

IPv6 Operations (v6ops)  
Internet-Draft  
Obsoletes: 7084 (if approved)  
Intended status: Informational  
Expires: December 12, 2017

J. Palet Martinez  
Consulintel, S.L.  
June 10, 2017

Minimum Requirements for IPv6-only Customer Edge Routers  
draft-palet-v6ops-rfc7084-bis2-00

Abstract

This document specifies minimum requirements for an IPv6-only Customer Edge (CE) router. Specifically, the current version of this document focuses on the basic provisioning of an IPv6-only CE router and the provisioning of IPv6 hosts attached to it. Neither the provisioning of IPv4 nor downstream routers are in the scope of this document. The document obsoletes RFC 7084.

Status of This Memo

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

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on December 12, 2017.

Copyright Notice

Copyright (c) 2017 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of

the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

## Table of Contents

1. Introduction . . . . .	2
1.1. Requirements Language . . . . .	3
2. Terminology . . . . .	3
3. Architecture . . . . .	4
3.1. Current IPv4 End-User Network Architecture . . . . .	4
3.2. IPv6 End-User Network Architecture . . . . .	4
3.2.1. Local Communication . . . . .	6
4. Requirements . . . . .	6
4.1. General Requirements . . . . .	6
4.2. WAN-Side Configuration . . . . .	7
4.3. LAN-Side Configuration . . . . .	11
4.4. Security Considerations . . . . .	13
5. Acknowledgements . . . . .	14
6. Contributors . . . . .	14
7. ANNEX A: Changes from RFC7084 . . . . .	14
8. References . . . . .	15
8.1. Normative References . . . . .	15
8.2. Informative References . . . . .	18
Author's Address . . . . .	18

## 1. Introduction

This document defines minimum IPv6 features for a very basic residential or small- office router, referred to as an "IPv6-only CE router", in order to establish an industry baseline for features to be implemented on such a router. This is, as well, the router to be used in remote locations where IPv6-only LANs/devices are used to connect sensors, displays, etc.

These routers don't support IPv4, neither functionalities for provisioning downstream routers.

This document specifies how an IPv6-only CE router automatically provisions its WAN interface, acquires address space for provisioning of its LAN interfaces, and fetches other configuration information from the service provider network. Automatic provisioning of more complex topology than a single router with multiple LAN interfaces is out of scope for this document.

This document doesn't cover the specific details of each possible access technology. For example, if the CE is supporting built-in or external 3GPP/LTE interfaces, [RFC7849] is a relevant reference. See [RFC4779] for a discussion of options available for deploying IPv6 in

wireline service provider access networks.

### 1.1. Requirements Language

Take careful note: Unlike other IETF documents, the key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are not used as described in RFC 2119 [RFC2119]. This document uses these keywords not strictly for the purpose of interoperability, but rather for the purpose of establishing industry-common baseline functionality. As such, the document points to several other specifications (preferable in RFC or stable form) to provide additional guidance to implementers regarding any protocol implementation required to produce a successful CE router that interoperates successfully with a particular subset of currently deploying and planned common IPv6 access networks.

## 2. Terminology

**End-User Network**                      one or more links attached to the IPv6-only CE router that connect IPv6 hosts.

**IPv6-only Customer Edge Router**    a node intended for home or small-office use that forwards IPv6 packets not explicitly addressed to itself. The IPv6-only CE router connects the end-user network to a service provider network. In other documents, the CE is named as CPE (Customer Premises Equipment or Customer Provided Equipment). In the context of this document, both terminologies are synonymous.

**IPv6 Host**                            any device implementing an IPv6 stack receiving IPv6 connectivity through the IPv6-only CE router.

**LAN Interface**                      an IPv6-only CE router's attachment to a link in the end-user network. Examples are Ethernet (simple or bridged), 802.11 wireless, or other LAN technologies. An IPv6-only CE router may have one or more network-layer LAN interfaces.

**Service Provider**                   an entity that provides access to the Internet. In this document, a service provider specifically offers Internet access using IPv6-only, and it may also

offer IPv4 Internet access, but non intended to be supported by this IPv6-only CE router. The service provider can provide such access over a variety of different transport methods such as FTTH, DSL, cable, wireless, 3GPP/LTE, and others.

#### WAN Interface

an IPv6-only CE router's attachment to a link used to provide connectivity to the service provider network; example link technologies include Ethernet (simple or bridged), PPP links, Frame Relay, or ATM networks.

### 3. Architecture

#### 3.1. Current IPv4 End-User Network Architecture

An end-user network will likely support both IPv4 and IPv6. It is not expected that an end user will change their existing network topology with the introduction of IPv6, however very simple networks may work perfectly with IPv6-only. There are some differences in how IPv6 works and is provisioned; these differences have implications for the network architecture. A typical IPv4 end-user network consists of a "plug and play" router with NAT functionality and a single link behind it, connected to the service provider network.

A typical IPv4 NAT deployment by default blocks all incoming connections. Opening of ports is typically allowed using a Universal Plug and Play Internet Gateway Device (UPnP IGD) [UPnP-IGD] or some other firewall control protocol.

Another consequence of using private address space in the end-user network is that it provides stable addressing; that is, it never changes even when you change service providers, and the addresses are always there even when the WAN interface is down or the customer edge router has not yet been provisioned.

Many existing routers support dynamic routing (which learns routes from other routers), and advanced end-users can build arbitrary, complex networks using manual configuration of address prefixes combined with a dynamic routing protocol.

#### 3.2. IPv6 End-User Network Architecture

The end-user network architecture for a simple IPv6-only network should provide equivalent or better capabilities and functionality than the current IPv4 architecture.

The end-user network is a stub network. Figure 1 illustrates the model topology for the end-user network.

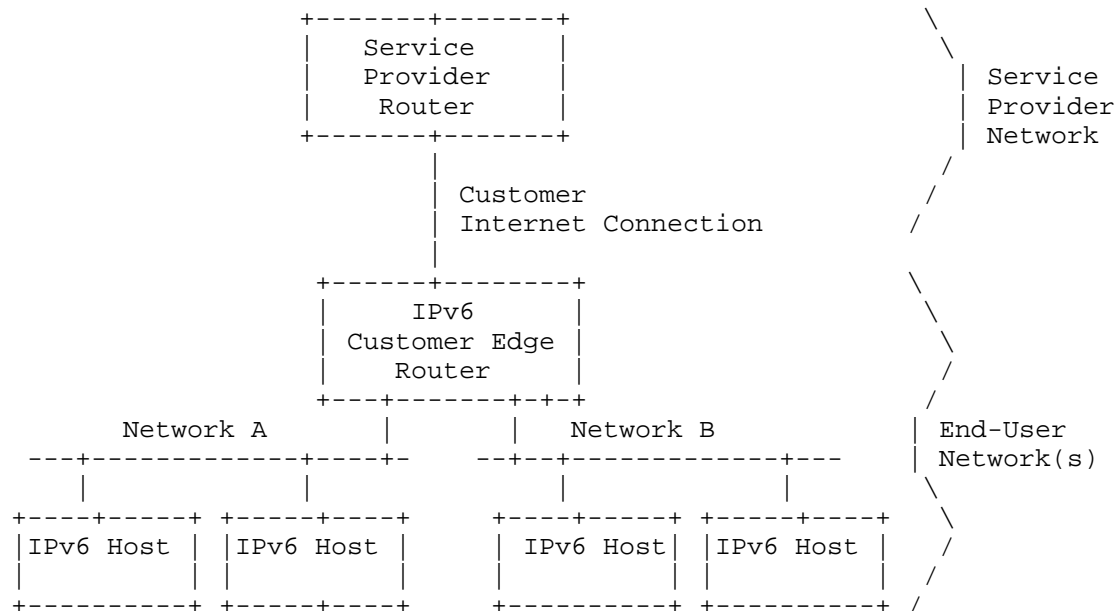


Figure 1: An Example of a Typical End-User Network

This architecture describes the:

- o Basic capabilities of an IPv6-only CE router
- o Provisioning of the WAN interface connecting to the service provider
- o Provisioning of the LAN interfaces

For IPv6 multicast traffic, the IPv6-only CE router may act as a Multicast Listener Discovery (MLD) proxy [RFC4605] and may support a dynamic multicast routing protocol.

The IPv6-only CE router may be manually configured in an arbitrary topology with a dynamic routing protocol. Automatic provisioning and configuration is described for a single IPv6-only CE router only.

### 3.2.1. Local Communication

Link-local IPv6 addresses are used by hosts communicating on a single link. Unique Local IPv6 Unicast Addresses (ULAs) [RFC4193] are used by hosts communicating within the end-user network across multiple links, but without requiring the application to use a globally routable address. The IPv6-only CE router defaults to acting as the demarcation point between two networks by providing a ULA boundary, a multicast zone boundary, and ingress and egress traffic filters.

At the time of this writing, several host implementations do not handle the case where they have an IPv6 address configured and no IPv6 connectivity, either because the address itself has a limited topological reachability (e.g., ULA) or because the IPv6-only CE router is not connected to the IPv6 network on its WAN interface. To support host implementations that do not handle multihoming in a multi-prefix environment [RFC7157], the IPv6-only CE router should not, as detailed in the requirements below, advertise itself as a default router on the LAN interface(s) when it does not have IPv6 connectivity on the WAN interface or when it is not provisioned with IPv6 addresses. For local IPv6 communication, the mechanisms specified in [RFC4191] are used.

ULA addressing is useful where the IPv6-only CE router has multiple LAN interfaces with hosts that need to communicate with each other. If the IPv6 CE router has only a single LAN interface (IPv6 link), then link-local addressing can be used instead.

## 4. Requirements

### 4.1. General Requirements

The IPv6-only CE router is responsible for implementing IPv6 routing; that is, the IPv6-only CE router must look up the IPv6 destination address in its routing table to decide to which interface it should send the packet.

In this role, the IPv6-only CE router is responsible for ensuring that traffic using its ULA addressing does not go out the WAN interface and does not originate from the WAN interface.

G-1: An IPv6-only CE router is an IPv6 node according to the IPv6 Node Requirements specification [RFC6434].

G-2: The IPv6-only CE router MUST implement ICMPv6 according to [RFC4443]. In particular, point-to-point links MUST be handled as described in Section 3.1 of [RFC4443].

- G-3: The IPv6-only CE router MUST NOT forward any IPv6 traffic between its LAN interface(s) and its WAN interface until the router has successfully completed the IPv6 address and the delegated prefix acquisition process.
- G-4: By default, an IPv6-only CE router that has no default router(s) on its WAN interface MUST NOT advertise itself as an IPv6 default router on its LAN interfaces. That is, the "Router Lifetime" field is set to zero in all Router Advertisement messages it originates [RFC4861].
- G-5: By default, if the IPv6-only CE router is an advertising router and loses its IPv6 default router(s) and/or detects loss of connectivity on the WAN interface, it MUST explicitly invalidate itself as an IPv6 default router on each of its advertising interfaces by immediately transmitting one or more Router Advertisement messages with the "Router Lifetime" field set to zero [RFC4861].
- G-6: The IPv6-only CE router MUST comply with [RFC7608].

#### 4.2. WAN-Side Configuration

The IPv6-only CE router will need to support connectivity to one or more access network architectures. This document describes an IPv6-only CE router that is not specific to any particular architecture or service provider and that supports all commonly used architectures.

IPv6 Neighbor Discovery and DHCPv6 protocols operate over any type of IPv6-supported link layer, and there is no need for a link-layer-specific configuration protocol for IPv6 network-layer configuration options as in, e.g., PPP IP Control Protocol (IPCP) for IPv4. This section makes the assumption that the same mechanism will work for any link layer, be it Ethernet, the Data Over Cable Service Interface Specification (DOCSIS), PPP, or others.

WAN-side requirements:

- W-1: When the IPv6-only CE router is attached to the WAN interface link, it MUST act as an IPv6 host for the purposes of stateless [RFC4862] or stateful [RFC3315] interface address assignment.
- W-2: The IPv6-only CE router MUST generate a link-local address and finish Duplicate Address Detection according to [RFC4862] prior to sending any Router Solicitations on the interface. The source address used in the subsequent Router Solicitation MUST be the link-local address on the WAN interface.

- W-3: Absent other routing information, the IPv6-only CE router MUST use Router Discovery as specified in [RFC4861] to discover a default router(s) and install a default route(s) in its routing table with the discovered router's address as the next hop.
- W-4: The IPv6-only CE router MUST act as a requesting router for the purposes of DHCPv6 prefix delegation ([RFC3633]).
- W-5: The IPv6-only CE router MUST use a persistent DHCP Unique Identifier (DUID) for DHCPv6 messages. The DUID MUST NOT change between network-interface resets or IPv6 CE router reboots.
- W-6: The WAN interface of the IPv6-only CE router SHOULD support a Port Control Protocol (PCP) client as specified in [RFC6887] for use by applications on the CE router. The PCP client SHOULD follow the procedure specified in Section 8.1 of [RFC6887] to discover its PCP server. This document takes no position on whether such functionality is enabled by default or mechanisms by which users would configure the functionality. Handling PCP requests from PCP clients in the LAN side of the CE router is out of scope.

Link-layer requirements:

- WLL-1: If the WAN interface supports Ethernet encapsulation, then the IPv6-only CE router MUST support IPv6 over Ethernet [RFC2464].
- WLL-2: If the WAN interface supports PPP encapsulation, the IPv6-only CE router MUST support IPv6 over PPP [RFC5072].

Address assignment requirements:

- WAA-1: The IPv6-only CE router MUST support Stateless Address Autoconfiguration (SLAAC) [RFC4862].
- WAA-2: The IPv6-only CE router MUST follow the recommendations in Section 4 of [RFC5942], and in particular the handling of the L flag in the Router Advertisement Prefix Information option.
- WAA-3: The IPv6-only CE router MUST support DHCPv6 [RFC3315] client behavior.
- WAA-4: The IPv6-only CE router MUST be able to support the following DHCPv6 options: Identity Association for Non-temporary Address (IA\_NA), Reconfigure Accept [RFC3315], and



DNS\_SERVERS [RFC3646]. The IPv6-only CE router SHOULD be able to support the DNS Search List (DNSSL) option as specified in [RFC3646].

- WAA-5: The IPv6-only CE router SHOULD implement the Network Time Protocol (NTP) as specified in [RFC5905] to provide a time reference common to the service provider for other protocols, such as DHCPv6, to use. If the IPv6-only CE router implements NTP, it requests the NTP Server DHCPv6 option [RFC5908] and uses the received list of servers as primary time reference, unless explicitly configured otherwise. LAN side support of NTP is out of scope for this document.
- WAA-6: If the IPv6-only CE router receives a Router Advertisement message (described in [RFC4861]) with the M flag set to 1, the IPv6 CE router MUST do DHCPv6 address assignment (request an IA\_NA option).
- WAA-7: If the IPv6-only CE router does not acquire a global IPv6 address(es) from either SLAAC or DHCPv6, then it MUST create a global IPv6 address(es) from its delegated prefix(es) and configure those on one of its internal virtual network interfaces, unless configured to require a global IPv6 address on the WAN interface.
- WAA-8: The IPv6-only CE router MUST support the SOL\_MAX\_RT option [RFC7083] and request the SOL\_MAX\_RT option in an Option Request Option (ORO).
- WAA-9: As a router, the IPv6-only CE router MUST follow the weak host (Weak End System) model [RFC1122]. When originating packets from an interface, it will use a source address from another one of its interfaces if the outgoing interface does not have an address of suitable scope.
- WAA-10: The IPv6-only CE router SHOULD implement the Information Refresh Time option and associated client behavior as specified in [RFC4242].

Prefix delegation requirements:

- WPD-1: The IPv6-only CE router MUST support DHCPv6 prefix delegation requesting router behavior as specified in [RFC3633] (Identity Association for Prefix Delegation (IA\_PD) option).
- WPD-2: The IPv6-only CE router MAY indicate as a hint to the delegating router the size of the prefix it requires. If so,

it MUST ask for a prefix large enough to assign one /64 for each of its interfaces, rounded up to the nearest nibble, and SHOULD be configurable to ask for more.

- WPD-3: The IPv6-only CE router MUST be prepared to accept a delegated prefix size different from what is given in the hint. If the delegated prefix is too small to address all of its interfaces, the IPv6-only CE router SHOULD log a system management error. [RFC6177] covers the recommendations for service providers for prefix allocation sizes.
- WPD-4: By default, the IPv6-only CE router MUST initiate DHCPv6 prefix delegation when either the M or O flags are set to 1 in a received Router Advertisement (RA) message. Behavior of the IPv6-only CE router to use DHCPv6 prefix delegation when the CE router has not received any RA or received an RA with the M and the O bits set to zero is out of scope for this document.
- WPD-5: Any packet received by the IPv6-only CE router with a destination address in the prefix(es) delegated to the CE router but not in the set of prefixes assigned by the CE router to the LAN must be dropped. In other words, the next hop for the prefix(es) delegated to the CE router should be the null destination. This is necessary to prevent forwarding loops when some addresses covered by the aggregate are not reachable [RFC4632].
- (a) The IPv6-only CE router SHOULD send an ICMPv6 Destination Unreachable message in accordance with Section 3.1 of [RFC4443] back to the source of the packet, if the packet is to be dropped due to this rule.
- WPD-6: If the IPv6-only CE router requests both an IA\_NA and an IA\_PD option in DHCPv6, it MUST accept an IA\_PD option in DHCPv6 Advertise/Reply messages, even if the message does not contain any addresses, unless configured to only obtain its WAN IPv6 address via DHCPv6; see [RFC7550].
- WPD-7: By default, an IPv6-only CE router MUST NOT initiate any dynamic routing protocol on its WAN interface.
- WPD-8: The IPv6-only CE router SHOULD support the [RFC6603] Prefix Exclude option.

#### 4.3. LAN-Side Configuration

The IPv6-only CE router distributes configuration information obtained during WAN interface provisioning to IPv6 hosts and assists IPv6 hosts in obtaining IPv6 addresses. It also supports connectivity of these devices in the absence of any working WAN interface.

An IPv6-only CE router is expected to support an IPv6 end-user network and IPv6 hosts that exhibit the following characteristics:

1. Link-local addresses may be insufficient for allowing IPv6 applications to communicate with each other in the end-user network. The IPv6-only CE router will need to enable this communication by providing globally scoped unicast addresses or ULAs [RFC4193], whether or not WAN connectivity exists.
2. IPv6 hosts should be capable of using SLAAC and may be capable of using DHCPv6 for acquiring their addresses.
3. IPv6 hosts may use DHCPv6 for other configuration information, such as the DNS\_SERVERS option for acquiring DNS information.

Unless otherwise specified, the following requirements apply to the IPv6-only CE router's LAN interfaces only.

ULA requirements:

- ULA-1: The IPv6-only CE router SHOULD be capable of generating a ULA prefix [RFC4193].
- ULA-2: An IPv6-only CE router with a ULA prefix MUST maintain this prefix consistently across reboots.
- ULA-3: The value of the ULA prefix SHOULD be configurable.
- ULA-4: By default, the IPv6-only CE router MUST act as a site border router according to Section 4.3 of [RFC4193] and filter packets with local IPv6 source or destination addresses accordingly.
- ULA-5: An IPv6-only CE router MUST NOT advertise itself as a default router with a Router Lifetime greater than zero whenever all of its configured and delegated prefixes are ULA prefixes.

LAN requirements:

- L-1: The IPv6-only CE router MUST support router behavior according

to Neighbor Discovery for IPv6 [RFC4861].

- L-2: The IPv6-only CE router MUST assign a separate /64 from its delegated prefix(es) (and ULA prefix if configured to provide ULA addressing) for each of its LAN interfaces.
- L-3: An IPv6-only CE router MUST advertise itself as a router for the delegated prefix(es) (and ULA prefix if configured to provide ULA addressing) using the "Route Information Option" specified in Section 2.3 of [RFC4191]. This advertisement is independent of having or not having IPv6 connectivity on the WAN interface.
- L-4: An IPv6-only CE router MUST NOT advertise itself as a default router with a Router Lifetime [RFC4861] greater than zero if it has no prefixes configured or delegated to it.
- L-5: The IPv6-only CE router MUST make each LAN interface an advertising interface according to [RFC4861].
- L-6: In Router Advertisement messages ([RFC4861]), the Prefix Information option's A and L flags MUST be set to 1 by default.
- L-7: The A and L flags' ([RFC4861]) settings SHOULD be user configurable.
- L-8: The IPv6-only CE router MUST support a DHCPv6 server capable of IPv6 address assignment according to [RFC3315] OR a stateless DHCPv6 server according to [RFC3736] on its LAN interfaces.
- L-9: Unless the IPv6-only CE router is configured to support the DHCPv6 IA\_NA option, it SHOULD set the M flag to zero and the O flag to 1 in its Router Advertisement messages [RFC4861].
- L-10: The IPv6-only CE router MUST support providing DNS information in the DHCPv6 DNS\_SERVERS and DOMAIN\_LIST options [RFC3646].
- L-11: The IPv6-only CE router MUST support providing DNS information in the Router Advertisement Recursive DNS Server (RDNSS) and DNS Search List options. Both options are specified in [RFC6106].
- L-12: The IPv6-only CE router SHOULD implement a DNS proxy as described in [RFC5625].
- L-13: The IPv6-only CE router SHOULD make available a subset of

DHCPv6 options (as listed in Section 5.3 of [RFC3736]) received from the DHCPv6 client on its WAN interface to its LAN-side DHCPv6 server.

- L-14: If the delegated prefix changes, i.e., the current prefix is replaced with a new prefix without any overlapping time period, then the IPv6-only CE router MUST immediately advertise the old prefix with a Preferred Lifetime of zero and a Valid Lifetime of either a) zero or b) the lower of the current Valid Lifetime and two hours (which must be decremented in real time) in a Router Advertisement message as described in Section 5.5.3, (e) of [RFC4862].
- L-15: The IPv6-only CE router MUST send an ICMPv6 Destination Unreachable message, code 5 (Source address failed ingress/egress policy) for packets forwarded to it that use an address from a prefix that has been invalidated.

#### 4.4. Security Considerations

It is considered a best practice to filter obviously malicious traffic (e.g., spoofed packets, "Martian" addresses, etc.). Thus, the IPv6-only CE router ought to support basic stateless egress and ingress filters. The IPv6-only CE router is also expected to offer mechanisms to filter traffic entering the customer network; however, the method by which vendors implement configurable packet filtering is beyond the scope of this document.

Security requirements:

- S-1: The IPv6-only CE router SHOULD support [RFC6092]. In particular, the IPv6-only CE router SHOULD support functionality sufficient for implementing the set of recommendations in [RFC6092], Section 4. This document takes no position on whether such functionality is enabled by default or mechanisms by which users would configure it.
- S-2: The IPv6-only CE router SHOULD support ingress filtering in accordance with BCP 38 [RFC2827]. Note that this requirement was downgraded from a MUST from RFC 6204 due to the difficulty of implementation in the CE router and the feature's redundancy with upstream router ingress filtering.
- S-3: If the IPv6-only CE router firewall is configured to filter incoming tunneled data, the firewall SHOULD provide the capability to filter decapsulated packets from a tunnel.

## 5. Acknowledgements

This document is an update of RFC7084, whose original authors were: Hemant Singh, Wes Beebee, Chris Donley and Barbara Stark. The rest of the text on this section and the Contributors section, are the original acknowledgements and Contributors sections of the earlier version of this document.

Thanks to the following people (in alphabetical order) for their guidance and feedback:

Mikael Abrahamsson, Tore Anderson, Merete Asak, Rajiv Asati, Scott Beuker, Mohamed Boucadair, Rex Bullinger, Brian Carpenter, Tassos Chatzithomaoglou, Lorenzo Colitti, Remi Denis-Courmont, Gert Doering, Alain Durand, Katsunori Fukuoka, Brian Haberman, Tony Hain, Thomas Herbst, Ray Hunter, Joel Jaeggli, Kevin Johns, Erik Kline, Stephen Kramer, Victor Kuarsingh, Francois-Xavier Le Bail, Arifumi Matsumoto, David Miles, Shin Miyakawa, Jean-Francois Mule, Michael Newbery, Carlos Pignataro, John Pomeroy, Antonio Querubin, Daniel Roesen, Hiroki Sato, Teemu Savolainen, Matt Schmitt, David Thaler, Mark Townsley, Sean Turner, Bernie Volz, Dan Wing, Timothy Winters, James Woodyatt, Carl Wuyts, and Cor Zwart.

This document is based in part on CableLabs' eRouter specification. The authors wish to acknowledge the additional contributors from the eRouter team:

Ben Bekele, Amol Bhagwat, Ralph Brown, Eduardo Cardona, Margo Dolas, Toerless Eckert, Doc Evans, Roger Fish, Michelle Kuska, Diego Mazzola, John McQueen, Harsh Parandekar, Michael Patrick, Saifur Rahman, Lakshmi Raman, Ryan Ross, Ron da Silva, Madhu Sudan, Dan Torbet, and Greg White.

## 6. Contributors

The following people have participated as co-authors or provided substantial contributions to this document: Ralph Droms, Kirk Erichsen, Fred Baker, Jason Weil, Lee Howard, Jean-Francois Tremblay, Yiu Lee, John Jason Brzozowski, and Heather Kirksey. Thanks to Ole Troan for editorship in the original RFC 6204 document.

## 7. ANNEX A: Changes from RFC7084

The -bis2 version of this document has some minor text edits here and there. Significant updates are:

1. Removed, in general requirements related to IPv4/dual-stack support.

2. References to IPv6 CE router changed to IPv6-only CE router.
  3. Removed WLL-3, as it was referring to dual-stack support.
  4. G-6 added in order to comply with [RFC7608].
  5. L-12 added to support for DNS proxy [RFC5625] as general LAN requirement.
  6. Removed transition support.
8. References
- 8.1. Normative References
- [RFC1122] Braden, R., Ed., "Requirements for Internet Hosts - Communication Layers", STD 3, RFC 1122, DOI 10.17487/RFC1122, October 1989, <<http://www.rfc-editor.org/info/rfc1122>>.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<http://www.rfc-editor.org/info/rfc2119>>.
- [RFC2464] Crawford, M., "Transmission of IPv6 Packets over Ethernet Networks", RFC 2464, DOI 10.17487/RFC2464, December 1998, <<http://www.rfc-editor.org/info/rfc2464>>.
- [RFC2827] Ferguson, P. and D. Senie, "Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing", BCP 38, RFC 2827, DOI 10.17487/RFC2827, May 2000, <<http://www.rfc-editor.org/info/rfc2827>>.
- [RFC3315] Droms, R., Ed., Bound, J., Volz, B., Lemon, T., Perkins, C., and M. Carney, "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", RFC 3315, DOI 10.17487/RFC3315, July 2003, <<http://www.rfc-editor.org/info/rfc3315>>.
- [RFC3633] Troan, O. and R. Droms, "IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6", RFC 3633, DOI 10.17487/RFC3633, December 2003, <<http://www.rfc-editor.org/info/rfc3633>>.
- [RFC3646] Droms, R., Ed., "DNS Configuration options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", RFC 3646, DOI 10.17487/RFC3646, December 2003, <<http://www.rfc-editor.org/info/rfc3646>>.

- [RFC3736] Droms, R., "Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6", RFC 3736, DOI 10.17487/RFC3736, April 2004, <<http://www.rfc-editor.org/info/rfc3736>>.
- [RFC4191] Draves, R. and D. Thaler, "Default Router Preferences and More-Specific Routes", RFC 4191, DOI 10.17487/RFC4191, November 2005, <<http://www.rfc-editor.org/info/rfc4191>>.
- [RFC4193] Hinden, R. and B. Haberman, "Unique Local IPv6 Unicast Addresses", RFC 4193, DOI 10.17487/RFC4193, October 2005, <<http://www.rfc-editor.org/info/rfc4193>>.
- [RFC4242] Venaas, S., Chown, T., and B. Volz, "Information Refresh Time Option for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", RFC 4242, DOI 10.17487/RFC4242, November 2005, <<http://www.rfc-editor.org/info/rfc4242>>.
- [RFC4443] Conta, A., Deering, S., and M. Gupta, Ed., "Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification", RFC 4443, DOI 10.17487/RFC4443, March 2006, <<http://www.rfc-editor.org/info/rfc4443>>.
- [RFC4605] Fenner, B., He, H., Haberman, B., and H. Sandick, "Internet Group Management Protocol (IGMP) / Multicast Listener Discovery (MLD)-Based Multicast Forwarding ("IGMP/MLD Proxying")", RFC 4605, DOI 10.17487/RFC4605, August 2006, <<http://www.rfc-editor.org/info/rfc4605>>.
- [RFC4632] Fuller, V. and T. Li, "Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan", BCP 122, RFC 4632, DOI 10.17487/RFC4632, August 2006, <<http://www.rfc-editor.org/info/rfc4632>>.
- [RFC4779] Asadullah, S., Ahmed, A., Popoviciu, C., Savola, P., and J. Palet, "ISP IPv6 Deployment Scenarios in Broadband Access Networks", RFC 4779, DOI 10.17487/RFC4779, January 2007, <<http://www.rfc-editor.org/info/rfc4779>>.
- [RFC4861] Narten, T., Nordmark, E., Simpson, W., and H. Soliman, "Neighbor Discovery for IP version 6 (IPv6)", RFC 4861, DOI 10.17487/RFC4861, September 2007, <<http://www.rfc-editor.org/info/rfc4861>>.
- [RFC4862] Thomson, S., Narten, T., and T. Jinmei, "IPv6 Stateless Address Autoconfiguration", RFC 4862, DOI 10.17487/RFC4862, September 2007, <<http://www.rfc-editor.org/info/rfc4862>>.



- [RFC5072] Varada, S., Ed., Haskins, D., and E. Allen, "IP Version 6 over PPP", RFC 5072, DOI 10.17487/RFC5072, September 2007, <<http://www.rfc-editor.org/info/rfc5072>>.
- [RFC5625] Bellis, R., "DNS Proxy Implementation Guidelines", BCP 152, RFC 5625, DOI 10.17487/RFC5625, August 2009, <<http://www.rfc-editor.org/info/rfc5625>>.
- [RFC5905] Mills, D., Martin, J., Ed., Burbank, J., and W. Kasch, "Network Time Protocol Version 4: Protocol and Algorithms Specification", RFC 5905, DOI 10.17487/RFC5905, June 2010, <<http://www.rfc-editor.org/info/rfc5905>>.
- [RFC5908] Gayraud, R. and B. Lourdelet, "Network Time Protocol (NTP) Server Option for DHCPv6", RFC 5908, DOI 10.17487/RFC5908, June 2010, <<http://www.rfc-editor.org/info/rfc5908>>.
- [RFC5942] Singh, H., Beebe, W., and E. Nordmark, "IPv6 Subnet Model: The Relationship between Links and Subnet Prefixes", RFC 5942, DOI 10.17487/RFC5942, July 2010, <<http://www.rfc-editor.org/info/rfc5942>>.
- [RFC6092] Woodyatt, J., Ed., "Recommended Simple Security Capabilities in Customer Premises Equipment (CPE) for Providing Residential IPv6 Internet Service", RFC 6092, DOI 10.17487/RFC6092, January 2011, <<http://www.rfc-editor.org/info/rfc6092>>.
- [RFC6106] Jeong, J., Park, S., Beloeil, L., and S. Madanapalli, "IPv6 Router Advertisement Options for DNS Configuration", RFC 6106, DOI 10.17487/RFC6106, November 2010, <<http://www.rfc-editor.org/info/rfc6106>>.
- [RFC6177] Narten, T., Huston, G., and L. Roberts, "IPv6 Address Assignment to End Sites", BCP 157, RFC 6177, DOI 10.17487/RFC6177, March 2011, <<http://www.rfc-editor.org/info/rfc6177>>.
- [RFC6434] Jankiewicz, E., Loughney, J., and T. Narten, "IPv6 Node Requirements", RFC 6434, DOI 10.17487/RFC6434, December 2011, <<http://www.rfc-editor.org/info/rfc6434>>.
- [RFC6603] Korhonen, J., Ed., Savolainen, T., Krishnan, S., and O. Troan, "Prefix Exclude Option for DHCPv6-based Prefix Delegation", RFC 6603, DOI 10.17487/RFC6603, May 2012, <<http://www.rfc-editor.org/info/rfc6603>>.

- [RFC6887] Wing, D., Ed., Cheshire, S., Boucadair, M., Penno, R., and P. Selkirk, "Port Control Protocol (PCP)", RFC 6887, DOI 10.17487/RFC6887, April 2013, <<http://www.rfc-editor.org/info/rfc6887>>.
- [RFC7083] Droms, R., "Modification to Default Values of SOL\_MAX\_RT and INF\_MAX\_RT", RFC 7083, DOI 10.17487/RFC7083, November 2013, <<http://www.rfc-editor.org/info/rfc7083>>.
- [RFC7608] Boucadair, M., Petrescu, A., and F. Baker, "IPv6 Prefix Length Recommendation for Forwarding", BCP 198, RFC 7608, DOI 10.17487/RFC7608, July 2015, <<http://www.rfc-editor.org/info/rfc7608>>.

## 8.2. Informative References

- [RFC7157] Troan, O., Ed., Miles, D., Matsushima, S., Okimoto, T., and D. Wing, "IPv6 Multihoming without Network Address Translation", RFC 7157, DOI 10.17487/RFC7157, March 2014, <<http://www.rfc-editor.org/info/rfc7157>>.
- [RFC7550] Troan, O., Volz, B., and M. Siodelski, "Issues and Recommendations with Multiple Stateful DHCPv6 Options", RFC 7550, DOI 10.17487/RFC7550, May 2015, <<http://www.rfc-editor.org/info/rfc7550>>.
- [RFC7849] Binet, D., Boucadair, M., Vizdal, A., Chen, G., Heatley, N., Chandler, R., Michaud, D., Lopez, D., and W. Haeffner, "An IPv6 Profile for 3GPP Mobile Devices", RFC 7849, DOI 10.17487/RFC7849, May 2016, <<http://www.rfc-editor.org/info/rfc7849>>.
- [TR-069] Broadband Forum, "CPE WAN Management Protocol", TR-069 Amendment 4, July 2011, <<http://www.broadband-forum.org/technical/trlist.php>>.
- [UPnP-IGD] UPnP Forum, "InternetGatewayDevice:2 Device Template Version 1.01", December 2010, <<http://upnp.org/specs/gw/igd2/>>.

Author's Address

Jordi Palet Martinez  
Consulintel, S.L.  
Molino de la Navata, 75  
La Navata - Galapagar, Madrid 28420  
Spain

EMail: [jordi.palet@consulintel.es](mailto:jordi.palet@consulintel.es)  
URI: <http://www.consulintel.es/>