

Network Working Group
Internet Draft
Document: <[draft-morton-ippm-composition-01.txt](#)>

A.Morton, Editor
AT&T Labs
E.Stephane
FranceTelecom

Category: Individual

Spatial Composition of Metrics

Status of this Memo

By submitting this Internet-Draft, each author represents that any applicable patent or other IPR claims of which he or she is aware have been or will be disclosed, and any of which he or she becomes aware will be disclosed, in accordance with [Section 6 of BCP 79](#).

This document is an Internet-Draft and is subject to all provisions of [section 3 of BCP 78](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

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."

The list of current Internet-Drafts can be accessed at <http://www.ietf.org/ietf/lid-abstracts.txt>

The list of Internet-Draft Shadow Directories can be accessed at <http://www.ietf.org/shadow.html>.

Copyright Notice

Copyright (C) The Internet Society (2005).

Abstract

This memo utilizes IPPM metrics that are applicable to both complete paths and sub-paths, and defines relationships to compose a complete path metric from the sub-path metrics with some accuracy w.r.t. the actual metrics. This is called Spatial Composition in [RFC 2330](#). The

current version of the memo gives some background and proposes wording for a Scope and Application section to define this new work. The description of several example metrics and statistics follow.

Morton, et al.

Individual exp. April 2006

Page 1

Spatial Composition of Metrics

October 2005

Contents

Status of this Memo.....	1
Copyright Notice.....	1
Abstract.....	1
Authors/Contributors.....	3
1 . Conventions used in this document.....	3
2 . Introduction.....	3
2.1 Motivation.....	4
3 . Proposed Scope and Application.....	5
3.1 Scope of Work.....	5
3.2 Application.....	6
3.3 Terminology.....	6
4 . One-way Delay Composition Metrics and Statistics.....	7
4.1 Name: Type-P-Finite-One-way-Delay-Poisson/Periodic-Stream.....	7
4.1.1 Metric Parameters:.....	7
4.1.2 Definition:.....	7
4.1.3 Discussion and other details.....	7
4.1.4 Mean Statistic.....	7
4.1.5 Composition Relationship: Sum of Mean Delays.....	8
4.1.6 Statement of Conjecture.....	8
4.1.7 Justification for the composite relationship.....	8
4.1.8 Sources of Error.....	8
4.1.9 Specific cases where the conjecture might fail.....	9
4.1.10 Application of Measurement Methodology.....	9
5 . Loss Metrics/Statistics.....	9
5.1 Name: Type-P-One-way-Packet-Loss-Poisson/Periodic-Stream.....	9
5.1.1 Metric Parameters:.....	10
5.1.2 Metric Units:.....	10
5.1.3 Discussion and other details.....	10
5.1.4 Statistic: Type-P-One-way-Packet-Loss-Empirical-Probability	10
5.1.5 Composition Relationship: Combination of Empirical	
Probabilities.....	11
5.1.6 Statement of Conjecture.....	11
5.1.7 Justification for the composite relationship.....	11
5.1.8 Sources of Error.....	11
5.1.9 Specific cases where the conjecture might fail.....	12
5.1.10 Application of Measurement Methodology.....	12
6 . Delay Variation Metrics/Statistics.....	12
7 . Other Metrics/Statistics: One-way combined Metric.....	12

7.1 Metric Name.....	13
7.1.1 Metric Parameters:.....	13
7.1.2 Definition:.....	13
7.1.3 Discussion and other details.....	13
7.1.4 Type-P-One-way-Combo-subpathes-stream.....	13
7.1.5 Type-P-One-way-composition.....	14
7.1.6 Type-P-One-way-composition-stream.....	14
7.1.7 Statement of Conjecture.....	15
7.1.8 Justification for the composite relationship.....	15
7.1.9 Sources of Error.....	15

Morton, et al. Individual exp. April 2006

Page 2

Spatial Composition of Metrics

October 2005

7.1.10 Specific cases where the conjecture might fail.....	15
7.1.11 Application of Measurement Methodology.....	15
8. Security Considerations.....	15
8.1 Denial of Service Attacks.....	15
8.2 User data confidentiality.....	16
8.3 Interference with the metric.....	16
9. IANA Considerations.....	16
10. Normative References.....	16
11. Informative References.....	17
12. Open issues.....	18
13. Acknowledgments.....	18
14. Author's Addresses.....	18
Full Copyright Statement.....	18
Intellectual Property.....	19
Acknowledgement.....	19

Authors/Contributors

Thus far, the following people have contributed useful ideas, suggestions, or the text of sections that have been incorporated into this memo:

- Phil Chimento <vze275m9@verizon.net>
- Reza Fardid <RFardid@Covad.COM>
- Roman Krzanowski <roman.krzanowski@verizon.com>
- Maurizio Molina <maurizio.molina@dante.org.uk>
- Al Morton <acmorton@att.com>
- Emile Stephan <emile.stephan@francetelecom.com>
- Lei Liang <L.Liang@surrey.ac.uk>

[1.](#) Conventions used in this document

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](#)]. Although [RFC 2119](#) was written with protocols in mind, the key words are used in this document for similar reasons. They are used to ensure the results of measurements from two different implementations are comparable, and to note instances when an implementation could perturb the network.

In this memo, the characters "<=" should be read as "less than or equal to" and ">=" as "greater than or equal to".

[2.](#) Introduction

The IPPM framework [RFC 2330](#) [[RFC2330](#)] describes two forms of metric composition, spatial and temporal. Spatial composition encompasses the definitions of performance metrics that are applicable to the complete path, and to various sub-paths. Also, the text suggests

Morton, et al.

Individual exp. April 2006

Page 3

Spatial Composition of Metrics

October 2005

that the concepts of the analytical framework (or A-frame) would help to define useful relationships between the complete path metrics and the sub-path metrics. The effectiveness of such metrics is dependent on their usefulness in analysis and applicability with practical measurement methods.

The relationships may involve conjecture, and [[RFC2330](#)] lists four points that the metric definitions should include:

- + the specific conjecture applied to the metric,
- + a justification of the practical utility of the composition in terms of making accurate measurements of the metric on the path,
- + a justification of the usefulness of the composition in terms of making analysis of the path using A-frame concepts more effective, and
- + an analysis of how the conjecture could be incorrect.

[RFC 2330](#) also gives an example where a conjecture that the delay of a path is very nearly the sum of the delays of the exchanges and clouds of the corresponding path digest. This example is particularly relevant to those who wish to assess the performance of an Inter-domain path without direct measurement, and the performance estimate of the complete path is related to the measured results for various sub-paths instead.

Approximate relationships between the sub-path and complete path metrics are useful, with knowledge of the circumstances where the relationships are/are not applicable. For example, we would not

process, beyond the measurement of the complete path?

Is the decomposition described above intended to estimate a metric for some/all disjoint sub-paths involved in the complete path?

[illegible]

3. Proposed Scope and Application

3.1 Scope of Work

For the primary IPPM metrics (currently Loss, Delay, and Delay Variation), this memo gives a set of complete path metrics that can be composed from the same or similar sub-path metrics. This means that the complete path metric may be composed from:

- + the same metric for each sub-path;
- + multiple metrics for each sub-path (possibly one that is the same as the complete path metric);
- + a single sub-path metrics that is different from the complete path metric;
- + different measurement techniques like active and passive (recognizing that PSAMP WG will define capabilities to sample packets to support measurement).

Each metric will clearly state:

- the definition (and statistic, where appropriate);
- the composition relationship;
- the specific conjecture on which the relationship is based;
- a justification of practical utility or usefulness for analysis using the A-frame concepts;
- one or more examples of how the conjecture could be incorrect and lead to inaccuracy;
- the information to be reported;

[3.2](#) Application

For each metric, the applicable circumstances are defined, in terms of whether the composition:

Requires the same test packets to traverse all sub-paths, or may use similar packets sent and collected separately in each sub-path.

Requires homogeneity of measurement methodologies, or can allow a degree of flexibility (e.g., active or passive methods produce the "same" metric). Also, the applicable sending streams will be specified, such as Poisson, Periodic, or both.

Needs information or access that will only be available within an operator's domain, or is applicable to Inter-domain composition.

Requires synchronized measurement time intervals in all sub-paths, or largely overlapping, or no timing requirements.

Requires assumption of sub-path independence w.r.t. the metric being defined/composed, or other assumptions.

Has known sources of inaccuracy/error, and identifies the sources.

[3.3](#) Terminology

This section will define the terminology applicable to both complete path and sub-path metrics.

Measurement Points:

<there must be a suitable definition for this in IPPM⁹⁹₉₂s literature>

Equivalent measure:

The equivalent measure is the end-to-end metric that a composite metric is estimating.

Equivalent path:

The Equivalent path is the list of sub path that is equivalent to the path of the end-to-end measure the composition measure is estimating.

[4. One-way Delay Composition Metrics and Statistics](#)

[4.1 Name: Type-P-Finite-One-way-Delay-Poisson/Periodic-Stream](#)

[4.1.1 Metric Parameters:](#)

- + Src, the IP address of a host
- + Dst, the IP address of a host
- + T, a time (start of test interval)
- + Tf, a time (end of test interval)
- + lambda, a rate in reciprocal seconds (for Poisson Streams)
- + incT, the nominal duration of inter-packet interval, first bit to first bit (for Periodic Streams)
- + T0, a time that MUST be selected at random from the interval [T, T+dT] to start generating packets and taking measurements (for Periodic Streams)
- + TstampSrc, the wire time of the packet as measured at MP(Src)
- + TstampDst, the wire time of the packet as measured at MP(Dst), assigned to packets that arrive within a "reasonable" time.

[4.1.2 Definition:](#)

Using the parameters above, we obtain the value of Type-P-One-way-Delay singleton as per [RFC 2679](#) [[RFC2679](#)]. For each packet [i] that has a finite One-way Delay (in other words, excluding packets which have undefined, or infinite one-way delay):

$$\text{Type-P-Finite-One-way-Delay-Poisson/Periodic-Stream}[i] = \text{FiniteDelay}[i] = \text{TstampDst} - \text{TstampSrc}$$

[4.1.3 Discussion and other details...](#)

[4.1.4 Mean Statistic](#)

- + L, the total number of packets received at Dst (sent between T0

and T_f)

The

Type-P-Finite-One-way-Delay-Mean =

$$\text{MeanDelay} = (1/L) \text{Sum}(\text{from } i=1 \text{ to } L, \text{FiniteDelay}[i])$$

where all packets $i=1$ through L have finite singleton delays.

[4.1.5](#) Composition Relationship: Sum of Mean Delays

The Type-P-Finite-Composite-One-way-Delay-Mean, or MeanDelay for the complete Source to Destination path can be calculated from sum of the Mean Delays of all its S constituent sub-paths.

+ S , the number of sub-paths involved in the complete Src-Dst path

Then the

Type-P-Finite-Composite-One-way-Delay-Mean =

$$\text{CompMeanDelay} = (1/S) \text{Sum}(\text{from } i=1 \text{ to } S, \text{MeanDelay}[i])$$

[4.1.6](#) Statement of Conjecture

The mean of a sufficiently large stream of packets measured on each sub-path during the interval $[T, T_f]$ will be representative of the true mean of the delay distribution (and the distributions themselves are sufficiently independent), such that the means may be added to produce an estimate of the complete path mean delay.

[4.1.7](#) Justification for the composite relationship

It is sometimes impractical to conduct active measurements between every Src-Dst pair. For example, it may not be possible to collect the desired sample size in each test interval when access link speed is limited, because of the potential for measurement traffic to degrade the user traffic performance. The conditions on a low-speed access link may be understood well-enough to permit use of a small sample size/rate, while a larger sample size/rate may be used on other sub-paths.

Also, since measurement operations have a real monetary cost, there is value in re-using measurements where they are applicable, rather than launching new measurements for every possible source-destination pair.

[4.1.8](#) Sources of Error

The measurement packets, each having source and destination addresses intended for collection at edges of the sub-path, may take a different specific path through the network equipment and parallel exchanges than packets with the source and destination addresses of the complete path. Therefore, the sub-path measurements may differ from the performance experienced by packets on the complete path. Multiple measurements employing sufficient sub-path address pairs might produce bounds on the extent of this error.

others...

[4.1.9](#) Specific cases where the conjecture might fail

If any of the sub-path distributions are bimodal, then the measured means may not be stable, and in this case the mean will not be a particularly useful statistic when describing the delay distribution of the complete path.

The mean may not be sufficiently robust statistic to produce a reliable estimate, or to be useful even if it can be measured.

others...

[4.1.10](#) Application of Measurement Methodology

The methodology:

SHOULD use similar packets sent and collected separately in each sub-path.

Allows a degree of flexibility (e.g., active or passive methods can produce the "same" metric, but timing and correlation of passive measurements is much more challenging).

Poisson and/or Periodic streams are RECOMMENDED.

Applicable to both Inter-domain and Intra-domain composition.

SHOULD have synchronized measurement time intervals in all sub-paths, but largely overlapping intervals MAY suffice.

REQUIRES assumption of sub-path independence w.r.t. the metric being defined/composed.

5. Loss Metrics/Statistics

>>>>>>>>>>>>>>>>>>>

Editor's note: there is considerable redundancy between the material in sections [5.1](#) and [4.1](#), need to determine how best to reduce it.

5.1 Name: Type-P-One-way-Packet-Loss-Poisson/Periodic-Stream

Morton, et al.

Individual exp. April 2006

Page 9

Spatial Composition of Metrics

October 2005

5.1.1 Metric Parameters:

- + Src, the IP address of a host
- + Dst, the IP address of a host
- + T, a time (start of test interval)
- + Tf, a time (end of test interval)
- + lambda, a rate in reciprocal seconds (for Poisson Streams)
- + incT, the nominal duration of inter-packet interval, first bit to first bit (for Periodic Streams)
- + T0, a time that MUST be selected at random from the interval [T, T+dT] to start generating packets and taking measurements (for Periodic Streams)
- + TstampSrc, the wire time of the packet as measured at MP(Src)
- + TstampDst, the wire time of the packet as measured at MP(Dst), assigned to packets that arrive within a "reasonable" time.
- + Tmax, a maximum waiting time for packets at the destination

5.1.2 Metric Units:

Using the parameters above, we obtain the value of Type-P-One-way-Packet-Loss singleton and stream as per [RFC 2680](#) [[RFC2680](#)]. We obtain a sequence of pairs with elements as follows:

- + TstampSrc, as above
- + L, either zero or one, where L=1 indicates loss and L=0 indicates

arrival at the destination within $T_{\text{stampSrc}} + T_{\text{max}}$.

[5.1.3](#) Discussion and other details...

[5.1.4](#) Statistic: Type-P-One-way-Packet-Loss-Empirical-Probability

Given the following stream parameter

+ N , the total number of packets sent between T_0 and T_f

We can define the Empirical Probability of Loss Statistic (E_p), consistent with Average Loss in [\[RFC2680\]](#), as follows:

Type-P-One-way-Packet-Loss-Empirical-Probability =

Morton, et al. Individual exp. April 2006

Page 10

Spatial Composition of Metrics

October 2005

$$E_p = (1/N) \text{Sum}(\text{from } i=1 \text{ to } N, L[i])$$

where all packets $i=1$ through N have a value for L .

[5.1.5](#) Composition Relationship: Combination of Empirical Probabilities

The Type Type-P-One-way-Composite-Packet-Loss-Empirical-Probability, or $\text{Comp}E_p$ for the complete Source to Destination path can be calculated by combining E_p of all its constituent sub-paths (E_{p1} , E_{p2} , E_{p3} , ... E_{pn}) as

Type-P-One-way-Composite-Packet-Loss-Empirical-Probability =
 $\text{Comp}E_p = 1 - \{(1 - E_{p1}) \times (1 - E_{p2}) \times (1 - E_{p3}) \times \dots \times (1 - E_{pn})\}$

[5.1.6](#) Statement of Conjecture

The empirical probability of loss calculated on a sufficiently large stream of packets measured on each sub-path during the interval $[T, T_f]$ will be representative of the true loss probability (and the probabilities themselves are sufficiently independent), such that the sub-path probabilities may be combined to produce an estimate of the complete path loss probability.

[5.1.7](#) Justification for the composite relationship

It is sometimes impractical to conduct active measurements between every Src-Dst pair. For example, it may not be possible to collect the desired sample size in each test interval when access link speed is limited, because of the potential for measurement traffic to

degrade the user traffic performance. The conditions on a low-speed access link may be understood well-enough to permit use of a small sample size/rate, while a larger sample size/rate may be used on other sub-paths.

Also, since measurement operations have a real monetary cost, there is value in re-using measurements where they are applicable, rather than launching new measurements for every possible source-destination pair.

[5.1.8](#) Sources of Error

The measurement packets, each having source and destination addresses intended for collection at edges of the sub-path, may take a different specific path through the network equipment and parallel exchanges than packets with the source and destination addresses of the complete path. Therefore, the sub-path measurements may differ from the performance experienced by packets on the complete path. Multiple measurements employing sufficient sub-path address pairs might produce bounds on the extent of this error.

others...

Morton, et al.

Individual exp. April 2006

Page 11

Spatial Composition of Metrics

October 2005

[5.1.9](#) Specific cases where the conjecture might fail

A concern for loss measurements combined in this way is that root causes may be correlated to some degree.

For example, if the links of different networks follow the same physical route, then a single event like a tunnel fire could cause an outage or congestion on remaining paths in multiple networks. Here it is important to ensure that measurements before the event and after the event are not combined to estimate the composite performance.

Or, when traffic volumes rise due to the rapid spread of an email-born worm, loss due to queue overflow in one network may help another network to carry its traffic without loss.

others...

[5.1.10](#) Application of Measurement Methodology

The methodology:

to end measure of a sub-path, or to the spatial measure of the sub-path:

- Type-P-One-way-Delay-Poisson-Stream as per [RFC2679];
- Type-P-One-way-Delay-Periodic-Stream as per [RFC3432];
- Type-P-One-way-Composition-Stream as defined below;
- Type-P-subpath-One-way-Delay-Stream as per [I-D.stephan-ippm-multimetrics].

7.1.2 Definition:

Using the value $\langle P_1, T_1, dt_1 \rangle \dots \langle P_n, T_n, dt_n \rangle$ of one of the One-way delay Stream listed above, we define Type-P-One-way-Combo as the couple (D,L) where D is the mean of the delay of the packets that have a finite One-way, and where L is the average of lost of packets (which have undefined, or infinite one-way delay).

D corresponds to the Type-P-Finite-One-way-Delay-Mean defined above.

L corresponds to the Type-P-One-way-Packet-Loss-Empirical-Probability defined above.

7.1.3 Discussion and other details...

7.1.4 Type-P-One-way-Combo-subpathes-stream

Parameters:

+ dT_1, \dots, dT_n a list of delay.

+ $\langle \text{Src}, H_1, H_2, \dots, H_n, \text{Dst} \rangle$, the equivalent path.

Definition:

Using Type-P-One-way-Combo-mean of each sub-path in the equivalent path we define a Type-P-One-way-subpathes-stream as the list of couples (D,L) of the sub-path list;

Results: $\{ \langle D_0, L_0 \rangle, \langle D_1, L_1 \rangle, \langle D_2, L_2 \rangle, \dots, \langle D_n, L_n \rangle \}$

[7.1.5](#) Type-P-One-way-composition

The composition over a path gives D and L which give an estimation of the end-to-end delay and end-to-end packet lost over this path.

Parameters:

- + $\langle \text{Src}, H1, H2, \dots, Hn, \text{Dst} \rangle$, the equivalent path.
- + $\{ \langle D0, L0 \rangle, \langle D1, L1 \rangle, \langle D2, L2 \rangle, \dots, \langle Dn, Ln \rangle \}$, the composition stream of the sub-paths of a path.

Definition:

Using Type-P-One-way-subpaths-stream we define Type-P-One-way-composition as the couple $\langle D, L \rangle$ where D is the mean of the delays D_i and where L is the average of lost of L_i .

Results: $\langle D, L \rangle$, where D is a delay and L is the lost

[7.1.6](#) Type-P-One-way-composition-stream

The sample of Type-P-One-way-composition is defined to permit the usage of the results of Type-P-One-way-composition measure in computation of Type-P-One-way-Combo-mean composition.

Parameters:

- + $T1, \dots, Tn$, a list of time;
- + $\langle D, L \rangle$, the delay and the lost computed by composition.

Definition:

Using Type-P-One-way-composition we define Type-P-One-way-composition-stream as the stream of couples $\langle D, L \rangle$ over time.

Results: $\langle T1, D1, L1 \rangle \dots \langle Tn, Dn, Ln \rangle$

[7.1.7](#) Statement of Conjecture

[7.1.8](#) Justification for the composite relationship

Combo metric is very easy to measure and to compose.

It gives the delay and the lost, so most of the need.

Combo metric may be performed on com metric too.

[7.1.9](#) Sources of Error

Packets may cross different sub path than the equivalent end-to-end measure because Type-P differ.

Packets may experiment different behavior than the equivalent end-to-end measure because of access classification based on packet addresses.

[7.1.10](#) Specific cases where the conjecture might fail

When

- + Sum of subpath differ from the equivalent path.
- + Type-P differ.
- + Size differ.

[7.1.11](#) Application of Measurement Methodology

The methodology:

Is applicable to Intra and interdomain;

SHOULD report the context of the measure;

[8.](#) Security Considerations

[8.1](#) Denial of Service Attacks

This metric requires a stream of packets sent from one host (source) to another host (destination) through intervening networks. This method could be abused for denial of service attacks directed at

destination and/or the intervening network(s).

Administrators of source, destination, and the intervening network(s) should establish bilateral or multi-lateral agreements regarding the timing, size, and frequency of collection of sample metrics. Use of this method in excess of the terms agreed between the participants may be cause for immediate rejection or discard of packets or other escalation procedures defined between the affected parties.

8.2 User data confidentiality

Active use of this method generates packets for a sample, rather than taking samples based on user data, and does not threaten user data confidentiality. Passive measurement must restrict attention to the headers of interest. Since user payloads may be temporarily stored for length analysis, suitable precautions MUST be taken to keep this information safe and confidential. In most cases, a hashing function will produce a value suitable for payload comparisons.

8.3 Interference with the metric

It may be possible to identify that a certain packet or stream of packets is part of a sample. With that knowledge at the destination and/or the intervening networks, it is possible to change the processing of the packets (e.g. increasing or decreasing delay) that may distort the measured performance. It may also be possible to generate additional packets that appear to be part of the sample metric. These additional packets are likely to perturb the results of the sample measurement.

To discourage the kind of interference mentioned above, packet interference checks, such as cryptographic hash, may be used.

9. IANA Considerations

Metrics defined in this memo will be registered in the IANA IPPM METRICS REGISTRY as described in initial version of the registry [[RFC4148](#)].

10. Normative References

- [RFC791] Postel, J., "Internet Protocol", STD 5, [RFC 791](#), September 1981.
Obtain via: <http://www.rfc-editor.org/rfc/rfc791.txt>

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [RFC 2119](#), March 1997.
Obtain via: <http://www.rfc-editor.org/rfc/rfc2119.txt>

Morton, et al.

Individual exp. April 2006

Page 16

Spatial Composition of Metrics

October 2005

- [RFC2330] Paxson, V., Almes, G., Mahdavi, J., and Mathis, M., "Framework for IP Performance Metrics", [RFC 2330](#), May 1998.
Obtain via: <http://www.rfc-editor.org/rfc/rfc2330.txt>
- [RFC2679] Almes, G., Kalidindi, S. and M. Zekauskas, "A one-way delay metric for IPPM", [RFC 2679](#), September 1999.
Obtain via: <http://www.rfc-editor.org/rfc/rfc2679.txt>
- [RFC2680] Almes, G., Kalidindi, S. and M. Zekauskas, "A one-way packet loss metric for IPPM", [RFC 2680](#), September 1999.
Obtain via: <http://www.rfc-editor.org/rfc/rfc2680.txt>
- [RFC3148] Mathis, M. and Allman, M., "A Framework for Defining Empirical Bulk Transfer Capacity Metrics", [RFC 3148](#), July 2001.
Obtain via: <http://www.rfc-editor.org/rfc/rfc3148.txt>
- [RFC3432] Raisanen, V., Grotefeld, G., and Morton, A., "Network performance measurement with periodic streams", [RFC 3432](#), November 2002.
- [RFC4148] Stephan, E., "IP Performance Metrics (IPPM) Metrics Registry", [BCP 108](#), [RFC 4148](#), August 2005.

11. Informative References

- [I.356] ITU-T Recommendation I.356, "B-ISDN ATM layer cell transfer performance", March 2000.
- [Pax98] V.Paxson, "Measurements and Analysis of End-to-End Internet Dynamics," Ph.D. dissertation, U.C. Berkeley, 1997, <ftp://ftp.ee.lbl.gov/papers/vp-thesis/dis.ps.gz>.
- [RFC3393] Demichelis, C., and Chimento, P., "IP Packet Delay

Variation Metric for IP Performance Metrics (IPPM)", [RFC 3393](#), November 2002.

[Y.1540] ITU-T Recommendation Y.1540, "Internet protocol data communication service - IP packet transfer and availability performance parameters", December 2002.

[I-D.stephan-ippm-multimetrics]

Stephan, E., "IP Performance Metrics (IPPM) for spatial and multicast", [draft-stephan-ippm-multimetrics-01](#) (work

Morton, et al. Individual exp. April 2006

Page 17

Spatial Composition of Metrics

October 2005

in progress), July 2005.

[12.](#) Open issues

Point1:

[13.](#) Acknowledgments

The authors would like to acknowledge many helpful discussions with . . . (lots of people, eventually).

[14.](#) Author's Addresses

Al Morton
AT&T Labs
Room D3 - 3C06
200 Laurel Ave. South
Middletown, NJ 07748 USA
Phone +1 732 420 1571
EMail: <acmorton@att.com>

Need addresses for:

- Phil Chimento <vze275m9@verizon.net>
- Reza Fardid <RFardid@Covad.COM>
- Roman Krzanowski <roman.krzanowski@verizon.com>
- Maurizio Molina <maurizio.molina@dante.org.uk>

- Emile Stephan <emile.stephan@francetelecom.com>
Stephan Emile
France Telecom Division R&D
2 avenue Pierre Marzin
Lannion, F-22307

Fax: +33 2 96 05 18 52
Email: emile.stephan@francetelecom.com
- Lei Liang <L.Liang@surrey.ac.uk>

Full Copyright Statement

Copyright (C) The Internet Society (2005).

This document is subject to the rights, licenses and restrictions contained in [BCP 78](#), and except as set forth therein, the authors retain all their rights.

Morton, et al. Individual exp. April 2006

Page 18

Spatial Composition of Metrics

October 2005

This document and the information contained herein are provided on an "AS IS" basis and THE CONTRIBUTOR, THE ORGANIZATION HE/SHE REPRESENTS OR IS SPONSORED BY (IF ANY), THE INTERNET SOCIETY AND THE INTERNET ENGINEERING TASK FORCE DISCLAIM ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Intellectual Property

The IETF takes no position regarding the validity or scope of any Intellectual Property Rights or other rights that might be claimed to pertain to the implementation or use of the technology described in this document or the extent to which any license under such rights might or might not be available; nor does it represent that it has made any independent effort to identify any such rights. Information on the procedures with respect to rights in RFC documents can be found in [BCP 78](#) and [BCP 79](#).

Copies of IPR disclosures made to the IETF Secretariat and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this specification can be obtained from the IETF on-line IPR repository

at <http://www.ietf.org/ipr>.

The IETF invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights that may cover technology that may be required to implement this standard. Please address the information to the IETF at ietf-ipr@ietf.org.

Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.