

Internet Engineering Task Force
Internet-Draft
Obsoletes: [6434](#) (if approved)
Intended status: Best Current Practice
Expires: August 31, 2018

T. Chown
Jisc
J. Loughney
Intel
T. Winters
UNH-IOL
February 27, 2018

IPv6 Node Requirements
draft-ietf-6man-rfc6434-bis-05

Abstract

This document defines requirements for IPv6 nodes. It is expected that IPv6 will be deployed in a wide range of devices and situations. Specifying the requirements for IPv6 nodes allows IPv6 to function well and interoperate in a large number of situations and deployments.

This document obsoletes [RFC 6434](#), and in turn [RFC 4294](#).

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 <https://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 August 31, 2018.

Copyright Notice

Copyright (c) 2018 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 (<https://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	3
1.1.	Scope of This Document	4
1.2.	Description of IPv6 Nodes	5
2.	Requirements Language	5
3.	Abbreviations Used in This Document	5
4.	Sub-IP Layer	5
5.	IP Layer	6
5.1.	Internet Protocol Version 6 - RFC 8200	6
5.2.	Support for IPv6 Extension Headers	7
5.3.	Protecting a node from excessive EH options	8
5.4.	Neighbor Discovery for IPv6 - RFC 4861	9
5.5.	SEcure Neighbor Discovery (SEND) - RFC 3971	10
5.6.	IPv6 Router Advertisement Flags Option - RFC 5175	10
5.7.	Path MTU Discovery and Packet Size	11
5.7.1.	Path MTU Discovery - RFC 8201	11
5.7.2.	Minimum MTU considerations	11
5.8.	ICMP for the Internet Protocol Version 6 (IPv6) - RFC 4443	11
5.9.	Default Router Preferences and More-Specific Routes - RFC 4191	11
5.10.	First-Hop Router Selection - RFC 8028	12
5.11.	Multicast Listener Discovery (MLD) for IPv6 - RFC 3810	12
5.12.	Explicit Congestion Notification (ECN) - RFC 3168	12
6.	Addressing and Address Configuration	12
6.1.	IP Version 6 Addressing Architecture - RFC 4291	12
6.2.	Host Address Availability Recommendations	13
6.3.	IPv6 Stateless Address Autoconfiguration - RFC 4862	13
6.4.	Privacy Extensions for Address Configuration in IPv6 - RFC 4941	14
6.5.	Stateful Address Autoconfiguration (DHCPv6) - RFC 3315	15
6.6.	Default Address Selection for IPv6 - RFC 6724	15
7.	DNS	15
8.	Configuring Non-Address Information	16
8.1.	DHCP for Other Configuration Information	16
8.2.	Router Advertisements and Default Gateway	16

8.3.	IPv6 Router Advertisement Options for DNS Configuration - RFC 8106	16
8.4.	DHCP Options versus Router Advertisement Options for Host Configuration	17
9.	Service Discovery Protocols	17

10.	IPv4 Support and Transition	18
10.1.	Transition Mechanisms	18
10.1.1.	Basic Transition Mechanisms for IPv6 Hosts and Routers - RFC 4213	18
11.	Application Support	18
11.1.	Textual Representation of IPv6 Addresses - RFC 5952	18
11.2.	Application Programming Interfaces (APIs)	18
12.	Mobility	19
13.	Security	19
13.1.	Requirements	21
13.2.	Transforms and Algorithms	21
14.	Router-Specific Functionality	21
14.1.	IPv6 Router Alert Option - RFC 2711	21
14.2.	Neighbor Discovery for IPv6 - RFC 4861	22
14.3.	Stateful Address Autoconfiguration (DHCPv6) - RFC 3315	22
14.4.	IPv6 Prefix Length Recommendation for Forwarding - BCP 198	22
15.	Constrained Devices	22
16.	Network Management	23
16.1.	Management Information Base (MIB) Modules	23
16.1.1.	IP Forwarding Table MIB	23
16.1.2.	Management Information Base for the Internet Protocol (IP)	23
16.1.3.	Interface MIB	23
16.2.	YANG Data Models	24
16.2.1.	IP Management YANG Model	24
16.2.2.	Interface Management YANG Model	24
17.	Security Considerations	24
18.	IANA Considerations	24
19.	Authors and Acknowledgments	24
19.1.	Authors and Acknowledgments (Current Document)	24
19.2.	Authors and Acknowledgments from RFC 6434	24
19.3.	Authors and Acknowledgments from RFC 4294	25
20.	Appendix: Changes from RFC 6434	26
21.	Appendix: Changes from RFC 4294	27
22.	References	29

22.1.	Normative References	29
22.2.	Informative References	35
	Authors' Addresses	40

[1.](#) Introduction

This document defines common functionality required by both IPv6 hosts and routers. Many IPv6 nodes will implement optional or additional features, but this document collects and summarizes requirements from other published Standards Track documents in one place.

Chown, et al.

Expires August 31, 2018

[Page 3]

Internet-Draft

IPv6 Node Requirements

February 2018

This document tries to avoid discussion of protocol details and references RFCs for this purpose. This document is intended to be an applicability statement and to provide guidance as to which IPv6 specifications should be implemented in the general case and which specifications may be of interest to specific deployment scenarios. This document does not update any individual protocol document RFCs.

Although this document points to different specifications, it should be noted that in many cases, the granularity of a particular requirement will be smaller than a single specification, as many specifications define multiple, independent pieces, some of which may not be mandatory. In addition, most specifications define both client and server behavior in the same specification, while many implementations will be focused on only one of those roles.

This document defines a minimal level of requirement needed for a device to provide useful internet service and considers a broad range of device types and deployment scenarios. Because of the wide range of deployment scenarios, the minimal requirements specified in this document may not be sufficient for all deployment scenarios. It is perfectly reasonable (and indeed expected) for other profiles to define additional or stricter requirements appropriate for specific usage and deployment environments. For example, this document does not mandate that all clients support DHCP, but some deployment scenarios may deem it appropriate to make such a requirement. For example, government agencies in the USA have defined profiles for specialized requirements for IPv6 in target environments (see [\[USGv6\]](#)).

As it is not always possible for an implementer to know the exact usage of IPv6 in a node, an overriding requirement for IPv6 nodes is that they should adhere to Jon Postel's Robustness Principle: "Be conservative in what you do, be liberal in what you accept from others" [[RFC0793](#)].

[1.1.](#) Scope of This Document

IPv6 covers many specifications. It is intended that IPv6 will be deployed in many different situations and environments. Therefore, it is important to develop requirements for IPv6 nodes to ensure interoperability.

This document assumes that all IPv6 nodes meet the minimum requirements specified here.

[1.2.](#) Description of IPv6 Nodes

From the Internet Protocol, Version 6 (IPv6) Specification [[RFC8200](#)], we have the following definitions:

IPv6 node - a device that implements IPv6.
IPv6 router - a node that forwards IPv6 packets not explicitly
 addressed to itself.
IPv6 host - any node that is not a router.

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

[3.](#) Abbreviations Used in This Document

AH Authentication Header
DAD Duplicate Address Detection
ESP Encapsulating Security Payload
ICMP Internet Control Message Protocol

IKE Internet Key Exchange
MIB Management Information Base
MLD Multicast Listener Discovery
MTU Maximum Transmission Unit
NA Neighbor Advertisement
NBMA Non-Broadcast Multiple Access
ND Neighbor Discovery
NS Neighbor Solicitation
NUD Neighbor Unreachability Detection
PPP Point-to-Point Protocol

[4.](#) Sub-IP Layer

An IPv6 node must include support for one or more IPv6 link-layer specifications. Which link-layer specifications an implementation should include will depend upon what link-layers are supported by the hardware available on the system. It is possible for a conformant IPv6 node to support IPv6 on some of its interfaces and not on others.

As IPv6 is run over new layer 2 technologies, it is expected that new specifications will be issued. In the following, we list some of the layer 2 technologies for which an IPv6 specification has been developed. It is provided for informational purposes only and may not be complete.

- Transmission of IPv6 Packets over Ethernet Networks [[RFC2464](#)]
- Transmission of IPv6 Packets over Frame Relay Networks Specification [[RFC2590](#)]
- Transmission of IPv6 Packets over IEEE 1394 Networks [[RFC3146](#)]
- Transmission of IPv6, IPv4, and Address Resolution Protocol (ARP) Packets over Fibre Channel [[RFC4338](#)]
- Transmission of IPv6 Packets over IEEE 802.15.4 Networks [[RFC4944](#)]
- Transmission of IPv6 via the IPv6 Convergence Sublayer over IEEE 802.16 Networks [[RFC5121](#)]

- IP version 6 over PPP [[RFC5072](#)]

In addition to traditional physical link-layers, it is also possible to tunnel IPv6 over other protocols. Examples include:

- Teredo: Tunneling IPv6 over UDP through Network Address Translations (NATs) [[RFC4380](#)]
- [Section 3](#) of "Basic Transition Mechanisms for IPv6 Hosts and Routers" [[RFC4213](#)]

[5.](#) IP Layer

[5.1.](#) Internet Protocol Version 6 - [RFC 8200](#)

The Internet Protocol Version 6 is specified in [[RFC8200](#)]. This specification MUST be supported.

The node MUST follow the packet transmission rules in [RFC 8200](#).

All conformant IPv6 implementations MUST be capable of sending and receiving IPv6 packets; forwarding functionality MAY be supported. Nodes MUST always be able to send, receive, and process fragment headers. Overlapping fragments MUST be handled as described in [[RFC5722](#)].

[RFC6946] discusses IPv6 atomic fragments, and recommends that IPv6 atomic fragments are processed independently of any other fragments, to protect against fragmentation-based attacks. [[RFC8021](#)] goes further and recommends the deprecation of atomic fragments. Nodes thus MUST NOT generate atomic fragments.

To mitigate a variety of potential attacks, nodes SHOULD avoid using predictable fragment Identification values in Fragment Headers, as discussed in [[RFC7739](#)].

All nodes SHOULD support the setting and use of the IPv6 Flow Label field as defined in the IPv6 Flow Label specification [[RFC6437](#)]. Forwarding nodes such as routers and load distributors MUST NOT depend only on Flow Label values being uniformly distributed. It is

RECOMMENDED that source hosts support the flow label by setting the Flow Label field for all packets of a given flow to the same value chosen from an approximation to a discrete uniform distribution.

[5.2.](#) Support for IPv6 Extension Headers

[RFC 8200](#) specifies extension headers and the processing for these headers.

Any unrecognized extension headers or options MUST be processed as described in [RFC 8200](#). Note that where [Section 4 of RFC 8200](#) refers to the action to be taken when a Next Header value in the current header is not recognized by a node, that action applies whether the value is an unrecognized Extension Header or an unrecognized upper layer protocol (ULP).

An IPv6 node MUST be able to process these headers. An exception is Routing Header type 0 (RH0), which was deprecated by [\[RFC5095\]](#) due to security concerns and which MUST be treated as an unrecognized routing type.

Further, [\[RFC7045\]](#) adds specific requirements for processing of Extension Headers, in particular that any forwarding node along an IPv6 packet's path, which forwards the packet for any reason, SHOULD do so regardless of any extension headers that are present.

[\[RFC7112\]](#) discusses issues with oversized IPv6 Extension Header chains, and states that when a node fragments an IPv6 datagram, it MUST include the entire IPv6 Header Chain in the First Fragment.

As stated in [RFC8200](#), extension headers (except for the Hop-by-Hop Options header) are not processed, inserted, or deleted by any node along a packet's delivery path, until the packet reaches the node (or each of the set of nodes, in the case of multicast) identified in the Destination Address field of the IPv6 header.

It should be noted that when future, new Extension Headers are defined, the consistent format described in [Section 4 of \[RFC6564\]](#) MUST be followed.

[5.3.](#) Protecting a node from excessive EH options

Per [RFC 8200](#), end hosts are expected to process all extension headers, destination options, and hop-by-hop options in a packet. Given that the only limit on the number and size of extension headers is the MTU, the processing of received packets could be considerable. It is also conceivable that a long chain of extension headers might be used as a form of denial-of-service attack. Accordingly, a host may place limits on the number and sizes of extension headers and options it is willing to process.

A host MAY limit the number of consecutive PAD1 options in destination options or hop-by-hop options to seven. In this case, if the more than seven consecutive PAD1 options are present the packet should be silently discarded. The rationale is that if padding of eight or more bytes is required then the PADN option should be used.

A host MAY limit number of bytes in a PADN option to be less than eight. In such a case, if a PADN option is present that has a length greater than seven then the packet should be silently discarded. The rationale for this guideline is that the purpose of padding is for alignment and eight bytes is the maximum alignment used in IPv6.

A host MAY disallow unknown options in destination options or hop-by-hop options. This should be configurable where the default is to accept unknown options and process them per [\[RFC8200\]](#). If a packet with unknown options is received and the host is configured to disallow them, then the packet should be silently discarded.

A host MAY impose a limit on the maximum number of non-padding options allowed in a destination options and hop-by-hop extension headers. If this feature is supported the maximum number should be configurable and the default value SHOULD be set to eight. The limits for destination options and hop-by-hop options may be separately configurable. If a packet is received and the number of destination or hop-by-hop options exceeds the limit, then the packet should be silently discarded.

A host MAY impose a limit on the maximum length of destination options or hop-by-hop options extension header. This value should be configurable and the default is to accept options of any length. If a packet is received and the length of destination or hop-by-hop options extension header exceeds the length limit, then the packet should be silently discarded.

5.4. Neighbor Discovery for IPv6 - [RFC 4861](#)

Neighbor Discovery is defined in [[RFC4861](#)]; the definition was updated by [[RFC5942](#)]. Neighbor Discovery SHOULD be supported. [RFC 4861](#) states:

Unless specified otherwise (in a document that covers operating IP over a particular link type) this document applies to all link types. However, because ND uses link-layer multicast for some of its services, it is possible that on some link types (e.g., Non-Broadcast Multi-Access (NBMA) links), alternative protocols or mechanisms to implement those services will be specified (in the appropriate document covering the operation of IP over a particular link type). The services described in this document that are not directly dependent on multicast, such as Redirects, next-hop determination, Neighbor Unreachability Detection, etc., are expected to be provided as specified in this document. The details of how one uses ND on NBMA links are addressed in [[RFC2491](#)].

Some detailed analysis of Neighbor Discovery follows:

Router Discovery is how hosts locate routers that reside on an attached link. Hosts MUST support Router Discovery functionality.

Prefix Discovery is how hosts discover the set of address prefixes that define which destinations are on-link for an attached link. Hosts MUST support Prefix Discovery.

Hosts MUST also implement Neighbor Unreachability Detection (NUD) for all paths between hosts and neighboring nodes. NUD is not required for paths between routers. However, all nodes MUST respond to unicast Neighbor Solicitation (NS) messages.

[RFC7048] discusses NUD, in particular cases where it behaves too impatiently. It states that if a node transmits more than a certain number of packets, then it SHOULD use the exponential backoff of the retransmit timer, up to a certain threshold point.

Hosts MUST support the sending of Router Solicitations and the receiving of Router Advertisements. The ability to understand individual Router Advertisement options is dependent on supporting the functionality making use of the particular option.

[RFC7559] discusses packet loss resiliency for Router Solicitations, and requires that nodes MUST use a specific exponential backoff

algorithm for RS retransmissions.

All nodes **MUST** support the sending and receiving of Neighbor Solicitation (NS) and Neighbor Advertisement (NA) messages. NS and NA messages are required for Duplicate Address Detection (DAD).

Hosts **SHOULD** support the processing of Redirect functionality. Routers **MUST** support the sending of Redirects, though not necessarily for every individual packet (e.g., due to rate limiting). Redirects are only useful on networks supporting hosts. In core networks dominated by routers, Redirects are typically disabled. The sending of Redirects **SHOULD** be disabled by default on backbone routers. They **MAY** be enabled by default on routers intended to support hosts on edge networks.

"IPv6 Host-to-Router Load Sharing" [[RFC4311](#)] includes additional recommendations on how to select from a set of available routers. [[RFC4311](#)] **SHOULD** be supported.

[5.5.](#) SEcure Neighbor Discovery (SEND) - [RFC 3971](#)

SEND [[RFC3971](#)] and Cryptographically Generated Addresses (CGAs) [[RFC3972](#)] provide a way to secure the message exchanges of Neighbor Discovery. SEND has the potential to address certain classes of spoofing attacks, but it does not provide specific protection for threats from off-link attackers.

There have been relatively few implementations of SEND in common operating systems and platforms, and thus deployment experience has been limited to date.

At this time, SEND is considered optional. Due to the complexity in deploying SEND, and its heavyweight provisioning, its deployment is only likely to be considered where nodes are operating in a particularly strict security environment.

[5.6.](#) IPv6 Router Advertisement Flags Option - [RFC 5175](#)

Router Advertisements include an 8-bit field of single-bit Router Advertisement flags. The Router Advertisement Flags Option extends the number of available flag bits by 48 bits. At the time of this

writing, 6 of the original 8 single-bit flags have been assigned, while 2 remain available for future assignment. No flags have been defined that make use of the new option, and thus, strictly speaking, there is no requirement to implement the option today. However, implementations that are able to pass unrecognized options to a higher-level entity that may be able to understand them (e.g., a user-level process using a "raw socket" facility) MAY take steps to handle the option in anticipation of a future usage.

[5.7.](#) Path MTU Discovery and Packet Size

[5.7.1.](#) Path MTU Discovery - [RFC 8201](#)

"Path MTU Discovery for IP version 6" [[RFC8201](#)] SHOULD be supported. From [[RFC8200](#)]:

It is strongly recommended that IPv6 nodes implement Path MTU Discovery [[RFC8201](#)], in order to discover and take advantage of path MTUs greater than 1280 octets. However, a minimal IPv6 implementation (e.g., in a boot ROM) may simply restrict itself to sending packets no larger than 1280 octets, and omit implementation of Path MTU Discovery.

The rules in [[RFC8200](#)] and [[RFC5722](#)] MUST be followed for packet fragmentation and reassembly.

One operational issue with Path MTU Discovery occurs when, contrary to the guidance in [[RFC4890](#)], firewalls block ICMP Packet Too Big messages. Path MTU Discovery relies on such messages to determine what size messages can be successfully sent. "Packetization Layer Path MTU Discovery" [[RFC4821](#)] avoids having a dependency on Packet Too Big messages.

[5.7.2.](#) Minimum MTU considerations

While an IPv6 link MTU can be set to 1280 bytes, it is recommended that for IPv6 UDP in particular, which includes DNS operation, the sender use a large MTU if they can, in order to avoid gratuitous fragmentation-caused packet drops.

[5.8.](#) ICMP for the Internet Protocol Version 6 (IPv6) - [RFC 4443](#)

ICMPv6 [[RFC4443](#)] MUST be supported. "Extended ICMP to Support Multi-Part Messages" [[RFC4884](#)] MAY be supported.

[5.9.](#) Default Router Preferences and More-Specific Routes - [RFC 4191](#)

"Default Router Preferences and More-Specific Routes" [[RFC4191](#)] provides support for nodes attached to multiple (different) networks, each providing routers that advertise themselves as default routers via Router Advertisements. In some scenarios, one router may provide connectivity to destinations the other router does not, and choosing the "wrong" default router can result in reachability failures. In order to resolve this scenario IPv6 Nodes MUST implement [[RFC4191](#)] and SHOULD implement the Type C host role defined in [RFC4191](#).

Chown, et al.

Expires August 31, 2018

[Page 11]

Internet-Draft

IPv6 Node Requirements

February 2018

[5.10.](#) First-Hop Router Selection - [RFC 8028](#)

In multihomed scenarios, where a host has more than one prefix, each allocated by an upstream network that is assumed to implement [BCP 38](#) ingress filtering, the host may have multiple routers to choose from.

Hosts that may be deployed in such multihomed environments SHOULD follow the guidance given in [[RFC8028](#)].

[5.11.](#) Multicast Listener Discovery (MLD) for IPv6 - [RFC 3810](#)

Nodes that need to join multicast groups MUST support MLDv2 [[RFC3810](#)]. MLD is needed by any node that is expected to receive and process multicast traffic and in particular MLDv2 is required for support for source-specific multicast (SSM) as per [[RFC4607](#)].

Previous versions of this document only required MLDv1 ([[RFC2710](#)]) to be implemented on all nodes. Since participation of any MLDv1-only nodes on a link require that all other nodes on the link then operate in version 1 compatibility mode, the requirement to support MLDv2 on all nodes was upgraded to a MUST. Further, SSM is now the preferred multicast distribution method, rather than ASM.

Note that Neighbor Discovery (as used on most link types -- see [Section 5.4](#)) depends on multicast and requires that nodes join

Solicited Node multicast addresses.

[5.12.](#) Explicit Congestion Notification (ECN) - [RFC 3168](#)

An ECN-aware router may set a mark in the IP header in order to signal impending congestion, rather than dropping a packet. The receiver of the packet echoes the congestion indication to the sender, which can then reduce its transmission rate as if it detected a dropped packet.

Nodes that may be deployed in environments where they would benefit from such early congestion notification SHOULD implement [\[RFC3168\]](#). In such cases, the updates presented in [\[RFC8311\]](#) may also be relevant.

[6.](#) Addressing and Address Configuration

[6.1.](#) IP Version 6 Addressing Architecture - [RFC 4291](#)

The IPv6 Addressing Architecture [\[RFC4291\]](#) MUST be supported.

The current IPv6 Address Architecture is based on a 64-bit boundary for subnet prefixes. The reasoning behind this decision is documented in [\[RFC7421\]](#).

Implementations MUST also support the Multicast flag updates documented in [\[RFC7371\]](#)

[6.2.](#) Host Address Availability Recommendations

Hosts may be configured with addresses through a variety of methods, including SLAAC, DHCPv6, or manual configuration.

[\[RFC7934\]](#) recommends that networks provide general-purpose end hosts with multiple global IPv6 addresses when they attach, and it describes the benefits of and the options for doing so. Routers SHOULD support [\[RFC7934\]](#) for assigning multiple address to a host. Host SHOULD support assigning multiple addresses as described in [\[RFC7934\]](#).

Nodes SHOULD support the capability to be assigned a prefix per host as documented in [[RFC8273](#)]. Such an approach can offer improved host isolation and enhanced subscriber management on shared network segments.

[6.3.](#) IPv6 Stateless Address Autoconfiguration - [RFC 4862](#)

Hosts MUST support IPv6 Stateless Address Autoconfiguration. It is recommended, as described in [[RFC8064](#)], that unless there is a specific requirement for MAC addresses to be embedded in an IID, nodes follow the procedure in [[RFC7217](#)] to generate SLAAC-based addresses, rather than using [[RFC4862](#)]. Addresses generated through [RFC7217](#) will be the same whenever a given device (re)appears on the same subnet (with a specific IPv6 prefix), but the IID will vary on each subnet visited.

Nodes that are routers MUST be able to generate link-local addresses as described in [[RFC4862](#)].

From [RFC 4862](#):

The autoconfiguration process specified in this document applies only to hosts and not routers. Since host autoconfiguration uses information advertised by routers, routers will need to be configured by some other means. However, it is expected that routers will generate link-local addresses using the mechanism described in this document. In addition, routers are expected to successfully pass the Duplicate Address Detection procedure

described in this document on all addresses prior to assigning them to an interface.

All nodes MUST implement Duplicate Address Detection. Quoting from [Section 5.4 of RFC 4862](#):

Duplicate Address Detection MUST be performed on all unicast addresses prior to assigning them to an interface, regardless of whether they are obtained through stateless autoconfiguration, DHCPv6, or manual configuration, with the following [exceptions noted therein].

"Optimistic Duplicate Address Detection (DAD) for IPv6" [[RFC4429](#)] specifies a mechanism to reduce delays associated with generating addresses via Stateless Address Autoconfiguration [[RFC4862](#)]. [RFC 4429](#) was developed in conjunction with Mobile IPv6 in order to reduce the time needed to acquire and configure addresses as devices quickly move from one network to another, and it is desirable to minimize transition delays. For general purpose devices, [RFC 4429](#) remains optional at this time.

[RFC7527] discusses enhanced DAD, and describes an algorithm to automate the detection of looped back IPv6 ND messages used by DAD. Nodes SHOULD implement this behaviour where such detection is beneficial.

[6.4.](#) Privacy Extensions for Address Configuration in IPv6 - [RFC 4941](#)

A node using Stateless Address Autoconfiguration [[RFC4862](#)] to form a globally unique IPv6 address using its MAC address to generate the IID will see that IID remain the same on any visited network, even though the network prefix part changes. Thus it is possible for 3rd party devices such nodes communicate with to track the activities of the node as it moves around the network. Privacy Extensions for Stateless Address Autoconfiguration [[RFC4941](#)] address this concern by allowing nodes to configure an additional temporary address where the IID is effectively randomly generated. Privacy addresses are then used as source addresses for new communications initiated by the node.

General issues regarding privacy issues for IPv6 addressing are discussed in [[RFC7721](#)].

[RFC 4941](#) SHOULD be supported. In some scenarios, such as dedicated servers in a data center, it provides limited or no benefit, or may complicate network management. Thus devices implementing this specification MUST provide a way for the end user to explicitly enable or disable the use of such temporary addresses.

Note that [RFC4941](#) can be used independently of traditional SLAAC, or of [RFC7217](#)-based SLAAC.

Implementers of [RFC 4941](#) should be aware that certain addresses are

reserved and should not be chosen for use as temporary addresses. Consult "Reserved IPv6 Interface Identifiers" [[RFC5453](#)] for more details.

[6.5.](#) Stateful Address Autoconfiguration (DHCPv6) - [RFC 3315](#)

DHCPv6 [[RFC3315](#)] can be used to obtain and configure addresses. In general, a network may provide for the configuration of addresses through SLAAC, DHCPv6, or both. There will be a wide range of IPv6 deployment models and differences in address assignment requirements, some of which may require DHCPv6 for stateful address assignment. Consequently, all hosts SHOULD implement address configuration via DHCPv6.

In the absence of observed Router Advertisement messages, IPv6 nodes MAY initiate DHCP to obtain IPv6 addresses and other configuration information, as described in [Section 5.5.2 of \[RFC4862\]](#).

Where devices are likely to be carried by users and attached to multiple visited networks, DHCPv6 client anonymity profiles SHOULD be supported as described in [[RFC7844](#)] to minimise the disclosure of identifying information. [Section 5 of RFC7844](#) describes operational considerations on the use of such anonymity profiles.

[6.6.](#) Default Address Selection for IPv6 - [RFC 6724](#)

IPv6 nodes will invariably have multiple addresses configured simultaneously, and thus will need to choose which addresses to use for which communications. The rules specified in the Default Address Selection for IPv6 [[RFC6724](#)] document MUST be implemented. [[RFC8028](#)] updates rule 5.5 from [[RFC6724](#)]; implementations SHOULD implement this rule.

[7.](#) DNS

DNS is described in [[RFC1034](#)], [[RFC1035](#)], [[RFC3363](#)], and [[RFC3596](#)]. Not all nodes will need to resolve names; those that will never need to resolve DNS names do not need to implement resolver functionality. However, the ability to resolve names is a basic infrastructure capability on which applications rely, and most nodes will need to provide support. All nodes SHOULD implement stub-resolver [[RFC1034](#)] functionality, as in [[RFC1034](#)], [Section 5.3.1](#), with support for:

- AAAA type Resource Records [[RFC3596](#)];

- reverse addressing in ip6.arpa using PTR records [[RFC3596](#)];
- Extension Mechanisms for DNS (EDNS0) [[RFC6891](#)] to allow for DNS packet sizes larger than 512 octets.

Those nodes are RECOMMENDED to support DNS security extensions [[RFC4033](#)] [[RFC4034](#)] [[RFC4035](#)].

A6 Resource Records, which were only ever defined with Experimental status in [[RFC3363](#)], are now classified as Historic, as per [[RFC6563](#)].

8. Configuring Non-Address Information

8.1. DHCP for Other Configuration Information

DHCP [[RFC3315](#)] Specifies a mechanism for IPv6 nodes to obtain address configuration information (see [Section 6.5](#)) and to obtain additional (non-address) configuration. If a host implementation supports applications or other protocols that require configuration that is only available via DHCP, hosts SHOULD implement DHCP. For specialized devices on which no such configuration need is present, DHCP may not be necessary.

An IPv6 node can use the subset of DHCP (described in [[RFC3736](#)]) to obtain other configuration information.

If an IPv6 node implements DHCP it MUST implement the DNS options [[RFC3646](#)] as most deployments will expect these options are available.

8.2. Router Advertisements and Default Gateway

There is no defined DHCPv6 Gateway option.

Nodes using the Dynamic Host Configuration Protocol for IPv6 (DHCPv6) are thus expected to determine their default router information and on-link prefix information from received Router Advertisements.

8.3. IPv6 Router Advertisement Options for DNS Configuration - [RFC 8106](#)

Router Advertisement Options have historically been limited to those that are critical to basic IPv6 functionality. Originally, DNS configuration was not included as an RA option, and DHCP was the recommended way to obtain DNS configuration information. Over time, the thinking surrounding such an option has evolved. It is now generally recognized that few nodes can function adequately without

having access to a working DNS resolver, and thus a Standards Track document has been published to provide this capability [[RFC8106](#)].

Implementations MUST include support for the DNS RA option [[RFC8106](#)].

[8.4.](#) DHCP Options versus Router Advertisement Options for Host Configuration

In IPv6, there are two main protocol mechanisms for propagating configuration information to hosts: Router Advertisements (RAs) and DHCP. RA options have been restricted to those deemed essential for basic network functioning and for which all nodes are configured with exactly the same information. Examples include the Prefix Information Options, the MTU option, etc. On the other hand, DHCP has generally been preferred for configuration of more general parameters and for parameters that may be client-specific. Generally speaking, however, there has been a desire to define only one mechanism for configuring a given option, rather than defining multiple (different) ways of configuring the same information.

One issue with having multiple ways of configuring the same information is that interoperability suffers if a host chooses one mechanism but the network operator chooses a different mechanism. For "closed" environments, where the network operator has significant influence over what devices connect to the network and thus what configuration mechanisms they support, the operator may be able to ensure that a particular mechanism is supported by all connected hosts. In more open environments, however, where arbitrary devices may connect (e.g., a WIFI hotspot), problems can arise. To maximize interoperability in such environments, hosts would need to implement multiple configuration mechanisms to ensure interoperability.

[9.](#) Service Discovery Protocols

[RFC6762] and [[RFC6763](#)] describe multicast DNS (mDNS) and DNS-Based Service Discovery (DNS-SD) respectively. These protocols, collectively commonly referred to as the 'Bonjour' protocols after their naming by Apple, provide the means for devices to discover services within a local link and, in the absence of a unicast DNS service, to exchange naming information.

Where devices are to be deployed in networks where service discovery would be beneficial, e.g., for users seeking to discover printers or display devices, mDNS and DNS-SD SHOULD be supported.

The IETF dnssd WG is defining solutions for DNS-based service discovery in multi-link networks.

[10.](#) IPv4 Support and Transition

IPv6 nodes MAY support IPv4.

[10.1.](#) Transition Mechanisms

[10.1.1.](#) Basic Transition Mechanisms for IPv6 Hosts and Routers - [RFC 4213](#)

If an IPv6 node implements dual stack and tunneling, then [[RFC4213](#)] MUST be supported.

[11.](#) Application Support

[11.1.](#) Textual Representation of IPv6 Addresses - [RFC 5952](#)

Software that allows users and operators to input IPv6 addresses in text form SHOULD support "A Recommendation for IPv6 Address Text Representation" [[RFC5952](#)].

[11.2.](#) Application Programming Interfaces (APIs)

There are a number of IPv6-related APIs. This document does not mandate the use of any, because the choice of API does not directly relate to on-the-wire behavior of protocols. Implementers, however, would be advised to consider providing a common API or reviewing existing APIs for the type of functionality they provide to applications.

"Basic Socket Interface Extensions for IPv6" [[RFC3493](#)] provides IPv6 functionality used by typical applications. Implementers should note that [RFC3493](#) has been picked up and further standardized by the Portable Operating System Interface (POSIX) [[POSIX](#)].

"Advanced Sockets Application Program Interface (API) for IPv6" [[RFC3542](#)] provides access to advanced IPv6 features needed by diagnostic and other more specialized applications.

"IPv6 Socket API for Source Address Selection" [[RFC5014](#)] provides facilities that allow an application to override the default Source Address Selection rules of [[RFC6724](#)].

"Socket Interface Extensions for Multicast Source Filters" [[RFC3678](#)] provides support for expressing source filters on multicast group memberships.

Chown, et al.

Expires August 31, 2018

[Page 18]

Internet-Draft

IPv6 Node Requirements

February 2018

"Extension to Sockets API for Mobile IPv6" [[RFC4584](#)] provides application support for accessing and enabling Mobile IPv6 [[RFC6275](#)] features.

12. Mobility

Mobile IPv6 [[RFC6275](#)] and associated specifications [[RFC3776](#)] [[RFC4877](#)] allow a node to change its point of attachment within the Internet, while maintaining (and using) a permanent address. All communication using the permanent address continues to proceed as expected even as the node moves around. The definition of Mobile IP includes requirements for the following types of nodes:

- mobile nodes
- correspondent nodes with support for route optimization
- home agents
- all IPv6 routers

At the present time, Mobile IP has seen only limited implementation and no significant deployment, partly because it originally assumed an IPv6-only environment rather than a mixed IPv4/IPv6 Internet. Recently, additional work has been done to support mobility in mixed-mode IPv4 and IPv6 networks [[RFC5555](#)].

More usage and deployment experience is needed with mobility before any specific approach can be recommended for broad implementation in all hosts and routers. Consequently, [RFC6275], [RFC5555], and associated standards such as [RFC4877] are considered a MAY at this time.

IPv6 for 3GPP [RFC7066] lists a snapshot of required IPv6 Functionalities at the time the document was published that would need to be implemented, going above and beyond the recommendations in this document. Additionally a 3GPP IPv6 Host MAY implement [RFC7278] for delivering IPv6 prefixes on the LAN link.

13. Security

This section describes the specification for security for IPv6 nodes.

Achieving security in practice is a complex undertaking. Operational procedures, protocols, key distribution mechanisms, certificate management approaches, etc., are all components that impact the level of security actually achieved in practice. More importantly, deficiencies or a poor fit in any one individual component can

significantly reduce the overall effectiveness of a particular security approach.

IPsec either can provide end-to-end security between nodes or or can provide channel security (for example, via a site-to-site IPsec VPN), making it possible to provide secure communication for all (or a subset of) communication flows at the IP layer between pairs of internet nodes. IPsec has two standard operating modes, Tunnel-mode and Transport-mode. In Tunnel-mode, IPsec provides network-layer security and protects an entire IP packet by encapsulating the original IP packet and then pre-pending a new IP header. In Transport-mode, IPsec provides security for the transport-layer (and above) by encapsulating only the transport-layer (and above) portion of the IP packet (i.e., without adding a 2nd IP header).

Although IPsec can be used with manual keying in some cases, such usage has limited applicability and is not recommended.

A range of security technologies and approaches proliferate today

(e.g., IPsec, Transport Layer Security (TLS), Secure SHell (SSH), SSL VPNs, etc.) No one approach has emerged as an ideal technology for all needs and environments. Moreover, IPsec is not viewed as the ideal security technology in all cases and is unlikely to displace the others.

Previously, IPv6 mandated implementation of IPsec and recommended the key management approach of IKE. This document updates that recommendation by making support of the IPsec Architecture [[RFC4301](#)] a SHOULD for all IPv6 nodes. Note that the IPsec Architecture requires (e.g., [Section 4.5 of RFC 4301](#)) the implementation of both manual and automatic key management. Currently, the default automated key management protocol to implement is IKEv2 [[RFC7296](#)].

This document recognizes that there exists a range of device types and environments where approaches to security other than IPsec can be justified. For example, special-purpose devices may support only a very limited number or type of applications, and an application-specific security approach may be sufficient for limited management or configuration capabilities. Alternatively, some devices may run on extremely constrained hardware (e.g., sensors) where the full IPsec Architecture is not justified.

Because most common platforms now support IPv6 and have it enabled by default, IPv6 security is an issue for networks that are ostensibly IPv4-only; see [[RFC7123](#)] for guidance on this area.

[13.1.](#) Requirements

"Security Architecture for the Internet Protocol" [[RFC4301](#)] SHOULD be supported by all IPv6 nodes. Note that the IPsec Architecture requires (e.g., [Section 4.5 of \[RFC4301\]](#)) the implementation of both manual and automatic key management. Currently, the default automated key management protocol to implement is IKEv2. As required in [[RFC4301](#)], IPv6 nodes implementing the IPsec Architecture MUST implement ESP [[RFC4303](#)] and MAY implement AH [[RFC4302](#)].

[13.2.](#) Transforms and Algorithms

The current set of mandatory-to-implement algorithms for the IPsec Architecture are defined in "Cryptographic Algorithm Implementation Requirements For ESP and AH" [[RFC8221](#)]. IPv6 nodes implementing the IPsec Architecture MUST conform to the requirements in [[RFC8221](#)]. Preferred cryptographic algorithms often change more frequently than security protocols. Therefore, implementations MUST allow for migration to new algorithms, as [RFC 8221](#) is replaced or updated in the future.

The current set of mandatory-to-implement algorithms for IKEv2 are defined in "Cryptographic Algorithms for Use in the Internet Key Exchange Version 2 (IKEv2)" [[RFC8247](#)]. IPv6 nodes implementing IKEv2 MUST conform to the requirements in [[RFC8247](#)] and/or any future updates or replacements to [[RFC8247](#)].

[14.](#) Router-Specific Functionality

This section defines general host considerations for IPv6 nodes that act as routers. Currently, this section does not discuss detailed routing-specific requirements. For the case of typical home routers, [[RFC7084](#)] defines basic requirements for customer edge routers.

Further recommendations on router-specific functionality can be found in [[I-D.ietf-v6ops-ipv6rtr-reqs](#)].

[14.1.](#) IPv6 Router Alert Option - [RFC 2711](#)

The IPv6 Router Alert Option [[RFC2711](#)] is an optional IPv6 Hop-by-Hop Header that is used in conjunction with some protocols (e.g., RSVP [[RFC2205](#)] or Multicast Listener Discovery (MLDv2) [[RFC3810](#)]). The Router Alert option will need to be implemented whenever such protocols that mandate its use are implemented. See [Section 5.11](#).

[14.2.](#) Neighbor Discovery for IPv6 - [RFC 4861](#)

Sending Router Advertisements and processing Router Solicitations MUST be supported.

[Section 7 of \[RFC6275\]](#) includes some mobility-specific extensions to Neighbor Discovery. Routers SHOULD implement Sections [7.3](#) and [7.5](#), even if they do not implement Home Agent functionality.

[14.3.](#) Stateful Address Autoconfiguration (DHCPv6) - [RFC 3315](#)

A single DHCP server ([\[RFC3315\]](#) or [\[RFC4862\]](#)) can provide configuration information to devices directly attached to a shared link, as well as to devices located elsewhere within a site. Communication between a client and a DHCP server located on different links requires the use of DHCP relay agents on routers.

In simple deployments, consisting of a single router and either a single LAN or multiple LANs attached to the single router, together with a WAN connection, a DHCP server embedded within the router is one common deployment scenario (e.g., [\[RFC7084\]](#)). There is no need for relay agents in such scenarios.

In more complex deployment scenarios, such as within enterprise or service provider networks, the use of DHCP requires some level of configuration, in order to configure relay agents, DHCP servers, etc. In such environments, the DHCP server might even be run on a traditional server, rather than as part of a router.

Because of the wide range of deployment scenarios, support for DHCP server functionality on routers is optional. However, routers targeted for deployment within more complex scenarios (as described above) SHOULD support relay agent functionality. Note that "Basic Requirements for IPv6 Customer Edge Routers" [\[RFC7084\]](#) requires implementation of a DHCPv6 server function in IPv6 Customer Edge (CE) routers.

[14.4.](#) IPv6 Prefix Length Recommendation for Forwarding - [BCP 198](#)

Forwarding nodes MUST conform to [BCP 198](#) [\[RFC7608\]](#) and thus IPv6 implementations of nodes that may forward packets MUST conform to the rules specified in [Section 5.1 of \[RFC4632\]](#).

[15.](#) Constrained Devices

The target for this document is general IPv6 nodes. In the case of constrained nodes, with limited CPU, memory, bandwidth or power, support for certain IPv6 functionality may need to be considered due

to those limitations. The requirements of this document are RECOMMENDED for all nodes, including constrained nodes, but compromises may need to be made in certain cases. Where such compromises are made, the interoperability of devices should be strongly considered, particularly where this may impact other nodes on the same link, e.g., only supporting MLDv1 will affect other nodes.

The IETF 6LowPAN (IPv6 over Low Power LWPAN) WG defined six RFCs, including a general overview and problem statement ([[RFC4919](#)], the means by which IPv6 packets are transmitted over IEEE 802.15.4 networks [[RFC4944](#)] and ND optimisations for that medium [[RFC6775](#)].

If an IPv6 node is concerned about the impact of IPv6 message power consumption, it SHOULD want to implement the recommendations in [[RFC7772](#)].

16. Network Management

Network management MAY be supported by IPv6 nodes. However, for IPv6 nodes that are embedded devices, network management may be the only possible way of controlling these nodes.

Existing network management protocols include SNMP [[RFC3411](#)], NETCONF [[RFC6241](#)] and RESTCONF [[RFC8040](#)].

16.1. Management Information Base (MIB) Modules

[RFC8096] clarifies the obsoleted status of various IPv6-specific MIB modules.

The following two MIB modules SHOULD be supported by nodes that support a Simple Network Management Protocol (SNMP) agent.

16.1.1. IP Forwarding Table MIB

The IP Forwarding Table MIB [[RFC4292](#)] SHOULD be supported by nodes that support an SNMP agent.

16.1.2. Management Information Base for the Internet Protocol (IP)

The IP MIB [[RFC4293](#)] SHOULD be supported by nodes that support an SNMP agent.

16.1.3. Interface MIB

The Interface MIB [[RFC2863](#)] SHOULD be supported by nodes that support an SNMP agent.

Internet-Draft

IPv6 Node Requirements

February 2018

[16.2.](#) YANG Data Models

The following YANG data models SHOULD be supported by nodes that support a NETCONF or RESTCONF agent.

[16.2.1.](#) IP Management YANG Model

The IP Management YANG Model [[I-D.ietf-netmod-rfc7277bis](#)] SHOULD be supported by nodes that support NETCONF or RESTCONF.

[16.2.2.](#) Interface Management YANG Model

The Interface Management YANG Model [[I-D.ietf-netmod-rfc7223bis](#)] SHOULD be supported by nodes that support NETCONF or RESTCONF.

[17.](#) Security Considerations

This document does not directly affect the security of the Internet, beyond the security considerations associated with the individual protocols.

Security is also discussed in [Section 13](#) above.

[18.](#) IANA Considerations

This document does not require any IANA actions.

[19.](#) Authors and Acknowledgments

[19.1.](#) Authors and Acknowledgments (Current Document)

For this version of the IPv6 Node Requirements document, the authors would like to thank Brian Carpenter, Dave Thaler, Tom Herbert, Erik Kline, Mohamed Boucadair, and Michayla Newcombe for their contributions.

[19.2.](#) Authors and Acknowledgments from [RFC 6434](#)

Ed Jankiewicz and Thomas Narten were named authors of the previous iteration of this document, [RFC6434](#).

For this version of the document, the authors thanked Hitoshi Asaeda,

Brian Carpenter, Tim Chown, Ralph Droms, Sheila Frankel, Sam Hartman, Bob Hinden, Paul Hoffman, Pekka Savola, Yaron Sheffer, and Dave Thaler.

Chown, et al.

Expires August 31, 2018

[Page 24]

Internet-Draft

IPv6 Node Requirements

February 2018

19.3. Authors and Acknowledgments from [RFC 4294](#)

The original version of this document ([RFC 4294](#)) was written by the IPv6 Node Requirements design team:

Jari Arkko
jari.arkko@ericsson.com

Marc Blanchet
marc.blanchet@viagenie.qc.ca

Samita Chakrabarti
samita.chakrabarti@eng.sun.com

Alain Durand
alain.durand@sun.com

Gerard Gastaud
gerard.gastaud@alcatel.fr

Jun-ichiro Itojun Hagino
itojun@iijlab.net

Atsushi Inoue
inoue@isl.rdc.toshiba.co.jp

Masahiro Ishiyama
masahiro@isl.rdc.toshiba.co.jp

John Loughney
john.loughney@nokia.com

Rajiv Raghunarayan
raraghun@cisco.com
Shoichi Sakane

shouichi.sakane@jp.yokogawa.com

Dave Thaler
dthaler@windows.microsoft.com

Juha Wiljakka
juha.wiljakka@Nokia.com

The authors would like to thank Ran Atkinson, Jim Bound, Brian Carpenter, Ralph Droms, Christian Huitema, Adam Machalek, Thomas Narten, Juha Ollila, and Pekka Savola for their comments. Thanks to Mark Andrews for comments and corrections on DNS text. Thanks to Alfred Hoenes for tracking the updates to various RFCs.

Chown, et al.

Expires August 31, 2018

[Page 25]

Internet-Draft

IPv6 Node Requirements

February 2018

20. Appendix: Changes from [RFC 6434](#)

There have been many editorial clarifications as well as significant additions and updates. While this section highlights some of the changes, readers should not rely on this section for a comprehensive list of all changes.

1. Restructured sections
2. Added 6LoWPAN to link layers as it has some deployment.
3. Removed DOD IPv6 Profile as it hasn't been updated.
4. Updated to MLDv2 support to a MUST since nodes are restricted if MLDv1 is used.
5. Require DNS RA Options so SLAAC-only devices can get DNS, [RFC8106](#) is a MUST.
6. Require [RFC3646](#) DNS Options for DHCPv6 implementations.
7. Added RESTCONF and NETCONF as possible options to Network management.
8. Added section on constrained devices.
9. Added text on [RFC7934](#), address availability to hosts (SHOULD).

10. Added text on [RFC7844](#), anonymity profiles for DHCPv6 clients.
11. mDNS and DNS-SD added as updated service discovery.
12. Added [RFC8028](#) as a SHOULD as a method for solving multi-prefix network
13. Added ECN [RFC3168](#) as a SHOULD, since recent reports have shown this as useful, and added a note on [RFC8311](#), which is related.
14. Added reference to [RFC7123](#) for Security over IPv4-only networks
15. Removed Jumbograms [RFC2675](#) as they aren't deployed.
16. Updated Obseleted RFCs to the new version of the RFC including 2460, 1981, 7321, 4307
17. Added [RFC7772](#) for power comsumptions considerations
18. Added why /64 boundries for more detail - [RFC 7421](#)

Chown, et al.

Expires August 31, 2018

[Page 26]

Internet-Draft

IPv6 Node Requirements

February 2018

19. Added a Unique IPv6 Prefix per Host to support currently deployed IPv6 networks
20. Clarified [RFC7066](#) was snapshot for 3GPP
21. Updated 4191 as a MUST, SHOULD for Type C Host as it helps solve multi-prefix problem
22. Removed IPv6 over ATM since there aren't many deployments
23. Added a note in [Section 6.6](#) for [RFC6724 Section 5.5/](#)
24. Added MUST for [BCP 198](#) for forwarding IPv6 packets
25. Added reference to [draft-ietf-v6ops-ipv6rtr-reqs](#) as it has more recommendations for a Router
26. Added reference to [RFC8064](#) for stable address creation.
27. Added text on protection from excessive EH options

28. Added text on dangers of 1280 MTU UDP, esp. wrt DNS traffic
29. Added text to clarify [RFC8200](#) behaviour for unrecognized EHs or unrecognized ULPs

21. Appendix: Changes from [RFC 4294](#)

There have been many editorial clarifications as well as significant additions and updates. While this section highlights some of the changes, readers should not rely on this section for a comprehensive list of all changes.

1. Updated the Introduction to indicate that this document is an applicability statement and is aimed at general nodes.
2. Significantly updated the section on Mobility protocols, adding references and downgrading previous SHOULDs to MAYs.
3. Changed Sub-IP Layer section to just list relevant RFCs, and added some more RFCs.
4. Added section on SEND (it is a MAY).
5. Revised section on Privacy Extensions [[RFC4941](#)] to add more nuance to recommendation.

Chown, et al.

Expires August 31, 2018

[Page 27]

Internet-Draft

IPv6 Node Requirements

February 2018

6. Completely revised IPsec/IKEv2 section, downgrading overall recommendation to a SHOULD.
7. Upgraded recommendation of DHCPv6 to SHOULD.
8. Added background section on DHCP versus RA options, added SHOULD recommendation for DNS configuration via RAs ([RFC6106](#)), and cleaned up DHCP recommendations.
9. Added recommendation that routers implement Sections [7.3](#) and [7.5](#) of [[RFC6275](#)].
10. Added pointer to subnet clarification document [[RFC5942](#)].

11. Added text that "IPv6 Host-to-Router Load Sharing" [[RFC4311](#)] SHOULD be implemented.
12. Added reference to [[RFC5722](#)] (Overlapping Fragments), and made it a MUST to implement.
13. Made "A Recommendation for IPv6 Address Text Representation" [[RFC5952](#)] a SHOULD.
14. Removed mention of "DNAME" from the discussion about [[RFC3363](#)].
15. Numerous updates to reflect newer versions of IPv6 documents, including [[RFC4443](#)], [[RFC4291](#)], [[RFC3596](#)], and [[RFC4213](#)].
16. Removed discussion of "Managed" and "Other" flags in RAs. There is no consensus at present on how to process these flags, and discussion of their semantics was removed in the most recent update of Stateless Address Autoconfiguration [[RFC4862](#)].
17. Added many more references to optional IPv6 documents.
18. Made "A Recommendation for IPv6 Address Text Representation" [[RFC5952](#)] a SHOULD.
19. Added reference to [[RFC5722](#)] (Overlapping Fragments), and made it a MUST to implement.
20. Updated MLD section to include reference to Lightweight MLD [[RFC5790](#)].
21. Added SHOULD recommendation for "Default Router Preferences and More-Specific Routes" [[RFC4191](#)].
22. Made "IPv6 Flow Label Specification" [[RFC6437](#)] a SHOULD.

[22.](#) References

[22.1.](#) Normative References

- [RFC1034] Mockapetris, P., "Domain names - concepts and facilities", STD 13, [RFC 1034](#), DOI 10.17487/RFC1034, November 1987, <<https://www.rfc-editor.org/info/rfc1034>>.

- [RFC1035] Mockapetris, P., "Domain names - implementation and specification", STD 13, [RFC 1035](#), DOI 10.17487/RFC1035, November 1987, <<https://www.rfc-editor.org/info/rfc1035>>.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC2710] Deering, S., Fenner, W., and B. Haberman, "Multicast Listener Discovery (MLD) for IPv6", [RFC 2710](#), DOI 10.17487/RFC2710, October 1999, <<https://www.rfc-editor.org/info/rfc2710>>.
- [RFC2711] Partridge, C. and A. Jackson, "IPv6 Router Alert Option", [RFC 2711](#), DOI 10.17487/RFC2711, October 1999, <<https://www.rfc-editor.org/info/rfc2711>>.
- [RFC2863] McCloghrie, K. and F. Kastenholz, "The Interfaces Group MIB", [RFC 2863](#), DOI 10.17487/RFC2863, June 2000, <<https://www.rfc-editor.org/info/rfc2863>>.
- [RFC3168] Ramakrishnan, K., Floyd, S., and D. Black, "The Addition of Explicit Congestion Notification (ECN) to IP", [RFC 3168](#), DOI 10.17487/RFC3168, September 2001, <<https://www.rfc-editor.org/info/rfc3168>>.
- [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, <<https://www.rfc-editor.org/info/rfc3315>>.
- [RFC3411] Harrington, D., Presuhn, R., and B. Wijnen, "An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks", STD 62, [RFC 3411](#), DOI 10.17487/RFC3411, December 2002, <<https://www.rfc-editor.org/info/rfc3411>>.

- [RFC3596] Thomson, S., Huitema, C., Ksinant, V., and M. Souissi, "DNS Extensions to Support IP Version 6", STD 88, [RFC 3596](#), DOI 10.17487/RFC3596, October 2003, <<https://www.rfc-editor.org/info/rfc3596>>.
- [RFC3736] Droms, R., "Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6", [RFC 3736](#), DOI 10.17487/RFC3736, April 2004, <<https://www.rfc-editor.org/info/rfc3736>>.
- [RFC3810] Vida, R., Ed. and L. Costa, Ed., "Multicast Listener Discovery Version 2 (MLDv2) for IPv6", [RFC 3810](#), DOI 10.17487/RFC3810, June 2004, <<https://www.rfc-editor.org/info/rfc3810>>.
- [RFC4033] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "DNS Security Introduction and Requirements", [RFC 4033](#), DOI 10.17487/RFC4033, March 2005, <<https://www.rfc-editor.org/info/rfc4033>>.
- [RFC4034] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Resource Records for the DNS Security Extensions", [RFC 4034](#), DOI 10.17487/RFC4034, March 2005, <<https://www.rfc-editor.org/info/rfc4034>>.
- [RFC4035] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Protocol Modifications for the DNS Security Extensions", [RFC 4035](#), DOI 10.17487/RFC4035, March 2005, <<https://www.rfc-editor.org/info/rfc4035>>.
- [RFC4213] Nordmark, E. and R. Gilligan, "Basic Transition Mechanisms for IPv6 Hosts and Routers", [RFC 4213](#), DOI 10.17487/RFC4213, October 2005, <<https://www.rfc-editor.org/info/rfc4213>>.
- [RFC4291] Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture", [RFC 4291](#), DOI 10.17487/RFC4291, February 2006, <<https://www.rfc-editor.org/info/rfc4291>>.
- [RFC4292] Haberman, B., "IP Forwarding Table MIB", [RFC 4292](#), DOI 10.17487/RFC4292, April 2006, <<https://www.rfc-editor.org/info/rfc4292>>.
- [RFC4293] Routhier, S., Ed., "Management Information Base for the Internet Protocol (IP)", [RFC 4293](#), DOI 10.17487/RFC4293, April 2006, <<https://www.rfc-editor.org/info/rfc4293>>.

Internet-Draft

IPv6 Node Requirements

February 2018

- [RFC4301] Kent, S. and K. Seo, "Security Architecture for the Internet Protocol", [RFC 4301](#), DOI 10.17487/RFC4301, December 2005, <<https://www.rfc-editor.org/info/rfc4301>>.
- [RFC4303] Kent, S., "IP Encapsulating Security Payload (ESP)", [RFC 4303](#), DOI 10.17487/RFC4303, December 2005, <<https://www.rfc-editor.org/info/rfc4303>>.
- [RFC4311] Hinden, R. and D. Thaler, "IPv6 Host-to-Router Load Sharing", [RFC 4311](#), DOI 10.17487/RFC4311, November 2005, <<https://www.rfc-editor.org/info/rfc4311>>.
- [RFC4443] Conta, A., Deering, S., and M. Gupta, Ed., "Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification", STD 89, [RFC 4443](#), DOI 10.17487/RFC4443, March 2006, <<https://www.rfc-editor.org/info/rfc4443>>.
- [RFC4607] Holbrook, H. and B. Cain, "Source-Specific Multicast for IP", [RFC 4607](#), DOI 10.17487/RFC4607, August 2006, <<https://www.rfc-editor.org/info/rfc4607>>.
- [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, <<https://www.rfc-editor.org/info/rfc4632>>.
- [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, <<https://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, <<https://www.rfc-editor.org/info/rfc4862>>.
- [RFC4941] Narten, T., Draves, R., and S. Krishnan, "Privacy Extensions for Stateless Address Autoconfiguration in IPv6", [RFC 4941](#), DOI 10.17487/RFC4941, September 2007, <<https://www.rfc-editor.org/info/rfc4941>>.
- [RFC5095] Abley, J., Savola, P., and G. Neville-Neil, "Deprecation

of Type 0 Routing Headers in IPv6", [RFC 5095](#),
DOI 10.17487/RFC5095, December 2007,
<<https://www.rfc-editor.org/info/rfc5095>>.

- [RFC5453] Krishnan, S., "Reserved IPv6 Interface Identifiers",
[RFC 5453](#), DOI 10.17487/RFC5453, February 2009,
<<https://www.rfc-editor.org/info/rfc5453>>.
- [RFC5722] Krishnan, S., "Handling of Overlapping IPv6 Fragments",
[RFC 5722](#), DOI 10.17487/RFC5722, December 2009,
<<https://www.rfc-editor.org/info/rfc5722>>.
- [RFC5790] Liu, H., Cao, W., and H. Asaeda, "Lightweight Internet
Group Management Protocol Version 3 (IGMPv3) and Multicast
Listener Discovery Version 2 (MLDv2) Protocols", [RFC 5790](#),
DOI 10.17487/RFC5790, February 2010,
<<https://www.rfc-editor.org/info/rfc5790>>.
- [RFC5942] Singh, H., Beebee, W., and E. Nordmark, "IPv6 Subnet
Model: The Relationship between Links and Subnet
Prefixes", [RFC 5942](#), DOI 10.17487/RFC5942, July 2010,
<<https://www.rfc-editor.org/info/rfc5942>>.
- [RFC5952] Kawamura, S. and M. Kawashima, "A Recommendation for IPv6
Address Text Representation", [RFC 5952](#),
DOI 10.17487/RFC5952, August 2010,
<<https://www.rfc-editor.org/info/rfc5952>>.
- [RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed.,
and A. Bierman, Ed., "Network Configuration Protocol
(NETCONF)", [RFC 6241](#), DOI 10.17487/RFC6241, June 2011,
<<https://www.rfc-editor.org/info/rfc6241>>.
- [RFC6437] Amante, S., Carpenter, B., Jiang, S., and J. Rajahalme,
"IPv6 Flow Label Specification", [RFC 6437](#),
DOI 10.17487/RFC6437, November 2011,
<<https://www.rfc-editor.org/info/rfc6437>>.
- [RFC6564] Krishnan, S., Woodyatt, J., Kline, E., Hoagland, J., and
M. Bhatia, "A Uniform Format for IPv6 Extension Headers",

[RFC 6564](#), DOI 10.17487/RFC6564, April 2012,
<<https://www.rfc-editor.org/info/rfc6564>>.

[RFC6724] Thaler, D., Ed., Draves, R., Matsumoto, A., and T. Chown, "Default Address Selection for Internet Protocol Version 6 (IPv6)", [RFC 6724](#), DOI 10.17487/RFC6724, September 2012, <<https://www.rfc-editor.org/info/rfc6724>>.

[RFC6762] Cheshire, S. and M. Krochmal, "Multicast DNS", [RFC 6762](#), DOI 10.17487/RFC6762, February 2013, <<https://www.rfc-editor.org/info/rfc6762>>.

Chown, et al.

Expires August 31, 2018

[Page 32]

Internet-Draft

IPv6 Node Requirements

February 2018

[RFC6763] Cheshire, S. and M. Krochmal, "DNS-Based Service Discovery", [RFC 6763](#), DOI 10.17487/RFC6763, February 2013, <<https://www.rfc-editor.org/info/rfc6763>>.

[RFC6775] Shelby, Z., Ed., Chakrabarti, S., Nordmark, E., and C. Bormann, "Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)", [RFC 6775](#), DOI 10.17487/RFC6775, November 2012, <<https://www.rfc-editor.org/info/rfc6775>>.

[RFC6891] Damas, J., Graff, M., and P. Vixie, "Extension Mechanisms for DNS (EDNS(0))", STD 75, [RFC 6891](#), DOI 10.17487/RFC6891, April 2013, <<https://www.rfc-editor.org/info/rfc6891>>.

[RFC6946] Gont, F., "Processing of IPv6 "Atomic" Fragments", [RFC 6946](#), DOI 10.17487/RFC6946, May 2013, <<https://www.rfc-editor.org/info/rfc6946>>.

[RFC7045] Carpenter, B. and S. Jiang, "Transmission and Processing of IPv6 Extension Headers", [RFC 7045](#), DOI 10.17487/RFC7045, December 2013, <<https://www.rfc-editor.org/info/rfc7045>>.

[RFC7048] Nordmark, E. and I. Gashinsky, "Neighbor Unreachability Detection Is Too Impatient", [RFC 7048](#), DOI 10.17487/RFC7048, January 2014, <<https://www.rfc-editor.org/info/rfc7048>>.

- [RFC7112] Gont, F., Manral, V., and R. Bonica, "Implications of Oversized IPv6 Header Chains", [RFC 7112](#), DOI 10.17487/RFC7112, January 2014, <<https://www.rfc-editor.org/info/rfc7112>>.
- [RFC7217] Gont, F., "A Method for Generating Semantically Opaque Interface Identifiers with IPv6 Stateless Address Autoconfiguration (SLAAC)", [RFC 7217](#), DOI 10.17487/RFC7217, April 2014, <<https://www.rfc-editor.org/info/rfc7217>>.
- [I-D.ietf-netmod-rfc7223bis] Bjorklund, M., "A YANG Data Model for Interface Management", [draft-ietf-netmod-rfc7223bis-03](#) (work in progress), January 2018.

Chown, et al.

Expires August 31, 2018

[Page 33]

Internet-Draft

IPv6 Node Requirements

February 2018

- [I-D.ietf-netmod-rfc7277bis] Bjorklund, M., "A YANG Data Model for IP Management", [draft-ietf-netmod-rfc7277bis-03](#) (work in progress), January 2018.
- [RFC7296] Kaufman, C., Hoffman, P., Nir, Y., Eronen, P., and T. Kivinen, "Internet Key Exchange Protocol Version 2 (IKEv2)", STD 79, [RFC 7296](#), DOI 10.17487/RFC7296, October 2014, <<https://www.rfc-editor.org/info/rfc7296>>.
- [RFC7527] Asati, R., Singh, H., Beebe, W., Pignataro, C., Dart, E., and W. George, "Enhanced Duplicate Address Detection", [RFC 7527](#), DOI 10.17487/RFC7527, April 2015, <<https://www.rfc-editor.org/info/rfc7527>>.
- [RFC7559] Krishnan, S., Anipko, D., and D. Thaler, "Packet-Loss Resiliency for Router Solicitations", [RFC 7559](#), DOI 10.17487/RFC7559, May 2015, <<https://www.rfc-editor.org/info/rfc7559>>.
- [RFC7608] Boucadair, M., Petrescu, A., and F. Baker, "IPv6 Prefix Length Recommendation for Forwarding", [BCP 198](#), [RFC 7608](#),

DOI 10.17487/RFC7608, July 2015,
<<https://www.rfc-editor.org/info/rfc7608>>.

[RFC7739] Gont, F., "Security Implications of Predictable Fragment Identification Values", [RFC 7739](#), DOI 10.17487/RFC7739, February 2016, <<https://www.rfc-editor.org/info/rfc7739>>.

[RFC8021] Gont, F., Liu, W., and T. Anderson, "Generation of IPv6 Atomic Fragments Considered Harmful", [RFC 8021](#), DOI 10.17487/RFC8021, January 2017, <<https://www.rfc-editor.org/info/rfc8021>>.

[RFC8028] Baker, F. and B. Carpenter, "First-Hop Router Selection by Hosts in a Multi-Prefix Network", [RFC 8028](#), DOI 10.17487/RFC8028, November 2016, <<https://www.rfc-editor.org/info/rfc8028>>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", [RFC 8040](#), DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.

[RFC8064] Gont, F., Cooper, A., Thaler, D., and W. Liu, "Recommendation on Stable IPv6 Interface Identifiers", [RFC 8064](#), DOI 10.17487/RFC8064, February 2017, <<https://www.rfc-editor.org/info/rfc8064>>.

[RFC8106] Jeong, J., Park, S., Beloeil, L., and S. Madanapalli, "IPv6 Router Advertisement Options for DNS Configuration", [RFC 8106](#), DOI 10.17487/RFC8106, March 2017, <<https://www.rfc-editor.org/info/rfc8106>>.

[RFC8200] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", STD 86, [RFC 8200](#), DOI 10.17487/RFC8200, July 2017, <<https://www.rfc-editor.org/info/rfc8200>>.

[RFC8201] McCann, J., Deering, S., Mogul, J., and R. Hinden, Ed., "Path MTU Discovery for IP version 6", STD 87, [RFC 8201](#), DOI 10.17487/RFC8201, July 2017, <<https://www.rfc-editor.org/info/rfc8201>>.

- [RFC8221] Wouters, P., Migault, D., Mattsson, J., Nir, Y., and T. Kivinen, "Cryptographic Algorithm Implementation Requirements and Usage Guidance for Encapsulating Security Payload (ESP) and Authentication Header (AH)", [RFC 8221](#), DOI 10.17487/RFC8221, October 2017, <<https://www.rfc-editor.org/info/rfc8221>>.
- [RFC8247] Nir, Y., Kivinen, T., Wouters, P., and D. Migault, "Algorithm Implementation Requirements and Usage Guidance for the Internet Key Exchange Protocol Version 2 (IKEv2)", [RFC 8247](#), DOI 10.17487/RFC8247, September 2017, <<https://www.rfc-editor.org/info/rfc8247>>.
- [RFC8311] Black, D., "Relaxing Restrictions on Explicit Congestion Notification (ECN) Experimentation", [RFC 8311](#), DOI 10.17487/RFC8311, January 2018, <<https://www.rfc-editor.org/info/rfc8311>>.

22.2. Informative References

- [I-D.ietf-v6ops-ipv6rtr-reqs]
Kahn, Z., Brzozowski, J., and R. White, "Requirements for IPv6 Routers", [draft-ietf-v6ops-ipv6rtr-reqs-01](#) (work in progress), January 2018.
- [RFC0793] Postel, J., "Transmission Control Protocol", STD 7, [RFC 793](#), DOI 10.17487/RFC0793, September 1981, <<https://www.rfc-editor.org/info/rfc793>>.
- [RFC2205] Braden, R., Ed., Zhang, L., Berson, S., Herzog, S., and S. Jamin, "Resource ReSerVation Protocol (RSVP) -- Version 1 Functional Specification", [RFC 2205](#), DOI 10.17487/RFC2205, September 1997, <<https://www.rfc-editor.org/info/rfc2205>>.

- [RFC2464] Crawford, M., "Transmission of IPv6 Packets over Ethernet Networks", [RFC 2464](#), DOI 10.17487/RFC2464, December 1998, <<https://www.rfc-editor.org/info/rfc2464>>.
- [RFC2491] Armitage, G., Schuster, P., Jork, M., and G. Harter, "IPv6 over Non-Broadcast Multiple Access (NBMA) networks", [RFC 2491](#), DOI 10.17487/RFC2491, January 1999, <<https://www.rfc-editor.org/info/rfc2491>>.

- [RFC2590] Conta, A., Malis, A., and M. Mueller, "Transmission of IPv6 Packets over Frame Relay Networks Specification", [RFC 2590](#), DOI 10.17487/RFC2590, May 1999, <<https://www.rfc-editor.org/info/rfc2590>>.
- [RFC3146] Fujisawa, K. and A. Onoe, "Transmission of IPv6 Packets over IEEE 1394 Networks", [RFC 3146](#), DOI 10.17487/RFC3146, October 2001, <<https://www.rfc-editor.org/info/rfc3146>>.
- [RFC3363] Bush, R., Durand, A., Fink, B., Gudmundsson, O., and T. Hain, "Representing Internet Protocol version 6 (IPv6) Addresses in the Domain Name System (DNS)", [RFC 3363](#), DOI 10.17487/RFC3363, August 2002, <<https://www.rfc-editor.org/info/rfc3363>>.
- [RFC3493] Gilligan, R., Thomson, S., Bound, J., McCann, J., and W. Stevens, "Basic Socket Interface Extensions for IPv6", [RFC 3493](#), DOI 10.17487/RFC3493, February 2003, <<https://www.rfc-editor.org/info/rfc3493>>.
- [RFC3542] Stevens, W., Thomas, M., Nordmark, E., and T. Jinmei, "Advanced Sockets Application Program Interface (API) for IPv6", [RFC 3542](#), DOI 10.17487/RFC3542, May 2003, <<https://www.rfc-editor.org/info/rfc3542>>.
- [RFC3646] Droms, R., Ed., "DNS Configuration options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", [RFC 3646](#), DOI 10.17487/RFC3646, December 2003, <<https://www.rfc-editor.org/info/rfc3646>>.
- [RFC3678] Thaler, D., Fenner, B., and B. Quinn, "Socket Interface Extensions for Multicast Source Filters", [RFC 3678](#), DOI 10.17487/RFC3678, January 2004, <<https://www.rfc-editor.org/info/rfc3678>>.
- [RFC6275] Perkins, C., Ed., Johnson, D., and J. Arkko, "Mobility Support in IPv6", [RFC 6275](#), DOI 10.17487/RFC6275, July 2011, <<https://www.rfc-editor.org/info/rfc6275>>.

- [RFC3776] Arkko, J., Devarapalli, V., and F. Dupont, "Using IPsec to

Protect Mobile IPv6 Signaling Between Mobile Nodes and Home Agents", [RFC 3776](#), DOI 10.17487/RFC3776, June 2004, <<https://www.rfc-editor.org/info/rfc3776>>.

- [RFC3971] Arkko, J., Ed., Kempf, J., Zill, B., and P. Nikander, "SEcure Neighbor Discovery (SEND)", [RFC 3971](#), DOI 10.17487/RFC3971, March 2005, <<https://www.rfc-editor.org/info/rfc3971>>.
- [RFC3972] Aura, T., "Cryptographically Generated Addresses (CGA)", [RFC 3972](#), DOI 10.17487/RFC3972, March 2005, <<https://www.rfc-editor.org/info/rfc3972>>.
- [RFC4191] Draves, R. and D. Thaler, "Default Router Preferences and More-Specific Routes", [RFC 4191](#), DOI 10.17487/RFC4191, November 2005, <<https://www.rfc-editor.org/info/rfc4191>>.
- [RFC4302] Kent, S., "IP Authentication Header", [RFC 4302](#), DOI 10.17487/RFC4302, December 2005, <<https://www.rfc-editor.org/info/rfc4302>>.
- [RFC4338] DeSanti, C., Carlson, C., and R. Nixon, "Transmission of IPv6, IPv4, and Address Resolution Protocol (ARP) Packets over Fibre Channel", [RFC 4338](#), DOI 10.17487/RFC4338, January 2006, <<https://www.rfc-editor.org/info/rfc4338>>.
- [RFC4380] Huitema, C., "Teredo: Tunneling IPv6 over UDP through Network Address Translations (NATs)", [RFC 4380](#), DOI 10.17487/RFC4380, February 2006, <<https://www.rfc-editor.org/info/rfc4380>>.
- [RFC4429] Moore, N., "Optimistic Duplicate Address Detection (DAD) for IPv6", [RFC 4429](#), DOI 10.17487/RFC4429, April 2006, <<https://www.rfc-editor.org/info/rfc4429>>.
- [RFC4584] Chakrabarti, S. and E. Nordmark, "Extension to Sockets API for Mobile IPv6", [RFC 4584](#), DOI 10.17487/RFC4584, July 2006, <<https://www.rfc-editor.org/info/rfc4584>>.
- [RFC4821] Mathis, M. and J. Heffner, "Packetization Layer Path MTU Discovery", [RFC 4821](#), DOI 10.17487/RFC4821, March 2007, <<https://www.rfc-editor.org/info/rfc4821>>.
- [RFC4877] Devarapalli, V. and F. Dupont, "Mobile IPv6 Operation with IKEv2 and the Revised IPsec Architecture", [RFC 4877](#), DOI 10.17487/RFC4877, April 2007, <<https://www.rfc-editor.org/info/rfc4877>>.

-
- [RFC4884] Bonica, R., Gan, D., Tappan, D., and C. Pignataro, "Extended ICMP to Support Multi-Part Messages", [RFC 4884](#), DOI 10.17487/RFC4884, April 2007, <<https://www.rfc-editor.org/info/rfc4884>>.
- [RFC4890] Davies, E. and J. Mohacsi, "Recommendations for Filtering ICMPv6 Messages in Firewalls", [RFC 4890](#), DOI 10.17487/RFC4890, May 2007, <<https://www.rfc-editor.org/info/rfc4890>>.
- [RFC4919] Kushalnagar, N., Montenegro, G., and C. Schumacher, "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals", [RFC 4919](#), DOI 10.17487/RFC4919, August 2007, <<https://www.rfc-editor.org/info/rfc4919>>.
- [RFC4944] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", [RFC 4944](#), DOI 10.17487/RFC4944, September 2007, <<https://www.rfc-editor.org/info/rfc4944>>.
- [RFC5014] Nordmark, E., Chakrabarti, S., and J. Laganier, "IPv6 Socket API for Source Address Selection", [RFC 5014](#), DOI 10.17487/RFC5014, September 2007, <<https://www.rfc-editor.org/info/rfc5014>>.
- [RFC5072] Varada, S., Ed., Haskins, D., and E. Allen, "IP Version 6 over PPP", [RFC 5072](#), DOI 10.17487/RFC5072, September 2007, <<https://www.rfc-editor.org/info/rfc5072>>.
- [RFC5121] Patil, B., Xia, F., Sarikaya, B., Choi, JH., and S. Madanapalli, "Transmission of IPv6 via the IPv6 Convergence Sublayer over IEEE 802.16 Networks", [RFC 5121](#), DOI 10.17487/RFC5121, February 2008, <<https://www.rfc-editor.org/info/rfc5121>>.
- [RFC5555] Soliman, H., Ed., "Mobile IPv6 Support for Dual Stack Hosts and Routers", [RFC 5555](#), DOI 10.17487/RFC5555, June 2009, <<https://www.rfc-editor.org/info/rfc5555>>.
- [RFC6563] Jiang, S., Conrad, D., and B. Carpenter, "Moving A6 to Historic Status", [RFC 6563](#), DOI 10.17487/RFC6563, March 2012, <<https://www.rfc-editor.org/info/rfc6563>>.
- [RFC7066] Korhonen, J., Ed., Arkko, J., Ed., Savolainen, T., and S. Krishnan, "IPv6 for Third Generation Partnership Project

(3GPP) Cellular Hosts", [RFC 7066](#), DOI 10.17487/RFC7066, November 2013, <<https://www.rfc-editor.org/info/rfc7066>>.

Chown, et al.

Expires August 31, 2018

[Page 38]

Internet-Draft

IPv6 Node Requirements

February 2018

- [RFC7084] Singh, H., Beebee, W., Donley, C., and B. Stark, "Basic Requirements for IPv6 Customer Edge Routers", [RFC 7084](#), DOI 10.17487/RFC7084, November 2013, <<https://www.rfc-editor.org/info/rfc7084>>.
- [RFC7123] Gont, F. and W. Liu, "Security Implications of IPv6 on IPv4 Networks", [RFC 7123](#), DOI 10.17487/RFC7123, February 2014, <<https://www.rfc-editor.org/info/rfc7123>>.
- [RFC7278] Byrne, C., Drown, D., and A. Vizdal, "Extending an IPv6 /64 Prefix from a Third Generation Partnership Project (3GPP) Mobile Interface to a LAN Link", [RFC 7278](#), DOI 10.17487/RFC7278, June 2014, <<https://www.rfc-editor.org/info/rfc7278>>.
- [RFC7371] Boucadair, M. and S. Venaas, "Updates to the IPv6 Multicast Addressing Architecture", [RFC 7371](#), DOI 10.17487/RFC7371, September 2014, <<https://www.rfc-editor.org/info/rfc7371>>.
- [RFC7421] Carpenter, B., Ed., Chown, T., Gont, F., Jiang, S., Petrescu, A., and A. Yourtchenko, "Analysis of the 64-bit Boundary in IPv6 Addressing", [RFC 7421](#), DOI 10.17487/RFC7421, January 2015, <<https://www.rfc-editor.org/info/rfc7421>>.
- [RFC7721] Cooper, A., Gont, F., and D. Thaler, "Security and Privacy Considerations for IPv6 Address Generation Mechanisms", [RFC 7721](#), DOI 10.17487/RFC7721, March 2016, <<https://www.rfc-editor.org/info/rfc7721>>.
- [RFC7772] Yourtchenko, A. and L. Colitti, "Reducing Energy Consumption of Router Advertisements", [BCP 202](#), [RFC 7772](#), DOI 10.17487/RFC7772, February 2016, <<https://www.rfc-editor.org/info/rfc7772>>.
- [RFC7844] Huitema, C., Mrugalski, T., and S. Krishnan, "Anonymity Profiles for DHCP Clients", [RFC 7844](#), DOI 10.17487/RFC7844, May 2016,

<<https://www.rfc-editor.org/info/rfc7844>>.

- [RFC7934] Colitti, L., Cerf, V., Cheshire, S., and D. Schinazi, "Host Address Availability Recommendations", [BCP 204](#), [RFC 7934](#), DOI 10.17487/RFC7934, July 2016, <<https://www.rfc-editor.org/info/rfc7934>>.

Chown, et al.

Expires August 31, 2018

[Page 39]

Internet-Draft

IPv6 Node Requirements

February 2018

- [RFC8096] Fenner, B., "The IPv6-Specific MIB Modules Are Obsolete", [RFC 8096](#), DOI 10.17487/RFC8096, April 2017, <<https://www.rfc-editor.org/info/rfc8096>>.
- [RFC8273] Brzozowski, J. and G. Van de Velde, "Unique IPv6 Prefix per Host", [RFC 8273](#), DOI 10.17487/RFC8273, December 2017, <<https://www.rfc-editor.org/info/rfc8273>>.
- [POSIX] IEEE, "IEEE Std. 1003.1-2008 Standard for Information Technology -- Portable Operating System Interface (POSIX), ISO/IEC 9945:2009", <<http://www.ieee.org>>.
- [USGv6] National Institute of Standards and Technology, "A Profile for IPv6 in the U.S. Government - Version 1.0", July 2008, <<http://www.antd.nist.gov/usgv6/usgv6-v1.pdf>>.

Authors' Addresses

Tim Chown
Jisc
Lumen House, Library Avenue
Harwell Oxford, Didcot OX11 0SG
United Kingdom

Email: tim.chown@jisc.ac.uk

John Loughney
Intel
Santa Clara, CA
USA

Email: john.loughney@gmail.com

Timothy Winters

University of New Hampshire, Interoperability Lab (UNH-IOL)

Durham, NH

United States

Email: twinters@iol.unh.edu