

Internet Engineering Task Force  
Internet-Draft  
Intended status: Informational  
Expires: January 12, 2012

H. Singh  
W. Beebee  
Cisco Systems, Inc.  
C. Donley  
CableLabs  
B. Stark  
ATT  
O. Troan, Ed.  
Cisco Systems, Inc.  
July 11, 2011

**Advanced Requirements for IPv6 Customer Edge Routers  
draft-ietf-v6ops-ipv6-cpe-router-bis-01**

Abstract

This document continues the work undertaken by the IPv6 CE Router Phase I work in the IETF v6ops Working Group. Advanced requirements or Phase II work is covered in this document.

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 January 12, 2012.

Copyright Notice

Copyright (c) 2011 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

<a href="#">1.</a>	Introduction . . . . .	<a href="#">3</a>
<a href="#">1.1.</a>	Requirements Language . . . . .	<a href="#">3</a>
<a href="#">2.</a>	Terminology . . . . .	<a href="#">3</a>
<a href="#">3.</a>	Conceptual Configuration Variables . . . . .	<a href="#">4</a>
<a href="#">4.</a>	Architecture . . . . .	<a href="#">4</a>
<a href="#">5.</a>	Advanced Features and Feature Requirements . . . . .	<a href="#">6</a>
<a href="#">5.1.</a>	DNS . . . . .	<a href="#">6</a>
<a href="#">5.2.</a>	Multicast Behavior . . . . .	<a href="#">6</a>
<a href="#">5.3.</a>	Routed network behavior . . . . .	<a href="#">7</a>
<a href="#">5.4.</a>	Transition Technologies Support . . . . .	<a href="#">7</a>
<a href="#">5.4.1.</a>	Dual-Stack(DS)-Lite . . . . .	<a href="#">7</a>
<a href="#">5.4.2.</a>	6rd . . . . .	<a href="#">9</a>
<a href="#">5.4.3.</a>	Transition Technologies Coexistence . . . . .	<a href="#">9</a>
<a href="#">5.5.</a>	Quality Of Service . . . . .	<a href="#">10</a>
<a href="#">5.6.</a>	Unicast Data Forwarding . . . . .	<a href="#">10</a>
<a href="#">5.7.</a>	Additional DHCPv6 WAN Requirement . . . . .	<a href="#">10</a>
<a href="#">6.</a>	Security Considerations . . . . .	<a href="#">10</a>
<a href="#">7.</a>	Acknowledgements . . . . .	<a href="#">10</a>
<a href="#">8.</a>	Contributors . . . . .	<a href="#">11</a>
<a href="#">9.</a>	IANA Considerations . . . . .	<a href="#">11</a>
<a href="#">10.</a>	References . . . . .	<a href="#">11</a>
<a href="#">10.1.</a>	Normative References . . . . .	<a href="#">11</a>
<a href="#">10.2.</a>	Informative References . . . . .	<a href="#">14</a>
	Authors' Addresses . . . . .	<a href="#">14</a>



## **1. Introduction**

This document defines Advanced IPv6 features for a residential or small office router referred to as an IPv6 CE router. Typically these routers also support IPv4. The IPv6 End-user Network Architecture for such a router is described in [[RFC6204](#)]. This version of the document includes the requirements for Advanced features.

### **1.1. 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 [RFC 2119](#) [[RFC2119](#)].

## **2. Terminology**

End-user Network	one or more links attached to the IPv6 CE router that connect IPv6 hosts.
IPv6 Customer Edge router	a node intended for home or small office use which forwards IPv6 packets not explicitly addressed to itself. The IPv6 CE router connects the end-user network to a service provider network.
IPv6 host	any device implementing an IPv6 stack receiving IPv6 connectivity through the IPv6 CE router
LAN interface	an IPv6 CE router's attachment to a link in the end-user network. Examples are Ethernets (simple or bridged), 802.11 wireless or other LAN technologies. An IPv6 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, and may also offer IPv4 Internet access. The Service Provider can provide such access over a variety of different transport methods such as DSL, cable, wireless, and others.



WAN interface an IPv6 CE router's attachment to a link used to provide connectivity to the Service Provider network; example link technologies include Ethernets (simple or bridged), PPP links, Frame Relay, or ATM networks as well as Internet-layer (or higher-layer) "tunnels", such as tunnels over IPv4 or IPv6 itself.

### **3. Conceptual Configuration Variables**

The CE Router maintains such a list of conceptual optional configuration variables.

1. Enable an IGP on the LAN.
2. Configure 6rd configuration.
3. Configure IPv6 for 6rd to have IPv6 traffic go to the 6rd Border Relay vs. directly to peers.

### **4. Architecture**

This document extends the architecture described in [[RFC6204](#)] to cover a strictly larger set of operational scenarios. In particular, QoS, multicast, DNS, routed network in the home, transition technologies, and conceptual configuration variables. This document also extends the model described in [[RFC6204](#)] to a two router topology where the two routers are connected back-to-back (the LAN of one router is connected to the WAN of the other router). This topology is depicted below:



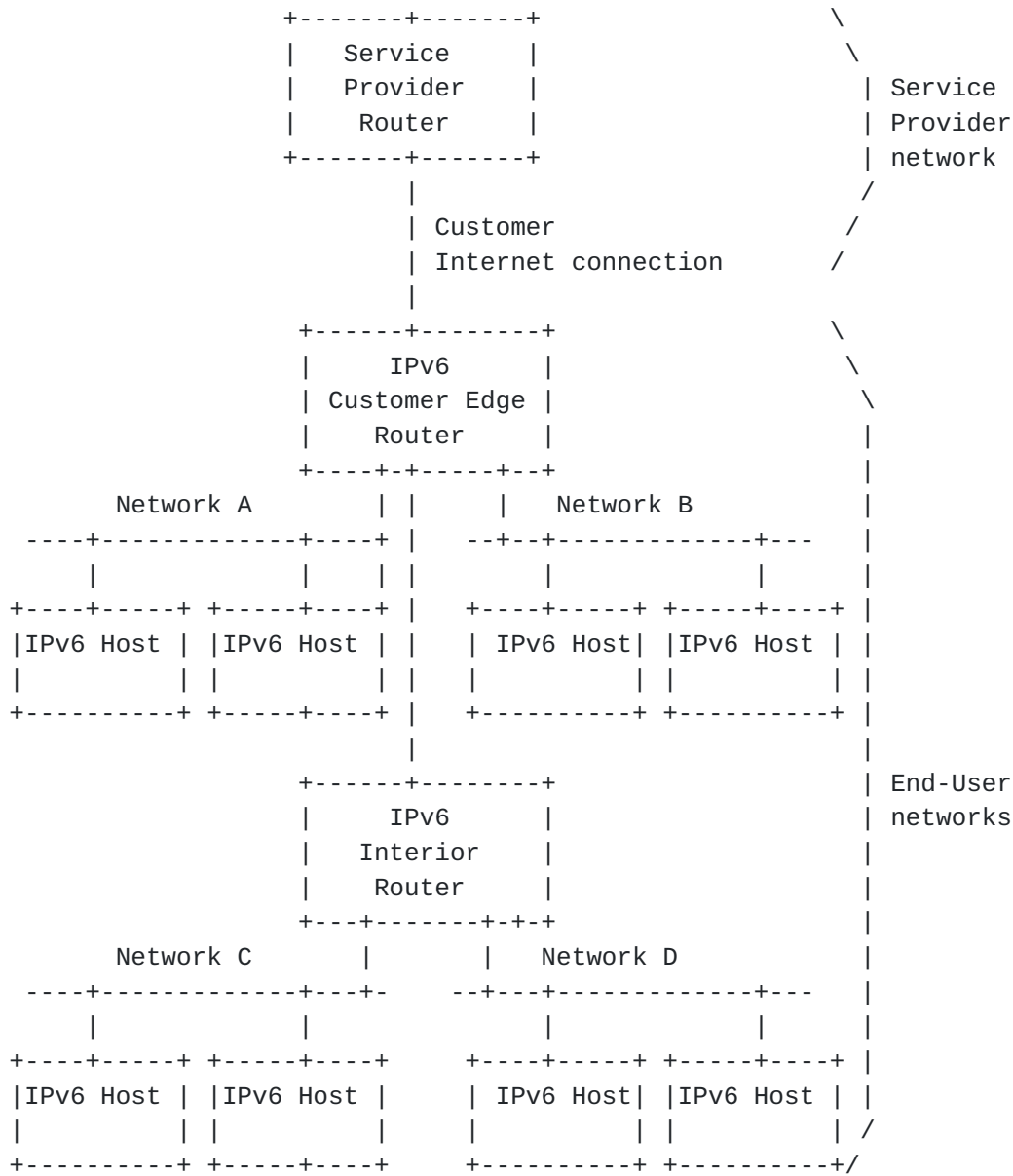


Figure 1.

For DNS, the operational expectation is that the end-user would be able to access home hosts from the home using DNS names instead of more cumbersome IPv6 addresses. Note that this is distinct from the requirement to access home hosts from outside the home.

End-users are expected to be able to receive multicast video in the home without requiring the CE router to include the cost of supporting full multicast routing protocols.





## 5. Advanced Features and Feature Requirements

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

### 5.1. DNS

D-1: The CE Router MAY include a DNS server authoritative for .local to handle local queries. If the service provider specifies one or more DNS resolvers in DHCP configuration options, the CE router SHOULD forward all non-local DNS queries unchanged to those servers. The CE Router MAY also include DNS64 functionality which is specified in [[RFC6147](#)].

### 5.2. Multicast Behavior

This section is only applicable to a CE Router with at least one LAN interface. A host in the home is expected to receive multicast video. Note the CE Router resides at edge of the home and the Service Provider, and the CE Router has at least one WAN connection for multiple LAN connections. In such a multiple LAN to a WAN topology at the CE Router edge, it is not necessary to run a multicast routing protocol and thus MLD Proxy as specified in [[RFC4605](#)] can be used. The CE Router discovers the hosts via a MLDv2 Router implementation on a LAN interface. A WAN interface of the CE Router interacts with the Service Provider router by sending MLD Reports and replying to MLD queries for multicast Group memberships for hosts in the home.

The CE router SHOULD implement MLD Proxy as specified in [[RFC4605](#)]. For the routed topology shown in Figure 1, each router implements a MLD Proxy. If the CE router implements MLD Proxy, the requirements on the CE Router for MLD Proxy are listed below.

WAN requirements, MLD Proxy:

WMLD-1: Consistent with [[RFC4605](#)], the CE router MUST NOT implement the router portion of MLDv2 for the WAN interface.

LAN requirements, MLD Proxy:

LMMLD-1: The CPE Router MUST follow the model described for MLD Proxy in [[RFC4605](#)] to implement multicast.



LMMLD-2: Consistent with [RFC4605], the LAN interfaces on the CPE router MUST NOT implement an MLDv2 Multicast Listener.

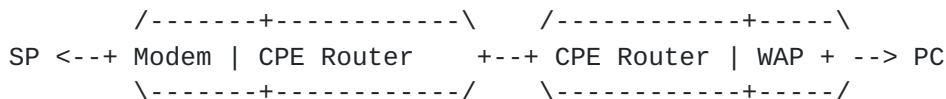
LAN requirements:

LM-1: If the CE Router has bridging configured between the LAN interfaces, then the LAN interfaces MUST support snooping of MLD [RFC3810] messages as per [RFC4541] .

**5.3. Routed network behavior**

CPE Router Behavior in a routed network:

R-1: One example of the CPE Router use in the home is shown below. The home has a broadband modem combined with a CPE Router, all in one device. The LAN interface of the device is connected to another standalone CPE Router that supports a wireless access point. To support such a network, this document recommends using prefix delegation of the prefix obtained either via IA\_PD from WAN interface or a ULA from the LAN interface. The network interface of the downstream router MAY obtain an IA\_PD via stateful DHCPv6. If the CPE router supports the routed network through a vendor specific automatic prefix delegation, the CPE router MUST support a DHCPv6 server or DHCPv6 relay agent. Further, if an IA\_PD is used, the Service Provider or user MUST allocate an IA\_PD or ULA prefix short enough to be delegated and subsequently used for SLAAC. Therefore, a prefix length shorter than /64 is needed. The CPE Router MAY support and IGP in the home network.



WAP = Wireless Access Point

Figure 2.

**5.4. Transition Technologies Support**

**5.4.1. Dual-Stack(DS)-Lite**

Even as users migrate from IPv4 to IPv6 addressing, a significant percentage of Internet resources and content will remain accessible



only through IPv4. Also, many end-user devices will only support IPv4. As a consequence, Service Providers require mechanisms to allow customers to continue to access content and resources using IPv4 even after the last IPv4 allocations have been fully depleted. One technology that can be used for IPv4 address extension is DS-Lite.

DS-Lite enables a Service Provider to share IPv4 addresses among multiple customers by combining two well-known technologies: IP in IP (IPv4-in-IPv6) tunneling and Carrier Grade NAT. More specifically, Dual-Stack-Lite encapsulates IPv4 traffic inside an IPv6 tunnel at the IPv6 CE Router and sends it to a Service Provider Address Family Translation Router (AFTR). Configuration of the IPv6 CE Router to support IPv4 LAN traffic is outside the scope of this document.

The IPv6 CE Router SHOULD implement DS-Lite functionality as specified in [[I-D.ietf-softwire-dual-stack-lite](#)].

WAN requirements:

- DLW-1: To facilitate IPv4 extension over an IPv6 network, if the CE Router supports DS-Lite functionality, the CE Router WAN interface MUST implement a B4 Interface as specified in [[I-D.ietf-softwire-dual-stack-lite](#)].
- DLW-2: If the IPv6 CE Router implements DS-Lite functionality, the CE Router MUST support using a DS-Lite DHCPv6 option [[I-D.ietf-softwire-ds-lite-tunnel-option](#)] to configure the DS-Lite tunnel. The IPv6 CE Router MAY use other mechanisms to configure DS-Lite parameters. Such mechanisms are outside the scope of this document.
- DLW-3: IPv6 CE Router MUST NOT perform IPv4 Network Address Translation (NAT) on IPv4 traffic encapsulated using DS-Lite.
- DLW-4: If the IPv6 CE Router is configured with a public IPv4 address on its WAN interface, where public IPv4 address is defined as any address which is not in the private IP address space specified in [[RFC1918](#)] and also not in the reserved IP address space specified in [[I-D.ietf-softwire-dual-stack-lite](#)], then the IPv6 CE Router MUST disable the DS-Lite B4 element.
- DLW-5: If DS-Lite is operational on the IPv6 CE Router, multicast data MUST NOT be sent on any DS-Lite tunnel.



### **5.4.2. 6rd**

The IPv6 CE Router can be used to offer IPv6 service to a LAN, even when the WAN access network only supports IPv4. One technology that supports IPv6 service over an IPv4 network is IPv6 Rapid Deployment (6rd). 6rd encapsulates IPv6 traffic from the end user LAN inside IPv4 at the IPv6 CE Router and sends it to a Service Provider Border Relay (BR). The IPv6 CE Router calculates a 6rd delegated IPv6 prefix during 6rd configuration, and sub-delegates the 6rd delegated prefix to devices in the LAN.

The IPv6 CE Router SHOULD implement 6rd functionality as specified in [[RFC5969](#)].

6rd requirements:

- 6RD-1: If the IPv6 CE Router implements 6rd functionality, the CE Router WAN interface MUST support at least one 6rd Virtual Interface and 6rd CE functionality as specified in [[RFC5969](#)].
- 6RD-2: If the IPv6 CE Router implements 6rd CE functionality, it MUST support user-entered configuration and using the 6rd DHCPv4 Option (212) for 6rd configuration. The IPv6 CE Router MAY use other mechanisms to configure 6rd parameters. Such mechanisms are outside the scope of this document.
- 6RD-3: If the CE router implements 6rd functionality, it MUST allow the user to specify whether all IPv6 traffic goes to the 6rd Border Relay, or whether other destinations within the same 6rd domain are routed directly to those destinations. The CE router MAY use other mechanisms to configure this. Such mechanisms are outside the scope of this document.
- 6RD-4: If 6rd is operational on the IPv6 CE Router, multicast data MUST NOT be sent on any 6rd tunnel.

### **5.4.3. Transition Technologies Coexistence**

Run the following four in parallel to provision CPE router connectivity to the Service Provider:

1. Initiate IPv4 address acquisition.
2. Initiate IPv6 address acquisition as specified by [[RFC6204](#)].
3. If 6rd is provisioned, initiate 6rd.





4. If DS-Lite is provisioned, initiate DS-Lite.

The default route for IPv6 through the native physical interface should have preference over the 6rd tunnel interface. The default route for IPv4 through the native physical interface should have preference over the DS-Lite tunnel interface.

### **5.5. Quality Of Service**

Q-1: The CPE router MAY support differentiated services [[RFC2474](#)].

### **5.6. Unicast Data Forwarding**

The null route introduced by the WPD-6 requirement in [[RFC6204](#)] has lower precedence than other routes except for the default route.

### **5.7. Additional DHCPv6 WAN Requirement**

When the WAN interface sends a DHCPV6 SOLICIT message, the CE router SHOULD request all mandatory information (IA\_NA and IA\_PD options) in the SOLICIT regardless of whether any partial information was received in response to previous SOLICITs.

## **6. Security Considerations**

None.

## **7. Acknowledgements**

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

Mikael Abrahamsson, Merete Asak, Scott Beuker, Mohamed Boucadair, Rex Bullinger, Brian Carpenter, Remi Denis-Courmont, Gert Doering, Alain Durand, Katsunori Fukuoka, Tony Hain, Thomas Herbst, Kevin Johns, Stephen Kramer, Victor Kuarsingh, Francois-Xavier Le Bail, Chad Mikkelson, David Miles, Shin Miyakawa, Jean-Francois Mule, Michael Newbery, Carlos Pignataro, John Pomeroy, Antonio Querubin, Teemu Savolainen, Matt Schmitt, Hiroki Sato, Mark Townsley, Bernie Volz, James Woodyatt, Dan Wing and Cor Zwart

This draft 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.

## **8. 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.

## **9. IANA Considerations**

This memo includes no request to IANA.

## **10. References**

### **10.1. Normative References**

- [I-D.ietf-softwire-ds-lite-tunnel-option]  
Hankins, D. and T. Mrugalski, "Dynamic Host Configuration Protocol for IPv6 (DHCPv6) Option for Dual- Stack Lite", [draft-ietf-softwire-ds-lite-tunnel-option-10](#) (work in progress), March 2011.
- [I-D.ietf-softwire-dual-stack-lite]  
Durand, A., Droms, R., Woodyatt, J., and Y. Lee, "Dual- Stack Lite Broadband Deployments Following IPv4 Exhaustion", [draft-ietf-softwire-dual-stack-lite-11](#) (work in progress), May 2011.
- [I-D.vyncke-advanced-ipv6-security]  
Vyncke, E. and M. Townsley, "Advanced Security for IPv6 CPE", [draft-vyncke-advanced-ipv6-security-01](#) (work in progress), March 2010.
- [RFC1122] Braden, R., "Requirements for Internet Hosts - Communication Layers", STD 3, [RFC 1122](#), October 1989.
- [RFC1918] Rekhter, Y., Moskowitz, R., Karrenberg, D., Groot, G., and E. Lear, "Address Allocation for Private Internets", [BCP 5](#), [RFC 1918](#), February 1996.
- [RFC2080] Malkin, G. and R. Minnear, "RIPng for IPv6", [RFC 2080](#),



January 1997.

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC2464] Crawford, M., "Transmission of IPv6 Packets over Ethernet Networks", [RFC 2464](#), December 1998.
- [RFC2474] Nichols, K., Blake, S., Baker, F., and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", [RFC 2474](#), December 1998.
- [RFC2827] Ferguson, P. and D. Senie, "Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing", [BCP 38](#), [RFC 2827](#), May 2000.
- [RFC3315] Droms, R., Bound, J., Volz, B., Lemon, T., Perkins, C., and M. Carney, "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", [RFC 3315](#), July 2003.
- [RFC3633] Troan, O. and R. Droms, "IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6", [RFC 3633](#), December 2003.
- [RFC3646] Droms, R., "DNS Configuration options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", [RFC 3646](#), December 2003.
- [RFC3736] Droms, R., "Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6", [RFC 3736](#), April 2004.
- [RFC3810] Vida, R. and L. Costa, "Multicast Listener Discovery Version 2 (MLDv2) for IPv6", [RFC 3810](#), June 2004.
- [RFC4075] Kalusivalingam, V., "Simple Network Time Protocol (SNTP) Configuration Option for DHCPv6", [RFC 4075](#), May 2005.
- [RFC4193] Hinden, R. and B. Haberman, "Unique Local IPv6 Unicast Addresses", [RFC 4193](#), October 2005.
- [RFC4242] Venaas, S., Chown, T., and B. Volz, "Information Refresh Time Option for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", [RFC 4242](#), November 2005.
- [RFC4294] Loughney, J., "IPv6 Node Requirements", [RFC 4294](#), April 2006.



- [RFC4443] Conta, A., Deering, S., and M. Gupta, "Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification", [RFC 4443](#), March 2006.
- [RFC4541] Christensen, M., Kimball, K., and F. Solensky, "Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches", [RFC 4541](#), May 2006.
- [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](#), August 2006.
- [RFC4632] Fuller, V. and T. Li, "Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan", [BCP 122](#), [RFC 4632](#), August 2006.
- [RFC4779] Asadullah, S., Ahmed, A., Popoviciu, C., Savola, P., and J. Palet, "ISP IPv6 Deployment Scenarios in Broadband Access Networks", [RFC 4779](#), January 2007.
- [RFC4861] Narten, T., Nordmark, E., Simpson, W., and H. Soliman, "Neighbor Discovery for IP version 6 (IPv6)", [RFC 4861](#), September 2007.
- [RFC4862] Thomson, S., Narten, T., and T. Jinmei, "IPv6 Stateless Address Autoconfiguration", [RFC 4862](#), September 2007.
- [RFC4864] Van de Velde, G., Hain, T., Droms, R., Carpenter, B., and E. Klein, "Local Network Protection for IPv6", [RFC 4864](#), May 2007.
- [RFC5072] S.Varada, Haskins, D., and E. Allen, "IP Version 6 over PPP", [RFC 5072](#), September 2007.
- [RFC5571] Storer, B., Pignataro, C., Dos Santos, M., Stevant, B., Toutain, L., and J. Tremblay, "Softwire Hub and Spoke Deployment Framework with Layer Two Tunneling Protocol Version 2 (L2TPv2)", [RFC 5571](#), June 2009.
- [RFC5942] Singh, H., Beebee, W., and E. Nordmark, "IPv6 Subnet Model: The Relationship between Links and Subnet Prefixes", [RFC 5942](#), July 2010.
- [RFC5969] Townsley, W. and O. Troan, "IPv6 Rapid Deployment on IPv4 Infrastructures (6rd) -- Protocol Specification", [RFC 5969](#), August 2010.





- [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.
- [RFC6204] Singh, H., Beebee, W., Donley, C., Stark, B., and O. Troan, "Basic Requirements for IPv6 Customer Edge Routers", [RFC 6204](#), April 2011.

## **10.2. Informative References**

- [I-D.ietf-behave-v6v4-framework]  
Baker, F., Li, X., Bao, C., and K. Yin, "Framework for IPv4/IPv6 Translation",  
[draft-ietf-behave-v6v4-framework-10](#) (work in progress),  
August 2010.
- [UPnP-IGD]  
UPnP Forum, "Universal Plug and Play (UPnP) Internet Gateway Device (IGD)", November 2001,  
<<http://www.upnp.org/standardizeddcps/igd.asp>>.

## Authors' Addresses

Hemant Singh  
Cisco Systems, Inc.  
1414 Massachusetts Ave.  
Boxborough, MA 01719  
USA

Phone: +1 978 936 1622  
Email: [shemant@cisco.com](mailto:shemant@cisco.com)  
URI: <http://www.cisco.com/>

Wes Beebee  
Cisco Systems, Inc.  
1414 Massachusetts Ave.  
Boxborough, MA 01719  
USA

Phone: +1 978 936 2030  
Email: [wbeebee@cisco.com](mailto:wbeebee@cisco.com)  
URI: <http://www.cisco.com/>



Chris Donley  
CableLabs  
858 Coal Creek Circle  
Louisville, CO 80027  
USA

Email: [c.donley@cablelabs.com](mailto:c.donley@cablelabs.com)

Barbara Stark  
ATT  
725 W Peachtree St  
Atlanta, GA 30308  
USA

Email: [barbara.stark@att.com](mailto:barbara.stark@att.com)

Ole Troan (editor)  
Cisco Systems, Inc.  
Veversmauet 8  
N-5017 BERGEN,  
Norway

Email: [ot@cisco.com](mailto:ot@cisco.com)

