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Composition of Metrics

Status of this Memo

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Abstract

This memo intends to define metrics that are applicable to both complete paths and sub-paths, where a corresponding relationship can be specified to compose the complete path metric from the sub-path metrics with sufficient accuracy. The current memo gives some background and proposes wording for a Scope and Application section to define this new work. The description of an example metric and statistic follows.

Contents

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

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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 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 expect that delay singletons from each sub-path would sum to produce an accurate estimate of a delay singleton for the complete path

(unless all the delays were essentially constant - very unlikely). However, other delay statistics (based on a reasonable sample size) may have a sufficiently large set of circumstances where they are applicable.

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

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

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).

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 Measurement Points

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

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):

```
Type-P-Finite-One-way-Delay-Poisson/Periodic-Stream[i] =
               FiniteDelay[i] = TstampDst - 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 Tf)

The

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

           MeanDelay = (1/L)Sum(from i=1 to L, 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-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 constituent sub-paths.

4.1.6 Statement of Conjecture

The mean of a sufficiently large stream of packets measured on each sub-path during the interval [T, Tf] 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. 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

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).

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

6. Delay Variation Metrics/Statistics

7. Other Metrics/Statistics

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

Since this metric does not define a protocol or well-known values, there are no IANA considerations in this memo.

10. Normative References

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