Internet Engineering Task Force
Internet-Draft
Intended status: BCP
Expires: January 4, 2013

M. Mawatari
Japan Internet Exchange Co.,Ltd.
M. Kawashima
NEC AccessTechnica, Ltd.
C. Byrne
T-Mobile USA

July 3, 2012

464XLAT: Combination of Stateful and Stateless Translation
draft-ietf-v6ops-464xlat-05

Abstract

This document describes an architecture (464XLAT) for providing limited IPv4 connectivity across an IPv6-only network by combining existing and well-known stateful protocol translation RFC 6146 in the core and stateless protocol translation RFC 6145 at the edge. 464XLAT is a simple and scalable technique to quickly deploy limited IPv4 access service to IPv6-only edge networks without encapsulation.

Status of this Memo

Copyright Notice

Table of Contents

1. Introduction

The IANA unallocated IPv4 address pool was exhausted on February 3, 2011. Each RIR's unallocated IPv4 address pool will exhaust in the near future. It will be difficult for many networks to assign IPv4 addresses to end users, despite substantial IP connectivity growth required for fast growing edge networks.

This document describes an IPv4 over IPv6 solution as one of the techniques for IPv4 service extension and encouragement of IPv6 deployment. 464XLAT is not a one for one replacement of full IPv4 functionality. The 464XLAT architecture only supports IPv4 in the client server model, where the server has global IPv4 address. This means it is not fit for IPv4 peer-to-peer communication or inbound IPv4 connections. 464XLAT builds on IPv6 transport and includes full any to any IPv6 communication.

The 464XLAT architecture described in this document uses IPv4/IPv6 translation standardized in [RFC6145] and [RFC6146]. It does not require DNS64 [RFC6147] since an IPv4 host may simply send IPv4 packets, including packets to an IPv4 DNS server, which will be translated on the CLAT to IPv6 and back to IPv4 on the PLAT. 464XLAT networks may use DNS64 [RFC6147] to enable single stateful translation [RFC6146] instead of 464XLAT double translation where possible. The 464XLAT architecture encourages IPv6 transition by making IPv4 services reachable across IPv6-only networks and providing IPv6 and IPv4 connectivity to single-stack IPv4 or IPv6 servers and peers.

By combining 464XLAT with BIH [RFC6535], it is also possible to provide single IPv4 to IPv6 translation service, which will be needed in the future case of IPv6-only servers and peers to be reached from legacy IPv4-only hosts across IPv6-only networks.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Terminology

PLAT: PLAT is Provider side translator(XLAT) that complies with [RFC6146]. It translates N:1 global IPv6 packets to global IPv4 packets, and vice versa.

CLAT: CLAT is Customer side translator(XLAT) that complies with [RFC6145]. It algorithmically translates 1:1 private IPv4 packets to global IPv6 packets, and vice versa. The CLAT function is applicable to a router or an end-node such as a mobile phone. CLAT SHOULD perform router function to facilitate packets forwarding through the stateless translation even if it is an end-node. In the case where the access network does not allow for a dedicated IPv6 prefix for translation, a NAT44 SHOULD be used between the router function and the stateless translator function. The CLAT as a common home router or 3G router is expected to perform gateway functions such as DHCP server and DNS proxy for local clients. The CLAT does not comply with the sentence "Both IPv4-translatable IPv6 addresses and IPv4-converted IPv6 addresses SHOULD use the same prefix." that is described on Section 3.3 in [RFC6052] due to using different IPv6 prefixes for CLAT-side and PLAT-side IPv4 addresses.

4. Motivation and Uniqueness of 464XLAT

1. Minimal IPv4 resource requirements, maximum IPv4 efficiency through statistical multiplexing

2. No new protocols required, quick deployment

3. IPv6-only networks are simpler and therefore less expensive to operate

5. Network Architecture

464XLAT architecture is shown in the following figure.

5.1. Wireline Network Architecture

The private IPv4 host on this diagram can reach global IPv4 hosts via translation on both CLAT and PLAT. On the other hand, the IPv6 host can reach other IPv6 hosts on the Internet directly without translation. This means that the CPE can not only have the function of CLAT but also the function of IPv6 native router for IPv6 native traffic.

```
                                  ----
                                 | v6 |
                                  ----
                                    |
    ----      |                 .---+---.                    .------.
   | v6 |-----+                /         \                  /        \
    ----      |    ------     /   IPv6    \     ------     /   IPv4   \
              +---| CLAT |---+  Internet   +---| PLAT |---+  Internet  |
    -------   |    ------     \           /     ------     \           /
   |v4p/v6 |--+                `---------'                  `----+----'
    -------   |                                                  |
    -----     |                                                -----
   | v4p |----+                                               | v4g |
    -----     |                                                -----

          <- v4p -> XLAT <--------- v6 --------> XLAT <- v4g ->
```

v6 : Global IPv6
v4p : Private IPv4
v4g : Global IPv4

Figure 1: Wireline Network Topology

5.2. Wireless 3GPP Network Architecture

The CLAT function on the UE provides an [RFC1918] address and IPv4 default route. The applications on the UE can use the private IPv4 address for reaching global IPv4 hosts via translation on both CLAT and PLAT. On the other hand, reaching IPv6 hosts (including host presented via DNS64 [RFC6147]) does not require the CLAT function on the UE.

```
                                   ----
                                  | v6 |
                                   ----
                                     |
                                 .---+---.
                                /         \
                               /   IPv6    \
                              |   Internet  |
                               \           /
      UE / Mobile Phone         ‘---------’
   +----------------------+          |
   |  ----     |          |      .---+---.                   .------.
   | | v6 |----+          |     /         \                 /        \
   |  ----     |    ------|    / IPv6 PDP  \     ------    /   IPv4   \
   |           +---| CLAT |---+ Mobile Core +---| PLAT |--+  Internet  |
   |           |    ------|    \    GGSN   /     ------    \          /
   |           |          |     \         ’                 ‘----+---’
   |  ------   |          |      ‘-------’                       |
   | | v4p |---+          |                                    -----
   |  ------   |          |                                   | v4g |
   +----------------------+                                    -----

           <- v4p -> XLAT <--------- v6 --------> XLAT <- v4g ->


     v6  : Global IPv6
     v4p : Private IPv4
     v4g : Global IPv4
```

Figure 2: Wireless 3GPP Network Topology

6. Applicability

6.1. Wireline Network Applicability

When an ISP has IPv6 464XLAT, the ISP can provide outgoing IPv4 service to end users across an IPv6 access network. The result is that edge network growth is no longer tightly coupled to the availability of scarce IPv4 addresses.

If the IXP or another provider operates the PLAT, the edge ISP is only required to deploy an IPv6 access network. All ISPs do not need IPv4 access networks. They can migrate their access network to a simple and highly scalable IPv6-only environment.

Incidentally, the effectiveness of 464XLAT was confirmed in the WIDE camp Spring 2012. The result is described in

[I-D.hazeyama-widecamp-ipv6-only-experience].

6.2. Wireless 3GPP Network Applicability

The vast majority of mobile networks are compliant to Pre-Release 9 3GPP standards. In Pre-Release 9 3GPP networks, GSM and UMTS networks must signal and support both IPv4 and IPv6 Packet Data Protocol (PDP) attachments to access IPv4 and IPv6 network destinations [RFC6459]. Since there are 2 PDPs required to support 2 address families, this is double the number of PDPs required to support the status quo of 1 address family, which is IPv4.

464XLAT in combination with stateful translation [RFC6146] and DNS64 [RFC6147] allows 85% of the Android applications to continue to work with single translation or native IPv6 access. For the remaining 15% of applications that require IPv4 connectivity, the CLAT function on the UE provides a private IPv4 address and IPv4 default-route on the host for the applications to reference and bind to. Connections sourced from the IPv4 interface are immediately routed to the CLAT function and passed to the IPv6-only mobile network, destine to the PLAT. In summary, the UE has the CLAT function that does a stateless translation [RFC6145], but only when required. The mobile network has a PLAT that does stateful translation [RFC6146].

464XLAT works with today’s existing systems as much as possible. 464XLAT is compatible with existing network based deep packet inspection solutions like 3GPP standardized Policy and Charging Control (PCC) [TS.23203].

7. Implementation Considerations

7.1. IPv6 Address Format

IPv6 address format in 464XLAT is defined in Section 2.2 of [RFC6052].

7.2. IPv4/IPv6 Address Translation Chart

7.2.1. Case of enabling only stateless XLATE on CLAT

This case should be used when a prefix delegation mechanism such as DHCPv6-PD [RFC3633] is available to assign a dedicated translation prefix to the CLAT.

```
                                   Source IPv4 address
                                  +-----------------------------+
                                  | Global IPv4 address         |
                                  | assigned to IPv4 pool@PLAT |
                       +--------+ +-----------------------------+
                       |  IPv4  |  Destination IPv4 address
                       | server | +-----------------------------+
                       +--------+ | Global IPv4 address         |
                           ^      | assigned to IPv4 server     |
                           |      +-----------------------------+
                       +--------+
                       |  PLAT  | Stateful XLATE(IPv4:IPv6=1:n)
                       +--------+
                           ^
                           |
        Source IPv6 address  (IPv6 cloud)
       +----------------------------------------------------------------+
       | IPv4-Embedded IPv6 address                                     |
       | defined in Section 2.2 of RFC6052                              |
       +----------------------------------------------------------------+
        Destination IPv6 address
       +----------------------------------------------------------------+
       | IPv4-Embedded IPv6 address                                     |
       | defined in Section 2.2 of RFC6052                              |
       +----------------------------------------------------------------+
                      (IPv6 cloud)
                           ^
                           |
                       +--------+
                       |        | In the case CLAT has a
                       |        | dedicated IPv6 prefix for
                       |  CLAT  | translation, the CLAT can
                       |        | perform with only Stateless
                       |        | XLATE (IPv4:IPv6=1:1).
                       +--------+
                           ^       Source IPv4 address
                           |      +-----------------------------+
                       +--------+ | Private IPv4 address        |
                       |  IPv4  | | assigned to IPv4 client     |
                       | client | +-----------------------------+
                       +--------+  Destination IPv4 address
                                  +-----------------------------+
                                  | Global IPv4 address         |
                                  | assigned to IPv4 server     |
                                  +-----------------------------+
```

Case of enabling only stateless XLATE on CLAT

7.2.2. Case of enabling NAT44 and stateless XLATE on CLAT

This case should be used when a prefix delegation mechanism is not available to assign a dedicated translation prefix to the CLAT. In this case, NAT44 SHOULD be used so that all IPv4 source addresses are mapped to a single IPv6 address.

```
                                 Source IPv4 address
                                +-----------------------------+
                                | Global IPv4 address         |
                                | assigned to IPv4 pool@PLAT |
                      +--------+ +-----------------------------+
                      |  IPv4  |  Destination IPv4 address
                      | server | +-----------------------------+
                      +--------+ | Global IPv4 address         |
                          ^      | assigned to IPv4 server     |
                          |      +-----------------------------+
                      +--------+
                      |  PLAT  | Stateful XLATE(IPv4:IPv6=1:n)
                      +--------+
                          ^
                          |
         Source IPv6 address  (IPv6 cloud)
        +----------------------------------------------------------------+
        | IPv4-Embedded IPv6 address                                     |
        | defined in Section 2.2 of RFC6052                              |
        +----------------------------------------------------------------+
         Destination IPv6 address
        +----------------------------------------------------------------+
        | IPv4-Embedded IPv6 address                                     |
        | defined in Section 2.2 of RFC6052                              |
        +----------------------------------------------------------------+
                      (IPv6 cloud)
                          ^
                          |
                      +--------+
                      |        | In the case CLAT does not have
                      |        | a dedicated IPv6 prefix for
                      |  CLAT  | translation, the CLAT can
                      |        | perform with NAT44 and
                      |        | Stateless XLATE
                      |        | (IPv4:IPv6=1:1).
                      +--------+
                          ^       Source IPv4 address
                          |      +-----------------------------+
                      +--------+ | Private IPv4 address        |
                      |  IPv4  | | assigned to IPv4 client     |
                      | client | +-----------------------------+
                      +--------+  Destination IPv4 address
                                 +-----------------------------+
                                 | Global IPv4 address         |
                                 | assigned to IPv4 server     |
                                 +-----------------------------+
```

Case of enabling NAT44 and stateless XLATE on CLAT

7.3. IPv6 Prefix Handling

7.3.1. Case of enabling only stateless XLATE on CLAT

From the delegated DHCPv6 [RFC3633] prefix, a /64 is dedicated to source and receive IPv6 packets associated with the stateless translation [RFC6145].

The CLAT MAY discover the Pref64::/n of the PLAT via some method such as DHCPv6 option, TR-069, DNS APL RR [RFC3123] or [I-D.ietf-behave-nat64-discovery-heuristic].

7.3.2. Case of enabling NAT44 and stateless XLATE on CLAT

In the case that DHCPv6-PD [RFC3633] is not available, the CLAT does not have dedicated IPv6 prefix for translation. If the CLAT does not have a dedicated IPv6 prefix for translation, the CLAT can perform with NAT44 and stateless translation [RFC6145].

Incoming source IPv4 packets from the LAN of [RFC1918] addresses are NAT44 to the CLAT IPv4 host address. Then, the CLAT will do a stateless translation [RFC6145] so that the IPv4 packets from the CLAT IPv4 host address are translated to the CLAT WAN IPv6 address as described in [RFC6052].

Its subnet prefix is made of the delegated prefix, completed if needed to a /64 by a subnet ID = 0. Its interface ID is the 464XLAT interface ID (Section 10).

The CLAT MAY discover the Pref64::/n of the PLAT via some method such as TR-069, DNS APL RR [RFC3123] or [I-D.ietf-behave-nat64-discovery-heuristic].

7.4. Traffic Treatment Scenarios

Server	Application and Host	Traffic Treatment	Location of Translation
IPv6	IPv6	End-to-end IPv6	None
IPv4	IPv6	Stateful Translation	PLAT
IPv4	IPv4	464XLAT	PLAT/CLAT
IPv6	IPv4	Stateless Translation	CLAT

Traffic Treatment Scenarios

The above chart shows most common traffic types and traffic treatment.

7.5. DNS Proxy Implementation

The CLAT SHOULD implement a DNS proxy as defined in [RFC5625]. The case of an IPv4-only node behind CLAT querying an IPv4 DNS server is undesirable since it requires both stateful and stateless translation for each DNS lookup. The CLAT SHOULD set itself as the DNS server via DHCP or other means and proxy DNS queries for IPv4 and IPv6 clients. Using the CLAT enabled home router or UE as a DNS proxy is a normal consume gateway function and simplifies the traffic flow so that only IPv6 native queries are made across the access network. The CLAT SHOULD allow for a client to query any DNS server of its choice and bypass the proxy.

7.6. CLAT in a Gateway

The CLAT is a stateless translation feature which can be implemented in a common home router or mobile phone that has a mobile router feature. The router with CLAT function SHOULD provide common router services such as DHCP of [RFC1918] addresses, DHCPv6, and DNS service. The router SHOULD set itself as the DNS server advertised via DHCP or other means to the clients so that it may implement the DNS proxy function to avoid double translation of DNS request.

7.7. CLAT to CLAT communications

While CLAT to CLAT IPv4 communication may work when the client IPv4 subnets do not overlap, this traffic flow is out of scope. 464XLAT is a hub and spoke architecture focused on enabling IPv4-only services over IPv6-only access networks.

8. Deployment Considerations

Even if the Internet access provider for consumers is different from the PLAT provider (e.g. another internet access provider), it can implement traffic engineering independently from the PLAT provider. Detailed reasons are below:

1. The Internet access provider for consumers can figure out IPv4 destination address from translated IPv6 packet header, so it can implement traffic engineering based on IPv4 destination address (e.g. traffic monitoring for each IPv4 destination address, packet filtering for each IPv4 destination address, etc.). The tunneling methods do not have such a advantage, without any deep packet inspection for processing the inner IPv4 packet of the tunnel packet.

2. If the Internet access provider for consumers can assign IPv6 prefix greater than /64 for each subscriber, this 464XLAT architecture can separate IPv6 prefix for native IPv6 packets and XLAT prefix for IPv4/IPv6 translation packets. Accordingly, it can identify the type of packets ("native IPv6 packets" and "IPv4/IPv6 translation packets"), and implement traffic engineering based on IPv6 prefix.

This 464XLAT architecture has two capabilities. One is a IPv4 -> IPv6 -> IPv4 translation for sharing global IPv4 addresses, another, if combined with BIH [RFC6535], is a IPv4 -> IPv6 translation for reaching IPv6-only servers from IPv4-only clients that can not support IPv6. IPv4-only clients must be support through the long period of global transition to IPv6.

9. Security Considerations

To implement a PLAT, see security considerations presented in Section 5 of [RFC6146].

To implement a CLAT, see security considerations presented in Section 7 of [RFC6145]. The CLAT MAY comply with [RFC6092].

10. IANA Considerations

IANA is requested to reserve a Modified EUI-64 identifier for 464XLAT according to section 2.2.2 of [RFC5342]. Its suggested value is 02-00-5E-00-00-00-00-00 to 02-00-5E-0F-FF-FF-FF-FF or 02-00-5E-10-00-00-00-00 to 02-00-5E-EF-FF-FF-FF-FF, depending on whether it should be taken in reserved or available values.

11. Acknowledgements

The authors would like to thank JPIX NOC members, JPIX 464XLAT trial service members, Seiichi Kawamura, Dan Drown, Brian Carpenter, Rajiv Asati, Washam Fan, Behcet Sarikaya, Jan Zorz, Tatsuya Oishi, Lorenzo Colitti, Erik Kline, Ole Troan, Maoke Chen, Gang Chen, Tom Petch, and Jouni Korhonen for their helpful comments. Special acknowledgments go to Remi Despres for his plentiful supports and suggestions, especially about using NAT44 with IANA's EUI-64 ID. We also would like to thank Fred Baker and Joel Jaeggli for their support.

12. References

12.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC6052] Bao, C., Huitema, C., Bagnulo, M., Boucadair, M., and X. Li, "IPv6 Addressing of IPv4/IPv6 Translators", RFC 6052, October 2010.

[RFC6144] Baker, F., Li, X., Bao, C., and K. Yin, "Framework for IPv4/IPv6 Translation", RFC 6144, April 2011.

[RFC6145] Li, X., Bao, C., and F. Baker, "IP/ICMP Translation Algorithm", RFC 6145, April 2011.

[RFC6146] Bagnulo, M., Matthews, P., and I. van Beijnum, "Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers", RFC 6146, April 2011.

12.2. Informative References

[I-D.hazeyama-widecamp-ipv6-only-experience]
Hazeyama, H., Hiromi, R., Ishihara, T., and O. Nakamura, "Experiences from IPv6-Only Networks with Transition Technologies in the WIDE Camp Spring 2012", draft-hazeyama-widecamp-ipv6-only-experience-01 (work in progress), March 2012.

[I-D.ietf-behave-nat64-discovery-heuristic]
Savolainen, T., Korhonen, J., and D. Wing, "Discovery of IPv6 Prefix Used for IPv6 Address Synthesis", draft-ietf-behave-nat64-discovery-heuristic-10 (work in progress), June 2012.

[RFC1918] Rekhter, Y., Moskowitz, R., Karrenberg, D., Groot, G., and E. Lear, "Address Allocation for Private Internets", BCP 5, RFC 1918, February 1996.

[RFC3123] Koch, P., "A DNS RR Type for Lists of Address Prefixes (APL RR)", RFC 3123, June 2001.

[RFC3633] Troan, O. and R. Droms, "IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6", RFC 3633, December 2003.

[RFC5342] Eastlake, D., "IANA Considerations and IETF Protocol Usage for IEEE 802 Parameters", BCP 141, RFC 5342, September 2008.

[RFC5625] Bellis, R., "DNS Proxy Implementation Guidelines", BCP 152, RFC 5625, August 2009.

[RFC6092] Woodyatt, J., "Recommended Simple Security Capabilities in Customer Premises Equipment (CPE) for Providing Residential IPv6 Internet Service", RFC 6092, January 2011.

[RFC6147] Bagnulo, M., Sullivan, A., Matthews, P., and I. van Beijnum, "DNS64: DNS Extensions for Network Address Translation from IPv6 Clients to IPv4 Servers", RFC 6147, April 2011.

[RFC6459] Korhonen, J., Soininen, J., Patil, B., Savolainen, T., Bajko, G., and K. Iisakkila, "IPv6 in 3rd Generation Partnership Project (3GPP) Evolved Packet System (EPS)", RFC 6459, January 2012.

[RFC6535] Huang, B., Deng, H., and T. Savolainen, "Dual-Stack Hosts Using "Bump-in-the-Host" (BIH)", RFC 6535, February 2012.

[TS.23203]
3GPP, "Policy and charging control architecture", 3GPP TS 23.203 10.7.0, June 2012.

Appendix A. Examples of IPv4/IPv6 Address Translation

The following are examples of IPv4/IPv6 Address Translation on the 464XLAT architecture.

Example 1. (Case of enabling only stateless XLATE on CLAT)

In the case that IPv6 prefix greater than /64 is assigned to end users by such as DHCPv6-PD [RFC3633], only the function of Stateless XLATE should be enabled on CLAT. Because the CLAT can use dedicated a /64 from the assigned IPv6 prefix for Stateless XLATE.

```
      Host & configuration value
   +------------------------------+
   |          IPv4 server         |
   |        [198.51.100.1]        |          IP packet header
   +------------------------------+   +---------------------------------+
                  ^                   | Source IP address               |
                  |                   | [192.0.2.1]                     |
                  |                   | Destination IP address          |
                  |                   | [198.51.100.1]                  |
   +------------------------------+   +---------------------------------+
   |             PLAT             |                  ^
   | IPv4 pool address            |                  |
   | [192.0.2.1 - 192.0.2.100]    |                  |
   | PLAT-side XLATE IPv6 prefix  |                  |
   | [2001:db8:1234::/96]         |                  |
   +------------------------------+   +---------------------------------+
                  ^                   | Source IP address               |
                  |                   | [2001:db8:aaaa::192.168.1.2]    |
                  |                   | Destination IP address          |
                  |                   | [2001:db8:1234::198.51.100.1]   |
   +------------------------------+   +---------------------------------+
   |             CLAT             |                  ^
   | PLAT-side XLATE IPv6 prefix  |                  |
   | [2001:db8:1234::/96]         |                  |
   | CLAT-side XLATE IPv6 prefix  |                  |
   | [2001:db8:aaaa::/96]         |                  |
   +------------------------------+   +---------------------------------+
                  ^                   | Source IP address               |
                  |                   | [192.168.1.2]                   |
                  |                   | Destination IP address          |
                  |                   | [198.51.100.1]                  |
   +------------------------------+   +---------------------------------+
   |          IPv4 client         |
   |        [192.168.1.2/24]      |
   +------------------------------+
   Delegated IPv6 prefix for client: 2001:db8:aaaa::/56
```

Example 2. (Case of enabling NAT44 and stateless XLATE on CLAT)

In the case that IPv6 prefix /64 is assigned to end users, the function of NAT44 and Stateless XLATE should be enabled on CLAT. Because the CLAT does not have dedicated IPv6 prefix for translation.

```
     Host & configuration value
   +------------------------------+
   |          IPv4 server         |
   |        [198.51.100.1]        |          IP packet header
   +------------------------------+   +--------------------------------+
                 ^                    | Source IP address              |
                 |                    | [192.0.2.1]                    |
                 |                    | Destination IP address         |
                 |                    | [198.51.100.1]                 |
   +------------------------------+   +--------------------------------+
   |             PLAT             |                  ^
   | IPv4 pool address            |                  |
   | [192.0.2.1 - 192.0.2.100]    |                  |
   | PLAT-side XLATE IPv6 prefix  |                  |
   | [2001:db8:1234::/96]         |                  |
   +------------------------------+   +--------------------------------+
                 ^                    | Source IP address              |
                 |                    | [2001:db8:aaaa:200:5e10:0:0]   |
                 |                    | Destination IP address         |
                 |                    | [2001:db8:1234::198.51.100.1]  |
   +------------------------------+   +--------------------------------+
   | CLAT Stateless XLATE function |                 ^
   | - - - - - - - - - - - - - - - |                 |
   | PLAT-side XLATE IPv6 prefix  |                  |
   | [2001:db8:1234::/96]         |                  |
   | CLAT-side XLATE IPv6 prefix  |                  |
   | [2001:db8:aaaa::/64]         |                  |
   | CLAT-side XLATE IPv6 EUI-64 ID|                 |
   | [02-00-5E-10-00-00-00-00]    |                  |
   + - - - - - - - - - - - - - - -+   +--------------------------------+
   |             ^                |   | Source IP address              |
   |             |                |   | [10.255.255.1]                 |
   |             |                |   | Destination IP address         |
   |             |                |   | [198.51.100.1]                 |
   + - - - - - - - - - - - - - - -+   +--------------------------------+
   | CLAT NAT44 function          |                  ^
   | - - - - - - - - - - - - - - - |                 |
   | NAT44 NATed address          |                  |
   | [10.255.255.1/32]            |                  |
   +------------------------------+   +--------------------------------+
                 ^                    | Source IP address              |
                 |                    | [192.168.1.2]                  |
                 |                    | Destination IP address         |
                 |                    | [198.51.100.1]                 |
   +------------------------------+   +--------------------------------+
   |          IPv4 client         |
   |        [192.168.1.2/24]      |
   +------------------------------+
```

Delegated IPv6 prefix for client: 2001:db8:aaaa::/64

Authors' Addresses

Masataka Mawatari
Japan Internet Exchange Co.,Ltd.
KDDI Otemachi Building 19F, 1-8-1 Otemachi,
Chiyoda-ku, Tokyo 100-0004
JAPAN

Phone: +81 3 3243 9579
Email: mawatari@jpix.ad.jp

Masanobu Kawashima
NEC AccessTechnica, Ltd.
800, Shimomata
Kakegawa-shi, Shizuoka 436-8501
JAPAN

Phone: +81 537 23 9655
Email: kawashimam@vx.jp.nec.com

Cameron Byrne
T-Mobile USA
Bellevue, Washington 98006
USA

Email: cameron.byrne@t-mobile.com