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**IP Performance Metrics (IPPM) for spatial and multicast
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Abstract

The IETF IP Performance Metrics (IPPM) working group has standardized metrics for measuring end-to-end performance between 2 points. This memo defines 2 sets of metrics to extend these end-to-end ones. It defines spatial metrics for measuring the performance of segments along a path and metrics for measuring the performance of a group of

users in multiparty communications.

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1. Introduction

The metrics specified in this memo are built on notions introduced and discussed in the IPPM Framework document, [RFC 2330](#) [[RFC2330](#)]. The reader should be familiar with these documents.

This memo makes use of definitions of end-to-end One-way Delay Metrics defined in the [RFC 2679](#) [[RFC2679](#)] to define metrics for decomposition of end-to-end one-way delays measurements.

This memo makes use of definitions of end-to-end One-way Packet loss Metrics defined in the [RFC 2680](#) [[RFC2680](#)] to define metrics for decomposition of end-to-end one-way packet loss measurements.

The IPPM WG defined a framework for metric definitions and end-to-end measurements:

- o A general framework for defining performance metrics, described in the Framework for IP Performance Metrics, [RFC 2330](#) [[RFC2330](#)];
- o A One-way Active Measurement Protocol Requirements, [RFC 3763](#) [[RFC3763](#)];
- o A One-way Active Measurement Protocol (OWAMP) [work in progress];
- o An IP Performance Metrics Registry , [RFC 4148](#) [[RFC4148](#)];

It specified a set of end-to-end metrics, which conform to this framework:

- o The IPPM Metrics for Measuring Connectivity, [RFC 2678](#) [[RFC2678](#)];
- o The One-way Delay Metric for IPPM, [RFC 2679](#) [[RFC2679](#)];
- o The One-way Packet Loss Metric for IPPM, [RFC 2680](#) [[RFC2680](#)];
- o The Round-trip Delay Metric for IPPM, [RFC 2681](#) [[RFC2681](#)];
- o A Framework for Defining Empirical Bulk Transfer Capacity Metrics [RFC 3148](#) [[RFC3148](#)];
- o One-way Loss Pattern Sample Metrics, [RFC 3357](#) [[RFC3357](#)];
- o IP Packet Delay Variation Metric for IPPM, [RFC 3393](#) [[RFC3393](#)];
- o Network performance measurement for periodic streams, [RFC 3432](#) [[RFC3432](#)];

- o Packet Reordering Metric for IPPM [Work in progress];

Based on these works, this memo defines 2 kinds of multi party metrics.

Firstly it defines spatial metrics:

- o A 'sample', called Type-P-Spatial-One-way-Delay-Stream, will be introduced to decompose an end-to-end Type-P-One-way-Delay in a spatial sequence of one-way delays.
- o A 'sample', called Type-P-Spatial-One-way-Packet-Loss-Stream, will be introduced to decompose an end-to-end Type-P-One-way-Packet-Loss in a spatial sequence of packet loss.
- o Using the Type-P-Spatial-One-way-Delay-Stream metric, a 'sample', called Type-P-Spatial-One-way-Jitter-Stream, will be introduced to decompose an end-to-end Type-P-One-way-ipdv in a spatial sequence of jitter.
- o Using the Type-P-Spatial-One-way-Delay-Stream metric, a 'sample', called Type-P-subpath-One-way-Delay-Stream, will be introduced to define the one-way-delay between any host of the path.
- o Using Type-P-subpath-x-Stream, a 'sample' Type-P-Passive-x-Stream will be introduced to define the Passive metrics. These metrics are designed for pure passive measurement methodology as introduced by PSAMP WG.

Then it defines one-to-group metrics.

- o Using one test packet sent from one sender to a group of receivers, a 'sample', called Type-P-one-to-group-One-way-Delay-Stream, will be introduced to define the list of Type-P-one-way-delay between this sender and the group of receivers.
- o Using one test packet sent from one sender to a group of receivers, a 'sample', called Type-P-one-to-group-One-way-Packet-Loss-Stream, will be introduced to define the list of Type-P-One-way-Packet-Loss between this sender and the group of receivers
- o Using one test packet sent from one sender to a group of receivers, a 'sample', called Type-P-one-to-group-One-way-Jitter-Stream, will be introduced to define the list of Type-P-One-way-ipdv between this sender and the group of receivers
- o Then a discussion section presents the set of statistics that may be computed on the top of these metrics to present the QoS in a

view of a group of users as well as the requirements of relative QoS on multiparty communications.

2. Terminology

2.1. Multiparty metric

A metric is said to be multiparty if the definition involved more than two sources or destinations in the measurements. All multiparty metrics define a set of hosts called "points of interest", where one host is the source and other hosts are the measurement collection points. For example, if the set of points of interest is $\langle ha, hb, hc, \dots, hn \rangle$, where ha is the source and $\langle hb, hc, \dots, hn \rangle$ are the destinations, then measurements may be conducted between $\langle ha, hb \rangle$, $\langle ha, hc \rangle$, \dots , $\langle ha, hn \rangle$.

2.2. Spatial metric

A metric is said to be spatial if one of the hosts involved is neither the source nor the destination of the metered packet.

2.3. Spatial metric points of interest

Points of interest of a spatial metric are the routers or sibling in the path between source and destination (in addition to the source and the destination themselves).

2.4. One-to-group metric

A metric is said to be one-to-group if the measured packet is sent by one source and (potentially) received by several destinations. Thus, the topology of the communication group can be viewed as a centre-distributed or server-client topology with the source as the centre/server in the topology.

2.5. One-to-group metric points of interest

Points of interest of One-to-group metrics are the set of host destinations receiving packets from the source (in addition to the source itself).

2.6. Reference point

The centre/server in the one-to-group measurement that is controlled by network operators can be a very good reference point where measurement data can be collected for further processing although the actual measurements have to be carried out at all points of interest.

I.e., the measurement points will be all clients/receivers while the reference point acts as source for the one-to-group metric. Thus, we can define the reference point as the host while the statistic calculation will be carried out.

2.7. Group of singletons

A group of singletons is the set of results of the observation of the behaviour of the same packet at different places of a network.

3. Motivations for spatial and one-to-group metrics

All IPPM metrics are defined for end-to-end measurement. These metrics provide very good guides for measurement in the pair communications. However, further efforts should be put to define metrics for multiparty measurements such as one to one trajectory metrics and one to multipoint metrics.

3.1. spatial metrics

Decomposition of instantaneous end-to-end measures is needed:

- o The PCE WG is extending existing protocols to permit remote path computation and path computation quality, including inter domain. One may say that in intra domain the decomposing the performance of a path is not wished. However such decomposition is desirable in interdomain to qualify each AS computation with the initial request. So it is necessary to define standard spatial metrics before going further in the computation of inter domain path with QoS constraint.
- o Traffic engineering and troubleshooting applications require spatial views of the one-way delay consumption, identification of the location of the lost of packets and the decomposition of the jitter over the path.
- o Monitoring the QoS of a multicast tree, of MPLS point-to-multipoint and inter-domain communication require spatial decomposition of the one-way delay, of the packet loss and of the jitter.
- o Composition of metrics is a need to scale in the measurement plane. The definition of composition metrics is a work in progress [[I-D.ietf-ippm-spatial-composition](#)]; . Spatial measure give typically the individual performance of an intra domain segment. It is the elementary piece of information to exchange for measuring interdomain performance based on composition of

metrics.

- o The PSAMP WG defines capabilities to sample packets in a way to support measurement. [[I-D.boschi-ipfix-reducing-redundancy](#)]; defines a method to collect packets information to measure the instantaneous spatial performance without injecting test traffic. Consequently it is urgent to define a set of common spatial metrics for passive and active techniques which respect the IPPM framework [[RFC2330](#)]. This need is emphasized by the fact that end-to-end spatial measurement involves the 2 techniques;

3.2. One-to-group metrics

While the node-to-node based spatial measures can provide very useful data in the view of each connection, we also need measures to present the performance of a multiparty communication in the view of a group with consideration that it involves a group of people rather than two. As a consequence a simple one-way metric cannot describe the multi-connection situation. We need some new metrics to collect performance of all the connections for further statistics analysis. A group of metrics are proposed in this stage named one-to-group performance metrics based on the unicast metrics defined in IPPM WG. One-to-group metrics are trying to composite one-way metrics from one source to a group of destinations to make up new metrics. The compositions are necessary for judging the network performance of multiparty communications and can also be used to describe the difference of the QoS served among a group of users.

One-to-group performance metrics are needed for several reasons:

- o For designing and engineering multicast trees and MPLS point-to-multipoint LSP;
- o For evaluating and controlling of the quality of the multicast services;
- o For controlling the performance of the inter domain multicast services;
- o For presenting and evaluating the relative QoS requirements for the multiparty communications.

To understand the connection situation between one source and any one receiver in the multiparty communication group, we need the collection of instantaneous end-to-end measures. It will give us very detailed insight into each branch of the multicast tree in terms of end-to-end absolute QoS. It can provide clear and helpful information for engineers to identify the connection with problems in

a complex multiparty routing tree.

3.3. Discussion on Group-to-one and Group-to-group metrics

We note that points of interest can also be selected to define measurements on Group-to-one and Group-to-group topologies. These topologies are currently beyond the scope of this memo, because they would involve multiple packets launched from different sources. However, we can give some clues here on these two cases.

The measurements for group-to-one topology can be easily derived from the one-to-group measurement. The measurement point is the reference point that is acting as a receiver while all of clients/receivers defined for one-to-group measurement act as sources in this case.

For the group-to-group connection topology, we can hardly define the reference point and, therefore, have difficulty to define the measurement points. However, we can always avoid this confusion by treating the connections as one-to-group or group-to-one in our measurements without consideration on how the real communication will be carried out. For example, if one group of hosts $\langle ha, hb, hc, \dots, hn \rangle$ are acting as sources to send data to another group of hosts $\langle Ha, Hb, Hc, \dots, Hm \rangle$, we can always decompose them into n one-to-group communications as $\langle ha, Ha, Hb, Hc, \dots, Hm \rangle$, $\langle hb, Ha, Hb, Hc, \dots, Hm \rangle$, $\langle hc, Ha, Hb, Hc, \dots, Hm \rangle$, ..., $\langle hn, Ha, Hb, Hc, \dots, Hm \rangle$.

4. Spatial metrics definitions

Spatial decomposition metrics are based on standard end-to-end metrics.

The definition of a spatial metric is coupled with the corresponding end-to-end metric. The methodology is based on the measure of the same test packet and parameters of the corresponding end-to-end metric.

4.1. A Definition for Spatial One-way Delay Stream

This section is coupled with the definition of Type-P-One-way-Delay. When a parameter from [section 3 of \[RFC2679\]](#) is first used in this section, it will be tagged with a trailing asterisk.

Sections [3.5](#) to [3.8](#) of [\[RFC2679\]](#) give requirements and applicability statements for end-to-end one-way-delay measurements. They are applicable to each point of interest H_i involved in the measure. Spatial one-way-delay measurement SHOULD be respectful of them, especially those related to methodology, clock, uncertainties and

reporting.

Following we adapt some of them and introduce points specific to spatial measurement.

4.1.1. Metric Name

Type-P-Spatial-One-way-Delay-Stream

4.1.2. Metric Parameters

- + Src*, the IP address of the sender.
- + Dst*, the IP address of the receiver.
- + i, An integer which ordered the hosts in the path.
- + Hi, exchange points of the path digest.
- + T*, a time, the sending (or initial observation) time for a measured packet.
- + dT* a delay, the one-way delay for a measured packet.
- + dT1,..., dTn a list of delay.
- + P*, the specification of the packet type.
- + <Src, H1, H2,..., Hn, Dst>, a path digest.

4.1.3. Metric Units

A sequence of times.

4.1.4. Definition

Given a Type-P packet sent by the sender Src at wire-time (first bit) T to the receiver Dst in the path <H1, H2,..., Hn>. Given the sequence of values <T+dT1,T+dT2,...,T+dTn,T+dT> such that dT is the Type-P-One-way-Delay from Src to Dst and such that for each Hi of the path, T+dTi is either a real number corresponding to the wire-time the packet passes (last bit received) Hi, or undefined if the packet never passes Hi.

Type-P-Spatial-One-way-Delay-Stream metric is defined for the path <Src, H1, H2,..., Hn, Dst> as the sequence of values <T,dT1,dT2,...,dTn,dT>.

4.1.5. Discussion

Following are specific issues which may occur:

- o the delay looks to decrease: $dTi > DTi+1$. this seem typically due to some clock synchronisation issue. this point is discussed in the [section 3.7.1](#). "Errors or uncertainties related to Clocks" of [\[RFC2679\]](#);
- o The location of the point of interest in the device influences the result (see [\[I-D.quittek-ipfix-middlebox\]](#)). If the packet is not observed on the input interface the delay includes buffering time and consequently an uncertainty due to the difference between 'wire time' and 'host time';

4.1.6. Interference with other test packet

To avoid packet collision it is preferable to include a sequence number in the packet.

4.1.7. loss threshold

To determine if a dTi is defined or undefined it is necessary to define a period of time after which a packet is considered loss.

4.1.8. Methodologies

[Section 3.6 of \[RFC2679\]](#) gives methodologies for end-to-end one-way-delay measurements. Most of them apply to each points interest Hi and are relevant to this section.

Generally, for a given Type-P, in a given Hi , the methodology would proceed as follows:

- o At each Hi , prepare to capture the packet sent a time T , take a timestamp Ti' , determine the internal delay correction dTi' , extract the timestamp T from the packet, then compute the one-way-delay from Src to Hi : $dTi = Ti' - dTi' - T$. The one-way delay is undefined (infinite) if the packet is not detected after the 'loss threshold' duration;
- o Gather the set of dTi of each Hi and order them according to the path to build the Type-P-Spatial-One-way-Delay-Stream metric $\langle T, dT1, dT2, \dots, dTn, dT \rangle$ over the path $\langle H1, H2, \dots, Hn \rangle$.

It is out of the scope of this document to define how each Hi detects the packet.

4.1.9. Reporting the metric

[Section 3.6 of \[RFC2679\]](#) indicates the items to report.

4.1.10. Path

It is clear that a end-to-end Type-P-One-way-Delay can't determine the list of hosts the packet passes through. [Section 3.8.4 of \[RFC2679\]](#) says that the path traversed by the packet SHOULD be reported but is practically impossible to determine.

This part of the job is provided by Type-P-Spatial-One-way-Delay-Stream metric because each point of interest H_i which captures the packet is part of the path.

4.2. A Definition of a sample of One-way Delay of a sub path

This metric is similar to the metric Type-P-One-way-Delay-Poisson-stream defined in [\[RFC2679\]](#) and to the metric Type-P-One-way-Delay-Periodic-Stream defined in [\[RFC3432\]](#).

Nevertheless its definition differs because it is based on the decomposition of end-to-end One-way delay using the metric Type-P-Spatial-One-way-Delay-Stream defined above.

It aims to define a sample of One-way-Delay between a pair of hosts of a path usable by active and passive measurements.

Sections [3.5](#) to [3.8](#) of [\[RFC2679\]](#) give requirements and applicability statements for end-to-end one-way-delay measurements. They are applicable to each point of interest H_i involved in the measure. Subpath one-way-delay measurement SHOULD be respectful of them, especially those related to methodology, clock, uncertainties and reporting.

4.2.1. Metric Name

Type-P-subpath-One-way-Delay-Stream

4.2.2. Metric Parameters

- + Src*, the IP address of the sender.
- + Dst*, the IP address of the receiver.
- + i, An integer which orders exchange points in the path.
- + k, An integer which orders the packets sent.
- + <Src, H1, H2, ..., Hn, Dst>, a path digest.
- + Ha, a host of the path digest different from Dst and Hb;
- + Hb, a host of the path digest different from Src and Ha.
Hb order in the path must greater than Ha;
- + Hi, exchange points of the path digest.
- + dT1, ..., dTn a list of delay.
- + P*, the specification of the packet type.

4.2.3. Metric Units

A sequence of pairs <Tk,dt>.

T is one of time of the sequence T1...Tn;

dT is a delay.

4.2.4. Definition

Given 2 hosts Ha and Hb of the path <Src, H1, H2, ..., Hn, Dst>, given a flow of packets of Type-P sent from Src to Dst at the times T1, T2... Tn. At each of these times, we obtain a Type-P-Spatial-One-way-Delay-Stream <T1,dT1.1, dT1.2, ..., dT1.n,dT1>. We define the value of the sample Type-P-subpath-One-way-Delay-Stream as the sequence made up of the couples <Tk,dTk.b - dTk.a>. dTk.a is the delay between Src and Ha. dTk.b is the delay between Src and Hb. 'dT1.b - dTk.a' is the one-way delay experienced by the packet sent at the time Tk by Src when going from Ha to Hb.

4.2.5. Discussion

Following are specific issues which may occur:

- o The definition permits the measure of $\langle Tk, dTk.b - dTk.a \rangle$ when a is Src.
- o The definition permits the measure of $\langle Tk, dTk.b - dTk.a \rangle$ when b is Dst.
- o the delay looks to decrease: $dTi > DTi+1$. this seem typically due to some clock synchronisation issue. this point is discussed in the [section 3.7.1](#). "Errors or uncertainties related to Clocks" of [RFC2679](#);
- o The location of the point of interest in the device influences the result (see [\[I-D.quittek-ipfix-middlebox\]](#)). If the packet is not observed on the input interface the delay includes buffering time and consequently an uncertainty due to the difference between 'wire time' and 'host time';
- o $dTk.b$ may be observed and not $dTk.a$.
- o Tk is unknown if the flow is made of end user packets, that is pure passive measure. In this case Tk may be forced to $Tk+dTk.a$. This motivate separate metrics names for pure passive measurement or specific reporting information.
- o Pure passive measure should consider packets of the same size and of the same Type-P.

[4.2.6](#). Interference with other packet

[4.2.7](#). loss threshold

To determine if a dTi is defined or undefined it is necessary to define a period of time after which a packet is considered loss.

[4.2.8](#). Methodologies

Both active and passive method should discussed.

[4.2.9](#). Reporting the metric

[Section 3.6 of \[RFC2679\]](#) indicates the items to report.

[4.2.10](#). Path

[4.3](#). A Definition for Spatial One-way Packet Loss Stream

This section is coupled with the definition of Type-P-One-way-Packet-Loss. Then when a parameter from the [section 2 of \[RFC2680\]](#) is first

used in this section, it will be tagged with a trailing asterisk.

Sections [2.5](#) to [2.8](#) of [[RFC2680](#)] give requirements and applicability statements for end-to-end one-way-Packet-Loss measurements. They are applicable to each point of interest H_i involved in the measure. Spatial packet loss measurement SHOULD be respectful of them, especially those related to methodology, clock, uncertainties and reporting.

Following we define the spatial metric, then we adapt some of the points above and introduce points specific to spatial measurement.

[4.3.1.](#) Metric Name

Type-P-Spatial-One-way-Packet-Loss-Stream

[4.3.2.](#) Metric Parameters

- + Src*, the IP address of the sender.
- + Dst*, the IP address of the receiver.
- + i, An integer which ordered the hosts in the path.
- + H_i , exchange points of the path digest.
- + T^* , a time, the sending (or initial observation) time for a measured packet.
- + dT_1, \dots, dT_n, dT , a list of delay.
- + P^* , the specification of the packet type.
- + $\langle \text{Src}, H_1, H_2, \dots, H_n, \text{Dst} \rangle$, a path digest.
- + $B_1, B_2, \dots, B_i, \dots, B_n$, a list of boolean values.

[4.3.3.](#) Metric Units

A sequence of boolean values.

[4.3.4.](#) Definition

Given a Type-P packet sent by the sender Src at time T to the receiver Dst in the path $\langle H_1, H_2, \dots, H_n \rangle$. Given the sequence of times $\langle T+dT_1, T+dT_2, \dots, T+dT_n, T+dT \rangle$ the packet passes $\langle H_1, H_2, \dots, H_n, \text{Dst} \rangle$,

Type-P-One-way-Packet-Lost-Stream metric is defined as the sequence of values $\langle B_1, B_2, \dots, B_n \rangle$ such that for each H_i of the path, a value of B_i of 0 means that dTi is a finite value, and a value of 1 means that dTi is undefined.

4.3.5. Discussion

Following are specific issues which may occur:

- o the result includes the sequence 1,0. This case means that the packet was seen by a host but not by its successor on the path;

- o

The location of the meter in the device influences the result:

- o Even if the packet is received by a device, it may be not observed by a meter located after a buffer;

4.3.6. Reporting

Section in progress.

4.4. A Definition for Spatial One-way Jitter Stream

This section uses parameters from the definition of Type-P-One-way-ipdv. When a parameter from [section 2 of \[RFC3393\]](#) is first used in this section, it will be tagged with a trailing asterisk.

Sections [3.5](#) to [3.7](#) of [\[RFC3393\]](#) give requirements and applicability statements for end-to-end one-way-ipdv measurements. They are applicable to each point of interest H_i involved in the measure. Spatial one-way-ipdv measurement SHOULD be respectful of them, especially those related to methodology, clock, uncertainties and reporting.

Following we adapt some of them and introduce points specific to spatial measurement.

4.4.1. Metric Name

Type-P-Spatial-One-way-Jitter-Stream

4.4.2. Metric Parameters

- + Src*, the IP address of the sender.
- + Dst*, the IP address of the receiver.
- + i, An integer which ordered the hosts in the path.
- + Hi, exchange points of the path digest.
- + T1*, the time the first packet was sent.
- + T2*, the time the second packet was sent.
- + P, the specification of the packet type.
- + P1, the first packet sent at time T1.
- + P2, the second packet sent at time T2.
- + <Src, H1, H2, ..., Hn, Dst>, a path digest.
- + <T1,dT1.1, dT1.2,..., dT1.n,dT1>,
the Type-P-Spatial-One-way-Delay-Stream for packet sent at
time T1;
- + <T2,dT2.1, dT2.2,..., dT2.n,dT2>,
the Type-P-Spatial-One-way-Delay-Stream for packet sent at
time T2;
- + L*, a packet length in bits. The packets of a Type P
packet stream from which the
Type-P-Spatial-One-way-Delay-Stream metric is taken MUST
all be of the same length.

4.4.3. Metric Units

A sequence of times.

4.4.4. Definition

Given the Type-P packet having the size L and sent by the sender Src at wire-time (first bit) T1 to the receiver Dst in the path <H1, H2, ..., Hn>.

Given the Type-P packet having the size L and sent by the sender Src

at wire-time (first bit) T_2 to the receiver Dst in the same path.

Given the Type-P-Spatial-One-way-Delay-Stream $\langle T_1, dT_{1.1}, dT_{1.2}, \dots, dT_{1,n}, dT_1 \rangle$ of the packet P_1 .

Given the Type-P-Spatial-One-way-Delay-Stream $\langle T_2, dT_{2.1}, dT_{2.2}, \dots, dT_{2,n}, dT_2 \rangle$ of the packet P_2 .

Type-P-Spatial-One-way-Jitter-Stream metric is defined as the sequence of values $\langle T_2 - T_1, dT_{2.1} - dT_{1.1}, dT_{2.2} - dT_{1.2}, \dots, dT_{2,n} - dT_{1,n}, dT_2 - dT_1 \rangle$ Such that for each H_i of the path $\langle H_1, H_2, \dots, H_n \rangle$, $dT_{2.i} - dT_{1.i}$ is either a real number if the packets P_1 and P_2 passes H_i at wire-time (last bit) $dT_{1.i}$, respectively $dT_{2.i}$, or undefined if at least one of them never passes H_i . $T_2 - T_1$ is the inter-packet emission interval and $dT_2 - dT_1$ is ddT^* the Type-P-One-way-ipdv at T_1, T_2^* .

4.4.5. Sections in progress

See sections [3.5](#) to [3.7](#) of [[RFC3393](#)].

4.5. Pure Passive Metrics

Spatial metrics may be measured without injecting test traffic as described in [[I-D.boschi-ipfix-reducing-redundancy](#)] .

4.5.1. Discussion on Passive measurement

One might says that most of the operational issues occur in the last mile and that consequently such measure are less useful than active measuremeent. Nevertheless they are usable for network TE and interdomain QoS monitoring, and composition of metric.

Such a technique have some limitations that are discussed below.

4.5.1.1. Passive One way delay

As the packet is not a test packet, it does not include the time it was sent.

Consequently a point of interest H_i ignores the time the packet was send. So It is not possible to measure the delay between Src and H_i in the same manner it is not possible to measure the delay between H_i and Dst.

4.5.1.2. Passive Packet loss

The packet is not a test packet, so it does not include a sequence

number.

Packet lost measurement does not require time synchronization and require only one point of observation. Nevertheless it requires the point of interest H_i to be expecting the packet. Practically H_i may not detect a loss of packet that occurs between Src and H_i .

A point of interest H_i ignores the time the packet is sent because the packet does not carry the time it was injected in the network. So a probe H_i can not compute dT_i .

An alternative to these issues consists in considering sample spatial One-way delay that T is the time when H_1 (the first passive probe of the path) observed the packet.

4.5.2. Reporting and composition

To avoid misunderstanding and to address specific reporting constraint a proposal consists in defining distinct metrics for pure passive measurement based on the definition above.

It is crucial to know the methodologies used because of the difference of method of detection (expecting Seq++); because of the difference of source of time (H_1 vs Src) and because of the difference of behavior of the source (Poisson/unknown).

4.5.3. naming and registry

Having distinct metrics identifiers for spatial metrics and passive spatial metrics in the [\[RFC4148\]](#) will avoid interoperability issues especially during composition of metrics.

They may be named

- o Type-P-Passive-One-way-delay-Stream
- o Type-P-Passive-One-way-Packet-Loss-Stream
- o Type-P-Passive-One-way-jitter-Stream

In the same way sample should be registered too. they may be named

- o Type-P-Passive-One-way-delay-Sample
- o Type-P-Passive-One-way-Packet-Loss-Sample
- o Type-P-Passive-One-way-jitter-Sample

[4.5.4.](#) **Passive One way delay metrics**

[4.5.5.](#) **Passive One way PacketLoss metrics**

[4.5.6.](#) **Passive One way jitter metrics**

[4.6.](#) **Discussion on spatial statistics**

Do we define min, max, avg of spatial metrics ?

having the maximum loss metric value could be interesting. Say, the segment between router A and B always contributes loss metric value of "1" means it could be the potential problem segment.

Uploading dTi of each Hi consume a lot of bandwidth. Computing statistics (min, max and avg) of dTi locally in each Hi reduce the bandwidth consumption.

[5.](#) **One-to-group metrics definitions**

[5.1.](#) **A Definition for one-to-group One-way Delay Stream**

[5.1.1.](#) **Metric Name**

Type-P-one-to-group-One-way-Delay-Stream

[5.1.2.](#) **Metric Parameters**

- o Src, the IP address of a host acting as the source.
- o Recv1,..., RecvN, the IP addresses of the N hosts acting as receivers.
- o T, a time.
- o dT1,...,dTn a list of time.
- o P, the specification of the packet type.
- o Gr, the multicast group address (optional). The parameter Gr is the multicast group address if the measured packets are transmitted by multicast. This parameter is to identify the measured traffic from other unicast and multicast traffic. It is set to be optional in the metric to avoid losing any generality, i.e. to make the metric also applicable to unicast measurement where there is only one receivers.

5.1.3. Metric Units

The value of a Type-P-one-to-group-One-way-Delay-Stream is a set of singletons metrics Type-P-One-way-Delay [[RFC2679](#)].

5.1.4. Definition

Given a Type P packet sent by the source Src at Time T, given the N hosts { Recv1,...,RecvN } which receive the packet at the time { T+dT1,...,T+dTn }, a Type-P-one-to-group-One-way-Delay-Stream is defined as the set of the Type-P-One-way-Delay singleton between Src and each receiver with value of { dT1, dT2,...,dTn }.

5.2. A Definition for one-to-group One-way Packet Loss Stream

5.2.1. Metric Name

Type-P-one-to-group-One-way-Packet-Loss-Stream

5.2.2. Metric Parameters

- o Src, the IP address of a host acting as the source.
- o Recv1,..., RecvN, the IP addresses of the N hosts acting as receivers.
- o T, a time.
- o T1,...,Tn a list of time.
- o P, the specification of the packet type.
- o Gr, the multicast group address (optional).

5.2.3. Metric Units

The value of a Type-P-one-to-group-One-way-Packet-Loss-Stream is a set of singletons metrics Type-P-One-way-Packet-Loss [[RFC2680](#)].

5.2.4. Definition

Given a Type P packet sent by the source Src at T and the N hosts, Recv1,...,RecvN, which should receive the packet at T1,...,Tn, a Type-P-one-to-group-One-way-Packet-Loss-Stream is defined as a set of the Type-P-One-way-Packet-Loss singleton between Src and each of the receivers {<T1,0|1>,<T2,0|1>,..., <Tn,0|1>}.

5.3. A Definition for one-to-group One-way Jitter Stream

5.3.1. Metric Name

Type-P-one-to-group-One-way-Jitter-Stream

5.3.2. Metric Parameters

- + Src, the IP address of a host acting as the source.
- + Recv1,..., RecvN, the IP addresses of the N hosts acting as receivers.
- + T1, a time.
- + T2, a time.
- + ddT1,...,ddTn, a list of time.
- + P, the specification of the packet type.
- + F, a selection function defining unambiguously the two packets from the stream selected for the metric.
- + Gr, the multicast group address (optional)

5.3.3. Metric Units

The value of a Type-P-one-to-group-One-way-Jitter-Stream is a set of singletons metrics Type-P-One-way-ipdv [[RFC3393](#)].

5.3.4. Definition

Given a Type P packet stream, Type-P-one-to-group-One-way- Jitter-Stream is defined for two packets from the source Src to the N hosts {Recv1,...,RecvN },which are selected by the selection function F, as the difference between the value of the Type-P-one-to-group-One-way-Delay-Stream from Src to { Recv1,..., RecvN } at time T1 and the value of the Type-P-one-to-group- One-way-Delay-Stream from Src to { Recv1,...,RecvN } at time T2. T1 is the wire-time at which Src sent the first bit of the first packet, and T2 is the wire-time at which Src sent the first bit of the second packet. This metric is derived from the Type-P-one-to- group-One-way-Delay-Stream metric.

Therefore, for a set of real number {ddT1,...,ddTn},Type-P-one- to-group-One-way-Jitter-Stream from Src to { Recv1,...,RecvN } at T1, T2 is {ddT1,...,ddTn} means that Src sent two packets, the first at wire-time T1 (first bit), and the second at wire-time T2 (first bit)

and the packets were received by $\{ \text{Recv1}, \dots, \text{RecvN} \}$ at wire-time $\{dT1+T1, \dots, dTn+T1\}$ (last bit of the first packet), and at wire-time $\{dT'1+T2, \dots, dT'n+T2\}$ (last bit of the second packet), and that $\{dT'1-dT1, \dots, dT'n-dTn\} = \{ddT1, \dots, ddTn\}$.

5.4. Discussion on one-to-group statistics

The defined one-to-group metrics above can all be directly achieved from the relevant unicast one-way metrics. They managed to collect all unicast measurement results of one-way metrics together in one profile and sort them by receivers and packets in a multicast group. They can provide sufficient information regarding the network performance in terms of each receiver and guide engineers to identify potential problem happened on each branch of a multicast routing tree. However, these metrics can not be directly used to conveniently present the performance in terms of a group and neither to identify the relative QoS situation.

One may say that no matter how many people join the communication, the connections can still be treated as a set of one-to-one connection. However, we might not describe a multiparty communication by a set of one-way measurement metrics because of the difficulty for understanding and the lack of convenience. For instance, an engineer might not describe the connections of a multiparty online conference in terms of one-to-group one-way delay for user A and B, B and C, and C and A because people might be confused. If there are more users in the same communication, the description might be very long. And he might use the one-way metrics with worst and the best value to give users an idea of the QoS range of the service they are providing. But it is not clear enough and might not be accurate in a large multiparty communication scenario.

From the QoS point of view, the multiparty communication services not only require the absolute QoS support but also the relative QoS. The relative QoS means the difference between absolute QoS of all users. Directly using the one-way metrics cannot present the relative QoS situation. However, if we use the variations of all users one-way parameters, we can have new metrics to measure the difference of the absolute QoS and hence provide the threshold value of relative QoS that a multiparty service might demand. A very good example of the high relative QoS requirement is the online gaming. A very light worse delay will result in failure in the game. We have to use the new statistic metrics to define exactly how small the relative delay the online gaming requires. There are many other services, e.g. online bidding, online stock market, etc., need a rule to judge the relative QoS requirement. Therefore, we can see the importance of new statistic metrics to feed this need.

We might use some one-to-group statistic conceptions to present the group performance and relative QoS. In this stage, we define one-to-group mean stream and one-to-group variation stream. These statistics are offered mostly to be illustrative of what could be done.

One-to-group mean streams are trying to measure the overall QoS for a multicast group associated to one source. It is a reflection of the absolute QoS of a multiparty communication service when we treat all receivers as one customer. It can also present the trend of the absolute QoS of all receivers, i.e., it shows that most of the receivers in the multiparty communication service trend to receive an absolute QoS close to the mean.

One-to-group variation streams are trying to measure how the QoS varies among all of the users in a multicast group associated to one source. The word "variation" in this memo is the population standard deviation. It reflects the relative QoS situation in a multiparty communication service, i.e., the level of the difference between the absolute QoS of each receivers.

Using the one-to-group mean and one-to-group variation concepts, we can have a much clear understand on the QoS of a multiparty communication service in terms of its trend and range. There can be mean and variation stream definitions for each of the three one-to-group metrics defined above. We only present the definition of Type-P-one-to-group-One-way- Delay-Mean-Stream and Type-P-one-to-group-One-way-Delay-Variation-Stream as examples in this memo.

5.4.1. Type-P-one-to-group-One-way-Delay-Mean-Stream

Given a Type-P-one-to-group-One-way-Delay-Stream, the mean stream of all { dT_1, dT_2, \dots, dT_n } for the packet from Src at time T to { Recv1, ..., RecvN }.

For example, suppose we take a sample and the results are:

```
Delay_Stream = <
{T1, ..., Tn}
{T'1, ..., T'n}
{T''1, ..., T''n}
>
```

Then the mean stream would be:

```
Delay_Mean_Stream = <
DM1
DM2
DM3
>
= <
sum{T1, ..., Tn}/n
sum{T'1, ..., T'n}/n
sum{T''1, ..., T''n}/n
>
```

5.4.2. Type-P-one-to-group-One-way-Delay-Variation-Stream

Given a Type-P-one-to-group-One-way-Delay-Stream, the variation stream of all { dT1, dT2, ..., dTn } for the packet from Src at time T to { Recv1, ..., RecvN }.

We still take the above Delay_Stream as a sample and the variation stream would be:

```
Delay_Variation_Stream = <
DV1
DV2
DV3
>
=<
(SUM{(T1-DM1)^2, ..., (Tn-DM1)^2})/n)^(1/2)
(SUM{(T'1-DM2)^2, ..., (T'n-DM2)^2})/n)^(1/2)
(SUM{(T''1-DM3)^2, ..., (T''n-DM3)^2})/n)^(1/2)
>
```

6. Extension from one-to-one to one-to-many measurement

The above one-to-group metrics were defined to compose measurement results of a group of users who receive the same data from one source. Moreover, this is one of efforts to introducing the one-to-many concern to the IPPM working group with respect to the fact that

all existing documents in the group are unicast oriented, which talk about only one-to-one single "path" in measurements. This concept can be extended from the "path" to "path tree" to cover both one-to-one and one-to-many communications. Actually, the one-to-one communications can be viewed as a special case of one-to-many from the routing point of view. The one-to-many communications build up a routing tree in the networks and one-to-one can be viewed as a special simplified tree without branches but only the "trunk".

Therefore, the one-to-group metrics described in this memo can even be viewed as general metrics to measure the delay, jitter and packet loss in IP networks. When it applies to one-to-one communications, the metrics will have N receivers while N equal to 1. And the statistic metrics for one-to-one communications are exactly the one-to-group metrics themselves when calculated using the methods given.

7. Open issues

8. Security Considerations

Active measumrement: see security section in owd pl, jitter rfcs (editor notes: add references).

passive measurement: The rate of packet sampling is controled by hash function. The analysis of such a function to generate packets that match the hash function may lead to a DoS attack toward the collector. The generation of packets with spoofing adresses may corrupt the results without any possibility to detect the spoofing.

TODO: one-to-group metrics defined here are not intrusive: they rely on measures of owd... nevertheless they require collection of singletons which may overload the network the measurement controller is attach to.

The one-to-group metrics are derived from one-way metrics and therefore, they have very close relationship.

9. Acknowledgments

Lei would like to acknowledge Zhili Sun from CCSR, University of Surrey, for his instruction and helpful comments on this work.

10. 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](#)].

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