

Network Working Group
Internet-Draft
Intended status: Best Current Practice
Expires: March 14, 2020

M. Bagnulo
UC3M
B. Claise
Cisco Systems, Inc.
P. Eardley
BT
A. Morton
AT&T Labs
A. Akhter
Consultant
September 11, 2019

**Registry for Performance Metrics
draft-ietf-ippm-metric-registry-20**

Abstract

This document defines the format for the IANA Performance Metrics Registry. This document also gives a set of guidelines for Registered Performance Metric requesters and reviewers.

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 March 14, 2020.

Copyright Notice

Copyright (c) 2019 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
2.	Terminology	4
3.	Scope	6
4.	Motivation for a Performance Metrics Registry	7
4.1.	Interoperability	7
4.2.	Single point of reference for Performance Metrics	8
4.3.	Side benefits	8
5.	Criteria for Performance Metrics Registration	9
6.	Performance Metric Registry: Prior attempt	9
6.1.	Why this Attempt Will Succeed	10
7.	Definition of the Performance Metric Registry	11
7.1.	Summary Category	12
7.1.1.	Identifier	12
7.1.2.	Name	13
7.1.3.	URIs	16
7.1.4.	Description	17
7.1.5.	Reference	17
7.1.6.	Change Controller	17
7.1.7.	Version (of Registry Format)	17
7.2.	Metric Definition Category	17
7.2.1.	Reference Definition	17
7.2.2.	Fixed Parameters	18
7.3.	Method of Measurement Category	18
7.3.1.	Reference Method	18
7.3.2.	Packet Stream Generation	19
7.3.3.	Traffic Filter	19
7.3.4.	Sampling Distribution	20
7.3.5.	Run-time Parameters	20
7.3.6.	Role	21
7.4.	Output Category	21
7.4.1.	Type	22
7.4.2.	Reference Definition	22
7.4.3.	Metric Units	22
7.4.4.	Calibration	22
7.5.	Administrative information	23
7.5.1.	Status	23
7.5.2.	Requester	23
7.5.3.	Revision	23
7.5.4.	Revision Date	23
7.6.	Comments and Remarks	23

8.	The Life-Cycle of Registered Performance Metrics	24
8.1.	Adding new Performance Metrics to the Performance Metrics Registry	24
8.2.	Revising Registered Performance Metrics	25
8.3.	Deprecating Registered Performance Metrics	27
9.	Security considerations	27
10.	IANA Considerations	28
10.1.	Registry Group	28
10.2.	Performance Metric Name Elements	28
10.3.	New Performance Metrics Registry	29
11.	Acknowledgments	30
12.	References	30
12.1.	Normative References	30
12.2.	Informative References	31
	Authors' Addresses	33

[1.](#) Introduction

The IETF specifies and uses Performance Metrics of protocols and applications transported over its protocols. Performance metrics are such an important part of the operations of IETF protocols that [\[RFC6390\]](#) specifies guidelines for their development.

The definition and use of Performance Metrics in the IETF happens in various working groups (WG), most notably:

The "IP Performance Metrics" (IPPM) WG is the WG primarily focusing on Performance Metrics definition at the IETF.

The "Metric Blocks for use with RTP's Extended Report Framework" (XRBLOCK) WG recently specified many Performance Metrics related to "RTP Control Protocol Extended Reports (RTCP XR)" [\[RFC3611\]](#), which establishes a framework to allow new information to be conveyed in RTCP, supplementing the original report blocks defined in "RTP: A Transport Protocol for Real-Time Applications", [\[RFC3550\]](#).

The "Benchmarking Methodology" WG (BMWG) defined many Performance Metrics for use in laboratory benchmarking of inter-networking technologies.

The "IP Flow Information eXport" (IPFIX) concluded WG specified an IANA process for new Information Elements. Some Performance Metrics related Information Elements are proposed on regular basis.

The "Performance Metrics for Other Layers" (PMOL) a concluded WG, defined some Performance Metrics related to Session Initiation Protocol (SIP) voice quality [[RFC6035](#)].

It is expected that more Performance Metrics will be defined in the future, not only IP-based metrics, but also metrics which are protocol-specific and application-specific.

Despite the importance of Performance Metrics, there are two related problems for the industry. First, ensuring that when one party requests another party to measure (or report or in some way act on) a particular Performance Metric, then both parties have exactly the same understanding of what Performance Metric is being referred to. Second, discovering which Performance Metrics have been specified, to avoid developing a new Performance Metric that is very similar, but not quite inter-operable. These problems can be addressed by creating a registry of performance metrics. The usual way in which the IETF organizes registries is with Internet Assigned Numbers Authority (IANA), and there is currently no Performance Metrics Registry maintained by the IANA.

This document requests that IANA create and maintain a Performance Metrics Registry, according to the maintenance procedures and the Performance Metrics Registry format defined in this memo. The resulting Performance Metrics Registry is for use by the IETF and others. Although the Registry formatting specifications herein are primarily for registry creation by IANA, any other organization that wishes to create a Performance Metrics Registry MAY use the same formatting specifications for their purposes. The authors make no guarantee of the registry format's applicability to any possible set of Performance Metrics envisaged by other organizations, but encourage others to apply it. In the remainder of this document, unless we explicitly say otherwise, we will refer to the IANA-maintained Performance Metrics Registry as simply the Performance Metrics Registry.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

Performance Metric: A Performance Metric is a quantitative measure of performance, targeted to an IETF-specified protocol or targeted to an application transported over an IETF-specified protocol. Examples of Performance Metrics are the FTP response time for a

complete file download, the DNS response time to resolve the IP address, a database logging time, etc. This definition is consistent with the definition of metric in [RFC2330] and broader than the definition of performance metric in [RFC6390].

Registered Performance Metric: A Registered Performance Metric is a Performance Metric expressed as an entry in the Performance Metrics Registry, administered by IANA. Such a performance metric has met all the registry review criteria defined in this document in order to be included in the registry.

Performance Metrics Registry: The IANA registry containing Registered Performance Metrics.

Proprietary Registry: A set of metrics that are registered in a proprietary registry, as opposed to Performance Metrics Registry.

Performance Metrics Experts: The Performance Metrics Experts is a group of designated experts [RFC8126] selected by the IESG to validate the Performance Metrics before updating the Performance Metrics Registry. The Performance Metrics Experts work closely with IANA.

Parameter: A Parameter is an input factor defined as a variable in the definition of a Performance Metric. A Parameter is a numerical or other specified factor forming one of a set that defines a metric or sets the conditions of its operation. All Parameters must be known to measure using a metric and interpret the results. There are two types of Parameters: Fixed and Run-time parameters. For the Fixed Parameters, the value of the variable is specified in the Performance Metrics Registry entry and different Fixed Parameter values result in different Registered Performance Metrics. For the Run-time Parameters, the value of the variable is defined when the metric measurement method is executed and a given Registered Performance Metric supports multiple values for the parameter. Although Run-time Parameters do not change the fundamental nature of the Performance Metric's definition, some have substantial influence on the network property being assessed and interpretation of the results.

Note: Consider the case of packet loss in the following two Active Measurement Method cases. The first case is packet loss as background loss where the Run-time Parameter set includes a very sparse Poisson stream, and only characterizes the times when packets were lost. Actual user streams likely see much higher loss at these times, due to tail drop or radio errors. The second case is packet loss as inverse of throughput where the Run-time Parameter set includes a very dense, bursty

stream, and characterizes the loss experienced by a stream that approximates a user stream. These are both "loss metrics", but the difference in interpretation of the results is highly dependent on the Run-time Parameters (at least), to the extreme where we are actually using loss to infer its compliment: delivered throughput.

Active Measurement Method: Methods of Measurement conducted on traffic which serves only the purpose of measurement and is generated for that reason alone, and whose traffic characteristics are known a priori. The complete definition of Active Methods is specified in [section 3.4](#) of [RFC7799]. Examples of Active Measurement Methods are the measurement methods for the One way delay metric defined in [RFC7679] and the one for round trip delay defined in [RFC2681].

Passive Measurement Method: Methods of Measurement conducted on network traffic, generated either from the end users or from network elements that would exist regardless whether the measurement was being conducted or not. The complete definition of Passive Methods is specified in [section 3.6](#) of [RFC7799]. One characteristic of Passive Measurement Methods is that sensitive information may be observed, and as a consequence, stored in the measurement system.

Hybrid Measurement Method: Hybrid Methods are Methods of Measurement that use a combination of Active Methods and Passive Methods, to assess Active Metrics, Passive Metrics, or new metrics derived from the a priori knowledge and observations of the stream of interest. The complete definition of Hybrid Methods is specified in [section 3.8](#) of [RFC7799].

3. Scope

This document is intended for two different audiences:

1. For those defining new Registered Performance Metrics, it provides specifications and best practices to be used in deciding which Registered Performance Metrics are useful for a measurement study, instructions for writing the text for each column of the Registered Performance Metrics, and information on the supporting documentation required for the new Performance Metrics Registry entry (up to and including the publication of one or more RFCs or I-Ds describing it).
2. For the appointed Performance Metrics Experts and for IANA personnel administering the new IANA Performance Metrics Registry, it defines a set of acceptance criteria against which

these proposed Registered Performance Metrics should be evaluated.

In addition, this document may be useful for other organizations who are defining a Performance Metric registry of their own, and may re-use the features of the Performance Metrics Registry defined in this document.

This Performance Metrics Registry is applicable to Performance Metrics issued from Active Measurement, Passive Measurement, and any other form of Performance Metric. This registry is designed to encompass Performance Metrics developed throughout the IETF and especially for the technologies specified in the following working groups: IPPM, XRBLOCK, IPFIX, and BMWG. This document analyzes an prior attempt to set up a Performance Metrics Registry, and the reasons why this design was inadequate [[RFC6248](#)]. Finally, this document gives a set of guidelines for requesters and expert reviewers of candidate Registered Performance Metrics.

This document makes no attempt to populate the Performance Metrics Registry with initial entries.

Based on [[RFC8126](#)] [Section 4.3](#), this document is processed as Best Current Practice (BCP) [[RFC2026](#)].

[4.](#) Motivation for a Performance Metrics Registry

In this section, we detail several motivations for the Performance Metrics Registry.

[4.1.](#) Interoperability

As any IETF registry, the primary use for a registry is to manage a registry for its use within one or more protocols. In the particular case of the Performance Metrics Registry, there are two types of protocols that will use the Performance Metrics in the Performance Metrics Registry during their operation (by referring to the Index values):

- o Control protocol: This type of protocol used to allow one entity to request another entity to perform a measurement using a specific metric defined by the Performance Metrics Registry. One particular example is the LMAP framework [[RFC7594](#)]. Using the LMAP terminology, the Performance Metrics Registry is used in the LMAP Control protocol to allow a Controller to request a measurement task to one or more Measurement Agents. In order to enable this use case, the entries of the Performance Metrics Registry must be sufficiently defined to allow a Measurement Agent

implementation to trigger a specific measurement task upon the reception of a control protocol message. This requirement heavily constrains the type of entries that are acceptable for the Performance Metrics Registry.

- o Report protocol: This type of protocol is used to allow an entity to report measurement results to another entity. By referencing to a specific Performance Metrics Registry, it is possible to properly characterize the measurement result data being reported. Using the LMAP terminology, the Performance Metrics Registry is used in the Report protocol to allow a Measurement Agent to report measurement results to a Collector.

It should be noted that the LMAP framework explicitly allows for using not only the IANA-maintained Performance Metrics Registry but also other registries containing Performance Metrics, either defined by other organizations or private ones. However, others who are creating Registries to be used in the context of an LMAP framework are encouraged to use the Registry format defined in this document, because this makes it easier for developers of LMAP Measurement Agents (MAs) to programmatically use information found in those other Registries' entries.

4.2. Single point of reference for Performance Metrics

A Performance Metrics Registry serves as a single point of reference for Performance Metrics defined in different working groups in the IETF. As we mentioned earlier, there are several WGs that define Performance Metrics in the IETF and it is hard to keep track of all them. This results in multiple definitions of similar Performance Metrics that attempt to measure the same phenomena but in slightly different (and incompatible) ways. Having a registry would allow both the IETF community and external people to have a single list of relevant Performance Metrics defined by the IETF (and others, where appropriate). The single list is also an essential aspect of communication about Performance Metrics, where different entities that request measurements, execute measurements, and report the results can benefit from a common understanding of the referenced Performance Metric.

4.3. Side benefits

There are a couple of side benefits of having such a registry. First, the Performance Metrics Registry could serve as an inventory of useful and used Performance Metrics, that are normally supported by different implementations of measurement agents. Second, the results of measurements using the Performance Metrics should be comparable even if they are performed by different implementations

and in different networks, as the Performance Metric is properly defined. [BCP 176](#) [[RFC6576](#)] examines whether the results produced by independent implementations are equivalent in the context of evaluating the completeness and clarity of metric specifications. This BCP defines the standards track advancement testing for (active) IPPM metrics, and the same process will likely suffice to determine whether Registered Performance Metrics are sufficiently well specified to result in comparable (or equivalent) results. Registered Performance Metrics which have undergone such testing SHOULD be noted, with a reference to the test results.

5. Criteria for Performance Metrics Registration

It is neither possible nor desirable to populate the Performance Metrics Registry with all combinations of Parameters of all Performance Metrics. The Registered Performance Metrics should be:

1. interpretable by the user.
2. implementable by the software designer,
3. deployable by network operators,
4. accurate, for interoperability and deployment across vendors,
5. Operationally useful, so that it has significant industry interest and/or has seen deployment,
6. Sufficiently tightly defined, so that different values for the Run-time Parameters does not change the fundamental nature of the measurement, nor change the practicality of its implementation.

In essence, there needs to be evidence that a candidate Registered Performance Metric has significant industry interest, or has seen deployment, and there is agreement that the candidate Registered Performance Metric serves its intended purpose.

6. Performance Metric Registry: Prior attempt

There was a previous attempt to define a metric registry [RFC 4148](#) [[RFC4148](#)]. However, it was obsoleted by [RFC 6248](#) [[RFC6248](#)] because it was "found to be insufficiently detailed to uniquely identify IPPM metrics... [there was too much] variability possible when characterizing a metric exactly" which led to the [RFC4148](#) registry having "very few users, if any".

A couple of interesting additional quotes from [RFC 6248](#) might help understand the issues related to that registry.

1. "It is not believed to be feasible or even useful to register every possible combination of Type P, metric parameters, and Stream parameters using the current structure of the IPPM Metrics Registry."
2. "The registry structure has been found to be insufficiently detailed to uniquely identify IPPM metrics."
3. "Despite apparent efforts to find current or even future users, no one responded to the call for interest in the [RFC 4148](#) registry during the second half of 2010."

The current approach learns from this by tightly defining each Registered Performance Metric with only a few variable (Run-time) Parameters to be specified by the measurement designer, if any. The idea is that entries in the Performance Metrics Registry stem from different measurement methods which require input (Run-time) parameters to set factors like source and destination addresses (which do not change the fundamental nature of the measurement). The downside of this approach is that it could result in a large number of entries in the Performance Metrics Registry. There is agreement that less is more in this context - it is better to have a reduced set of useful metrics rather than a large set of metrics, some with with questionable usefulness.

[6.1.](#) Why this Attempt Will Succeed

As mentioned in the previous section, one of the main issues with the previous registry was that the metrics contained in the registry were too generic to be useful. This document specifies stricter criteria for performance metric registration (see [section 6](#)), and imposes a group of Performance Metrics Experts that will provide guidelines to assess if a Performance Metric is properly specified.

Another key difference between this attempt and the previous one is that in this case there is at least one clear user for the Performance Metrics Registry: the LMAP framework and protocol. Because the LMAP protocol will use the Performance Metrics Registry values in its operation, this actually helps to determine if a metric is properly defined. In particular, since we expect that the LMAP control protocol will enable a controller to request a measurement agent to perform a measurement using a given metric by embedding the Performance Metrics Registry value in the protocol, a metric is properly specified if it is defined well-enough so that it is possible (and practical) to implement the metric in the measurement agent. This was the failure of the previous attempt: a registry entry with an undefined Type-P ([section 13 of RFC 2330](#) [[RFC2330](#)]) allows implementation to be ambiguous.

7. Definition of the Performance Metric Registry

This Performance Metrics Registry is applicable to Performance Metrics used for Active Measurement, Passive Measurement, and any other form of Performance Metric. Each category of measurement has unique properties, so some of the columns defined below are not applicable for a given metric category. In this case, the column(s) SHOULD be populated with the "NA" value (Non Applicable). However, the "NA" value MUST NOT be used by any metric in the following columns: Identifier, Name, URI, Status, Requester, Revision, Revision Date, Description. In the future, a new category of metrics could require additional columns, and adding new columns is a recognized form of registry extension. The specification defining the new column(s) MUST give guidelines to populate the new column(s) for existing entries (in general).

The columns of the Performance Metrics Registry are defined below. The columns are grouped into "Categories" to facilitate the use of the registry. Categories are described at the 7.x heading level, and columns are at the 7.x.y heading level. The Figure below illustrates this organization. An entry (row) therefore gives a complete description of a Registered Performance Metric.

Each column serves as a check-list item and helps to avoid omissions during registration and expert review.

Registry Categories and Columns, shown as

Category

Column | Column |

Summary

Identifier | Name | URIs | Desc. | Reference | Change Controller | Ver |

Metric Definition

Reference Definition | Fixed Parameters |

Method of Measurement

Reference	Packet	Traffic	Sampling	Run-time	Role
Method	Stream	Filter	Distribution	Parameters	
	Generation				

Output

Type	Reference	Units	Calibration
	Definition		

Administrative Information

Status | Request | Rev | Rev.Date |

Comments and Remarks

[7.1.](#) Summary Category

[7.1.1.](#) Identifier

A numeric identifier for the Registered Performance Metric. This identifier MUST be unique within the Performance Metrics Registry.

The Registered Performance Metric unique identifier is an unbounded integer (range 0 to infinity).

The Identifier 0 should be Reserved. The Identifier values from 64512 to 65536 are reserved for private use.

When adding newly Registered Performance Metrics to the Performance Metrics Registry, IANA SHOULD assign the lowest available identifier to the new Registered Performance Metric.

If a Performance Metrics Expert providing review determines that there is a reason to assign a specific numeric identifier, possibly leaving a temporary gap in the numbering, then the Performance Expert SHALL inform IANA of this decision.

7.1.2. Name

As the name of a Registered Performance Metric is the first thing a potential human implementor will use when determining whether it is suitable for their measurement study, it is important to be as precise and descriptive as possible. In future, users will review the names to determine if the metric they want to measure has already been registered, or if a similar entry is available as a basis for creating a new entry.

Names are composed of the following elements, separated by an underscore character "_":

MetricType_Method_SubTypeMethod_... Spec_Units_Output

- o MetricType: a combination of the directional properties and the metric measured, such as:

RTDelay (Round Trip Delay)

RTDNS (Response Time Domain Name Service)

RLDNS (Response Loss Domain Name Service)

OWDelay (One Way Delay)

RTLoss (Round Trip Loss)

OWLoss (One Way Loss)

OWPDV (One Way Packet Delay Variation)

OWIPDV (One Way Inter-Packet Delay Variation)

OWReorder (One Way Packet Reordering)

OWDuplic (One Way Packet Duplication)

OWBTC (One Way Bulk Transport Capacity)

OWMBM (One Way Model Based Metric)

SPMonitor (Single Point Monitor)

MPMonitor (Multi-Point Monitor)

- o Method: One of the methods defined in [[RFC7799](#)], such as:

Active (depends on a dedicated measurement packet stream and observations of the stream)

Passive (depends **solely** on observation of one or more existing packet streams)

HybridType1 (observations on one stream that combine both active and passive methods)

HybridType2 (observations on two or more streams that combine both active and passive methods)

Spatial (Spatial Metric of [RFC5644](#))

- o SubTypeMethod: One or more sub-types to further describe the features of the entry, such as:

ICMP (Internet Control Message Protocol)

IP (Internet Protocol)

DSCPxx (where xx is replaced by a Diffserv code point)

UDP (User Datagram Protocol)

TCP (Transport Control Protocol)

QUIC (QUIC transport protocol)

HS (Hand-Shake, such as TCP's 3-way HS)

Poisson (Packet generation using Poisson distribution)

Periodic (Periodic packet generation)

SendOnRcv (Sender keeps one packet in-transit by sending when previous packet arrives)

PayloadxxxxB (where xxxx is replaced by an integer, the number of octets in the Payload))

SustainedBurst (Capacity test, worst case)

StandingQueue (test of bottleneck queue behavior)

SubTypeMethod values are separated by a hyphen "-" character, which indicates that they belong to this element, and that their order is unimportant when considering name uniqueness.

- o Spec: RFC number and major section number that specifies this Registry entry in the form RFCXXXXsecY, such as RFC7799sec3.
Note: the RFC number is not the Primary Reference specification for the metric definition, such as [[RFC7679](#)] for One-way Delay; it will contain the placeholder "RFCXXXXsecY" until the RFC number is assigned to the specifying document, and would remain blank in private registry entries without a corresponding RFC.
- o Units: The units of measurement for the output, such as:
 - Seconds
 - Ratio (unitless)
 - Percent (value multiplied by 100)
 - Logical (1 or 0)
 - Packets
 - BPS (Bits per Second)
 - PPS (Packets per Second)
 - EventTotal (for unit-less counts)
 - Multiple (more than one type of unit)
 - Enumerated (a list of outcomes)
 - Unitless
- o Output: The type of output resulting from measurement, such as:
 - Singleton
 - Raw (multiple Singletons)
 - Count
 - Minimum
 - Maximum

Median

Mean

95Percentile (95th Percentile)

99Percentile (99th Percentile)

StdDev (Standard Deviation)

Variance

PFI (Pass, Fail, Inconclusive)

FlowRecords (descriptions of flows observed)

LossRatio (lost packets to total packets, ≤ 1)

An example is:

RTDelay_Active_IP-UDP-Periodic_RFCXXXXsecY_Seconds_95Percentile

as described in section 4 of [[I-D.ietf-ippm-initial-registry](#)].

Note that private registries following the format described here SHOULD use the prefix "Priv_" on any name to avoid unintended conflicts (further considerations are described in [section 10](#)). Private registry entries usually have no specifying RFC, thus the Spec: element has no clear interpretation.

[7.1.3](#). URIs

The URIs column MUST contain a URL [[RFC3986](#)] that uniquely identifies and locates the metric entry so it is accessible through the Internet. The URL points to a file containing all the human-readable information for one registry entry. The URL SHALL reference a target file that is HTML-formatted and contains URLs to referenced sections of HTML-ized RFCs. These target files for different entries can be more easily edited and re-used when preparing new entries. The exact form of the URL for each target file will be determined by IANA and reside on "iana.org". The major sections of [[I-D.ietf-ippm-initial-registry](#)] provide an example of a target file in HTML form (sections [4](#) and higher).

7.1.4. Description

A Registered Performance Metric description is a written representation of a particular Performance Metrics Registry entry. It supplements the Registered Performance Metric name to help Performance Metrics Registry users select relevant Registered Performance Metrics.

7.1.5. Reference

This entry gives the specification containing the candidate registry entry which was reviewed and agreed, if such an RFC or other specification exists.

7.1.6. Change Controller

This entry names the entity responsible for approving revisions to the registry entry, and SHALL provide contact information (for an individual, where appropriate).

7.1.7. Version (of Registry Format)

This entry gives the version number for the registry format used. Formats complying with this memo MUST use 1.0. The version number SHALL NOT change unless a new RFC is published that changes the registry format.

7.2. Metric Definition Category

This category includes columns to prompt all necessary details related to the metric definition, including the RFC reference and values of input factors, called fixed parameters, which are left open in the RFC but have a particular value defined by the performance metric.

7.2.1. Reference Definition

This entry provides a reference (or references) to the relevant section(s) of the document(s) that define the metric, as well as any supplemental information needed to ensure an unambiguous definition for implementations. The reference needs to be an immutable document, such as an RFC; for other standards bodies, it is likely to be necessary to reference a specific, dated version of a specification.

7.2.2. Fixed Parameters

Fixed Parameters are Parameters whose value must be specified in the Performance Metrics Registry. The measurement system uses these values.

Where referenced metrics supply a list of Parameters as part of their descriptive template, a sub-set of the Parameters will be designated as Fixed Parameters. As an example for active metrics, Fixed Parameters determine most or all of the IPPM Framework convention "packets of Type-P" as described in [[RFC2330](#)], such as transport protocol, payload length, TTL, etc. An example for passive metrics is for RTP packet loss calculation that relies on the validation of a packet as RTP which is a multi-packet validation controlled by MIN_SEQUENTIAL as defined by [[RFC3550](#)]. Varying MIN_SEQUENTIAL values can alter the loss report and this value could be set as a Fixed Parameter.

Parameters MUST have well-defined names. For human readers, the hanging indent style is preferred, and any Parameter names and definitions that do not appear in the Reference Method Specification MUST appear in this column (or Run-time Parameters column).

Parameters MUST have a well-specified data format.

A Parameter which is a Fixed Parameter for one Performance Metrics Registry entry may be designated as a Run-time Parameter for another Performance Metrics Registry entry.

7.3. Method of Measurement Category

This category includes columns for references to relevant sections of the RFC(s) and any supplemental information needed to ensure an unambiguous method for implementations.

7.3.1. Reference Method

This entry provides references to relevant sections of the RFC(s) describing the method of measurement, as well as any supplemental information needed to ensure unambiguous interpretation for implementations referring to the RFC text.

Specifically, this section should include pointers to pseudocode or actual code that could be used for an unambiguous implementation.

7.3.2. Packet Stream Generation

This column applies to Performance Metrics that generate traffic as part of their Measurement Method, including but not necessarily limited to Active metrics. The generated traffic is referred as a stream and this column describes its characteristics.

Each entry for this column contains the following information:

- o Value: The name of the packet stream scheduling discipline
- o Reference: the specification where the parameters of the stream are defined

The packet generation stream may require parameters such as the average packet rate and distribution truncation value for streams with Poisson-distributed inter-packet sending times. In case such parameters are needed, they should be included either in the Fixed parameter column or in the run time parameter column, depending on whether they will be fixed or will be an input for the metric.

The simplest example of stream specification is Singleton scheduling (see [[RFC2330](#)]), where a single atomic measurement is conducted. Each atomic measurement could consist of sending a single packet (such as a DNS request) or sending several packets (for example, to request a webpage). Other streams support a series of atomic measurements in a "sample", with a schedule defining the timing between each transmitted packet and subsequent measurement. Principally, two different streams are used in IPPM metrics, Poisson distributed as described in [[RFC2330](#)] and Periodic as described in [[RFC3432](#)]. Both Poisson and Periodic have their own unique parameters, and the relevant set of parameters names and values should be included either in the Fixed Parameters column or in the Run-time parameter column.

7.3.3. Traffic Filter

This column applies to Performance Metrics that observe packets flowing through (the device with) the measurement agent i.e. that is not necessarily addressed to the measurement agent. This includes but is not limited to Passive Metrics. The filter specifies the traffic that is measured. This includes protocol field values/ranges, such as address ranges, and flow or session identifiers.

The traffic filter itself depends on needs of the metric itself and a balance of an operator's measurement needs and a user's need for privacy. Mechanics for conveying the filter criteria might be the BPF (Berkley Packet Filter) or PSAMP [[RFC5475](#)] Property Match

Filtering which reuses IPFIX [[RFC7012](#)]. An example BPF string for matching TCP/80 traffic to remote destination net 192.0.2.0/24 would be "dst net 192.0.2.0/24 and tcp dst port 80". More complex filter engines might be supported by the implementation that might allow for matching using Deep Packet Inspection (DPI) technology.

The traffic filter includes the following information:

Type: the type of traffic filter used, e.g. BPF, PSAMP, OpenFlow rule, etc. as defined by a normative reference

Value: the actual set of rules expressed

[7.3.4.](#) Sampling Distribution

The sampling distribution defines out of all the packets that match the traffic filter, which one of those are actually used for the measurement. One possibility is "all" which implies that all packets matching the Traffic filter are considered, but there may be other sampling strategies. It includes the following information:

Value: the name of the sampling distribution

Reference definition: pointer to the specification where the sampling distribution is properly defined.

The sampling distribution may require parameters. In case such parameters are needed, they should be included either in the Fixed parameter column or in the run time parameter column, depending on whether they will be fixed or will be an input for the metric.

Sampling and Filtering Techniques for IP Packet Selection are documented in the PSAMP (Packet Sampling) [[RFC5475](#)], while the Framework for Packet Selection and Reporting, [[RFC5474](#)] provides more background information. The sampling distribution parameters might be expressed in terms of the Information Model for Packet Sampling Exports, [[RFC5477](#)], and the Flow Selection Techniques, [[RFC7014](#)].

[7.3.5.](#) Run-time Parameters

Run-Time Parameters are Parameters that must be determined, configured into the measurement system, and reported with the results for the context to be complete. However, the values of these parameters is not specified in the Performance Metrics Registry (like the Fixed Parameters), rather these parameters are listed as an aid to the measurement system implementer or user (they must be left as variables, and supplied on execution).

Where metrics supply a list of Parameters as part of their descriptive template, a sub-set of the Parameters will be designated as Run-Time Parameters.

Parameters MUST have well defined names. For human readers, the hanging indent style is preferred, and the names and definitions that do not appear in the Reference Method Specification MUST appear in this column.

A Data Format for each Run-time Parameter MUST be specified in this column, to simplify the control and implementation of measurement devices. For example, parameters that include an IPv4 address can be encoded as a 32 bit integer (i.e. binary base64 encoded value) or ip-address as defined in [[RFC6991](#)]. The actual encoding(s) used must be explicitly defined for each Run-time parameter. IPv6 addresses and options MUST be accommodated, allowing Registered Metrics to be used in either address family.

Examples of Run-time Parameters include IP addresses, measurement point designations, start times and end times for measurement, and other information essential to the method of measurement.

[7.3.6.](#) Role

In some methods of measurement, there may be several roles defined, e.g., for a one-way packet delay active measurement there is one measurement agent that generates the packets and another agent that receives the packets. This column contains the name of the Role(s) for this particular entry. In the one-way delay example above, there should be two entries in the Role registry column, one for each Role (Source and Destination). When a measurement agent is instructed to perform the "Source" Role for one-way delay metric, the agent knows that it is required to generate packets. The values for this field are defined in the reference method of measurement (and this frequently results in abbreviated role names such as "Src").

When the Role column of a registry entry defines more than one Role, then the Role SHALL be treated as a Run-time Parameter and supplied for execution. It should be noted that the LMAP framework [[RFC7594](#)] distinguishes the Role from other Run-time Parameters, and defines a special parameter "Roles" inside the registry-grouping function list in the LMAP YANG model[RFC8194].

[7.4.](#) Output Category

For entries which involve a stream and many singleton measurements, a statistic may be specified in this column to summarize the results to

a single value. If the complete set of measured singletons is output, this will be specified here.

Some metrics embed one specific statistic in the reference metric definition, while others allow several output types or statistics.

7.4.1. Type

This column contains the name of the output type. The output type defines a single type of result that the metric produces. It can be the raw results (packet send times and singleton metrics), or it can be a summary statistic. The specification of the output type MUST define the format of the output. In some systems, format specifications will simplify both measurement implementation and collection/storage tasks. Note that if two different statistics are required from a single measurement (for example, both "Xth percentile mean" and "Raw"), then a new output type must be defined ("Xth percentile mean AND Raw"). See the Naming section above for a list of Output Types.

7.4.2. Reference Definition

This column contains a pointer to the specification(s) where the output type and format are defined.

7.4.3. Metric Units

The measured results must be expressed using some standard dimension or units of measure. This column provides the units.

When a sample of singletons (see [Section 11](#) of [RFC2330] for definitions of these terms) is collected, this entry will specify the units for each measured value.

7.4.4. Calibration

Some specifications for Methods of Measurement include the possibility to perform an error calibration. [Section 3.7.3 of \[RFC7679\]](#) is one example. In the registry entry, this field will identify a method of calibration for the metric, and when available, the measurement system SHOULD perform the calibration when requested and produce the output with an indication that it is the result of a calibration method. In-situ calibration could be enabled with an internal loopback that includes as much of the measurement system as possible, performs address manipulation as needed, and provides some form of isolation (e.g., deterministic delay) to avoid send-receive interface contention. Some portion of the random and systematic error can be characterized this way.

For one-way delay measurements, the error calibration must include an assessment of the internal clock synchronization with its external reference (this internal clock is supplying timestamps for measurement). In practice, the time offsets of clocks at both the source and destination are needed to estimate the systematic error due to imperfect clock synchronization (the time offsets are smoothed, thus the random variation is not usually represented in the results).

Both internal loopback calibration and clock synchronization can be used to estimate the *available accuracy* of the Output Metric Units. For example, repeated loopback delay measurements will reveal the portion of the Output result resolution which is the result of system noise, and thus inaccurate.

7.5. Administrative information

7.5.1. Status

The status of the specification of this Registered Performance Metric. Allowed values are 'current' and 'deprecated'. All newly defined Information Elements have 'current' status.

7.5.2. Requester

The requester for the Registered Performance Metric. The requester MAY be a document, such as RFC, or person.

7.5.3. Revision

The revision number of a Registered Performance Metric, starting at 0 for Registered Performance Metrics at time of definition and incremented by one for each revision.

7.5.4. Revision Date

The date of acceptance or the most recent revision for the Registered Performance Metric. The date SHALL be determined by the reviewing Performance Metrics Expert in the case of Expert Review, or by IANA in the case of Standards Action.

7.6. Comments and Remarks

Besides providing additional details which do not appear in other categories, this open Category (single column) allows for unforeseen issues to be addressed by simply updating this informational entry.

8. The Life-Cycle of Registered Performance Metrics

Once a Performance Metric or set of Performance Metrics has been identified for a given application, candidate Performance Metrics Registry entry specifications prepared in accordance with [Section 7](#) should be submitted to IANA to follow the process for review by the Performance Metric Experts, as defined below. This process is also used for other changes to the Performance Metrics Registry, such as deprecation or revision, as described later in this section.

It is desirable that the author(s) of a candidate Performance Metrics Registry entry seek review in the relevant IETF working group, or offer the opportunity for review on the working group mailing list.

8.1. Adding new Performance Metrics to the Performance Metrics Registry

Requests to add Registered Performance Metrics in the Performance Metrics Registry SHALL be submitted to IANA, which forwards the request to a designated group of experts (Performance Metric Experts) appointed by the IESG; these are the reviewers called for by the Expert Review [[RFC8126](#)] policy defined for the Performance Metrics Registry. The Performance Metric Experts review the request for such things as compliance with this document, compliance with other applicable Performance Metric-related RFCs, and consistency with the currently defined set of Registered Performance Metrics.

Submission to IANA MAY be during IESG review (leading to IETF Standards Action), where an Internet Draft proposes one or more Registered Performance Metrics to be added to the Performance Metrics Registry, including the text of the proposed Registered Performance Metric(s).

Authors of proposed Registered Performance Metrics SHOULD review compliance with the specifications in this document to check their submissions before sending them to IANA.

At least one Performance Metric Expert should endeavor to complete referred reviews in a timely manner. If the request is acceptable, the Performance Metric Experts signify their approval to IANA, and IANA updates the Performance Metrics Registry. If the request is not acceptable, the Performance Metric Experts MAY coordinate with the requester to change the request to be compliant, otherwise IANA SHALL coordinate resolution of issues on behalf of the expert. The Performance Metric Experts MAY choose to reject clearly frivolous or inappropriate change requests outright, but such exceptional circumstances should be rare.

This process should not in any way be construed as allowing the Performance Metric Experts to overrule IETF consensus. Specifically, any Registered Performance Metrics that were added to the Performance Metrics Registry with IETF consensus require IETF consensus for revision or deprecation.

Decisions by the Performance Metric Experts may be appealed as in [Section 7 of \[RFC8126\]](#).

8.2. Revising Registered Performance Metrics

A request for Revision is only permitted when the requested changes maintain backward-compatibility with implementations of the prior Performance Metrics Registry entry describing a Registered Performance Metric (entries with lower revision numbers, but the same Identifier and Name).

The purpose of the Status field in the Performance Metrics Registry is to indicate whether the entry for a Registered Performance Metric is 'current' or 'deprecated'.

In addition, no policy is defined for revising the Performance Metric entries in the IANA Registry or addressing errors therein. To be clear, changes and deprecations within the Performance Metrics Registry are not encouraged, and should be avoided to the extent possible. However, in recognition that change is inevitable, the provisions of this section address the need for revisions.

Revisions are initiated by sending a candidate Registered Performance Metric definition to IANA, as in [Section 8.1](#), identifying the existing Performance Metrics Registry entry, and explaining how and why the existing entry should be revised.

The primary requirement in the definition of procedures for managing changes to existing Registered Performance Metrics is avoidance of measurement interoperability problems; the Performance Metric Experts must work to maintain interoperability above all else. Changes to Registered Performance Metrics may only be done in an interoperable way; necessary changes that cannot be done in a way to allow interoperability with unchanged implementations MUST result in the creation of a new Registered Performance Metric (with a new Name, replacing the RFCXXXsecY portion of the name) and possibly the deprecation of the earlier metric.

A change to a Registered Performance Metric SHALL be determined to be backward-compatible only when:

1. it involves the correction of an error that is obviously only editorial; or
2. it corrects an ambiguity in the Registered Performance Metric's definition, which itself leads to issues severe enough to prevent the Registered Performance Metric's usage as originally defined; or
3. it corrects missing information in the metric definition without changing its meaning (e.g., the explicit definition of 'quantity' semantics for numeric fields without a Data Type Semantics value); or
4. it harmonizes with an external reference that was itself corrected.

If a Performance Metric revision is deemed permissible and backward-compatible by the Performance Metric Experts, according to the rules in this document, IANA SHOULD execute the change(s) in the Performance Metrics Registry. The requester of the change is appended to the original requester in the Performance Metrics Registry. The Name of the revised Registered Performance Metric, including the RFCXXXXsecY portion of the name, SHALL remain unchanged (even when the change is the result of IETF Standards Action; the revised registry entry SHOULD reference the new RFC in an appropriate category and column).

Each Registered Performance Metric in the Performance Metrics Registry has a revision number, starting at zero. Each change to a Registered Performance Metric following this process increments the revision number by one.

When a revised Registered Performance Metric is accepted into the Performance Metrics Registry, the date of acceptance of the most recent revision is placed into the revision Date column of the registry for that Registered Performance Metric.

Where applicable, additions to Registered Performance Metrics in the form of text Comments or Remarks should include the date, but such additions may not constitute a revision according to this process.

Older version(s) of the updated metric entries are kept in the registry for archival purposes. The older entries are kept with all fields unmodified (version, revision date) except for the status field that SHALL be changed to "Deprecated".

8.3. Deprecating Registered Performance Metrics

Changes that are not permissible by the above criteria for Registered Performance Metric's revision may only be handled by deprecation. A Registered Performance Metric MAY be deprecated and replaced when:

1. the Registered Performance Metric definition has an error or shortcoming that cannot be permissibly changed as in [Section 8.2](#) Revising Registered Performance Metrics; or
2. the deprecation harmonizes with an external reference that was itself deprecated through that reference's accepted deprecation method.

A request for deprecation is sent to IANA, which passes it to the Performance Metric Experts for review. When deprecating an Performance Metric, the Performance Metric description in the Performance Metrics Registry must be updated to explain the deprecation, as well as to refer to any new Performance Metrics created to replace the deprecated Performance Metric.

The revision number of a Registered Performance Metric is incremented upon deprecation, and the revision Date updated, as with any revision.

The use of deprecated Registered Performance Metrics should result in a log entry or human-readable warning by the respective application.

Names and Metric IDs of deprecated Registered Performance Metrics must not be reused.

The deprecated entries are kept with all fields unmodified, except the version, revision date, and the status field (changed to "Deprecated").

9. Security considerations

This draft defines a registry structure, and does not itself introduce any new security considerations for the Internet. The definition of Performance Metrics for this registry may introduce some security concerns, but the mandatory references should have their own considerations for security, and such definitions should be reviewed with security in mind if the security considerations are not covered by one or more reference standards.

10. IANA Considerations

With the background and processes described in earlier sections, this document requests the following IANA Actions. Note that mock-ups of the implementation of this set of requests have been prepared with IANA's help during development of this memo, and have been captured in the Proceedings of IPPM working group sessions.

10.1. Registry Group

The new registry group SHALL be named, "PERFORMANCE METRICS Group".

10.2. Performance Metric Name Elements

This document specifies the procedure for Performance Metrics Name Element Registry setup. IANA is requested to create a new set of registries for Performance Metric Name Elements called "Registered Performance Metric Name Elements". Each Registry, whose names are listed below:

MetricType:

Method:

SubTypeMethod:

Spec:

Units:

Output:

will contain the current set of possibilities for Performance Metrics Registry Entry Names.

To populate the Registered Performance Metric Name Elements at creation, the IANA is asked to use the lists of values for each name element listed in [Section 7.1.2](#). The Name Elements in each registry are case-sensitive.

When preparing a Metric entry for Registration, the developer SHOULD choose Name elements from among the registered elements. However, if the proposed metric is unique in a significant way, it may be necessary to propose a new Name element to properly describe the metric, as described below.

A candidate Metric Entry RFC or document for Expert Review would propose one or more new element values required to describe the

unique entry, and the new name element(s) would be reviewed along with the metric entry. New assignments for Registered Performance Metric Name Elements will be administered by IANA through Expert Review [[RFC8126](#)], i.e., review by one of a group of experts, the Performance Metric Experts, who are appointed by the IESG upon recommendation of the Transport Area Directors.

[10.3.](#) New Performance Metrics Registry

This document specifies the procedure for Performance Metrics Registry setup. IANA is requested to create a new registry for Performance Metrics called "Performance Metrics Registry". This Registry will contain the following Summary columns:

Identifier:

Name:

URIs:

Description:

Reference:

Change Controller:

Version:

Descriptions of these columns and additional information found in the template for registry entries (categories and columns) are further defined in section [Section 7](#).

The "Identifier" 0 should be Reserved. "The Identifier" values from 64512 to 65536 are reserved for private use.

Names starting with the prefix Priv_ are reserved for private use, and are not considered for registration. The "Name" column entries are further defined in section [Section 7](#).

The "URIs" column will have a URL to the full template of each registry entry. The Registry Entry text SHALL be HTML-ized to aid the reader, with links to reference RFCs (similar to the way that Internet Drafts are HTML-ized, the same tool can perform the function).

The "Reference" column will include an RFC number, an approved specification designator from another standards body, or the contact person.

New assignments for Performance Metrics Registry will be administered by IANA through Expert Review [[RFC8126](#)], i.e., review by one of a group of experts, the Performance Metric Experts, who are appointed by the IESG upon recommendation of the Transport Area Directors, or by Standards Action. The experts can be initially drawn from the Working Group Chairs, document editors, and members of the Performance Metrics Directorate, among other sources of experts.

Extensions of the Performance Metrics Registry require IETF Standards Action. Only one form of registry extension is envisaged:

1. Adding columns, or both categories and columns, to accommodate unanticipated aspects of new measurements and metric categories.

If the Performance Metrics Registry is extended in this way, the Version number of future entries complying with the extension SHALL be incremented (either in the unit or tenths digit, depending on the degree of extension).

11. Acknowledgments

Thanks to Brian Trammell and Bill Cervený, IPPM chairs, for leading some brainstorming sessions on this topic. Thanks to Barbara Stark and Juergen Schoenwaelder for the detailed feedback and suggestions. Thanks to Andrew McGregor for suggestions on metric naming. Thanks to Michelle Cotton for her early IANA review, and to Amanda Barber for answering questions related to the presentation of the registry and accessibility of the complete template via URL.

12. References

12.1. Normative References

- [RFC2026] Bradner, S., "The Internet Standards Process -- Revision 3", [BCP 9](#), [RFC 2026](#), DOI 10.17487/RFC2026, October 1996, <<https://www.rfc-editor.org/info/rfc2026>>.
- [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>>.

- [RFC3986] Berners-Lee, T., Fielding, R., and L. Masinter, "Uniform Resource Identifier (URI): Generic Syntax", STD 66, [RFC 3986](#), DOI 10.17487/RFC3986, January 2005, <<https://www.rfc-editor.org/info/rfc3986>>.
- [RFC6390] Clark, A. and B. Claise, "Guidelines for Considering New Performance Metric Development", [BCP 170](#), [RFC 6390](#), DOI 10.17487/RFC6390, October 2011, <<https://www.rfc-editor.org/info/rfc6390>>.
- [RFC6576] Geib, R., Ed., Morton, A., Fardid, R., and A. Steinmitz, "IP Performance Metrics (IPPM) Standard Advancement Testing", [BCP 176](#), [RFC 6576](#), DOI 10.17487/RFC6576, March 2012, <<https://www.rfc-editor.org/info/rfc6576>>.
- [RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", [BCP 26](#), [RFC 8126](#), DOI 10.17487/RFC8126, June 2017, <<https://www.rfc-editor.org/info/rfc8126>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

12.2. Informative References

- [I-D.ietf-ippm-initial-registry]
Morton, A., Bagnulo, M., Eardley, P., and K. D'Souza, "Initial Performance Metrics Registry Entries", [draft-ietf-ippm-initial-registry-11](#) (work in progress), March 2019.
- [RFC2681] Almes, G., Kalidindi, S., and M. Zekauskas, "A Round-trip Delay Metric for IPPM", [RFC 2681](#), DOI 10.17487/RFC2681, September 1999, <<https://www.rfc-editor.org/info/rfc2681>>.
- [RFC3432] Raisanen, V., Grotefeld, G., and A. Morton, "Network performance measurement with periodic streams", [RFC 3432](#), DOI 10.17487/RFC3432, November 2002, <<https://www.rfc-editor.org/info/rfc3432>>.
- [RFC3550] Schulzrinne, H., Casner, S., Frederick, R., and V. Jacobson, "RTP: A Transport Protocol for Real-Time Applications", STD 64, [RFC 3550](#), DOI 10.17487/RFC3550, July 2003, <<https://www.rfc-editor.org/info/rfc3550>>.

- [RFC3611] Friedman, T., Ed., Caceres, R., Ed., and A. Clark, Ed., "RTP Control Protocol Extended Reports (RTCP XR)", [RFC 3611](#), DOI 10.17487/RFC3611, November 2003, <<https://www.rfc-editor.org/info/rfc3611>>.
- [RFC4148] Stephan, E., "IP Performance Metrics (IPPM) Metrics Registry", [BCP 108](#), [RFC 4148](#), DOI 10.17487/RFC4148, August 2005, <<https://www.rfc-editor.org/info/rfc4148>>.
- [RFC5474] Duffield, N., Ed., Chiou, D., Claise, B., Greenberg, A., Grossglauser, M., and J. Rexford, "A Framework for Packet Selection and Reporting", [RFC 5474](#), DOI 10.17487/RFC5474, March 2009, <<https://www.rfc-editor.org/info/rfc5474>>.
- [RFC5475] Zseby, T., Molina, M., Duffield, N., Niccolini, S., and F. Raspall, "Sampling and Filtering Techniques for IP Packet Selection", [RFC 5475](#), DOI 10.17487/RFC5475, March 2009, <<https://www.rfc-editor.org/info/rfc5475>>.
- [RFC5477] Dietz, T., Claise, B., Aitken, P., Dressler, F., and G. Carle, "Information Model for Packet Sampling Exports", [RFC 5477](#), DOI 10.17487/RFC5477, March 2009, <<https://www.rfc-editor.org/info/rfc5477>>.
- [RFC6035] Pendleton, A., Clark, A., Johnston, A., and H. Sinnreich, "Session Initiation Protocol Event Package for Voice Quality Reporting", [RFC 6035](#), DOI 10.17487/RFC6035, November 2010, <<https://www.rfc-editor.org/info/rfc6035>>.
- [RFC6248] Morton, A., "[RFC 4148](#) and the IP Performance Metrics (IPPM) Registry of Metrics Are Obsolete", [RFC 6248](#), DOI 10.17487/RFC6248, April 2011, <<https://www.rfc-editor.org/info/rfc6248>>.
- [RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", [RFC 6991](#), DOI 10.17487/RFC6991, July 2013, <<https://www.rfc-editor.org/info/rfc6991>>.
- [RFC7012] Claise, B., Ed. and B. Trammell, Ed., "Information Model for IP Flow Information Export (IPFIX)", [RFC 7012](#), DOI 10.17487/RFC7012, September 2013, <<https://www.rfc-editor.org/info/rfc7012>>.
- [RFC7014] D'Antonio, S., Zseby, T., Henke, C., and L. Peluso, "Flow Selection Techniques", [RFC 7014](#), DOI 10.17487/RFC7014, September 2013, <<https://www.rfc-editor.org/info/rfc7014>>.

- [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>>.
- [RFC7679] Almes, G., Kalidindi, S., Zekauskas, M., and A. Morton, Ed., "A One-Way Delay Metric for IP Performance Metrics (IPPM)", STD 81, [RFC 7679](#), DOI 10.17487/RFC7679, January 2016, <<https://www.rfc-editor.org/info/rfc7679>>.
- [RFC7799] Morton, A., "Active and Passive Metrics and Methods (with Hybrid Types In-Between)", [RFC 7799](#), DOI 10.17487/RFC7799, May 2016, <<https://www.rfc-editor.org/info/rfc7799>>.
- [RFC8194] Schoenwaelder, J. and V. Bajpai, "A YANG Data Model for LMAP Measurement Agents", [RFC 8194](#), DOI 10.17487/RFC8194, August 2017, <<https://www.rfc-editor.org/info/rfc8194>>.

Authors' Addresses

Marcelo Bagnulo
Universidad Carlos III de Madrid
Av. Universidad 30
Leganes, Madrid 28911
SPAIN

Phone: 34 91 6249500
Email: marcelo@it.uc3m.es
URI: <http://www.it.uc3m.es>

Benoit Claise
Cisco Systems, Inc.
De Kleetlaan 6a b1
1831 Diegem
Belgium

Email: bclaise@cisco.com

Philip Eardley
BT
Adastral Park, Martlesham Heath
Ipswich
ENGLAND

Email: philip.eardley@bt.com

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

Email: acmorton@att.com

Aamer Akhter
Consultant
118 Timber Hitch
Cary, NC
USA

Email: aakhter@gmail.com

