IPv6 Transition Techniques in Fixed Networks Update

Jouni Korhonen

Nokia Siemens Networks

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Foreword

- This presentation is about some relevant **recent** IPv6 transition developments in the IETF.
- The presented "tools" are generic for most transition needs and work for both fixed broadband and wireless broadband networks.
- Not all transition techniques are applicable as-is or sensible for wireless broadband networks.
- This presentation focuses on general issues and networks. The next presentation focuses on wireless cellular (broadband) networks.
- This presentation is not how to extend the lifetime of IPv4. The next presentation covers that to some extent.

Motivations for Migrating to IPv6

- Running out of IPv4 addresses for end users, not necessarily now but maybe in few years time. IPv4 becomes an expensive resource..
- Fear that some killer application hoards globally all remaining IPv4 addresses in an unpredictable manner (ruins ISPs' and LIR/RIRs' address reservation plans).
- Get the existing IPv4 addresses used in ISP's core to a better use if the core can be switched to IPv6.
- One might dream that IPv6 re-enables end-to-end connectivity of end hosts ;)
- Extending the lifetime of IPv4 is OK but becoming increasingly complex and costly (e.g. nested NATs, NAT state management & hole punching for always on devices)

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Migration Approaches for ISPs

- Offer IPv6 Internet connectivity to end users (quickly):
  - ..but run IPv6 on top of ISP's existing IPv4 core network.
- Find more IPv4 addresses for end users:
  - Migrate the core network to IPv6 and free IPv4 addresses.
  - Run IPv4 on top of IPv6 core network.
- Offer IPv6-only service for end users:
  - Migrate core network to IPv6.
  - Offer connectivity to IPv4 Internet using translation.
- General questions and decision points:
  - Tunneling vs. translation approach for transition.
  - End host impact and transparency..

Adding new Hammers to the Toolbox

- New hammers:
  - IPv6 Rapid Deployment (6rd)
  - Dual-Stack Lite (DS-lite).. (also Gateway Initiated DS-Lite, DS-Extra-Lite but they are not part of this presentation)
  - NAT64/DNS64
- Why old tools are not enough (ISATAP, 6to4, ...) ??
  - e.g. ISATAP (and 6 over 4) are tunnel mechanisms which create a virtual Ethernet connecting isolated Dual-Stack enabled hosts.
  - e.g. 6to4 is a tunnel mechanisms which allow isolated IPv6-enabled sites to connect to each other over IPv4 Internet.
  - Former is within an organization, the latter is between organizations.
- Different deployment scenarios "need" different tools.

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The Common Ground

- Mainstream operating systems **are** IPv6 (Dual-Stack) enabled already today:
  - Windows, Linux, BSD, OSX, Symbian, WinCE, ...
- Big ISPs & tier-1 operators are IPv6 capable:
  - e.g. NTT, Hurricane, Sprint, ..
- IPv6 connectivity does exist in a global sense:
  - AAAAs found in DNS,
  - Routes do exists..

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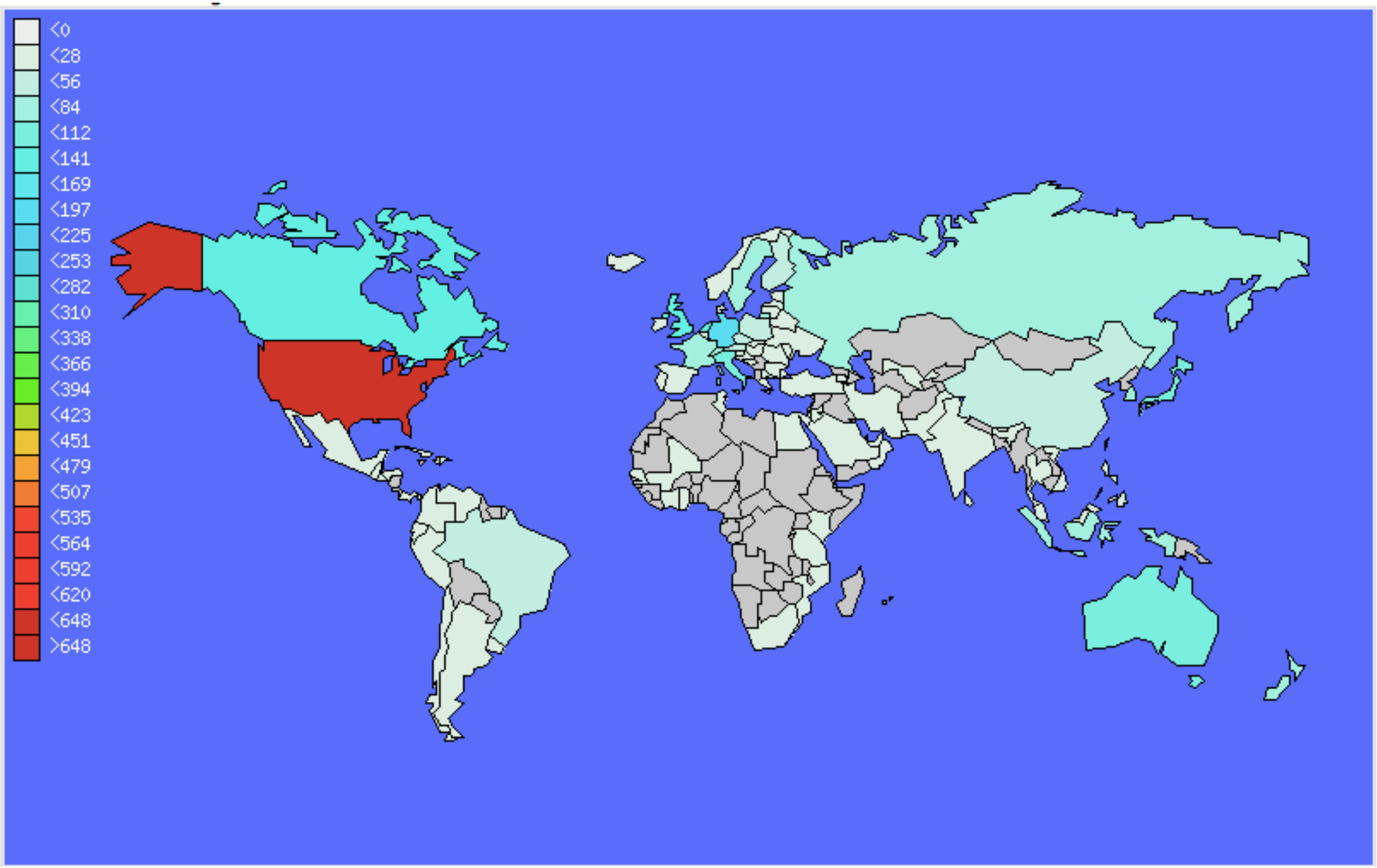
IPv6 BGP Weather Map ;)

1	United States	677
2	Germany	183
3	Canada	113
4	Netherlands	112
5	United Kingdom	112
6	Japan	110
7	Australia	86
8	Italy	86
9	France	69
10	Russian Federation	66
11	Korea, Republic of	65
12	Sweden	64
13	Indonesia	61
14	EU	61
15	Switzerland	59
16	New Zealand	58
17	China	50
18	Poland	47
19	Czech Republic	42
20	Brazil	42
21	Austria	41
22	Hong Kong	33
23	Finland	29
24	Thailand	27



- Analyzing:
  - 1963 originating AS numbers
  - 2825 prefixes
  - 109 countries

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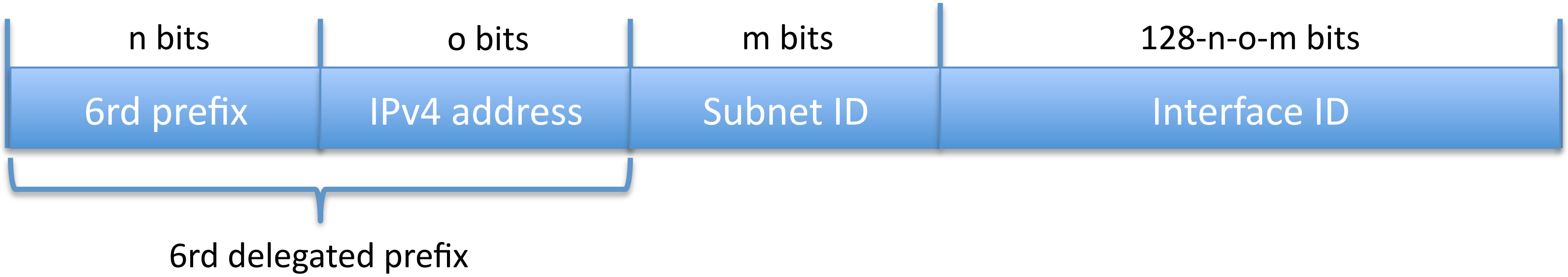
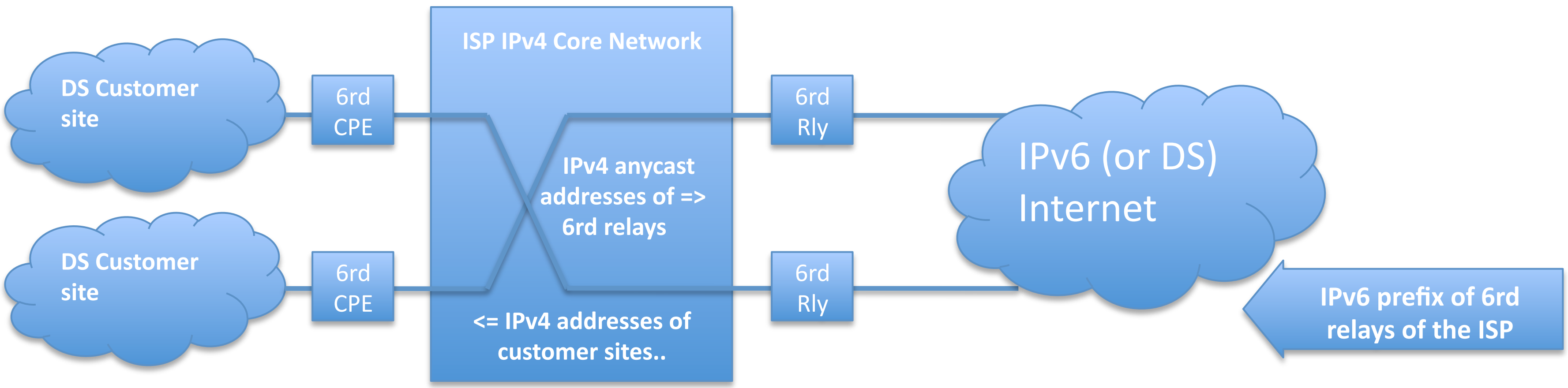
IPv6 Rapid Deployment (6rd)

- Described in RFC5569 (the original idea) and draft-ietf-software-ipv6-6rd (with IETF tweaks).
- It does share obvious similarities with 6to4…
- Basically offers:
  - IPv6 tunneled over existing IPv4 core network.
  - Build-in prefix delegation.
  - Ability to use ISP's own LIR assigned prefixes instead of well-known IANA allocated prefix (unlike it is the case with 6to4).
- Requires more or less total control over CPEs.
- The "idea" is to rapidly connect customer sites to IPv6 Internet and migrating the core slowly to IPv6 – while offering both IPv4/IPv6 for customers.

6rd Address Format and Architecture



- Addressing follows RFC4291 -> n+o+m basically always equals to 64.
- IPv4 address can be private or public -> it's the CPE address within the ISP core.
- Aggregation of IPv4 addresses is possible i.e. common IPv4 prefix bits are not encoded into the 6rd delegated prefix.



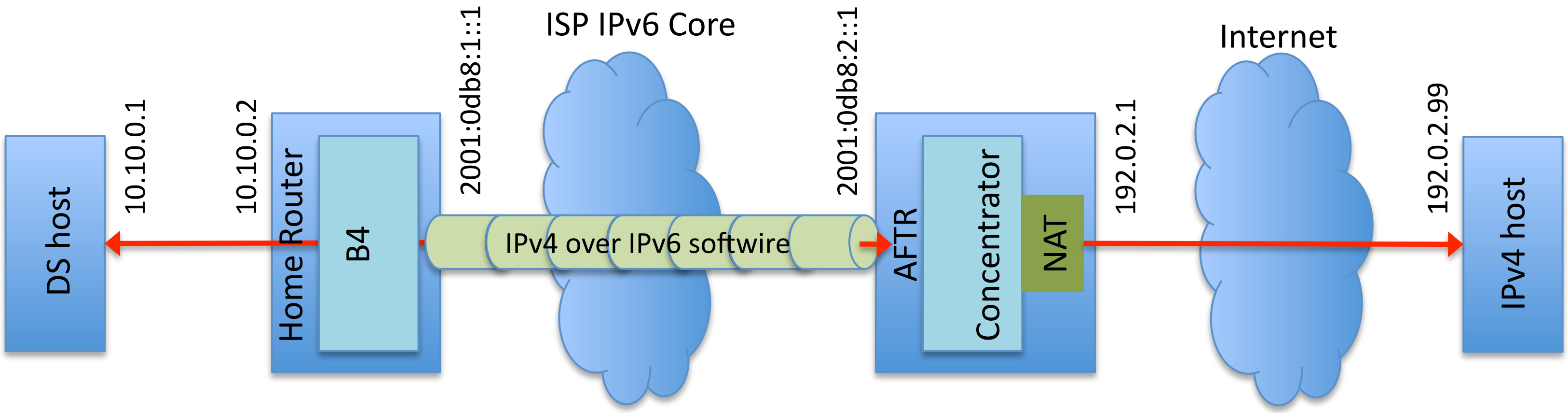
- CPEs learn configurations (prefix, relay address etc) by manual configuration or via DHCP.

Dual-Stack Lite (DS-Lite)

- Allows using IPv4 addresses over IPv6 ISP's core network.
  - Designed for cable/DSL to release IPv4 addresses used in core for a "better" use.
  - IPv4 over IPv6 tunneling between a **Home Router** (B4) at the customer premises and a **large scale NAT44** (AFTR) at the ISP core network edge.
  - Makes IPv4 numbers actually meaningless as the underlying IPv6 tunnel identifiers are used to identify the Home Router/subscriber.
  - Customer IPv6 traffic can be router natively in the ISP core.
- Two (actually four..) flavors:
  - Home Router is the DS-Lite tunnel endpoint. (no end host modifications)
  - End host is the DS-Lite tunnel endpoint. (e.g. a mobile phone..)
- B4 discovers the ATFR either using manual configuration or DHCPv6.
- B4 must implement DNS proxy for IPv4 end hosts..
- AFTR can also implement ALGs and allow mappings for "home servers".
- A well-known IPv4 address range is reserved. 192.0.0.0/29 is the reserved subnet address and 192.0.0.1 is reserved for the AFTR element.
- Described in draft-ietf-softwire-dual-stack-lite.

DS-Lite Deployment Example

- Typical fixed broadband deployment example.. where the B4 functionality is located in the Home Router.
- Every host could actually share the same IPv4 number.. Identification is based e.g. on the tunnel IPv6 addresses.
- The NAT function is AFTR NATs host's "IPv4 number" to AFTR's public IPv4 address (NAPT)

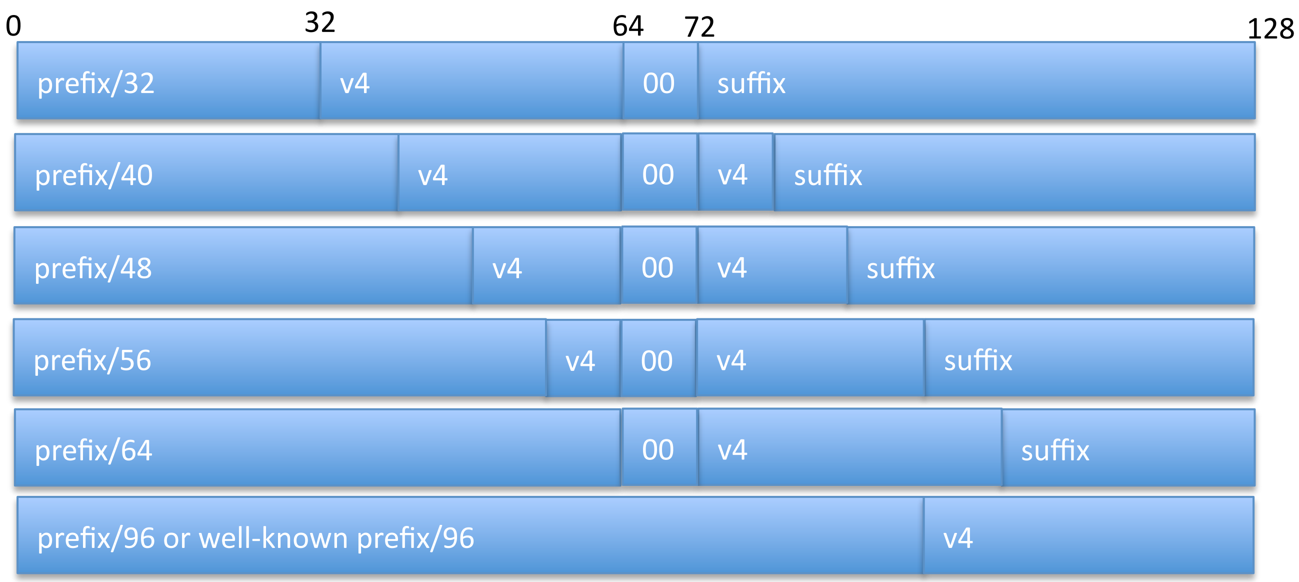


NAT64

- Allows IPv6 nodes to access IPv4 Internet using address translation. (Reverse direction, NAT46, is also defined but not presented here)
- Two flavors:
  - Stateless NAT64 and Stateful NAT64.
- In the **stateless mode**, a specific IPv6 address range will represent IPv4 systems (IPv4-converted addresses), and the **IPv6 systems have addresses (IPv4-translatable addresses)** that can be algorithmically mapped to a subset of the service provider's IPv4 addresses.
  - Use of network specific prefix for everything is preferred.
- In the **stateful mode**, a specific IPv6 address range will represent IPv4 systems (IPv4-converted addresses), but the **IPv6 systems may use any RFC4291 addresses** (except that range used for translation).
- Described in draft-ietf-behave-v6v4-xlate-stateful, draft-ietf-behave-v6v4-xlate, draft-ietf-behave-v6v4-framework and draft-ietf-behave-address-format.

NAT64 Address Formats

- IPv4-Converted IPv6 addresses: IPv6 addresses used to represent IPv4 nodes in an IPv6 network.
- IPv4-Translatable IPv6 addresses: IPv6 addresses assigned to IPv6 nodes for use with stateless translation.
- Usage restrictions in order to e.g. avoid injecting IPv4 routes into the IPv6 Internet.
- The address must always be compliant with RFC4291 and especially take the EUI-64 based modified interface identifier into account (u & g bits..).
- A well-known prefix 64:ff9b::/96 is reserved for algorithmic translation.



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DNS64

- Provides mapping of A records to AAAA records. (reverse direction, DNS46, is also possible but not presented here)
- Tightly coupled with NAT64, however, NAT64 **can** operate without DNS64.
- An IPv6 host queries for AAAA record for some FQDN:
  1. Query must go through the DNS64 on the IPv6 “site”.
  2. If the query cannot be served locally or no AAAAs found from Internet DNS, then (or already in parallel)
  3. DNS64 queries for A records from Internet DNS, and
  4. synthesizes AAAA records from the A response using IPv4-converted addresses.
- Lots of details with DNS to sort out/deal with though..

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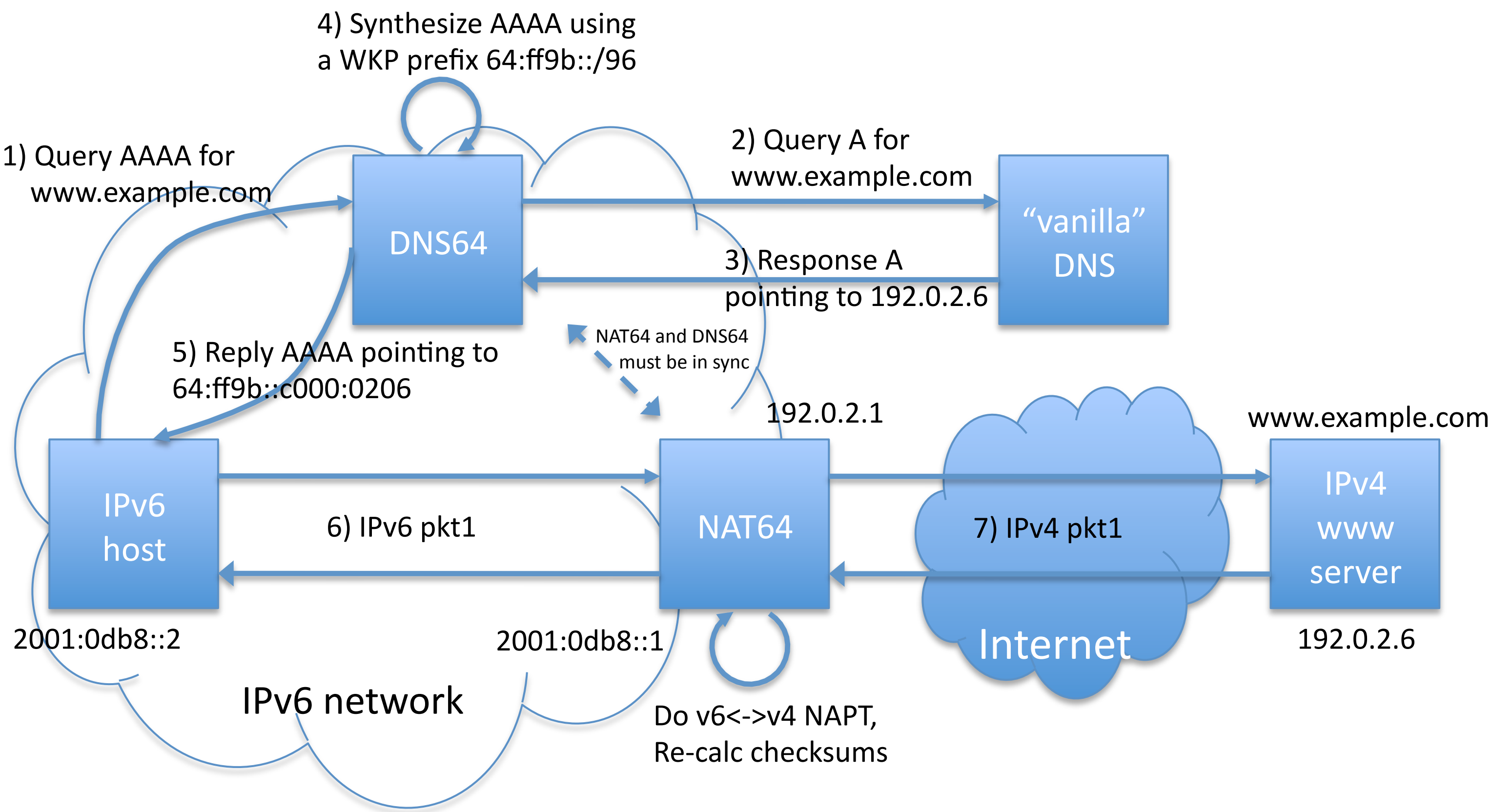
Example using Stateful NAT64/DNS64



-> src=2001:0db8::2,1234 & dst=64:ff9b::c000:0206::,80
<- src=64:ff9b::c000:0206::,80 & dst=2001:0db8::2,1234

-> src=192.0.2.1,4321 & dst=192.0.2.6,80
<- src=192.0.2.6,80 & dst=192.0.2.1,4321

Summary

- New IPv6 migration tools under development in the IETF:
  - Based on both tunneling and translation.
- For different deployment scenarios:
  - Deploy IPv6 over IPv4 core network using ISPs own prefix instead of well-known prefix.
  - Deploy (or rather extend IPv4 availability/lifetime) IPv4 over IPv6 core network.
  - New translation technique to and from IPv6 to IPv4, including DNS resource record synthesizing on demand.
- Driven by cable/DSL operators' needs.. Cellular operators might need yet different set of migration tools, **if any**.
- To be seen if any of these will actually have a real role when the migration really takes off… there is always Dual-Stack.

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