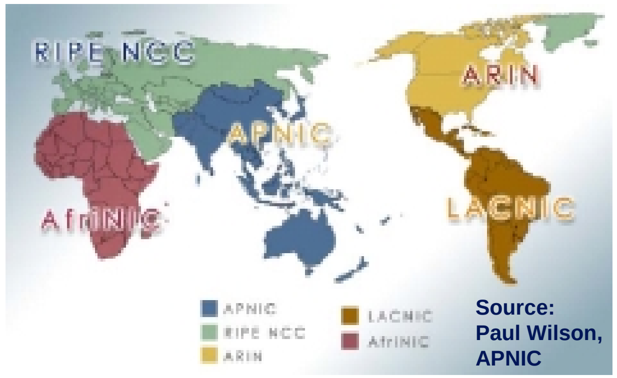
Global Routing Prefix	Subnet ID	Interface ID
n bits	64-n bits	64 bits

- NLA/TLA disappears
- SLA maintained under “Subnet ID” name
- Further structure left to regional registries
  - “...allocation of IPv6 addresses is related to policy and to the stewardship of the IP address space and routing table size which the RIRs have been managing for IPv4”

Address Delegation Hierarchy



Regional Internet Registries:



National Internet Registries (APNIC region)

Local Internet Registries (ISP's)

End Users

RIRs IPv6 Address Allocation and Assignment Policy

- Jointly defined by ARIN, APNIC and RIPE
  - see RIPE-267, January 2003
- Based on RFC recommendations 3177 from IETF
- Definition of policies for the assignment and allocation of globally unique IPv6 addresses to Internet Service Providers (ISPs) and other organizations
  - considered to be an interim policy
  - It will be reviewed in the future, subject to greater experience in the administration of IPv6.
- Goals:
  - Uniqueness, Registration, Aggregation, Conservation, Fairness, Minimized overhead
  - Aggregation is the most important
- Main design decision: fixed prefixes boundaries (/32, /48, /64)

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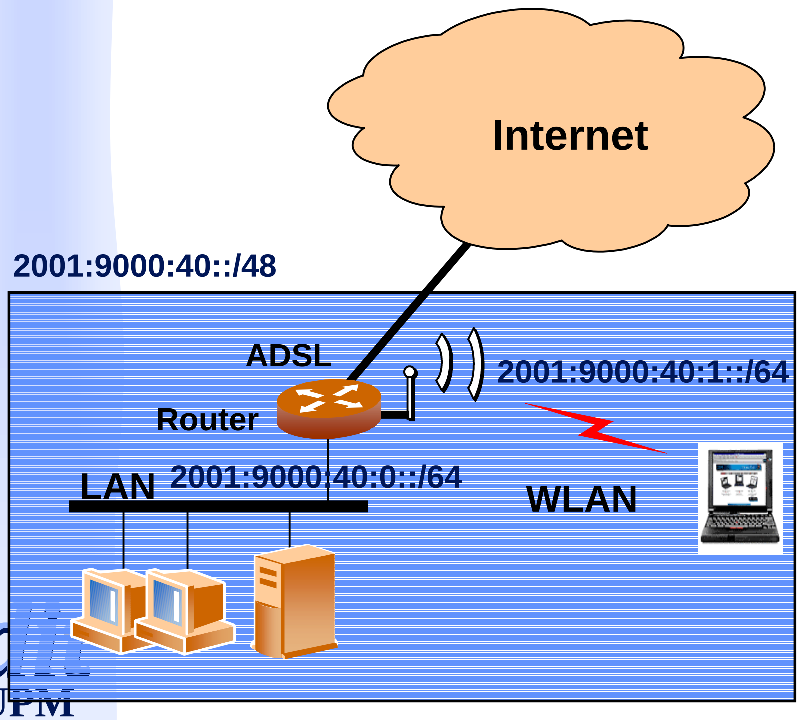
Policies for Allocations and Assignments

- Minimum allocation size by RIRs: /32
- ALLOCATION to LIRs (ISP):
  - Initially: /32
    - If they plan for making at least 200 /48 assignments to other organizations within two years.
  - Subsequent /32 allocations when justified (HD-ratio of 0.8)
- ASSIGNATION to End Sites:
  - In general: /48 (16 bits for end-site subnets)
    - except for very large subscribers (multiple /48 when justified)
    - Same allocation for home network subscribers (on-demand or always-on connections), small and large enterprises
  - when known that only one subnet is needed by design: /64
    - Ex: Mobile networks, such as vehicles or mobile phones with an additional network interface
  - when known that only one device is connecting: /128
    - Ex: PPP connection
- REGISTRATION:
  - Address allocations must be register in a database accessible by RIRs

Example: Home ADSL network

- Requirements:
  - two /64 prefixes for LAN and WLAN
- Assigning a /48 means assigning 65536 prefixes!!



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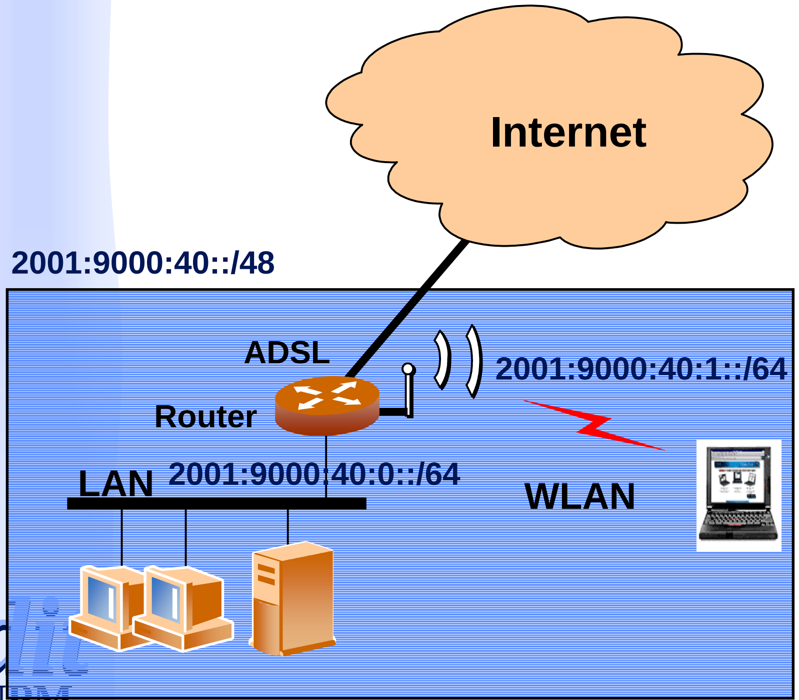

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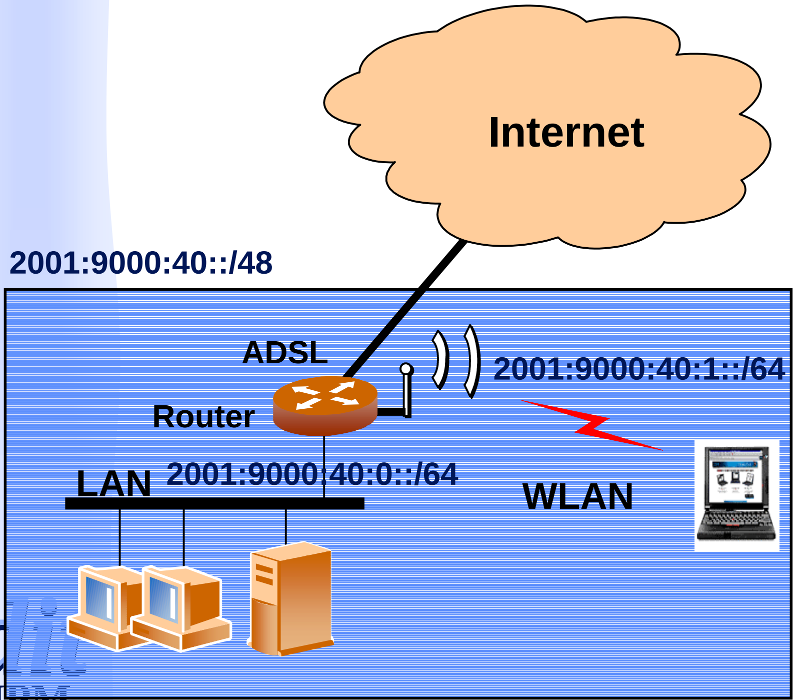

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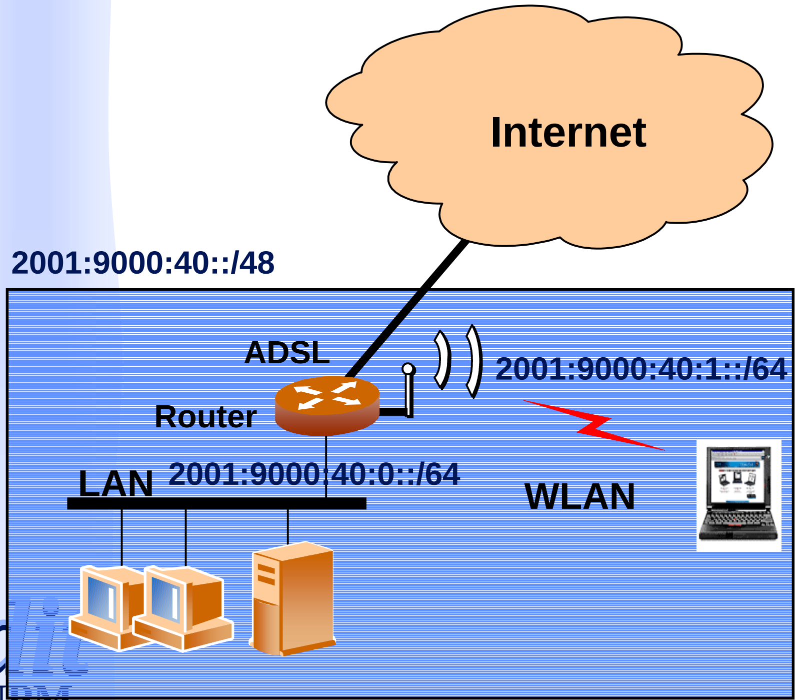

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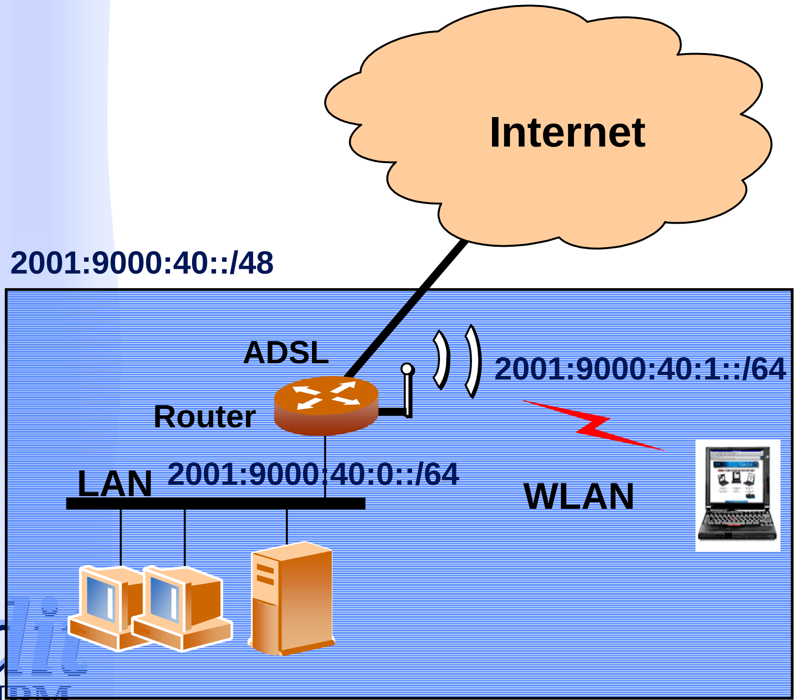

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- There are more than 35 trillions of /48 prefixes
- Even taking into account assignation losses:
  - At least 178.000 millions of /48 prefixes available
- Advantages of fixed boundary:
  - Easy change of ISP
  - Easy renumbering
  - Easy multihoming
  - Easy growth of subscriber networks
  - No need to judge sites' needs

Routing Header

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- Main applications:
  - Provider Selection (combined with anycast addresses)
  - Mobility

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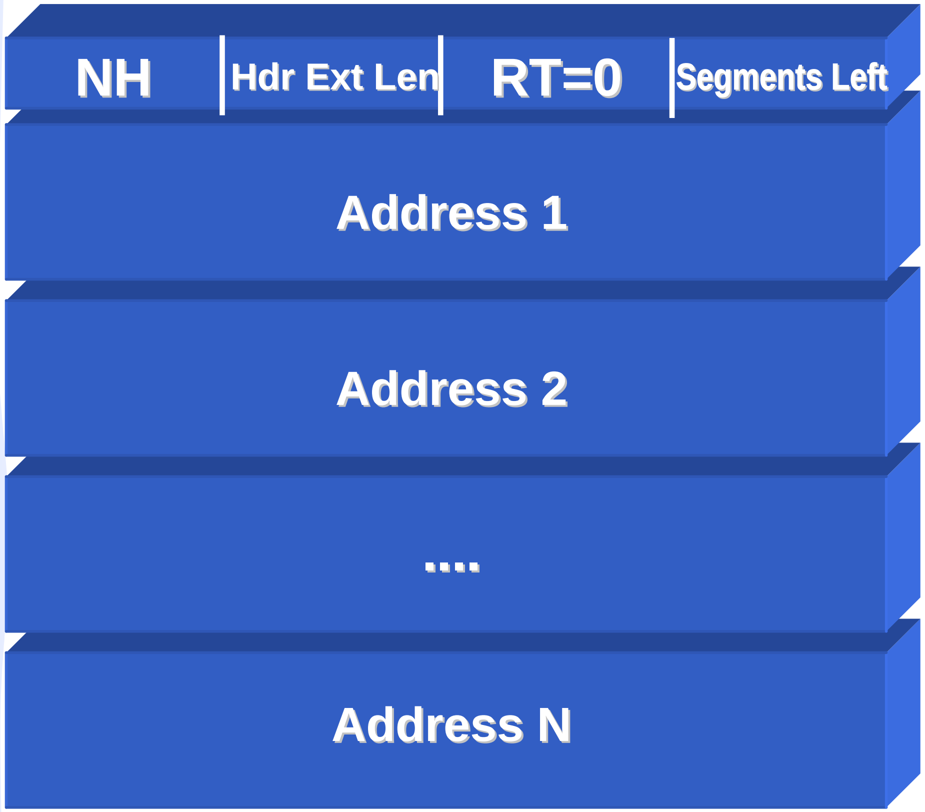

Routing Header

- Format:

- Differences with IPv4:
  - Datagram destination address is substituted by the next address in the list.
  - Responses to datagrams with RH must include the same RH but with the list of addresses inverted.
  - Strict/loose option eliminated
- RH security issues being discussed

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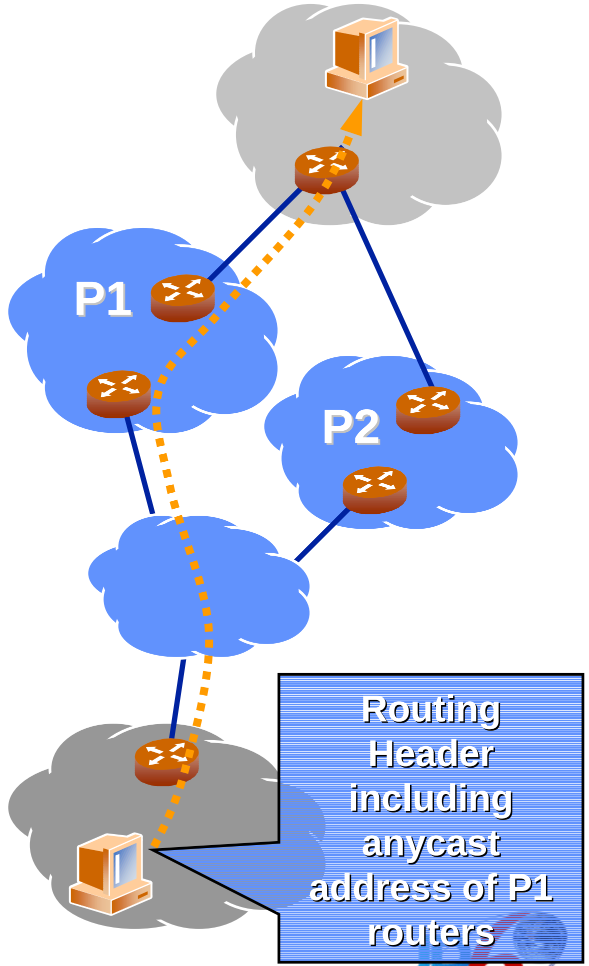
- They are experimental. They can be used, for example, to enable Provider Selection



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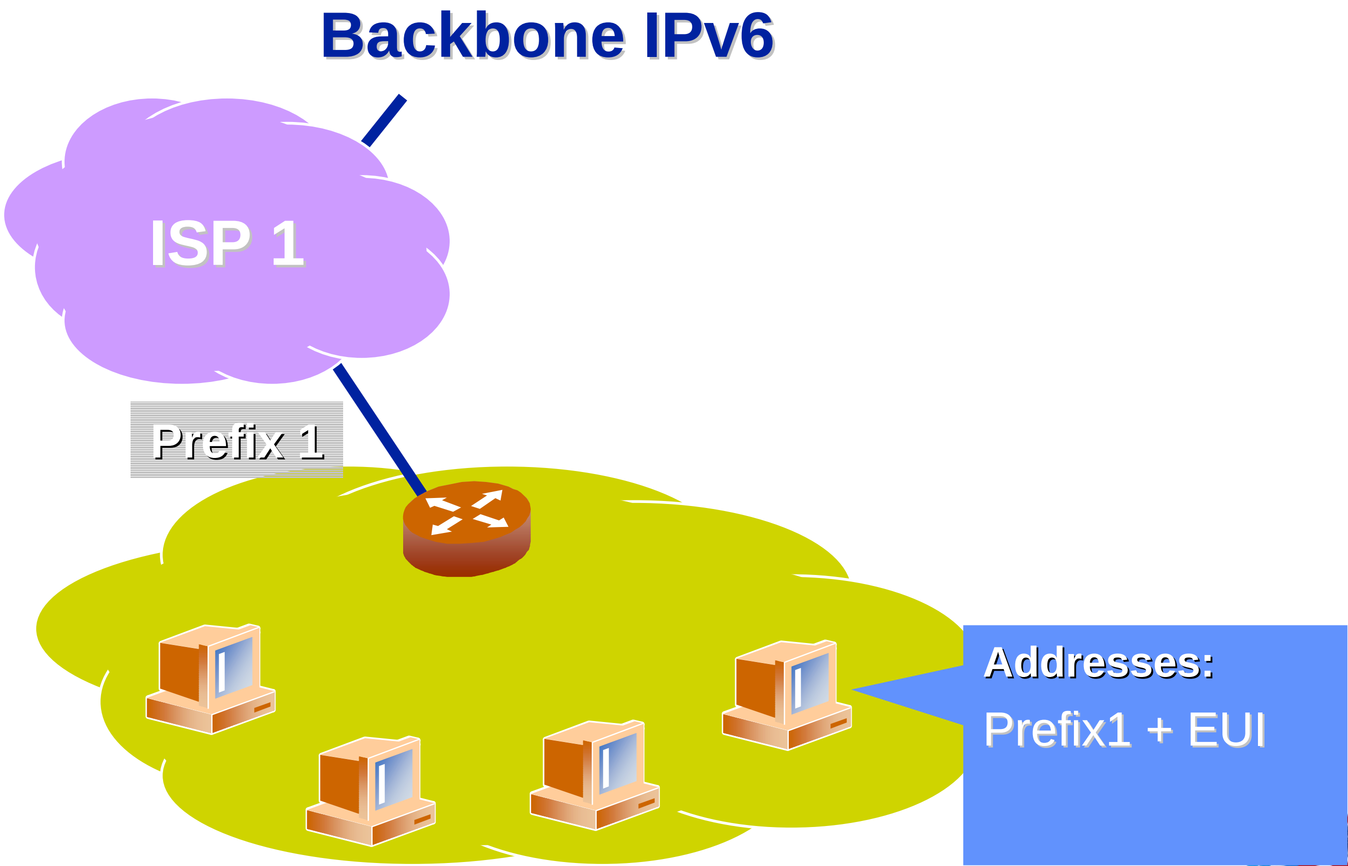

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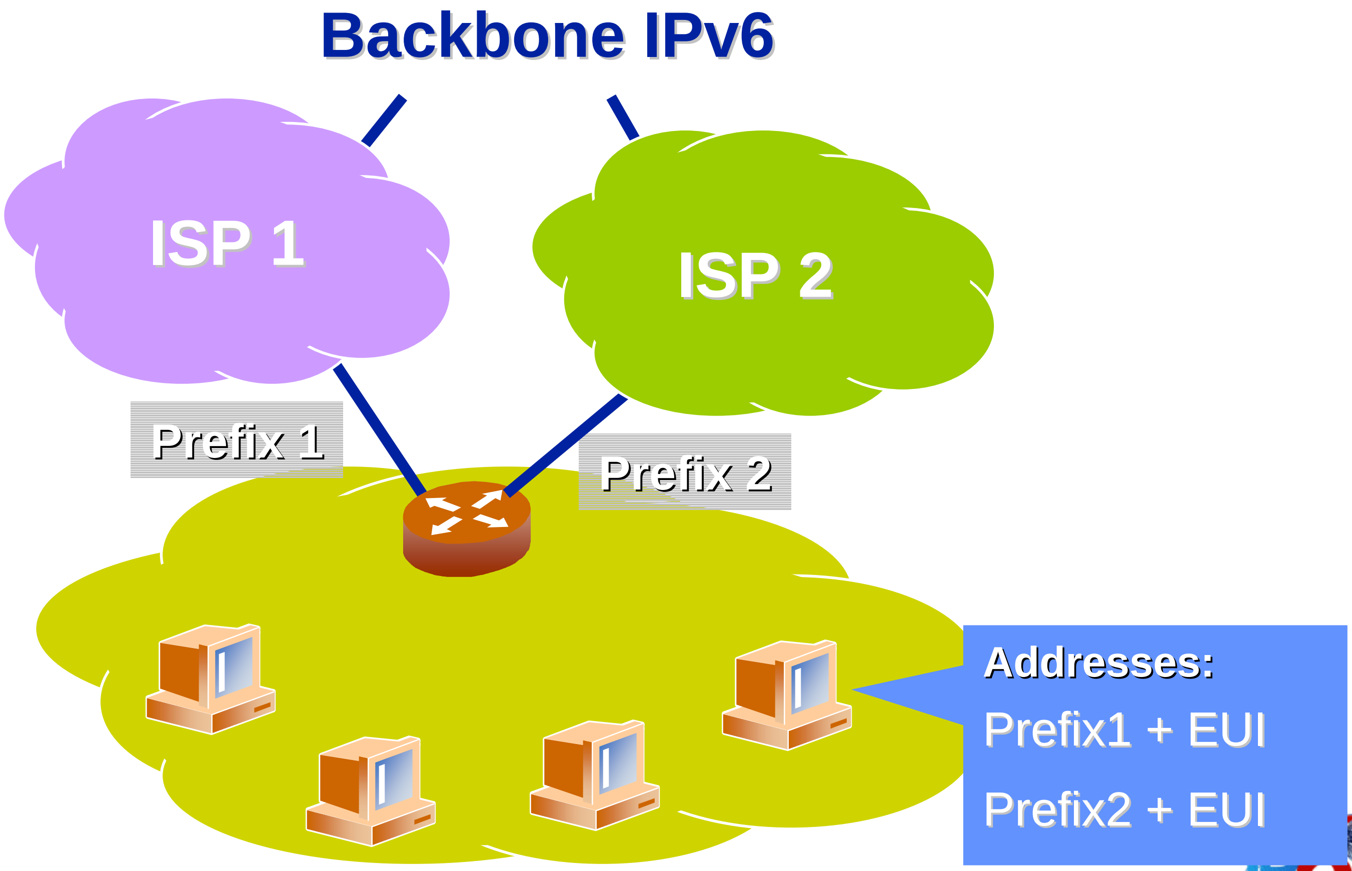

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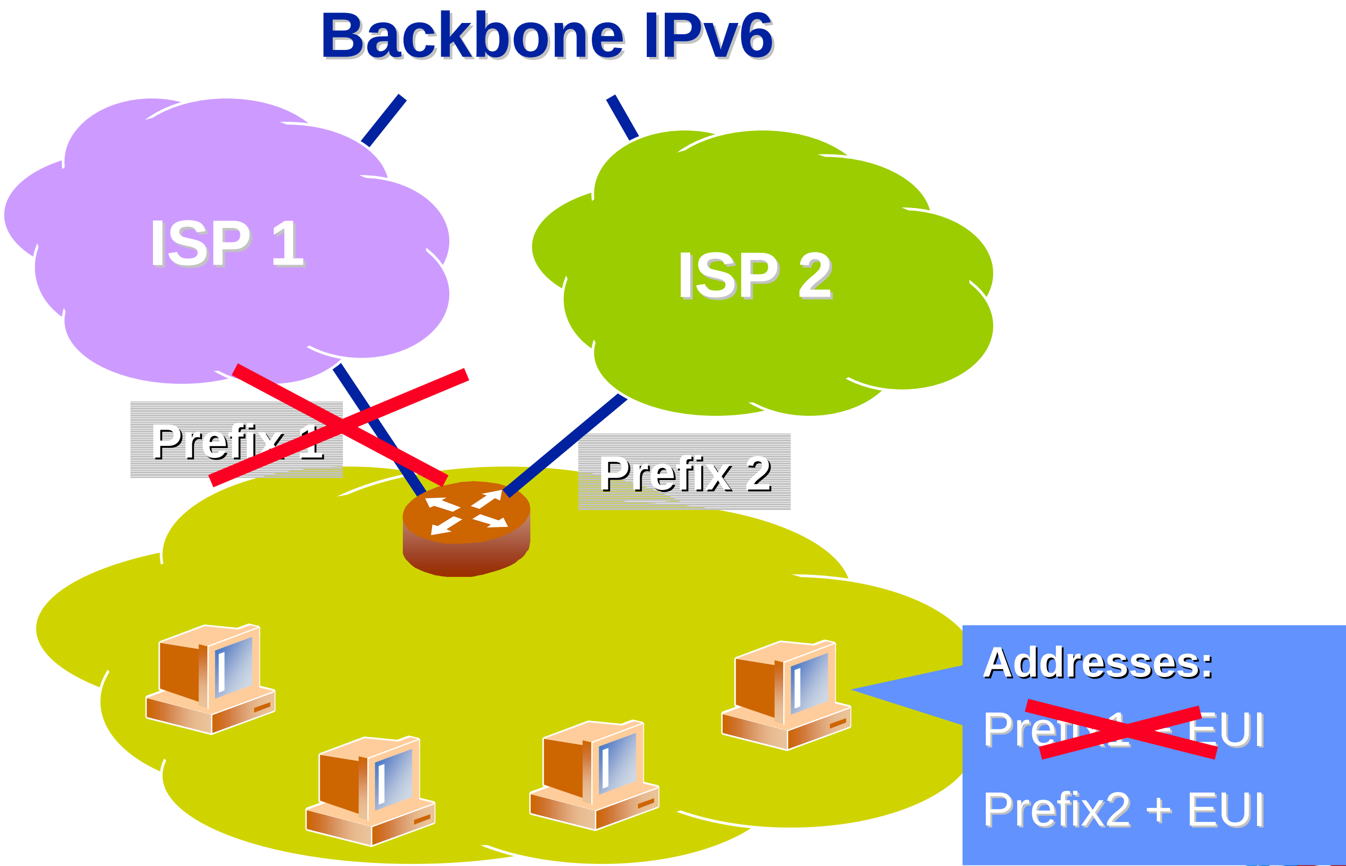

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  - A6 records. Composed of:
    - An interface identifier
    - A reference to a prefix
  - To renumber you only need to change the prefix DNS record, not the host records

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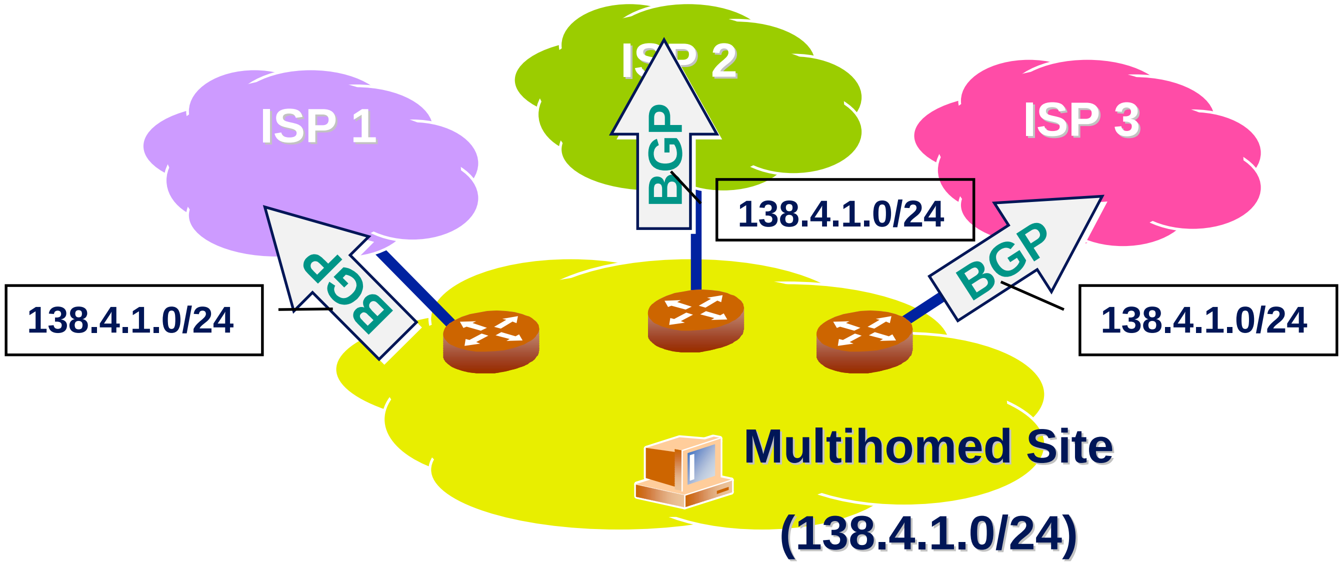
    - An interface identifier
    - A reference to a prefix
  - To renumber you only need to change the prefix DNS record, not the host records

Multihoming

- Two types:
  - Host multihoming
    - Two or more unicast address on an interface
    - Two or more network interfaces
  - Site multihoming
    - Multiple connections to the same ISP
    - Connections to multiple ISPs
- Why multihome?
  - Redundancy against router/link/ISP failure
  - Load sharing
  - Local connectivity across large geography
  - etc

Multihoming in IPv4

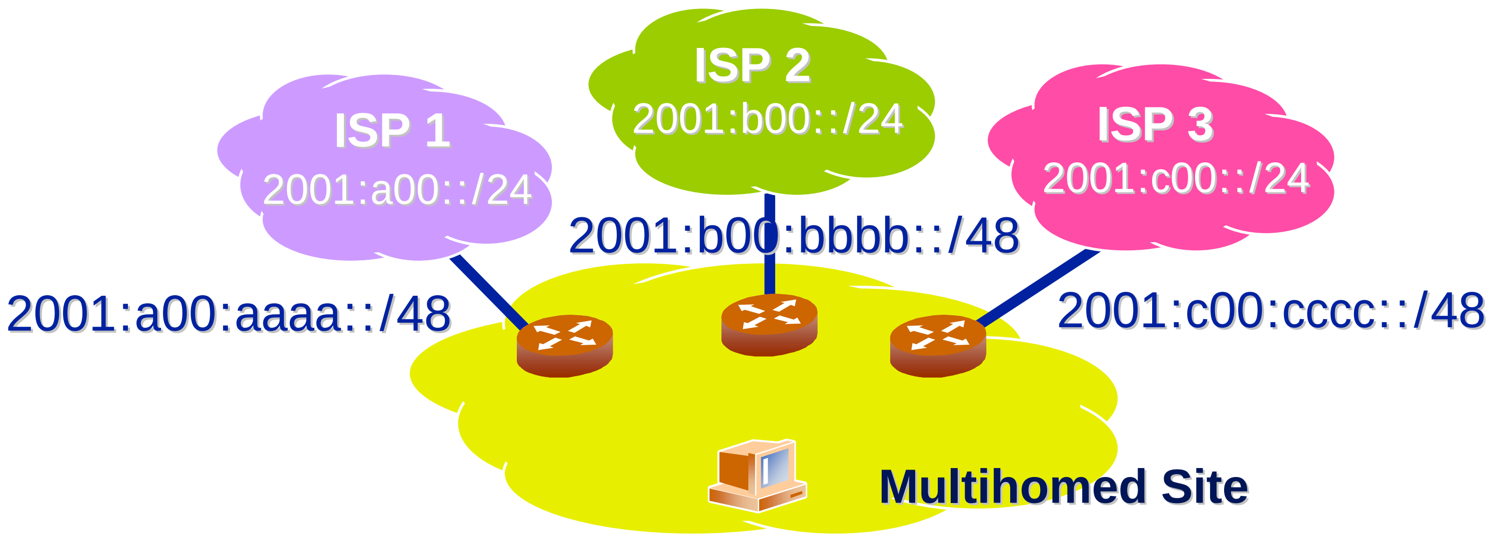
- Typically, IPv4 multihomed sites:
  - use provider independent (PI) addresses
  - have their own ASN and run BGP with its ISPs
  - export its PI prefix through each ISP peering



- Problems:
  - Routing table explosion
  - Internet instability (route flaps visible)

Multihoming in IPv6

- Multihomed sites receive one prefix from each ISP



- IPv4-style multihome forbidden:
  - IPv6 routing model does not allow the announcement of prefixes belonging to one ISP through other ISP's connections

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- See *ipv6mh* for more information
  - http://arneill-py.sacramento.ca.us/ipv6mh

IPv6 Dynamic Routing Protocols (I)

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- In general, minimal modifications are needed to existing protocols to adapt them to IPv6:
  - mainly related to address format
  - In some cases, modifications to support IPv4 and IPv6 simultaneously *(Integrated Routing)*

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  - mainly related to address format
  - In some cases, modifications to support IPv4 and IPv6 simultaneously *(Integrated Routing)*
- RIPng (RFC 2080)
  - Minimal modifications to RIPv2
- OSPFv6 = OSPFv3 for IPv6 (RFC 2740)
  - Minimal changes: address format, prefixes, ids., etc
  - Authentication eliminated from OSPF (
    - it uses IPv6 AH/ESP extension headers
    - draft-ietf-ospf-ospfv3-auth-01.txt
  - It does not use Integrated Routing: *"Ships in the night"*
    - two copies of OSPF running: one for IPv4 and another for IPv6

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IPv6 Dynamic Routing Protocols (II)

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  - Modifications:
    - RFC 2858 defines multiprotocol extensions (IPv6, IPX, etc) to BGP-4. Compatibility with BGP-4
      - Integrating Routing approach
    - RFC 2545 defines how to use extensions for IPv6 (Scopes, Next Hop, etc)

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  - RFC 2894. Router Renumbering for IPv6