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464XLAT: Combination of Stateful and Stateless Translation
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Abstract

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

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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 mobile devices, smart-grid, and cloud nodes.

This document describes an IPv4 over IPv6 solution as one of the techniques for IPv4 address extension and encouragement of IPv6 deployment.

The 464XLAT architecture described in this document uses IPv4/IPv6 translation standardized in [RFC6145] and [RFC6146]. It does not require DNS64 [RFC6147], but it may use DNS64 to enable single stateful translation [RFC6146] instead of 464XLAT double translation where possible. It is also possible to provide single IPv4/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. 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.

Running a single-stack IPv6-only network has several operational benefits in terms of increasing scalability and decreasing operational complexity. Unfortunately, there are meaningful cases where IPv6-only networks fail to meet subscriber expectations, as described in [I-D.arkko-ipv6-only-experience]. The 464XLAT overcomes the issues described in [I-D.arkko-ipv6-only-experience] to provide subscribers the full dual-stack functionality while providing the network operator the benefits of a simple yet highly scalable single-stack IPv6 network.

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). A stateful translator complies with [RFC6146] that performs 1:N translation. It translates IPv6 address to global IPv4 address, and vice versa.

CLAT: CLAT is Customer side translator(XLAT). A stateless translator complies with [RFC6145] that performs 1:1 translation. It algorithmically translates private IPv4 address to global IPv6 address, and vice versa. CLAT function is applicable to a router, or end-node such as a mobile phone. The presence of DNS64 [RFC6147] and any port mapping algorithm are not required.

UE: The 3GPP term for user equipment. The most common type of UE is a mobile phone.

PDP: A Packet Data Protocol (PDP) Context is the equivalent of a virtual connection between the host and a gateway.

4. Motivation and Uniqueness of 464XLAT

1. Minimal IPv4 resource requirements

464XLAT is the most efficient use of scarce IPv4 addresses for networks that have fast growing edges. The primary motivation for deploying IPv6 is the exhaustion of IPv4 addresses and the risk that exhaustion poses to future internet growth. 464XLAT directly takes on the challenge of IPv4 address exhaustion by providing efficient stateful IPv4 address sharing at the PLAT and decoupling the edge network growth from the availability of scarce IPv4 addresses.

464XLAT has low barriers to entry since only a small amount of IPv4 addresses are needed to support the stateful translation [RFC6146] function in the PLAT.

Given that network operators are deploying IPv6 because IPv4 resources are scarce, solutions that require dual-stack (no IPv4 multiplexing) or stateless address sharing (bounded static address multiplexing) are simply not IPv4-efficient enough to solve the two-pronged challenge of IPv4 address scarcity and continued exponential network edge growth.

2. No new protocols required

464XLAT can be deployed today, it uses existing RFCs ([RFC6145] and [RFC6146]), and there exists implementations for both wireline network (in CLAT in the Home Gateway) and wireless 3GPP network (in CLAT in the UE). The ability to quickly deploy 464XLAT is a critical feature given the urgency of IPv4 exhaustion and brisk pace of internet growth.

3. Cost-effective transition to IPv6

When combined with DNS64 [RFC6147], the 464XLAT architecture only requires double translation in the case of IPv4-referrals or IPv4-only socket calls. Consequently, the network traffic in the ISP backbone network is predominately IPv6 end-to-end or single translation. This is especially cost-effective in wireless 3GPP network that would otherwise require two separate PDP connections to support IPv4 and IPv6.

While translation on the CLAT is not always used, the CLAT function is crucial for enabling the IPv4-only applications and providing IP address family service parity to the end-users. All IPv6-native flows pass end-to-end without any translation. This is a beneficial solution for end-users, content providers, and network operators that scale best with end-to-end IPv6 communication.

In summary, the 464XLAT architecture works today for service providers that require large-scale strategic IPv6 deployments to overcome the challenges of IPv4 address scarcity. Unlike other transition architectures associated with tunneling or [I-D.mdt-softwire-mapping-address-and-port], 464XLAT properly assumes that IPv4 is scarce and IPv6 must work with today’s existing systems as much as possible. In the case of tunneling, the tunneling solutions like Dual-Stack Lite [RFC6333] are known to break existing network based deep packet inspection solutions like 3GPP standardized Policy and Charging Control (PCC). 464XLAT does not require much IPv4 address space to enable stateful translation [RFC6146] function in the PLAT while providing global IPv4 and IPv6 reachability to IPv6-only wireline and wireless subscribers.

5. Network Architecture

464XLAT architecture is shown in the following figure.

5.1. Wireline Network Architecture

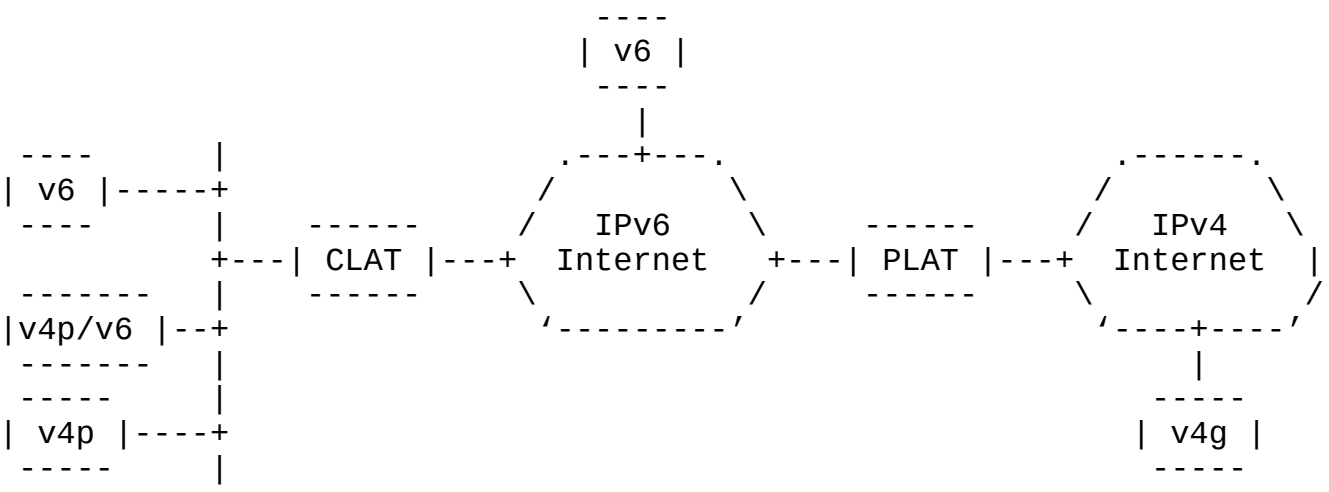


Figure 1: Wireline Network Topology

5.2. Wireless 3GPP Network Architecture

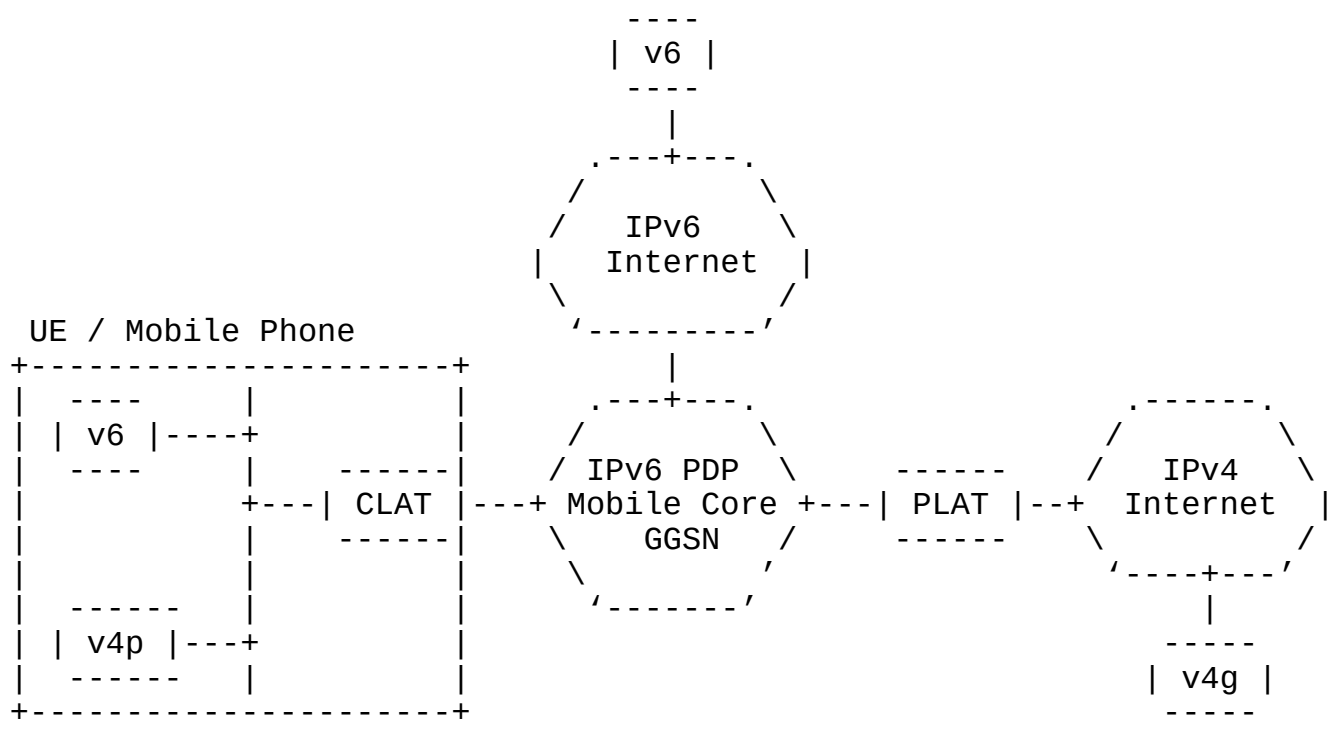


Figure 2: Wireless 3GPP Network Topology

6. Applicability

6.1. Wireline Network Applicability

When an ISP has IPv6 access network infrastructure and 464XLAT, the ISP can provide 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 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, Japan

Internet Exchange(JPIX) is providing 464XLAT trial service since July 2010.

6.2. Wireless 3GPP Network Applicability

The vast majority of mobile wireless 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 PDP attachments to access IPv4 and IPv6 network destinations. 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. Doubling the PDP count to support IPv4 and IPv6 is generally not operationally viable since a large portion of the network cost is derived from the number of PDP attachments, both in terms of licenses from the network hardware vendors and in terms of actual hardware resources required to support and maintain the PDP signaling and mobility events. Doubling the number of PDP attachments has been one of the major barriers to introducing IPv6 in mobile networks. Dual-stack IPv4 and IPv6 simply costs more from the network provider perspective and does not result in any new revenues.

Now that both global and private IPv4 addresses are scarce to the extent that it is a substantial business risk and limiting growth in many areas, the mobile network providers must support IPv6 to solve the IP address scarcity issue. It is not feasible to simply turn on additional IPv6 PDP network attachments since that does not solve the near-term IPv4 scarcity issues and it increases cost. The most logical path forward is to replace IPv4 with IPv6 and replace the common NAT44 with stateful translation [RFC6146] and DNS64 [RFC6147]. Extensive live network testing with hundreds of friendly-users has shown that IPv6-only network attachments for mobile devices covers over 90% of the common use-cases in Symbian and Android mobile operating systems. The remaining 10% of use-cases do not work because the application requires an IPv4 socket or the application does an IPv4-referral. These findings are consistent with the mobile IPv6-only user experience in [I-D.arkko-ipv6-only-experience].

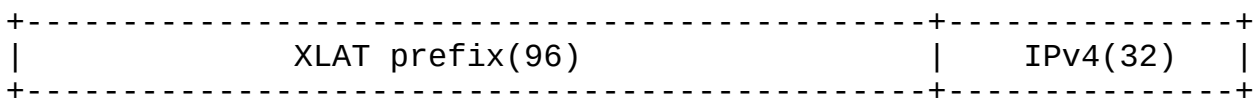
464XLAT in combination with stateful translation [RFC6146] and DNS64 [RFC6147] allows 90% of the applications to continue to work with single translation. For the remaining 10% of applications that require IPv4 connectivity, the CLAT function on the UE provides a private IPv4 address and IPv4 default-route 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, and the mobile network has a PLAT

that does stateful translation [RFC6146].

7. Implementation Considerations

7.1. IPv6 Address Format

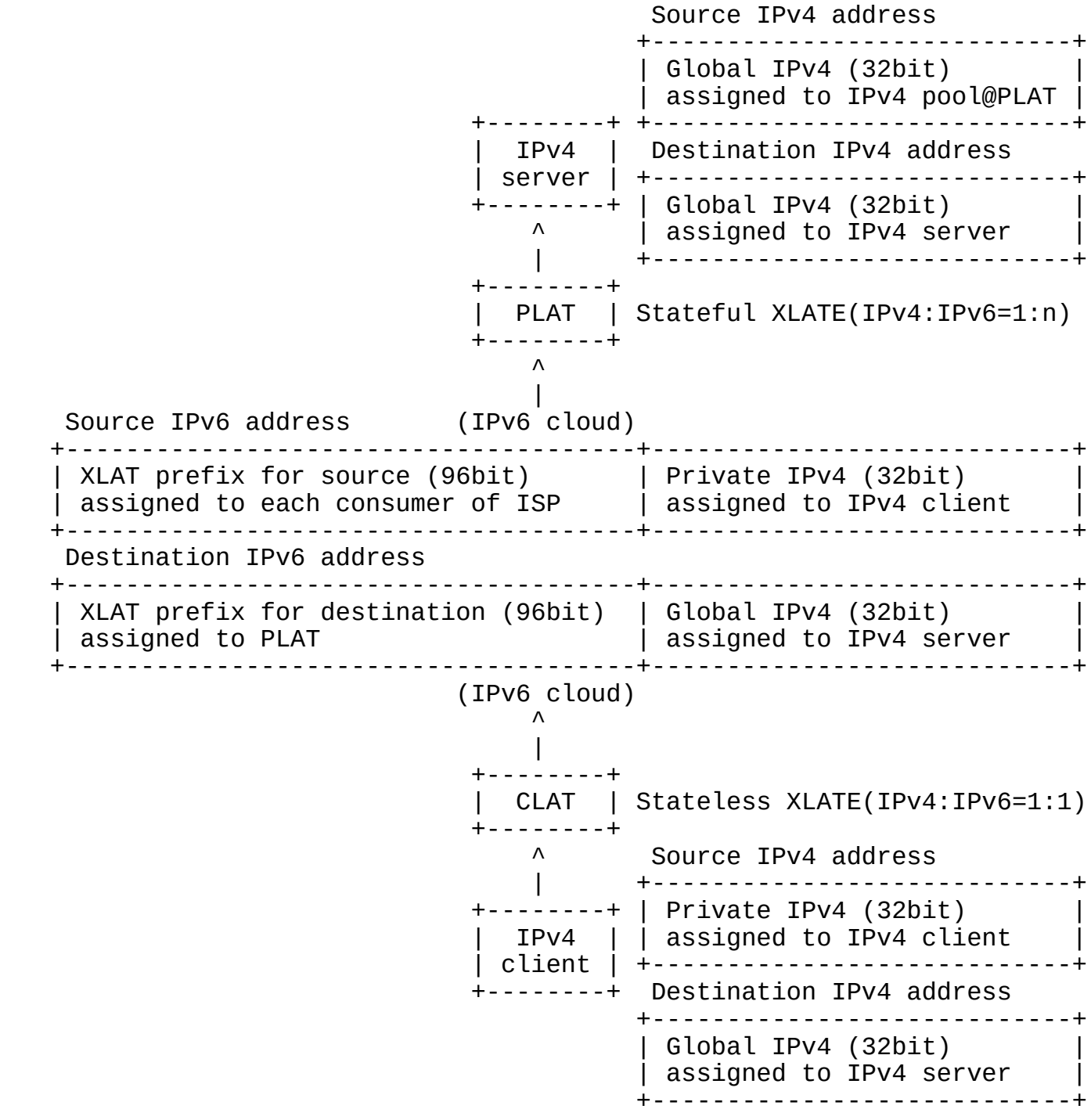
IPv6 address format in 464XLAT is presented in the following format.



IPv6 Address Format for 464XLAT

Source address and destination address have IPv4 address embedded in the low-order 32 bits of the IPv6 address. The format is defined in Section 2.2 of [RFC6052]. However, 464XLAT does not use the Well-Known IPv6 Prefix "64:ff9b::/96".

7.2. IPv4/IPv6 Address Translation Chart



IPv4/IPv6 Address Translation Chart

7.3. 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.

7.4. DNS Proxy Implementation

If a router implement CLAT function, it performs DNS Proxy for IPv4 hosts and IPv6 hosts in end-user network. It MUST provide name resolution with IPv6 transport. It does not need DNS64 [RFC6147] function.

7.5. IPv6 Prefix Handling

If CLAT gets a single /64 prefix from WAN interface, it MUST perform NDP for 464XLAT IPv6 addresses.

7.6. IPv6 Fragment Header Consideration

In the 464XLAT environment, the PLAT and CLAT SHOULD include an IPv6 Fragment Header, since IPv4 host does not set the DF bit. However, the IPv6 Fragment Header has been shown to cause operational difficulties in practice due to limited firewall fragmentation support, etc. Therefore, the PLAT and CLAT may provide a configuration function that allows the PLAT and CLAT not to include the Fragment Header for the non-fragmented IPv6 packets. At any rate, both behaviors SHOULD match.

7.7. Auto IPv6 Prefix Assignment

Source IPv6 prefix assignment in CLAT is via DHCPv6 prefix delegation or another method. Destination IPv6 prefix assignment in CLAT is via

some method. (e.g., DHCPv6 option, TR-069, DNS, HTTP, [I-D.ietf-behave-nat64-discovery-heuristic], etc.)

8. Deployment Considerations

Even if the Internet access provider for consumers is different from the PLAT provider (another Internet access provider or Internet exchange provider, etc.), 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 source address and IPv4 destination address from translated IPv6 packet header, so it can implement traffic engineering based on IPv4 source address and 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 IPv6 -> IPv4 -> IPv6 translation for sharing global IPv4 addresses, another 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

This document has no actions for IANA.

11. Acknowledgements

The authors would like to thank JPIX NOC members, JPIX 464XLAT trial service members, Seiichi Kawamura, and Dan Drown for their helpful comments.

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.arkko-ipv6-only-experience]
Arkko, J. and A. Keranen, "Experiences from an IPv6-Only Network", draft-arkko-ipv6-only-experience-04 (work in progress), October 2011.

[I-D.ietf-behave-nat64-discovery-heuristic]
Savolainen, T. and J. Korhonen, "Discovery of a Network-Specific NAT64 Prefix using a Well-Known Name", draft-ietf-behave-nat64-discovery-heuristic-04 (work in progress), December 2011.

[I-D.ietf-v6ops-3gpp-eps]
Korhonen, J., Soininen, J., Patil, B., Savolainen, T., Bajko, G., and K. Iisakkila, "IPv6 in 3GPP Evolved Packet System", draft-ietf-v6ops-3gpp-eps-08 (work in progress), September 2011.

[I-D.mdt-softwire-mapping-address-and-port]

Troan, O., "Mapping of Address and Port (MAP)", draft-mdt-softwire-mapping-address-and-port-02 (work in progress), November 2011.

[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.

[RFC6333] Durand, A., Droms, R., Woodyatt, J., and Y. Lee, "Dual-Stack Lite Broadband Deployments Following IPv4 Exhaustion", RFC 6333, August 2011.

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