Using NAT64/464XLAT in ISP and Enterprise Networks

RIPE NCC::Educa IPv6-only

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@JordiPalet

(jordi.palet@theipv6company.com)

RFC8585 and RFC8683

- Our experience comes from actual customer deployments
  - Most recent 25.000.000 subscribers (DSL, GPON and cellular)

- And we contributed to IETF according to that:
  - RFC8585 tells your CE providers what you need
  - RFC8683 is about your network

- However … every network is a different (and special) animal

- Key problem: Misconceptions about IPv6 (is not IPv4) and IPv6-only
  - https://datatracker.ietf.org/doc/draft-palet-v6ops-ipv6-only/

RFC8683

- How an ISP (broadband or cellular) or Enterprise should deploy 464XLAT/NAT64?

- Is NAT64 (with DNS64) a valid approach?

- What are the issues to consider?

- What are the possible deployment scenarios?

  – There are hosts that will be validating DNSSEC?

  – Are IPv4 literals or non-IPv6-compliant APIs used?

  – There are IPv4-only hosts or apps?

    - As a result, two major groups

      – Known to work

      – Known to work under special conditions

        - Not part of this presentation, very special scenarios
        - Example, "close networks" or "strict control" of all the clients or servers

NAT64 + DNS64
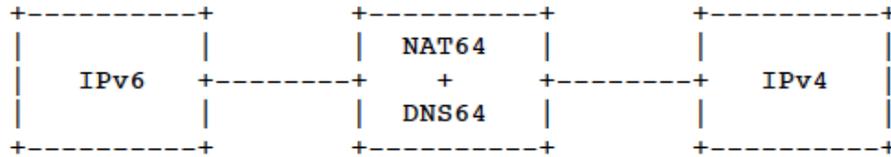
```
+----------+        +----------+        +----------+
|          |        |  NAT64   |        |          |
|   IPv6   +--------+    +     +--------+   IPv4   |
|          |        |  DNS64   |        |          |
+----------+        +----------+        +----------+
```
Figure 1: NAT64 with DNS64
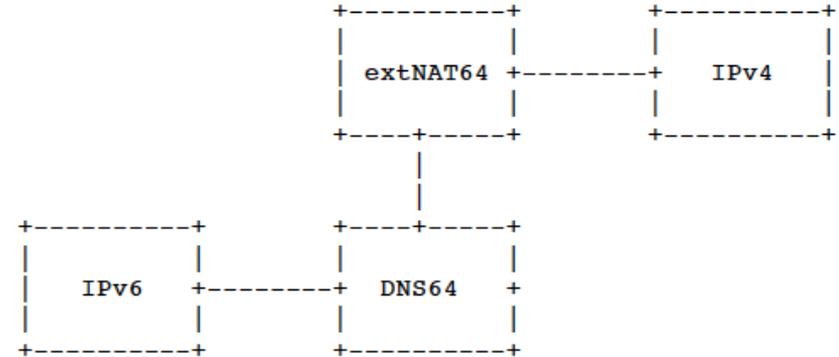
```
                              +----------+        +----------+
                              |          |        |          |
                              | extNAT64 +--------+   IPv4   |
                              |          |        |          |
                              +----+-----+        +----------+
                                   |
                                   |
                                   |
        +----------+        +----+-----+
        |          |        |          |
        |   IPv6   +--------+  DNS64   +
        |          |        |          |
        +----------+        +----------+
```
Figure 2: NAT64 in external service provider
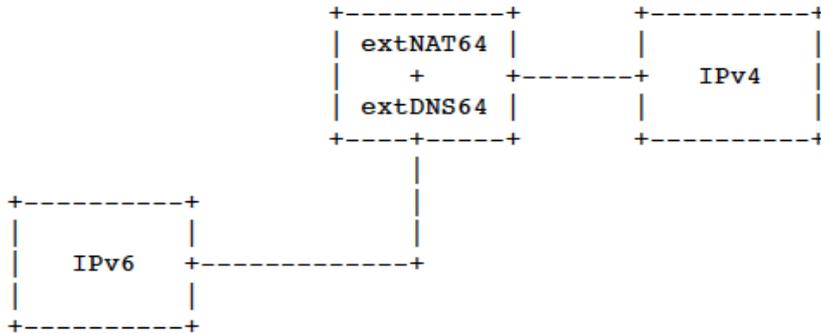
```
                +----------+        +----------+
                | extNAT64 |        |          |
                |    +     +--------+   IPv4   |
                | extDNS64 |        |          |
                +----+-----+        +----------+
                     |
                     |
                     |
+----------+         |
|          |         |
|   IPv6   +---------+
|          |
+----------+
```
Figure 3: NAT64 and DNS64 in external provider
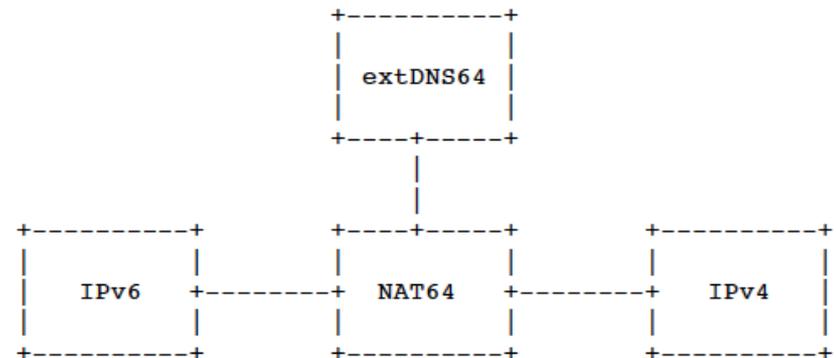
```
                              +----------+
                              |          |
                              | extDNS64 |
                              |          |
                              +----+-----+
                                   |
                                   |
+----------+        +----+-----+        +----------+
|          |        |          |        |          |
|   IPv6   +--------+  NAT64   +--------+   IPv4   |
|          |        |          |        |          |
+----------+        +----------+        +----------+
```
Figure 4: NAT64; DNS64 by external provider

464XLAT with DNS64

```
+-----------+         +-----------+         +-----------+
|   IPv6    |         |   NAT64   |         |           |
|     +     +---------+     +     +---------+    IPv4    |
|   CLAT    |         |   DNS64   |         |           |
+-----------+         +-----------+         +-----------+
```
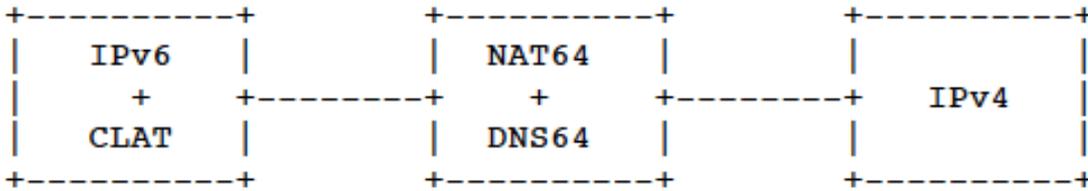
Figure 5: 464XLAT with DNS64

```
                                    +-----------+         +-----------+
                                    |           |         |           |
                                    | extNAT64  +---------+    IPv4   |
                                    |           |         |           |
                                    +----+------+         +-----------+
                                         |
                                         |
         +-----------+         +----+------+
         |   IPv6    |         |           |
         |     +     +---------+   DNS64   +
         |   CLAT    |         |           |
         +-----------+         +-----------+
```
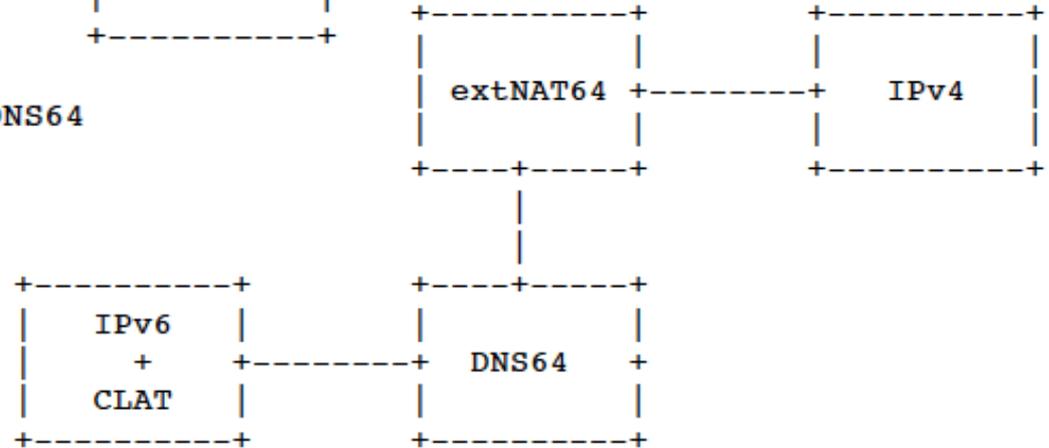
Figure 6: 464XLAT with DNS64; NAT64 in external provider

```
         +-----------+         +-----------+
         | extNAT64  |         |           |
         |     +     +---------+    IPv4   |
         | extDNS64  |         |           |
         +----+------+         +-----------+
              |
              |
+-----------+ |
|   IPv6    | |
|     +     +-------------+
|   CLAT    |
+-----------+
```
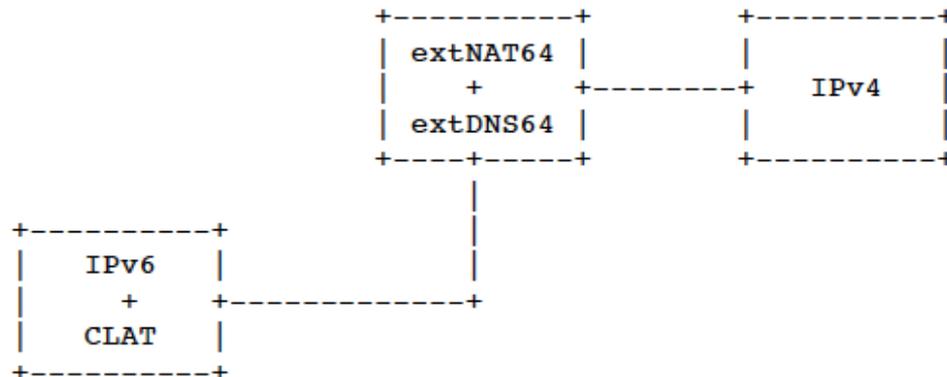
Figure 7: 464XLAT with DNS64; NAT64 and DNS64 in external provider

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464XLAT without DNS64

```
+-----------+            +-----------+            +-----------+
|   IPv6    |            |           |            |           |
|     +     +------------+   NAT64   +------------+   IPv4    |
|   CLAT    |            |           |            |           |
+-----------+            +-----------+            +-----------+
```
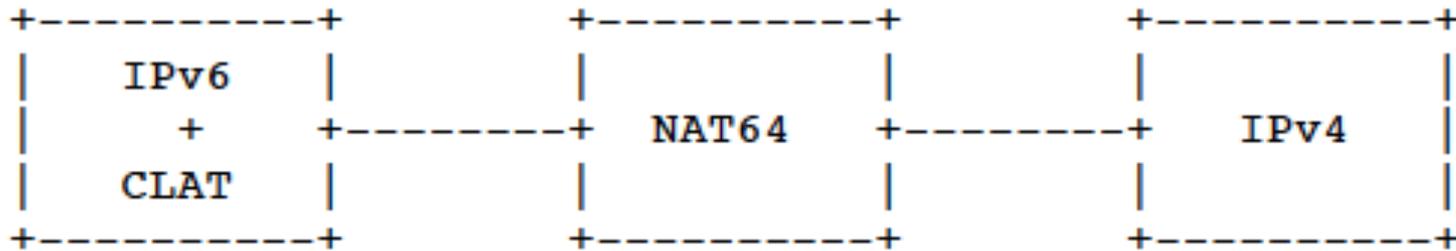
Figure 8: 464XLAT without DNS64

```
                                    +-----------+       +-----------+
                                    |           |       |           |
                                    | extNAT64  +-------+   IPv4    |
                                    |           |       |           |
                                    +----+------+       +-----------+
                                         |
                                         |
+-----------+                            |
|   IPv6    |                            |
|     +     +----------------------------+
|   CLAT    |
+-----------+
```
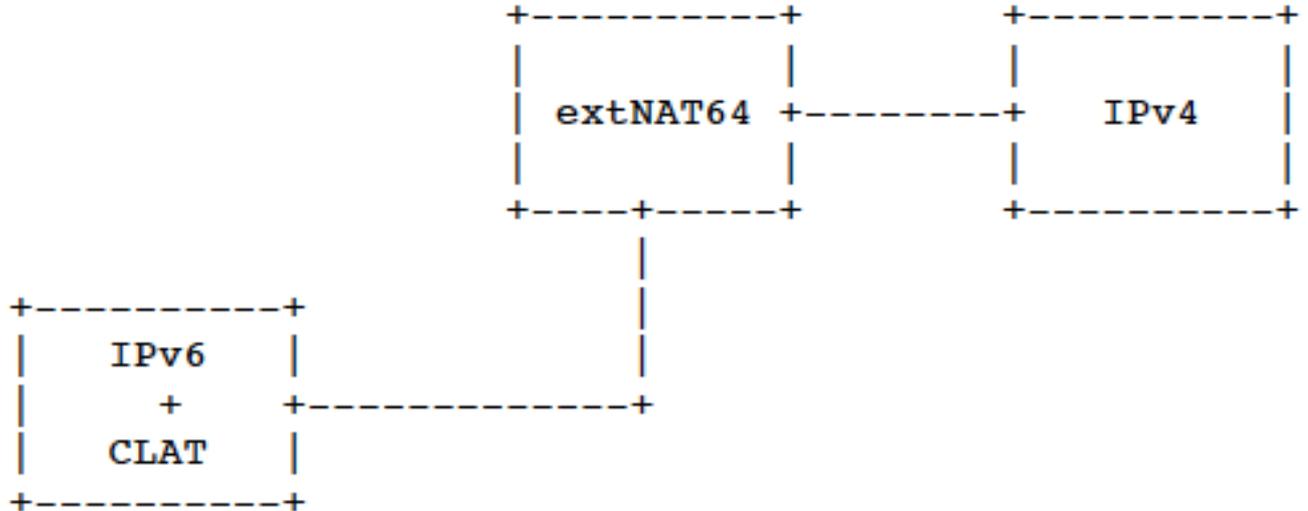
Figure 9: 464XLAT without DNS64; NAT64 in external provider

Comparing Scenarios

Item / Figure	1	2	3	4	5	6	7	8	9	10	11	12
DNSSEC	-	-	-	-	-	-	-	+	+	+	+	+
Literal/APIs	-	-	-	-	+	+	+	+	+	-	-	-
IPv4-only	-	-	-	-	+	+	+	+	+	-	-	-
Foreign DNS	-	-	-	-	+	+	+	+	+	-	+	-
DNS load opt.	+	+	+	+	+	+	+	+	+	+	+	+
Connect. opt.	+	+	+	+	+	+	+	*	*	+	+	+

- **-**   Scenario "bad" for that criteria.
- **+**   Scenario "good" for that criteria.
- *****   Scenario "bad" for that criteria, however it is typically resolved, with the support of Happy Eyeballs v2 [RFC8305].

Enterprise Networks

```
+-------------------------------------+
|          Enterprise Network         |
| +-----------+      +-----------+ |   +-----------+
| |  IPv6     |      |  NAT64    | |   |  IPv4     |
| |  only     +--------+    +    | +-------+  +     |
| |  LANs     |      |  DNS64    | |   |  IPv6     |
| +-----------+      +-----------+ |   +-----------+
+-------------------------------------+
```
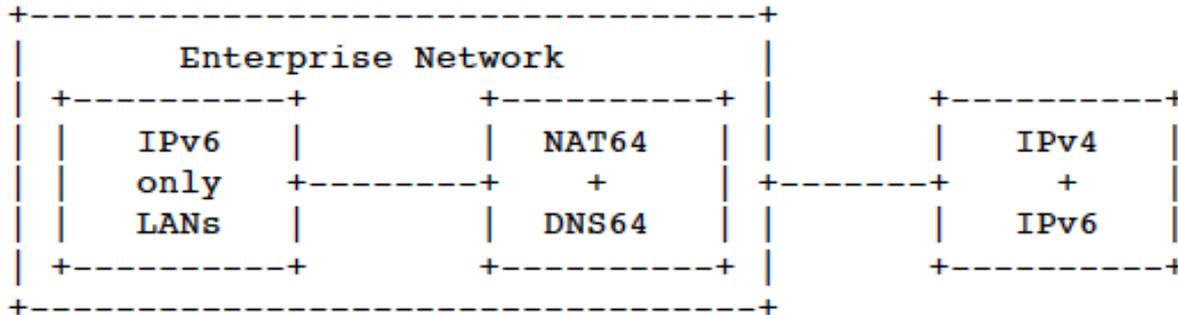
Figure 14: IPv6-only enterprise with NAT64 and DNS64

```
              +-----------------------------------+
              |          Enterprise Network       |
              | +-----------+      +-----------+ |   +-----------+
              | |  IPv6     |      |           | |   |  IPv4     |
              | |    +      +--------+  NAT64   | +-------+  +     |
              | |  CLAT     |      |           | |   |  IPv6     |
              | +-----------+      +-----------+ |   +-----------+
              +-----------------------------------+
```
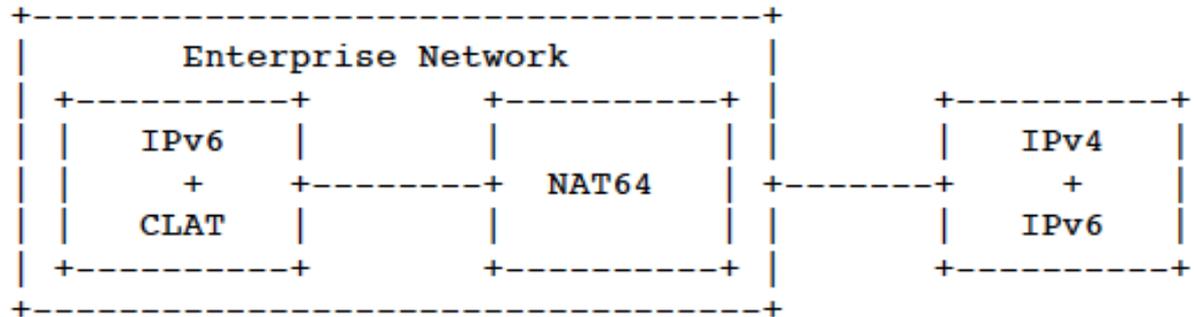
Figure 15: DS enterprise with CLAT, DS Internet, without DNS64

```
+-----------------------------------+
|          Enterprise Network       |
| +-----------+      +-----------+ |   +-----------+
| |  IPv6     |      |           | |   |  IPv6     |     |
| |    +      +--------+  CLAT    | +-------+  NAT64   |
| |  IPv4     |      |           | |   |  only     |     |
| +-----------+      +-----------+ |   +-----------+
+-----------------------------------+
```
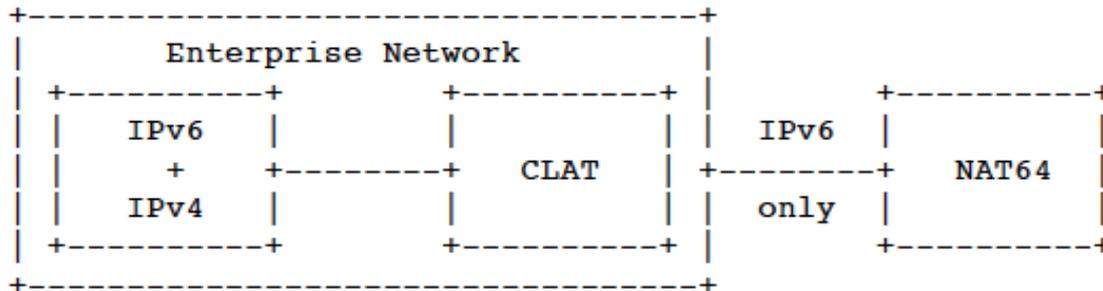
Figure 16: DS enterprise with CLAT, IPv6-only Access, without DNS64

ISPs Considerations

- Broadband access elements that need to be re-configured:
  - BRAS/BNG/MSAN/DSLAM/OLT
  - Radius
  - Provisioning systems
  - Billing apps
  - Monitoring
  - Do they work well if IPv6-only is provided?
  - Do you have control on all the devices, or need to rely on vendors?

- CEs: Do they fully support RFC8585 or only 464XLAT?
  - How they configure the NAT64 prefix
  - How to handle the existing CEs
    - Reflash?
    - Replace?
    - Marketing operation to upgrade customers?

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Packet Switched Network

- Are the HLR/HSS able to deliver IPv6-only?

- Can you configure a single APN to cover all the cases?
  - IPv6, IPv4v6 and IPv4 PDP contexts?
  - You need to support all kind of UEs!
    - Gradual transition to IPv6-only with OTA updates

- Do you have control on all the elements or need to coordinate with vendors?

- UEs:
  - Android supports IPv6-only and CLAT by default
  - iOS requires the operator's Apple liaison support
    - Apple will enable the right APN, IPv6 and CLAT or HEv2
  - Windows 10 has specific CLAT support
  - You can "hack" a few iOS devices with your own profile to override the standard config (useful for a test-bed)

What could be the Impact?

- Before deploying 464XLAT, assess the impact in the network
- Look at DPI and other relevant data:
  - What apps
  - How much traffic each
  - How much traffic into CDNs/caches
  - Usage of DNSSEC
  - Logging
- Allowed failure rate?
  - Can we have some customer groups with dual-stack?
  - HA
  - ALGs to be supported
- How much traffic will pass thru?
  - Typically only 24% (and going low)

Summary

- NAT64 (with DNS64) is not a solution

- 464XLAT works in all the cases

  - A CLAT solve the issues even if DNS64 is not present or is broken

- Savings!

  - CapEx and OpEx
    - Avoid paying for IPv4 addresses
  - If you replace CEs, reduce your investment in NAT64
    - You can "sell" the CEs to customers because new "features"
      - Better WiFi coverage and security
      - New functions: opportunity for triple-play or 4K IPTV
      - More bandwidth
      - Move customers from DSL to GPON and analog voice to VoIP
      - IoT offering
      - Upgraded warrantee

Thanks!

Contact:

@JordiPalet
jordi.palet@theipv6company.com