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IP Options and IPv6 Updates for IPPM's Active Metric Framework: Packets  
of Type-P and Standard-Formed Packets  
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## Abstract

This memo updates the IP Performance Metrics (IPPM) Framework [RFC 2330](#) with new considerations for measurement methodology and testing. The memo updates the definition of standard-formed packets in [RFC 2330](#) to include IPv6 packets. It also augments distinguishing aspects of packets, referred to as Type-P for test packets in [RFC 2330](#).

Two points (at least) are worthwhile discussing further: extent of coverage for 6Lo and IPv6 Header Compression, and the continued need to define a "minimal standard-formed packet".

## 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](#)].

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## [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 SHOULD 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. 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 Network Address Translator (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. 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.

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.

#### [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 ([\[RFC2460\]](#) 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 (including Extension Headers) as given in the IPv6 header.
- o Either the packet possesses sufficient Hop Count to travel from the Source to the Destination if the Hop Count is decremented by one at each hop, or it possesses the maximum Hop Count 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 [\[RFC7045\]](#).

Compressed IPv6 headers must be compliant with [\[RFC4494\]](#), as updated by [\[RFC6282\]](#), in order to be declared "standard-formed".

The topic of IPv6 Extension Headers brings current controversies into focus as noted by [\[RFC6564\]](#) and [\[RFC7045\]](#). 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.

We further require 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 this length analysis. In practice, the path MTU will restrict the length of standard-formed packets that can successfully traverse the path.

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-

P-connectivity with the IP Diffserv Field set to 0", since standard-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.

A particular type of standard-formed packet often useful to consider is the "minimal IP packet from A to B" - this is an IP packet with

the following properties:

- + It is standard-formed.
- + Its data payload is 0 octets.
- + It contains no options or Extension Headers.

(Note that we do not define its protocol field, as different values may lead to different treatment by the network.)

When defining IP metrics we keep in mind that no packet smaller or simpler than this can be transmitted over a correctly operating IP network.

## [5.](#) Conclusions

This memo adds the key considerations for utilizing IPv6 in two critical conventions of the IPPM Framework. It is RECOMMENDED to adopt these new considerations in measurements involving IPv6.

## [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



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