

Network Working Group  
Internet-Draft  
Updates: [2330](#) (if approved)  
Intended status: Informational  
Expires: October 7, 2018

A. Morton  
AT&T Labs  
J. Fabini  
TU Wien  
N. Elkins  
Inside Products, Inc.  
M. Ackermann  
Blue Cross Blue Shield of Michigan  
V. Hegde  
Consultant  
April 5, 2018

IPv6, IPv4 and Coexistence Updates for IPPM's Active Metric Framework  
draft-ietf-ippm-2330-ipv6-04

## Abstract

This memo updates the IP Performance Metrics (IPPM) Framework [RFC 2330](#) with new considerations for measurement methodology and testing. It updates the definition of standard-formed packets in [RFC 2330](#) to include IPv6 packets, deprecates the definition of minimum standard-formed packet, and augments distinguishing aspects of packets, referred to as Type-P for test packets in [RFC 2330](#). This memo identifies that IPv4-IPv6 co-existence can challenge measurements within the scope of the IPPM Framework. Exemplary use cases include, but are not limited to IPv4-IPv6 translation, NAT, protocol encapsulation, IPv6 header compression, or use of IPv6 over Low-Power Wireless Area Networks (6LoWPAN).

## 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](#)].

## 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

Internet-Draft

IPPM IPv6 Update

April 2018

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 October 7, 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

<a href="#">1.</a>	Introduction . . . . .	<a href="#">2</a>
<a href="#">2.</a>	Scope . . . . .	<a href="#">3</a>
<a href="#">3.</a>	Packets of Type-P . . . . .	<a href="#">3</a>
<a href="#">4.</a>	Standard-Formed Packets . . . . .	<a href="#">5</a>
<a href="#">5.</a>	NAT, IPv4-IPv6 Transition and Compression Techniques . . . . .	<a href="#">8</a>
<a href="#">6.</a>	Security Considerations . . . . .	<a href="#">9</a>
<a href="#">7.</a>	IANA Considerations . . . . .	<a href="#">10</a>
<a href="#">8.</a>	Acknowledgements . . . . .	<a href="#">10</a>
<a href="#">9.</a>	References . . . . .	<a href="#">10</a>
<a href="#">9.1.</a>	Normative References . . . . .	<a href="#">10</a>
<a href="#">9.2.</a>	Informative References . . . . .	<a href="#">13</a>
	Authors' Addresses . . . . .	<a href="#">13</a>

## [1.](#) Introduction

The IETF IP Performance Metrics (IPPM) working group first created a framework for metric development in [[RFC2330](#)]. This framework has stood the test of time and enabled development of many fundamental metrics. It has been updated in the area of metric composition [[RFC5835](#)], and in several areas related to active stream measurement of modern networks with reactive properties [[RFC7312](#)].

The IPPM framework [[RFC2330](#)] recognized (in [section 13](#)) that many aspects of IP packets can influence its processing during transfer across the network.

In [Section 15 of \[RFC2330\]](#), the notion of a "standard-formed" packet is defined. However, the definition was never updated to include IPv6, as the original authors planned.

In particular, IPv6 Extension Headers and protocols which use IPv6 header compression are growing in use. This memo seeks to provide the needed updates.

## [2.](#) Scope

The purpose of this memo is to expand the coverage of IPPM metrics to include IPv6, and to highlight additional aspects of test packets and make them part of the IPPM performance metric framework.

The scope is to update key sections of [[RFC2330](#)], adding considerations that will aid the development of new measurement methodologies intended for today's IP networks. Specifically, this memo expands the Type-P examples in [section 13 of \[RFC2330\]](#) and expands the definition (in [section 15 of \[RFC2330\]](#)) of a standard-formed packet to include IPv6 header aspects and other features.

Other topics in [[RFC2330](#)] which might be updated or augmented are deferred to future work. This includes the topics of passive and various forms of hybrid active/passive measurements.

## [3.](#) Packets of Type-P

A fundamental property of many Internet metrics is that the measured value of the metric depends on characteristics of the IP packet(s) used to make the measurement. Potential influencing factors include IP header fields and their values, but also higher-layer protocol headers and their values. Consider an IP-connectivity metric: one obtains different results depending on whether one is interested in connectivity for packets destined for well-known TCP ports or unreserved UDP ports, or those with invalid IPv4 checksums, or those with TTL or Hop Limit of 16, for example. In some circumstances

these distinctions will result in special treatment of packets in intermediate nodes and end systems (for example, if Diffserv [[RFC2780](#)], ECN [[RFC3168](#)], Router Alert, Hop-by-hop extensions [[RFC7045](#)], or Flow Labels [[RFC6437](#)] are used, or in the presence of firewalls or RSVP reservations).

Because of this distinction, we introduce the generic notion of a "packet of Type-P", where in some contexts P will be explicitly defined (i.e., exactly what type of packet we mean), partially defined (e.g., "with a payload of B octets"), or left generic. Thus we may talk about generic IP-Type-P-connectivity or more specific IP-port-HTTP-connectivity. Some metrics and methodologies may be

fruitfully defined using generic Type-P definitions which are then made specific when performing actual measurements.

Whenever a metric's value depends on the type of the packets involved in the metric, the metric's name will include either a specific type or a phrase such as "Type-P". Thus we will not define an "IP-connectivity" metric but instead an "IP-Type-P-connectivity" metric and/or perhaps an "IP-port-HTTP-connectivity" metric. This naming convention serves as an important reminder that one must be conscious of the exact type of traffic being measured.

If the information constituting Type-P at the Source is found to have changed at the Destination (or at a measurement point between the Source and Destination, as in [[RFC5644](#)]), then the modified values MUST be noted and reported with the results. Some modifications occur according to the conditions encountered in transit (such as congestion notification) or due to the requirements of segments of the Source to Destination path. For example, the packet length will change if IP headers are converted to the alternate version/address family, or if optional Extension Headers are added or removed. Even header fields like TTL/Hop Limit that typically change in transit may be relevant to specific tests. For example Neighbor Discovery Protocol (NDP) [[RFC4861](#)] packets are transmitted with Hop Limit value set to 255, and the validity test specifies that the Hop Limit MUST have a value of 255 at the receiver, too. So, while other tests may intentionally exclude the TTL/Hop Limit value from their Type-P definition, for this particular test the correct Hop Limit value is of high relevance and MUST be part of the Type-P definition.

Local policies in intermediate nodes based on examination of IPv6 Extension Headers may affect measurement repeatability. If intermediate nodes follow the recommendations of [[RFC7045](#)], repeatability may be improved to some degree.

A closely related note: it would be very useful to know if a given Internet component (like host, link, or path) treats equally a class C of different types of packets. If so, then any one of those types of packets can be used for subsequent measurement of the component. This suggests we devise a metric or suite of metrics that attempt to determine C.

Load balancing over parallel paths is one particular example where such a class C would be more complex to determine in IPPM measurements. Load balancers often use flow identifiers, computed as hashes of (specific parts of) the packet header, for deciding among the available parallel paths a packet will traverse. Packets with identical hashes are assigned to the same flow and forwarded to the same resource in the load balancer's pool. The presence of a load

balancer on the measurement path, as well as the specific headers and fields that are used for the forwarding decision, are not known when measuring the path as a black-box. Potential assessment scenarios include the measurement of one of the parallel paths, and the measurement of all available parallel paths that the load balancer can use. Knowledge of a load balancer's flow definition (alternatively: its class C specific treatment in terms of header fields in scope of hash operations) is therefore a prerequisite for repeatable measurements. A path may have more than one stage of load balancing, adding to class C definition complexity.

#### [4.](#) Standard-Formed Packets

Unless otherwise stated, all metric definitions that concern IP packets include an implicit assumption that the packet is *\*standard-formed\**. A packet is standard-formed if it meets all of the following criteria:

- + It includes a valid IP header: see below for version-specific criteria.
- + It is not an IP fragment.

- + The Source and Destination addresses correspond to the intended Source and Destination, including Multicast Destination addresses.
- + If a transport header is present, it contains a valid checksum and other valid fields.

For an IPv4 ( [\[RFC0791\]](#) and updates) packet to be standard-formed, the following additional criteria are REQUIRED:

- o The version field is 4
- o The Internet Header Length (IHL) value is  $\geq 5$ ; the checksum is correct.
- o Its total length as given in the IPv4 header corresponds to the size of the IPv4 header plus the size of the payload.
- o Either the packet possesses sufficient TTL to travel from the Source to the Destination if the TTL is decremented by one at each hop, or it possesses the maximum TTL of 255.
- o It does not contain IP options unless explicitly noted.

For an IPv6 ([\[RFC8200\]](#) and updates) packet to be standard-formed, the following criteria are REQUIRED:

- o The version field is 6.
- o Its total length corresponds to the size of the IPv6 header (40 octets) plus the length of the payload as given in the IPv6 header.
- o The payload length value for this packet (including Extension Headers) conforms to the IPv6 specifications.
- o Either the packet possesses sufficient Hop Limit to travel from the Source to the Destination if the Hop Limit is decremented by one at each hop, or it possesses the maximum Hop Limit of 255.
- o Either the packet does not contain IP Extension Headers, or it contains the correct number and type of headers as specified in

the packet, and the headers appear in the standard-conforming order (Next Header).

- o All parameters used in the header and Extension Headers are found in the IANA Registry of Internet Protocol Version 6 (IPv6) Parameters, partly specified in [[IANA-6P](#)].

Two mechanisms require some discussion in the context of standard-formed packets, namely IPv6 over Low-Power Wireless Area Networks (6LowPAN, [[RFC4494](#)]) and Robust Header Compression (ROHC, [[RFC3095](#)]). IPv6 over Low-Power Wireless Area Networks (6LowPAN), as defined in [[RFC4494](#)] and updated by [[RFC6282](#)] with header compression and [[RFC6775](#)] with neighbor discovery optimizations proposes solutions for using IPv6 in resource-constrained environments. An adaptation layer enables the transfer IPv6 packets over networks having a MTU smaller than the minimum IPv6 MTU. Fragmentation and re-assembly of IPv6 packets, as well as the resulting state that would be stored in intermediate nodes, poses substantial challenges to measurements. Likewise, ROHC operates stateful in compressing headers on subpaths, storing state in intermediate hosts. The modification of measurement packets' Type-P by ROHC and 6LowPAN, as well as requirements with respect to the concept of standard-formed packets for these two protocols requires substantial work. Because of these reasons we consider ROHC and 6LowPAN packets to be out of the scope of this document.

The topic of IPv6 Extension Headers brings current controversies into focus as noted by [[RFC6564](#)] and [[RFC7045](#)]. However, measurement use cases in the context of the IPPM framework like in-situ OAM in enterprise environments or IPv6 Performance and Diagnostic Metrics (PDM) Destination Option measurements [[RFC8250](#)] can benefit from inspection, modification, addition or deletion of IPv6 extension headers in hosts along the measurement path.

As a particular use case, hosts on the path may store sending and intermediate timestamps into dedicated extension headers to support measurements, monitoring, auditing, or reproducibility in critical environments. [[RFC8250](#)] endorses the use and manipulation of IPv6 extension headers for measurement purposes, consistent with other approved IETF specifications.

The following additional considerations apply when IPv6 Extension

Headers are present:

- o Extension Header inspection: Some intermediate nodes may inspect Extension Headers or the entire IPv6 packet while in transit. In exceptional cases, they may drop the packet or route via a sub-optimal path, and measurements may be unreliable or unrepeatable. The packet (if it arrives) may be standard-formed, with a corresponding Type-P.
- o Extension Header modification: In Hop-by-Hop headers, some TLV encoded options may be permitted to change at intermediate nodes while in transit. The resulting packet may be standard-formed, with a corresponding Type-P.
- o Extension Header insertion or deletion: It is possible that Extension Headers could be added to, or removed from the header chain. The resulting packet may be standard-formed, with a corresponding Type-P.
- o A change in packet length (from the corresponding packet observed at the Source) or header modification is a significant factor in Internet measurement, and REQUIRES a new Type-P to be reported.

It is further REQUIRED that if a packet is described as having a "length of B octets", then  $0 \leq B \leq 65535$ ; and if B is the payload length in octets, then  $B \leq (65535 - \text{IP header size in octets, including any Extension Headers})$ . The jumbograms defined in [\[RFC2675\]](#) are not covered by the above length analysis, but if the IPv6 Jumbogram Payload Hop-by-Hop Option Header is present, then a packet with corresponding length MUST be considered standard-formed. In practice, the path MTU will restrict the length of standard-formed packets that can successfully traverse the path. Path MTU Discovery for IP version 6 (PMTUD, [\[RFC8201\]](#)) or Packetization Layer Path MTU Discovery (PLPMTUD, [\[RFC4821\]](#)) is recommended to prevent fragmentation (or ICMP error messages) as a result of IPv6 extension header manipulation.

So, for example, one might imagine defining an IP connectivity metric as "IP-type-P-connectivity for standard-formed packets with the IP Diffserv field set to 0", or, more succinctly, "IP-type-



formed is already implied by convention. Changing the contents of a field, such as the Diffserv Code Point, ECN bits, or Flow Label may have a profound affect on packet handling during transit, but does not affect a packet's status as standard-formed. Likewise, the addition, modification, or deletion of extension headers may change the handling of packets in transit hosts.

[RFC2330] defines the "minimal IP packet from A to B" as a particular type of standard-formed packet often useful to consider. When defining IP metrics no packet smaller or simpler than this can be transmitted over a correctly operating IP network. However, the concept of the minimal IP packet has not been employed (since typical active measurement systems employ a transport layer and a payload) and its practical use is limited. Therefore, this memo deprecates the concept of the "minimal IP packet from A to B".

## 5. NAT, IPv4-IPv6 Transition and Compression Techniques

This memo adds the key considerations for utilizing IPv6 in two critical conventions of the IPPM Framework, namely packets of Type-P and standard-formed packets. The need for co-existence of IPv4 and IPv6 has originated transitioning standards like the Framework for IPv4/IPv6 Translation in [[RFC6144](#)] or IP/ICMP Translation Algorithms in [[RFC7915](#)] and [[RFC7757](#)].

The definition and execution of measurements within the context of the IPPM Framework is challenged whenever such translation mechanisms are present along the measurement path. In particular use cases like IPv4-IPv6 translation, NAT, protocol encapsulation, or IPv6 header compression may result in modification of the measurement packet's Type-P along the path. All these changes **MUST** be reported. Exemplary consequences include, but are not limited to:

- o Modification or addition of headers or header field values in intermediate nodes. As noted in [Section 4](#) for IPv6 extension header manipulation, NAT, IPv4-IPv6 transitioning or IPv6 header compression mechanisms may result in changes of the measurement packets' Type-P, too. Consequently, hosts along the measurement path may treat packets differently because of the Type-P modification. Measurements at observation points along the path may also need extra context to uniquely identify a packet.
- o Network Address Translators (NAT) on the path can have unpredictable impact on latency measurement (in terms of the amount of additional time added), and possibly other types of measurements. It is not usually possible to control this impact (as testers may not have any control of the underlying network or

middleboxes). There is a possibility that stateful NAT will lead to unstable performance for a flow with specific Type-P, since state needs to be created for the first packet of a flow, and state may be lost later if the NAT runs out of resources. However, this scenario does not invalidate the Type-P for testing – for example the purpose of a test might be exactly to quantify the NAT's impact on delay variation. The presence of NAT may mean that the measured performance of Type-P will change between the source and the destination. This can cause an issue when attempting to correlate measurements conducted on segments of the path that include or exclude the NAT. Thus, it is a factor to be aware of when conducting measurements.

- o Variable delay due to internal state. One side effect of changes due to IPv4-IPv6 transitioning mechanisms is the variable delay that intermediate nodes spend for header modifications. Similar to NAT the allocation of internal state and establishment of context within intermediate nodes may cause variable delays, depending on the measurement stream pattern and position of a packet within the stream. For example the first packet in a stream will typically trigger allocation of internal state in an intermediate IPv4-IPv6 transition host. Subsequent packets can benefit from lower processing delay due to the existing internal state. However, large inter-packet delays in the measurement stream may result in the intermediate host deleting the associated state and needing to re-establish it on arrival of another stream packet. It is worth noting that this variable delay due to internal state allocation in intermediate nodes can be an explicit use case for measurements.
- o Variable delay due to packet length. IPv4-IPv6 transitioning or header compression mechanisms modify the length of measurement packets. The modification of the packet size may or may not change the way how the measurement path treats the packets.

## 6. Security Considerations

The security considerations that apply to any active measurement of live paths are relevant here as well. See [[RFC4656](#)] and [[RFC5357](#)].

When considering privacy of those involved in measurement or those whose traffic is measured, the sensitive information available to potential observers is greatly reduced when using active techniques which are within this scope of work. Passive observations of user traffic for measurement purposes raise many privacy issues. We refer the reader to the privacy considerations described in the Large Scale

Measurement of Broadband Performance (LMAP) Framework [[RFC7594](#)], which covers active and passive techniques.

## [7.](#) IANA Considerations

This memo makes no requests of IANA.

## [8.](#) Acknowledgements

The authors thank Brian Carpenter for identifying the lack of IPv6 coverage in IPPM's Framework, and for listing additional distinguishing factors for packets of Type-P. Both Brian and Fred Baker discussed many of the interesting aspects of IPv6 with the co-authors, leading to a more solid first draft: thank you both. Thanks to Bill Jouris for an editorial pass through the pre-00 text.

## [9.](#) References

### [9.1.](#) Normative References

- [RFC0791] Postel, J., "Internet Protocol", STD 5, [RFC 791](#), DOI 10.17487/RFC0791, September 1981, <<https://www.rfc-editor.org/info/rfc791>>.
- [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>>.
- [RFC2330] Paxson, V., Almes, G., Mahdavi, J., and M. Mathis, "Framework for IP Performance Metrics", [RFC 2330](#), DOI 10.17487/RFC2330, May 1998, <<https://www.rfc-editor.org/info/rfc2330>>.
- [RFC2675] Borman, D., Deering, S., and R. Hinden, "IPv6 Jumbograms", [RFC 2675](#), DOI 10.17487/RFC2675, August 1999, <<https://www.rfc-editor.org/info/rfc2675>>.
- [RFC2780] Bradner, S. and V. Paxson, "IANA Allocation Guidelines For Values In the Internet Protocol and Related Headers", [BCP 37](#), [RFC 2780](#), DOI 10.17487/RFC2780, March 2000, <<https://www.rfc-editor.org/info/rfc2780>>.

- [RFC3095] Bormann, C., Burmeister, C., Degermark, M., Fukushima, H., Hannu, H., Jonsson, L-E., Hakenberg, R., Koren, T., Le, K., Liu, Z., Martensson, A., Miyazaki, A., Svanbro, K., Wiebke, T., Yoshimura, T., and H. Zheng, "RObust Header Compression (ROHC): Framework and four profiles: RTP, UDP, ESP, and uncompressed", [RFC 3095](#), DOI 10.17487/RFC3095, July 2001, <<https://www.rfc-editor.org/info/rfc3095>>.

Morton, et al.

Expires October 7, 2018

[Page 10]

---

Internet-Draft

IPPM IPv6 Update

April 2018

- [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>>.
- [RFC4494] Song, JH., Poovendran, R., and J. Lee, "The AES-CMAC-96 Algorithm and Its Use with IPsec", [RFC 4494](#), DOI 10.17487/RFC4494, June 2006, <<https://www.rfc-editor.org/info/rfc4494>>.
- [RFC4656] Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)", [RFC 4656](#), DOI 10.17487/RFC4656, September 2006, <<https://www.rfc-editor.org/info/rfc4656>>.
- [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>>.
- [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>>.
- [RFC5357] Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)", [RFC 5357](#), DOI 10.17487/RFC5357, October 2008, <<https://www.rfc-editor.org/info/rfc5357>>.
- [RFC5644] Stephan, E., Liang, L., and A. Morton, "IP Performance Metrics (IPPM): Spatial and Multicast", [RFC 5644](#), DOI 10.17487/RFC5644, October 2009,

<<https://www.rfc-editor.org/info/rfc5644>>.

- [RFC5835] Morton, A., Ed. and S. Van den Berghe, Ed., "Framework for Metric Composition", [RFC 5835](#), DOI 10.17487/RFC5835, April 2010, <<https://www.rfc-editor.org/info/rfc5835>>.
- [RFC6144] Baker, F., Li, X., Bao, C., and K. Yin, "Framework for IPv4/IPv6 Translation", [RFC 6144](#), DOI 10.17487/RFC6144, April 2011, <<https://www.rfc-editor.org/info/rfc6144>>.
- [RFC6282] Hui, J., Ed. and P. Thubert, "Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks", [RFC 6282](#), DOI 10.17487/RFC6282, September 2011, <<https://www.rfc-editor.org/info/rfc6282>>.

Morton, et al.

Expires October 7, 2018

[Page 11]

---

Internet-Draft

IPPM IPv6 Update

April 2018

- [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>>.
- [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>>.
- [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>>.
- [RFC7312] Fabini, J. and A. Morton, "Advanced Stream and Sampling Framework for IP Performance Metrics (IPPM)", [RFC 7312](#), DOI 10.17487/RFC7312, August 2014, <<https://www.rfc-editor.org/info/rfc7312>>.

- [RFC7757] Anderson, T. and A. Leiva Popper, "Explicit Address Mappings for Stateless IP/ICMP Translation", [RFC 7757](#), DOI 10.17487/RFC7757, February 2016, <<https://www.rfc-editor.org/info/rfc7757>>.
- [RFC7915] Bao, C., Li, X., Baker, F., Anderson, T., and F. Gont, "IP/ICMP Translation Algorithm", [RFC 7915](#), DOI 10.17487/RFC7915, June 2016, <<https://www.rfc-editor.org/info/rfc7915>>.
- [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>>.

- [RFC8250] Elkins, N., Hamilton, R., and M. Ackermann, "IPv6 Performance and Diagnostic Metrics (PDM) Destination Option", [RFC 8250](#), DOI 10.17487/RFC8250, September 2017, <<https://www.rfc-editor.org/info/rfc8250>>.

## [9.2.](#) Informative References

- [IANA-6P] IANA, "IANA Internet Protocol Version 6 (IPv6) Parameters", Internet Assigned Numbers Authority <https://www.iana.org/assignments/ipv6-parameters>, January 2018.
- [RFC7594] Eardley, P., Morton, A., Bagnulo, M., Burbridge, T., Aitken, P., and A. Akhter, "A Framework for Large-Scale Measurement of Broadband Performance (LMAP)", [RFC 7594](#), DOI 10.17487/RFC7594, September 2015, <<https://www.rfc-editor.org/info/rfc7594>>.

## Authors' Addresses

Al Morton  
AT&T Labs  
200 Laurel Avenue South  
Middletown, NJ 07748  
USA

Phone: +1 732 420 1571  
Fax: +1 732 368 1192  
Email: [acmorton@att.com](mailto:acmorton@att.com)  
URI: <http://home.comcast.net/~acmacm/>

Joachim Fabini  
TU Wien  
Gusshausstrasse 25/E389  
Vienna 1040  
Austria

Phone: +43 1 58801 38813  
Fax: +43 1 58801 38898  
Email: [Joachim.Fabini@tuwien.ac.at](mailto:Joachim.Fabini@tuwien.ac.at)  
URI: <http://www.tc.tuwien.ac.at/about-us/staff/joachim-fabini/>

Morton, et al.

Expires October 7, 2018

[Page 13]

---

Internet-Draft

IPPM IPv6 Update

April 2018

Nalini Elkins  
Inside Products, Inc.  
Carmel Valley, CA 93924  
USA

Email: [nalini.elkins@insidethestack.com](mailto:nalini.elkins@insidethestack.com)

Michael S. Ackermann  
Blue Cross Blue Shield of Michigan

Email: mackermann@bcbsm.com

Vinayak Hegde  
Consultant  
Brahma Sun City, Wadgaon-Sheri  
Pune, Maharashtra 411014  
INDIA

Phone: +91 9449834401  
Email: vinayakh@gmail.com  
URI: <http://www.vinayakhegde.com>