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464XLAT: Combination of Stateful and Stateless Translation

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 (as described in RFC 6146) in the core and stateless protocol translation (as described in 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

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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, that will be translated to IPv6 on the customer-side translator (CLAT) 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.

2. 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 IP routing and forwarding to facilitate packets forwarding through the stateless translation even if it is an end-node. The CLAT as a common home router or wireless Third Generation Partnership Project (3GPP) router is expected to perform gateway functions such as being a DHCP server and DNS proxy for local clients. The CLAT uses different IPv6 prefixes for CLAT-side and PLAT-side IPv4 addresses and therefore does not comply with the sentence "Both IPv4-translatable IPv6 addresses and IPv4-converted IPv6 addresses SHOULD use the same prefix." in

Section 3.3 of [RFC6052]. The CLAT does not facilitate communications between a local IPv4-only node and an IPv6-only node on the Internet.

3. Motivation and Uniqueness of 464XLAT

The list below describes the motivation for 464XLAT and its unique characteristics.

- 464XLAT has minimal IPv4 resource requirements and maximum IPv4 efficiency through statistical multiplexing.
- No new protocols are required; there is quick deployment.
- IPv6-only networks are simpler and therefore less expensive to operate than dual-stack networks.
- 464XLAT has consistent native IP-based monitoring and traffic engineering. Capacity-planning techniques can be applied without the indirection or obfuscation of a tunnel.

4. Network Architecture

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

Wireline Network Architecture can be used in situations where there are clients behind the CLAT, regardless of the type of access service -- for example, fiber to the home (FTTH), Data Over Cable Service Interface Specification (DOCSIS), or WiFi.

Wireless 3GPP Network Architecture can be used in situations where a client terminates the wireless access network and possibly acts as a router with tethered clients.

4.1. Wireline Network Architecture

The private IPv4 host in this diagram can reach global IPv4 hosts via translation on both the 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 Customer Premises Equipment (CPE) / CLAT can not only have the function of a CLAT but also the function of an IPv6 native router for native IPv6 traffic. In this diagram, the v4p host behind the CLAT has [RFC1918] addresses.

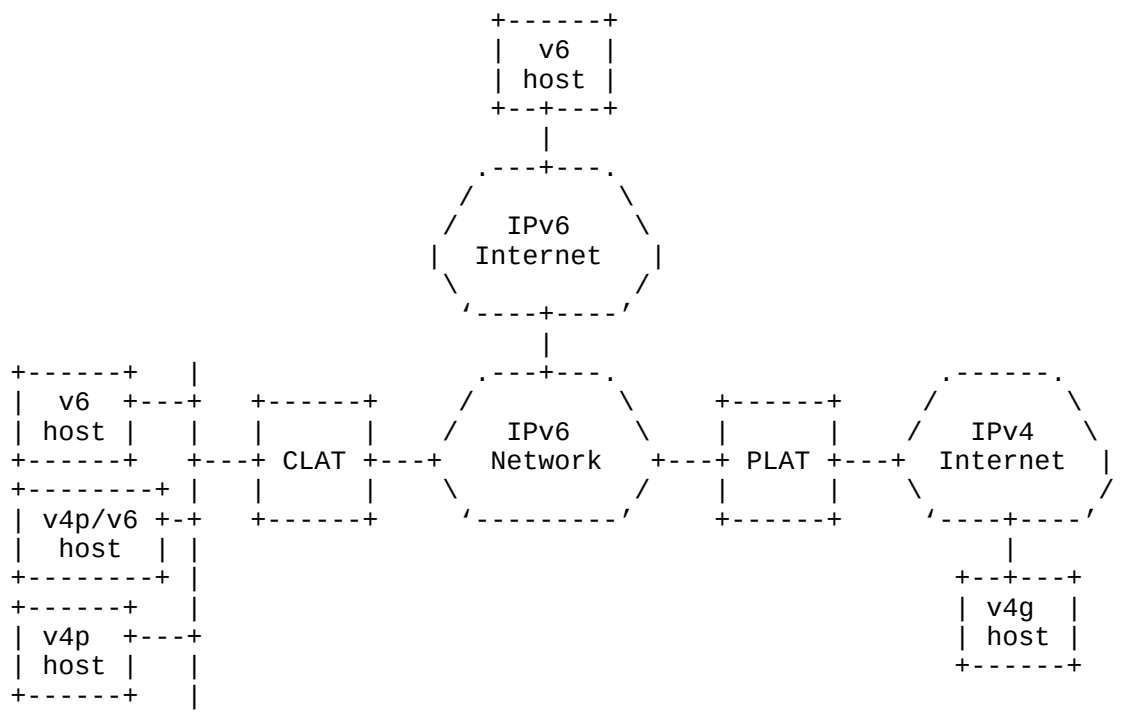

Figure 1: Wireline Network Topology

4.2. Wireless 3GPP Network Architecture

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

Presenting a private IPv4 network for tethering via NAT44 and stateless translation on the UE is also an application of the CLAT.

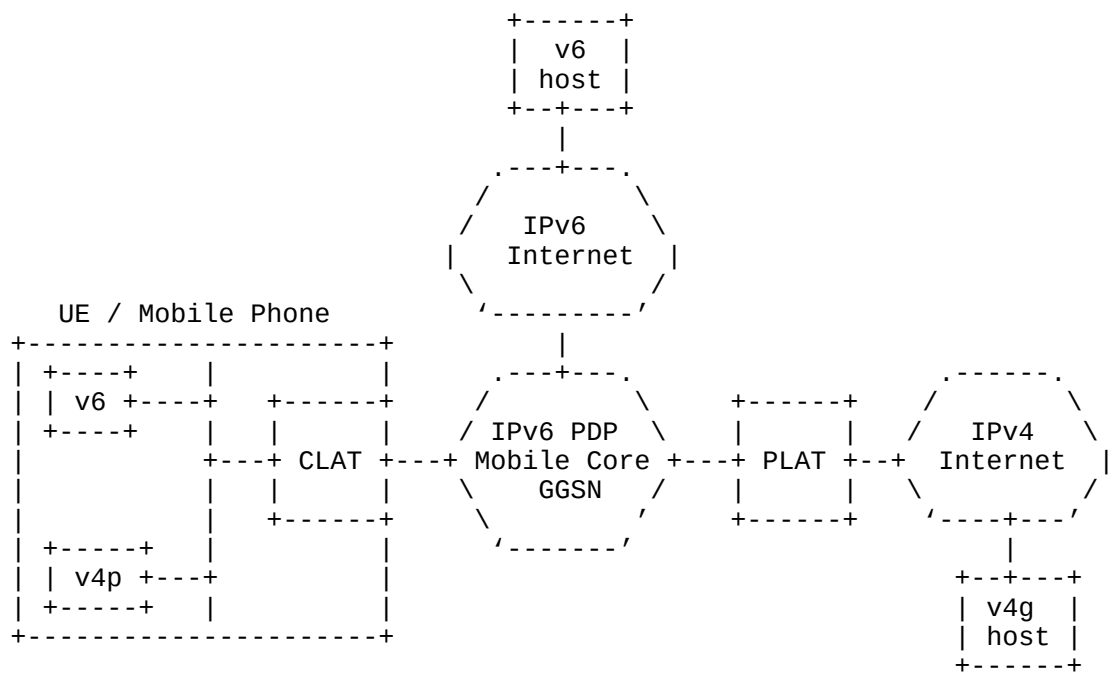

Figure 2: Wireless 3GPP Network Topology

5. Applicability

5.1. Wireline Network Applicability

When an Internet Service Provider (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.

5.2. Wireless 3GPP Network Applicability

At the time of writing, in April 2013, the vast majority of mobile networks are compliant to Pre-Release 9 3GPP standards. In Pre-Release 9 3GPP networks, Global System for Mobile Communications (GSM) and Universal Mobile Telecommunications System (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 cases of connecting to an IPv4 literal or IPv4 socket 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 performs the CLAT function that does a stateless translation [RFC6145], but only when required by an IPv4-only scenario such as IPv4 literals or IPv4-only sockets. 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 solutions for network-based deep packet inspection like 3GPP standardized Policy and Charging Control (PCC) [TS.23203].

6. Implementation Considerations

6.1. IPv6 Address Format

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

6.2. IPv4/IPv6 Address Translation Chart

This chart offers an explanation about address translation architecture using a combination of stateful translation at the PLAT and stateless translation at the CLAT. The client on this chart is delegated an IPv6 prefix from a prefix delegation mechanism such as DHCPv6 Prefix Delegation (DHCPv6-PD) [RFC3633]; therefore, it has a dedicated IPv6 prefix for translation.

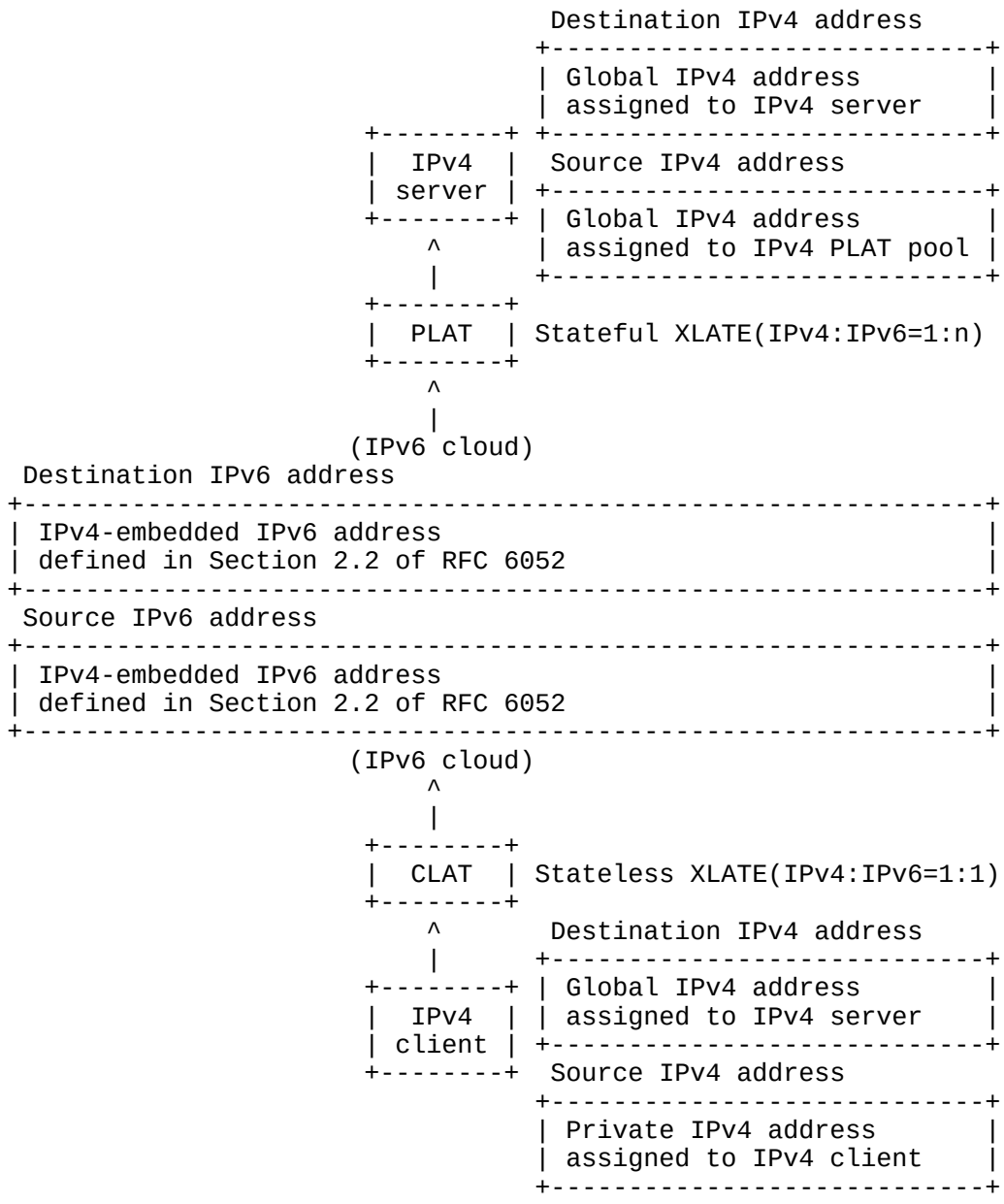

Figure 3: Case of Enabling Only Stateless XLATE on CLAT

6.3. IPv6 Prefix Handling

There are two relevant IPv6 prefixes that the CLAT must be aware of.

First, CLAT must know its own IPv6 prefixes. The CLAT should acquire a /64 for the uplink interface, a /64 for all downlink interfaces, and a dedicated /64 prefix for the purpose of sending and receiving statelessly translated packets. When a dedicated /64 prefix is not available for translation from DHCPv6-PD [RFC3633], the CLAT may perform NAT44 for all IPv4 LAN packets so that all the LAN-originated IPv4 packets appear from a single IPv4 address and are then statelessly translated to one interface IPv6 address that is claimed by the CLAT via the Neighbor Discovery Protocol (NDP) and defended with Duplicate Address Detection (DAD).

Second, the CLAT must discover the PLAT-side translation IPv6 prefix used as a destination of the PLAT. The CLAT will use this prefix as the destination of all translation packets that require stateful translation to the IPv4 Internet. It may discover the PLAT-side translation prefix using [Discovery-Heuristic]. In the future, some other mechanisms, such as a new DHCPv6 option, will possibly be defined to communicate the PLAT-side translation prefix.

6.4. 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 should 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. DNS queries from the client that are not sent to the DNS proxy on the CLAT must be allowed and are translated and forwarded just like any other IP traffic.

6.5. CLAT in a Gateway

The CLAT feature can be implemented in a common home router or mobile phone that has a tethering feature. Routers with a CLAT feature should also provide common router services such as DHCP of [RFC1918] addresses, DHCPv6, NDP with Router Advertisement, and DNS service.

6.6. CLAT-to-CLAT Communications

464XLAT is a hub and spoke architecture focused on enabling IPv4-only services over IPv6-only networks. Interactive Connectivity Establishment (ICE) [RFC5245] may be used to support peer-to-peer communication within a 464XLAT network.

7. Deployment Considerations

7.1. 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 the IPv4 destination address from the translated IPv6 packet header, so it can implement traffic engineering based on the 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 the 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.

7.2. Traffic Treatment Scenarios

The below table outlines how different permutations of connectivity are treated in the 464XLAT architecture.

Note: 464XLAT double translation treatment will be stateless when a dedicated /64 is available for translation on the CLAT. Otherwise, the CLAT will have both stateful and stateless since it requires NAT44 from the LAN to a single IPv4 address and then stateless translation to a single IPv6 address.

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

Traffic Treatment Scenarios

8. Security Considerations

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

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

9. Acknowledgements

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10. References

10.1. Normative References

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10.2. Informative References

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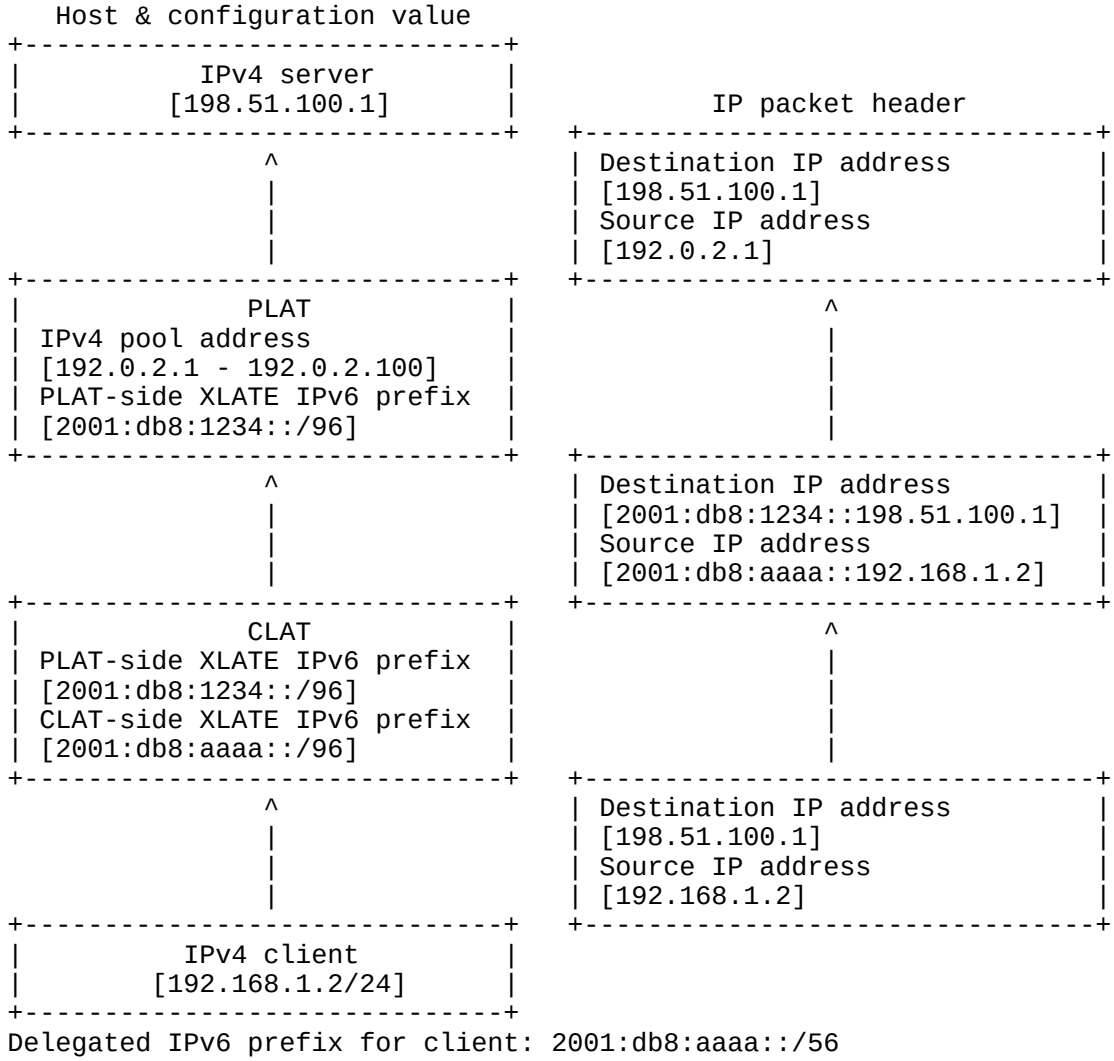
[TS.23203] 3GPP, "Policy and charging control architecture", 3GPP TS 23.203 10.7.0, June 2012.

Appendix A. Examples of IPv4/IPv6 Address Translation

The following is an example of IPv4/IPv6 address translation on the 464XLAT architecture.

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



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