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464XLAT: Combination of Stateful and Stateless Translation

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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

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

With the exhaustion of the unallocated IPv4 address pools, it will be difficult for many networks to assign IPv4 addresses to end users.

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 a 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 customer side translator(CLAT) to IPv6 and back to IPv4 on the provider side translator(PLAT). 464XLAT networks may use DNS64 [RFC6147] to enable single stateful translation [RFC6146] instead of 464XLAT double translation where possible. The 464XLAT architecture encourages the 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 IPv4-only hosts across IPv6-only networks.

2. BCP Scenario

This BCP only applies when the following two criteria are present:

1. There is an IPv6-only network that uses stateful translation [RFC6146] as the only mechanism for providing IPv4 access.

2. There are IPv4-only applications or hosts that must communicate across the IPv6-only network to reach the IPv4 Internet.

3. 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].

4. Terminology

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

CLAT: CLAT is Customer side translator(XLAT) that complies with [RFC6145]. It algorithmically translates 1:1 private IPv4 addresses to global IPv6 addresses, and vice versa. The CLAT function is applicable to a router or an end-node such as a mobile phone. The 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 wireless 3GPP 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.

5. 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.

6. Network Architecture

Examples of 464XLAT architectures are show in the figures in the following sections.

Wireline Network Architecture can fit in the situations that there are the clients behind the CLAT in the same way regardless of the type of access service, for example FTTH, Cable, or WiFi.

Wireless 3GPP Network Architecture can fit in the situations that client and node that terminate access network is same host in the same way.

6.1. 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/CLAT can not only have the function of a CLAT but also the function of an IPv6 native router for native IPv6 traffic. The v4p host behind the CLAT on this diagram with the private IPv4 addresses.

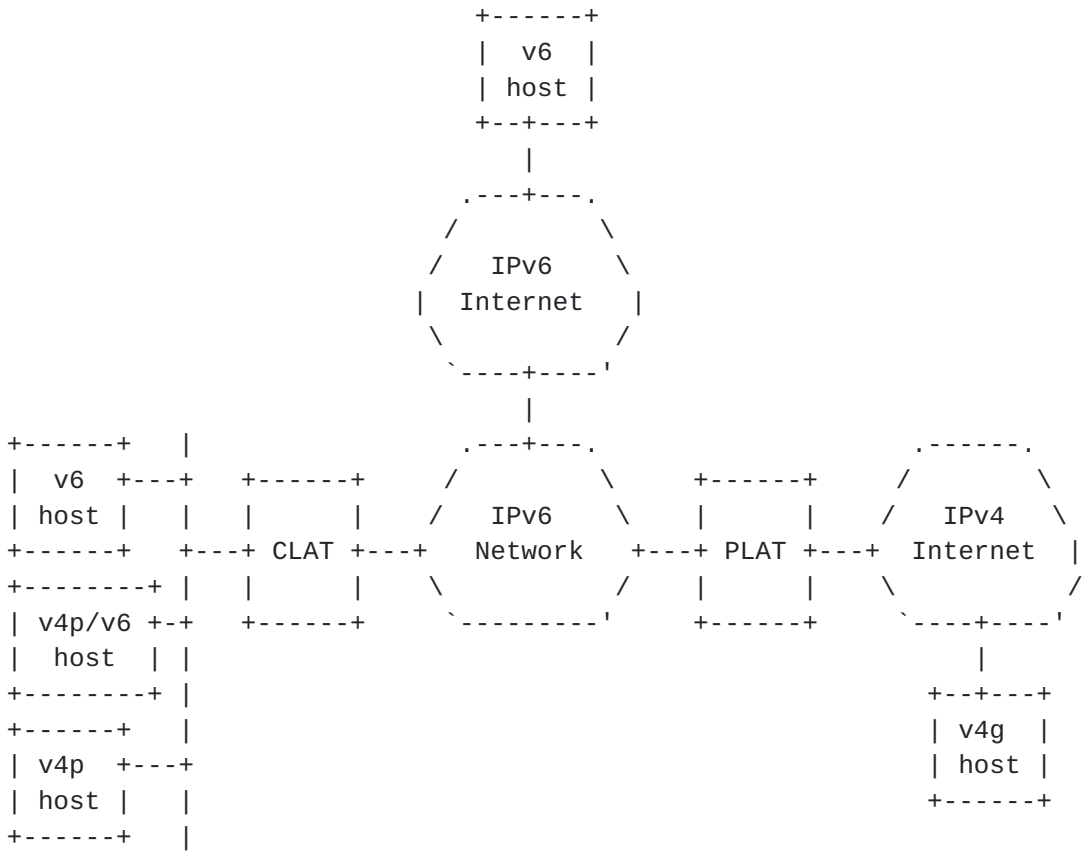


Figure 1: Wireline Network Topology

6.2. Wireless 3GPP Network Architecture

The CLAT function on the User Equipment (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.

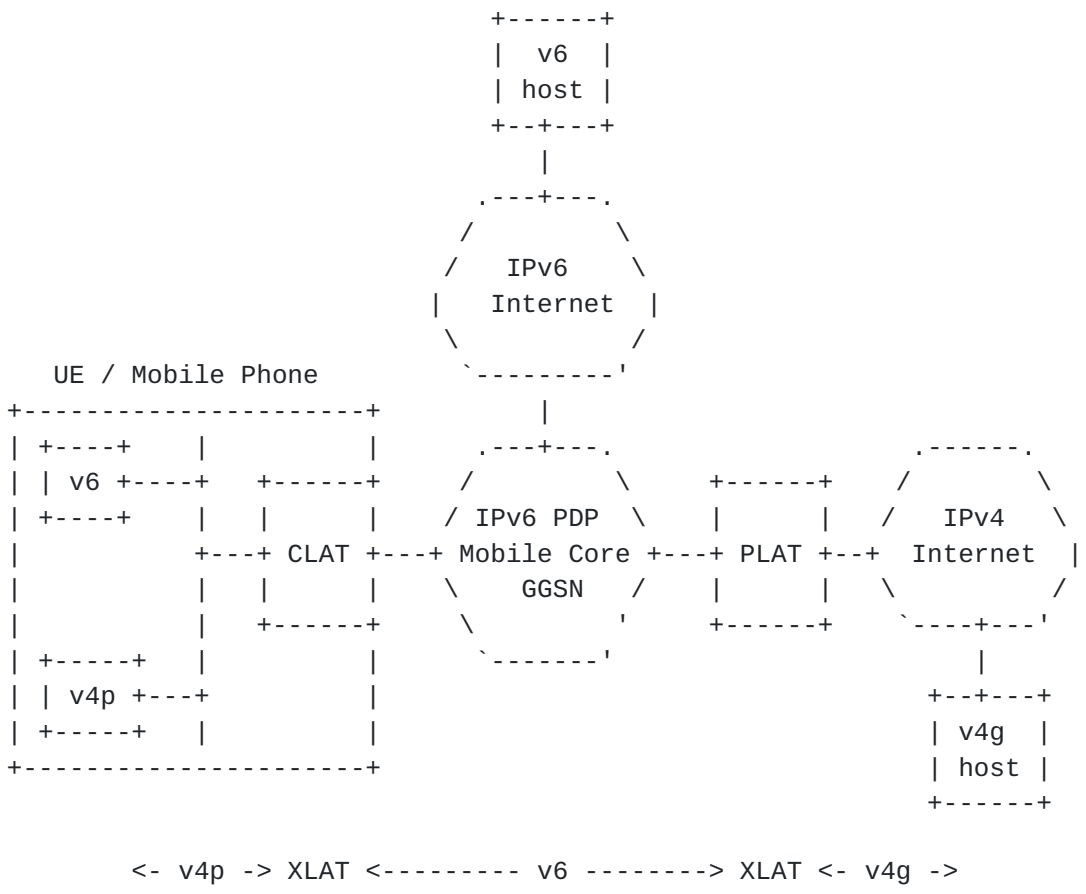


Figure 2: Wireless 3GPP Network Topology

7. Applicability

7.1. Wireline Network Applicability

When an ISP has IPv6 access service and provides 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 another ISP 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].

7.2. 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 two PDPs required to support two address families, this is double the number of PDPs required to support the status quo of one address family, which is IPv4.

For the IPv4 literal or IPv4 socket 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, destined for 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].

8. Implementation Considerations

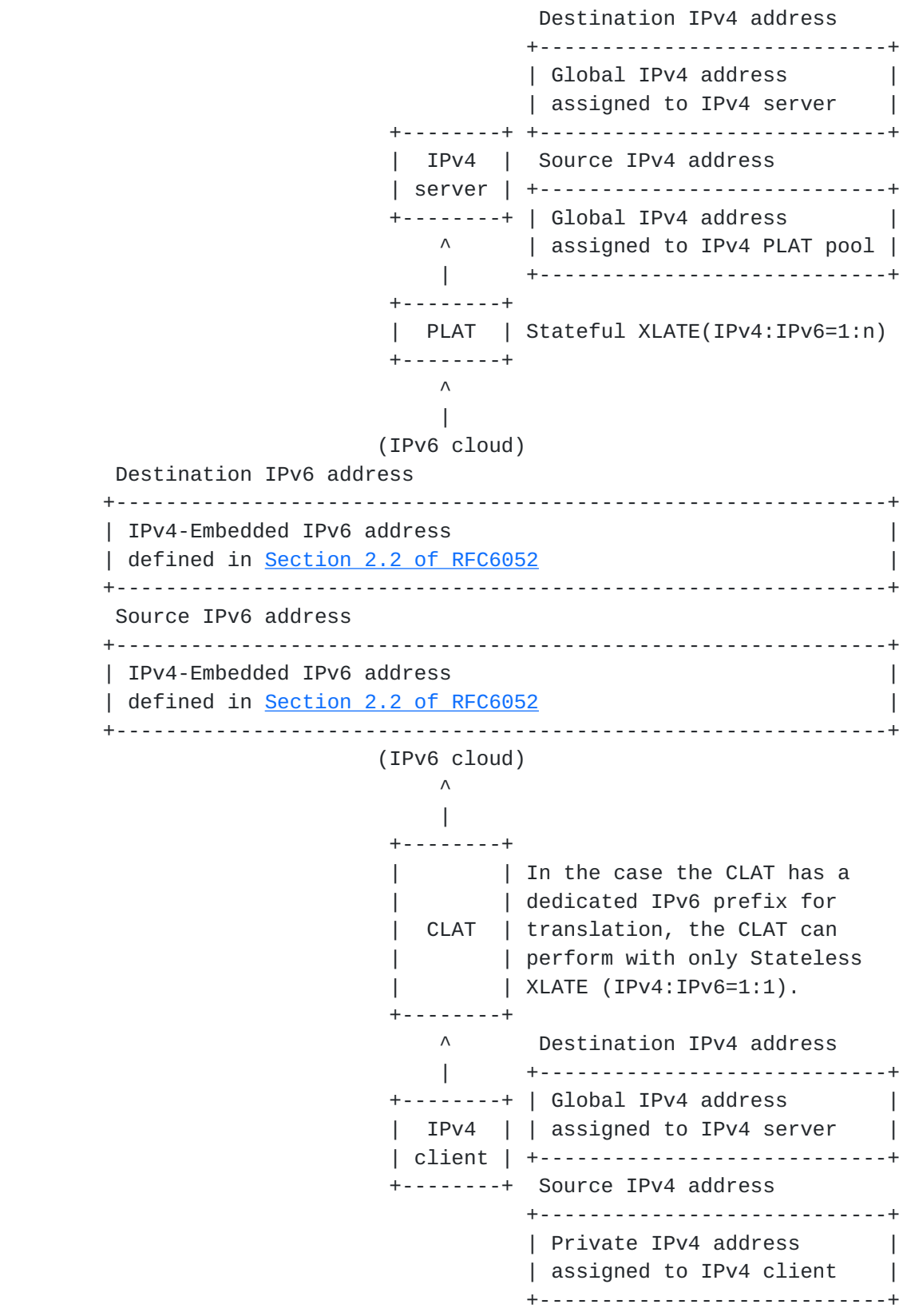
8.1. IPv6 Address Format

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

8.2. IPv4/IPv6 Address Translation Chart

8.2.1. Case of enabling only stateless XLATE on CLAT

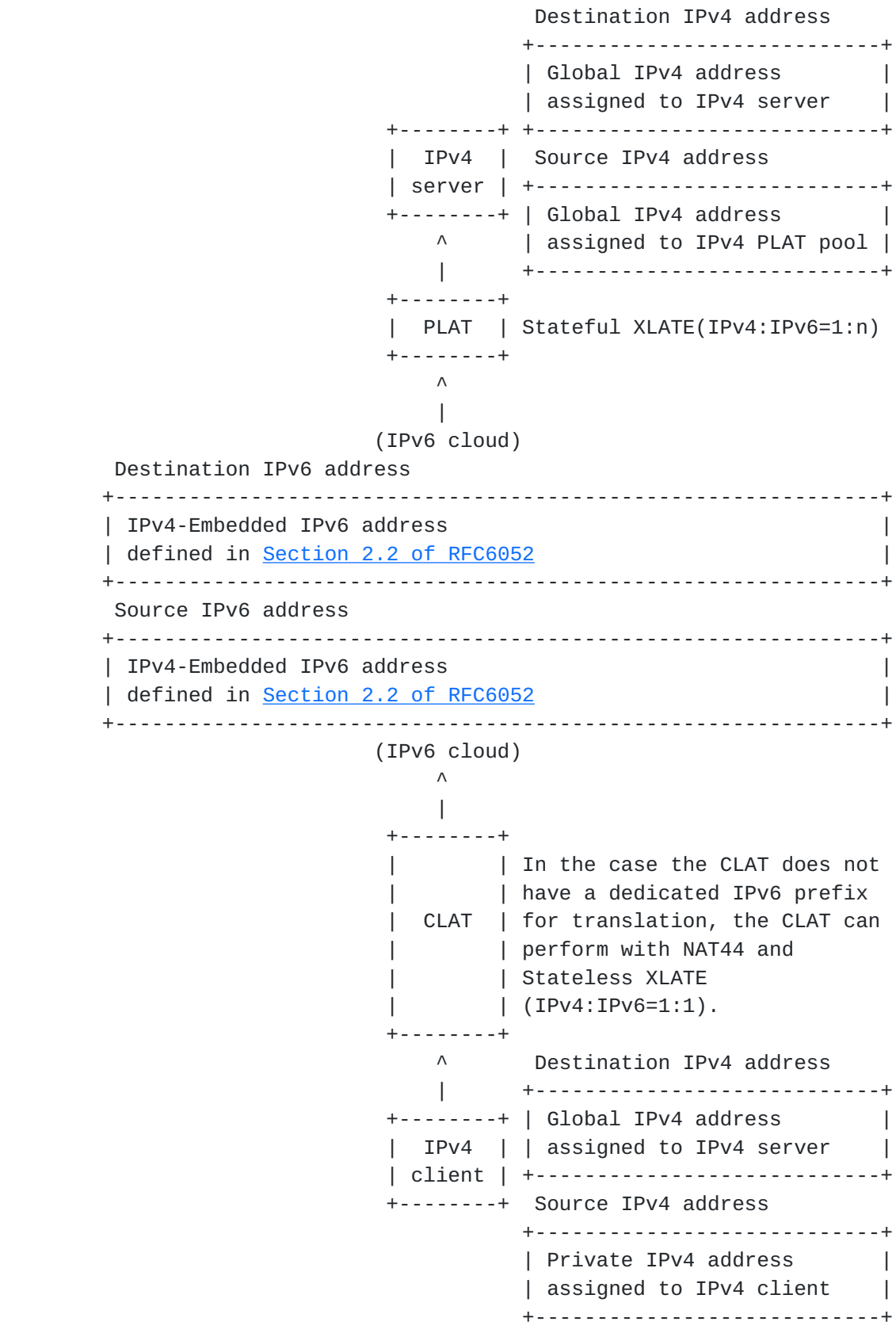
This case should be used when a prefix delegation mechanism such as DHCPv6-PD [RFC3633] is available to assign a dedicated translation prefix to the CLAT.



Case of enabling only stateless XLATE on CLAT

8.2.2. 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.


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

Case of enabling NAT44 and stateless XLATE on CLAT

8.3. IPv6 Prefix Handling

8.3.1. 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].

8.3.2. Case of enabling NAT44 and stateless XLATE on CLAT

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

IPv4 packets from the LAN are NAT44 to the private IPv4 host address of the CLAT that is not included in LAN segment of CLAT. 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 [RFC6145].

If the CLAT cannot perform ND Proxy [RFC4389] due to the restriction of the implementation, the CLAT may use a dedicated IANA assigned EUI-64 ID for creating a translated IPv6 address to be used in stateless translation [RFC6145]. This will allow the CLAT to avoid possible IPv6 address duplication issues between an IPv6 address for stateless translation [RFC6145] in the CLAT and an IPv6 address assigned to native IPv6 nodes behind the CLAT. This document describes an example for this case in Example 2. of the Appendix A.

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].

8.4. DNS Proxy Implementation

The CLAT SHOULD implement a DNS proxy as defined in [RFC5625]. The case of an IPv4-only node behind the 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 LAN clients. Using the CLAT enabled home router or UE as a DNS

proxy is a normal consumer 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.

8.5. 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 tethering feature. The router with CLAT function SHOULD provide common router services such as DHCP of [RFC1918] addresses, DHCPv6, and DNS service.

8.6. 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 networks.

9. Deployment Considerations

9.1. Traffic Engineering

Even if the ISP for end users is different from the PLAT provider (e.g. another ISP), it can implement traffic engineering independently from the PLAT provider. Detailed reasons are below:

1. The ISP for end users 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 an advantage, without any deep packet inspection for processing the inner IPv4 packet of the tunnel packet.

2. If the ISP for end users can assign an IPv6 prefix greater than /64 to each subscriber, this 464XLAT architecture can separate IPv6 prefix for native IPv6 packets and the XLAT prefixes 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 the IPv6 prefix.

9.2. Traffic Treatment Scenarios

This 464XLAT architecture has capabilities. One is a IPv4 -> IPv6 -> IPv4 translation for sharing global IPv4 addresses as a basic function, 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.

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	BIH	CLAT

Traffic Treatment Scenarios

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

10. 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].

11. 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.

12. Acknowledgements

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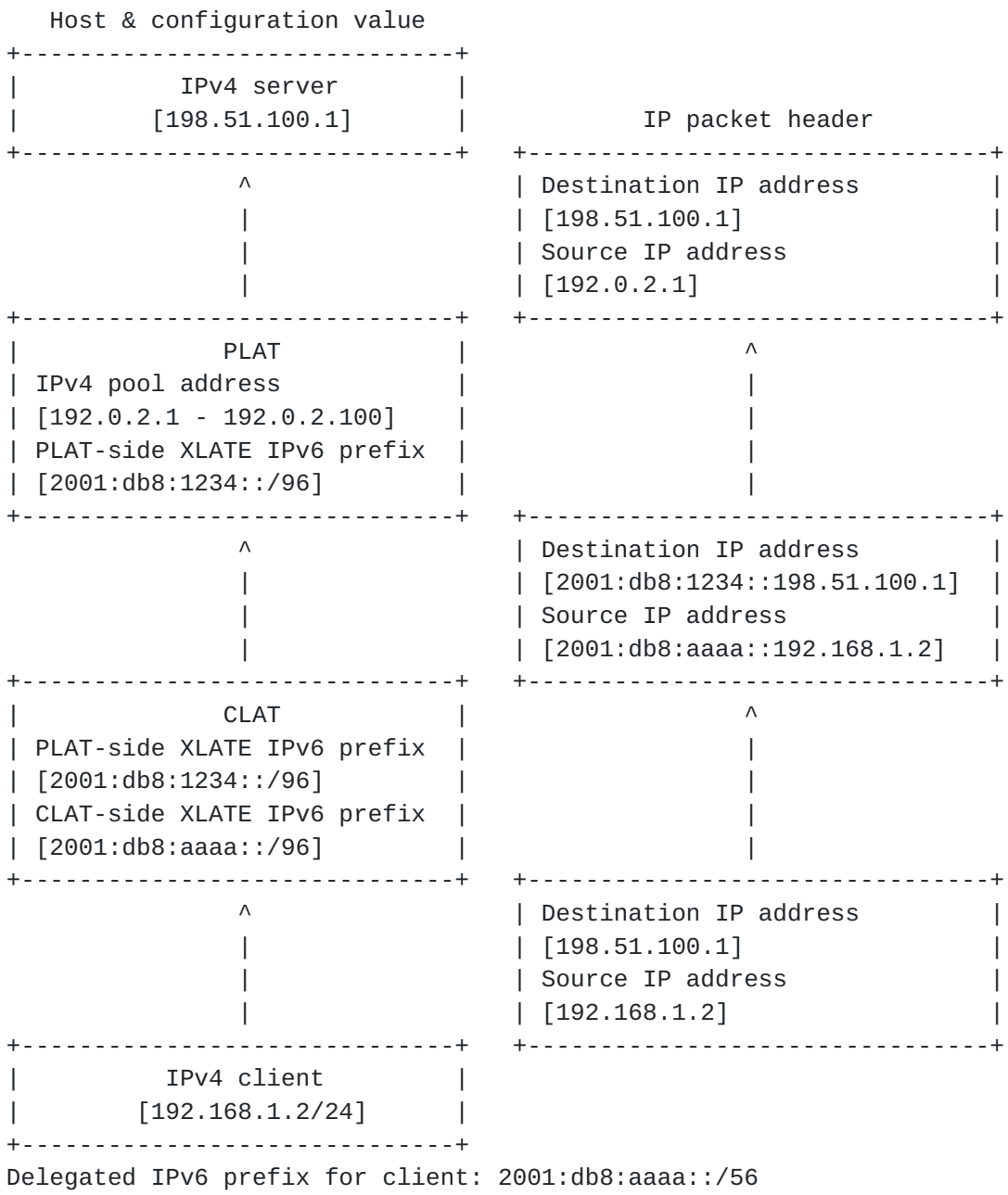
Appendix A. Examples of IPv4/IPv6 Address Translation

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

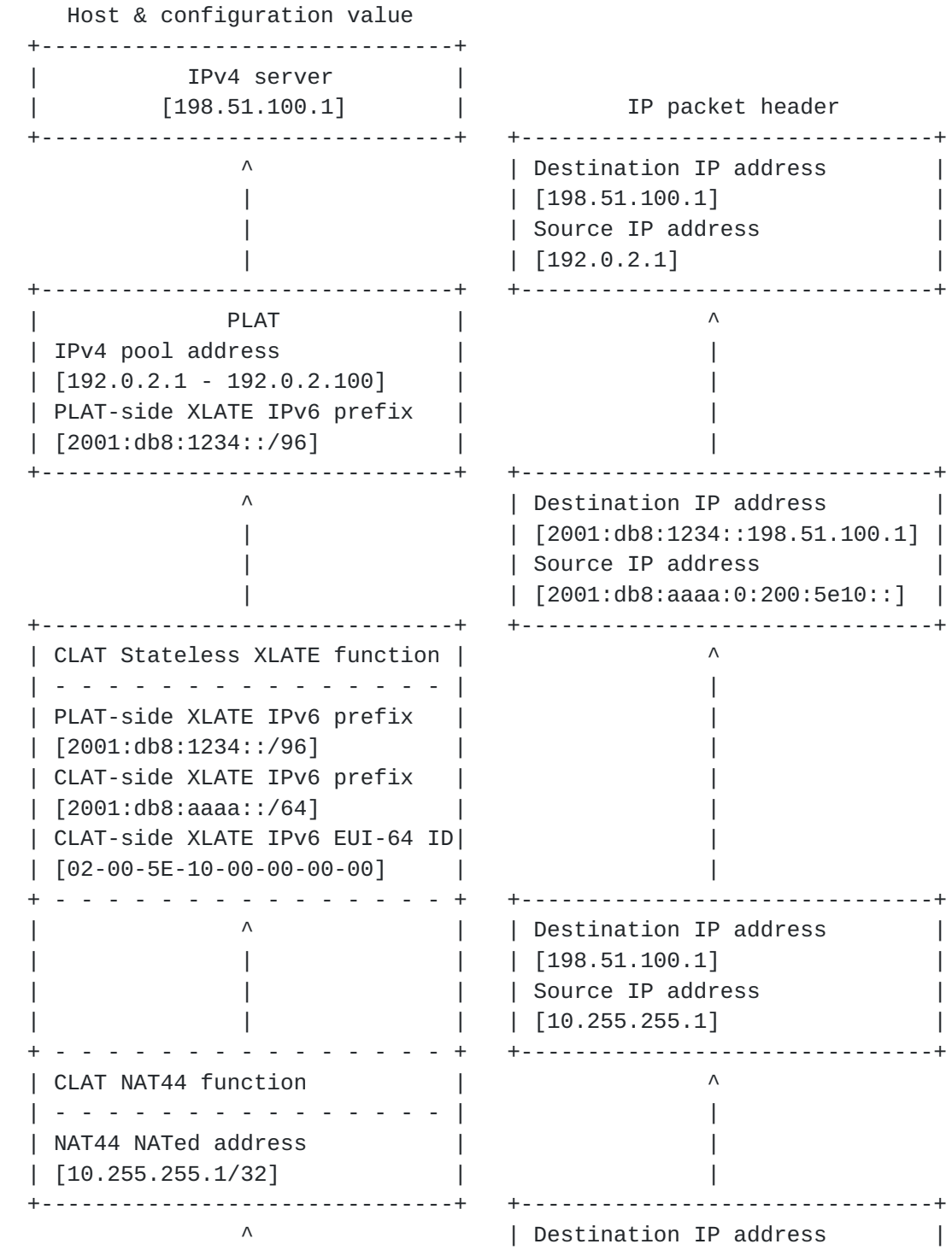
Example 1. (Case of enabling only stateless XLATE on CLAT)

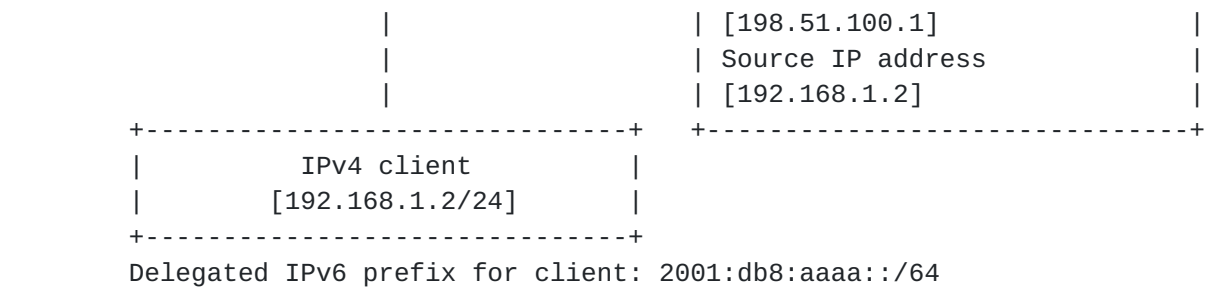
In the case that an IPv6 prefix greater than /64 is assigned to an end user by such as DHCPv6-PD [RFC3633], only the Stateless XLATE functionality should be enabled on the CLAT as the CLAT can use a dedicated /64 from the assigned IPv6 prefix.



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.





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