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One-way Passive Measurement of End-to-End Quality  
draft-kikuchi-passive-measure-02.txt

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## Abstract

This draft describes a passive measurement method for one-way end-to-end quality. This method reports both whether a flow of packets is in-sequence or not and error types on detecting out-of-sequence. The method consumes small resource therefore it can be adapted to many protocols that have sequence number field.

## Table of Contents

<a href="#">1.</a>	Introduction . . . . .	<a href="#">3</a>
<a href="#">1.1.</a>	Requirements notation . . . . .	<a href="#">3</a>
<a href="#">2.</a>	Metrics . . . . .	<a href="#">4</a>
<a href="#">3.</a>	Measurement Method . . . . .	<a href="#">5</a>
<a href="#">3.1.</a>	Counters and Functions . . . . .	<a href="#">5</a>
<a href="#">3.2.</a>	Measurement Algorithm . . . . .	<a href="#">5</a>
<a href="#">4.</a>	Requirements to Sequence Numbering . . . . .	<a href="#">7</a>
<a href="#">4.1.</a>	Indication of Sequence Number . . . . .	<a href="#">7</a>
<a href="#">4.2.</a>	Field Length . . . . .	<a href="#">7</a>
<a href="#">5.</a>	An Evaluation Trial . . . . .	<a href="#">8</a>
<a href="#">5.1.</a>	Usefulness . . . . .	<a href="#">8</a>
<a href="#">5.2.</a>	Qualifying Metrics . . . . .	<a href="#">8</a>
<a href="#">5.3.</a>	Reporting Model . . . . .	<a href="#">9</a>
<a href="#">6.</a>	Algorithm Behavior . . . . .	<a href="#">10</a>
<a href="#">7.</a>	Security Considerations . . . . .	<a href="#">15</a>
<a href="#">Appendix A.</a>	Acknowledgements . . . . .	<a href="#">16</a>
<a href="#">8.</a>	References . . . . .	<a href="#">17</a>
<a href="#">8.1.</a>	Normative References . . . . .	<a href="#">17</a>
<a href="#">8.2.</a>	Informative References . . . . .	<a href="#">17</a>
	Authors' Addresses . . . . .	<a href="#">18</a>
	Intellectual Property and Copyright Statements . . . . .	<a href="#">19</a>

## 1. Introduction

This draft describes a passive measurement method for one-way end-to-end connections quality. This method reports both

- o whether a flow of packets is in-sequence or out-of-sequence, and
- o error types on detecting out-of-sequence.

The purpose of the measurement by this method is to maintain transports in operation [[I-D.kikuchi-tunnel-measure-req](#)] so that the algorithm was designed to be lightweight. The algorithm detects out-of-sequence packets strictly though; the error metrics is even not accurate because the metrics should only provide some hints to operators.

The algorithm requires a sequence number field in the packet headers, such as extended GRE[RFC2784] [[RFC2890](#)], PWE3[RFC3985] and RTP[RFC3550].

### 1.1. Requirements notation

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 [[RFC2119](#)].

## 2. Metrics

We firstly define ``in-sequence'' of a flow.

- o in-sequence: the order of arrival packets at the egress of a flow is the same order as departure at the ingress.
- o out-of-sequence: a packet exists, which violates in-sequence state of a flow.

We secondly define the metrics of types of out-of-sequence packet.

- o dup-train: packet that is identical to the immediately preceding arrival packet
- o skipping: packet that should arrive next or more lately
- o astern: packet that arrives after the successive packets' arrival

The metrics ``dup-train'', ``skipping'' and ``astern'' are similar to duplication, lost and reordering respectively though, these metrics above have different names because the definitions are slightly different from any metrics defined before.

- o ``dup-train'' does not mean naive duplication because the pair of dup-train packets should arrive uninterruptedly by another packet.
- o ``skipping'' happens on ``packet loss'' and even by ``reordering''.

- o ``astern'' might count inaccurately for as reordering packets on complicated situation.

This kind of difference comes from the request of let the algorithm lightweight described in [Section 3](#). An accurate algorithm must have much space for keeping the order of arrival packets until the exact irregular reason will be become clear, moreover it takes much computing power according to the space consumption. Those rough metrics above allow to shrink the space that keeps just one sequence number of the previously arrival packet.

Note that we do not define some kinds of ``rates'' because they are easy to derived from total numbers of irregular packets. For example, if you use SNMP [[RFC3411](#)] the rates are calculated from periodical polling by an SNMP manager.

### [3.](#) Measurement Method

In this section, we illustrate a method to measure qualities defined in the previous section. The protocol should have the sequence number field in its headers.

#### [3.1.](#) Counters and Functions

Egress router of a flow must have a register, named ``recvseq'', that maintains the number that the successive arriving packet should have. The ``recvseq'' register should be initialized by the specific number depends on the target protocol.

The router must also have the following counters:

- o duptrcnt: the number of dup-train packets,
- o skipcnt: the number of skipping packets, and
- o astrncnt: the number of astern packets

Let the counters above be unsigned integer and initialized by 0 on

the birth of the flow. The length of the counters should be the same as the sequence number field defined in the protocol.

### [3.2.](#) Measurement Algorithm

This algorithm determines whether a receiving packet is normal or not while comparing a counter "recvseq" with the sequence number of the packet named "seqno". The basic idea consists of the following conditions.

1. if recvseq and seqno are same then "in-sequence",
2. else if seqno is just a predecessor of recvseq then "dup-train";
3. otherwise if seqno proceed then "skipping" else "astern".

The following C-like codes specifies the algorithm in detail. The function measure will be invoked by every one of the receptions of packets.

```
boolean measure(packet_t packet)
{
    unsigned int seqno;
    seqno = packet->header->seqno; // getting seq # from header

    if (seqno == recvseq) {
        recvseq++;
        return true;           // in-sequence
    } elseif (seqno+1 == recvseq) { // same # as predecessor's
        duptrcnt++;           // determines a dup-train
        return false;         // out-of-seq by dup-train
    }

    signed int diff;
    diff = (signed int)(seqno - recvseq);
}
```

```

        if (diff > 0) {
            skipcnt += diff;
            recvseq = seqno;
        } else {
            astrncnt++;
        }
        return false;
    }
    // from past or future?
    // determines a skipping
    // means it is a past packet
    // determines a astern
    // out-of-seq w/o dup-train

```

Figure 1

The function ``measure'' returns true only if the packet is in-sequence otherwise false on out-of-sequence. The value can be used to discard the packet when the protocol does not allow passing irregular packets to its higher layer.

#### 4. Requirements to Sequence Numbering

In this section, we describe the requirements for protocols to adopt this method.

##### 4.1. Indication of Sequence Number

The protocol MUST indicate whether sequence numbering is enabled or

not.

There are two ways to indicate whether the sequence numbers are enabled or not. One is to prepare an indication field in the header independent from the sequence number field.

The other is to indicate a special sequence number, typically 0, meaning disabled. In this case, the measurement process needs additional steps on wrapping sequence number overflow because the sequence number will skip 0 that does not seem continuous even if the flow packets are still in-sequence.

#### [4.2.](#) Field Length

The length of sequence number field SHOULD be long enough according to the transmission speed. Otherwise, the period of a lap of the sequence number becomes too short and the reliability of the measurement decreases.

For example, the algorithm may determine packets loss as reordering, when there is a set of burst packets loss in case of the path change. It is necessary to determine whether a burst packet loss occurred or if it was simply the arrival of a very past packet when the difference of the sequence numbers between two continuous packets is very large. The typical technique is to use half of the representable maximum value. This is simple and adequate if the field is long enough.

However, the existence of the sequence number field generates more amounts of transmission packets. Thus, if an insufficiently long field creates overhead for protocols that are sensitive to resource consumption. The sequence number field length should be considered as a tradeoff between bandwidth efficiency and quality assurance.

#### [5.](#) An Evaluation Trial



Here we try to evaluate the metrics according to the framework described in [[I-D.morton-perf-metrics-framework](#)].

### 5.1. Usefullness

Firstly, we check the usefullness of the metrics listed in the section 3.1 of [[I-D.morton-perf-metrics-framework](#)].

1. The degree to which its absence would cause significant loss of information on the behavior or state of the application or system being measured?
  - \* YES for TSPs who have SLA contracts with their customers.
  - \* NO for best effort oriented flows.
2. The correlation between the metric and the quality of service / experience delivered to the user (person or other application)?
  - \* YES. It shows primitive quality to determine a flow traffic in operation.
  - \* NO. There is no correlation to any application because the metrics are independent from specific applications.
3. The degree to which the metric is able to support the identification and location of problems affecting service quality?
  - \* YES. It helps for operators to find out that problems come from whether application or transport.
  - \* NO. It does not indicate that problems come from whether TSP or intermediate ISPs.

### 5.2. Qualifying Metrics

Secondly, we qualify the metrics by the list in the section 3.5 of [[I-D.morton-perf-metrics-framework](#)].

- o Unambiguously defined? Yes. The description is not by a concrete specification in natural language but in C-code.
- o Units of Measure Specified? Yes.

- o Measurement Errors Identified? Refer to [Section 4.2](#) for less sequence field length.
- o Repeatable? Yes.
- o Implementable? Yes, very much.
- o Assumptions concerning underlying process? Not discussed.
- o Use cases? Yes. Some examples are shown in [Section 6](#). Moreover, there is an implementation using the metrics in a multi-homing solution with [[RFC4908](#)], which has been provided by Intec Netcore Inc.
- o Correlation with application performance / user experience? The discussion is done in [Section 5.1](#).

### [5.3](#). Reporting Model

The document does not define any reporting model for the metric.

## 6. Algorithm Behavior

The following diagrams show the behavior of the algorithm on receiving out-of-sequence packets. Figure 3 shows the legend of flow diagram here. The left and right sides represent the sender and receiver of a flow respectively. Time flows upper to lower in the diagrams. This illustrates a normal transmission with the sequence number  $n$ .

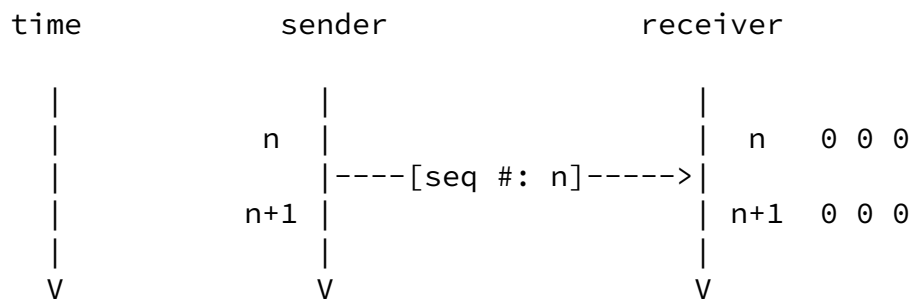


Figure 2

Figure 3, Figure 4 and Figure 5 show simple cases, such as loss, duplication and reordering of packets respectively.

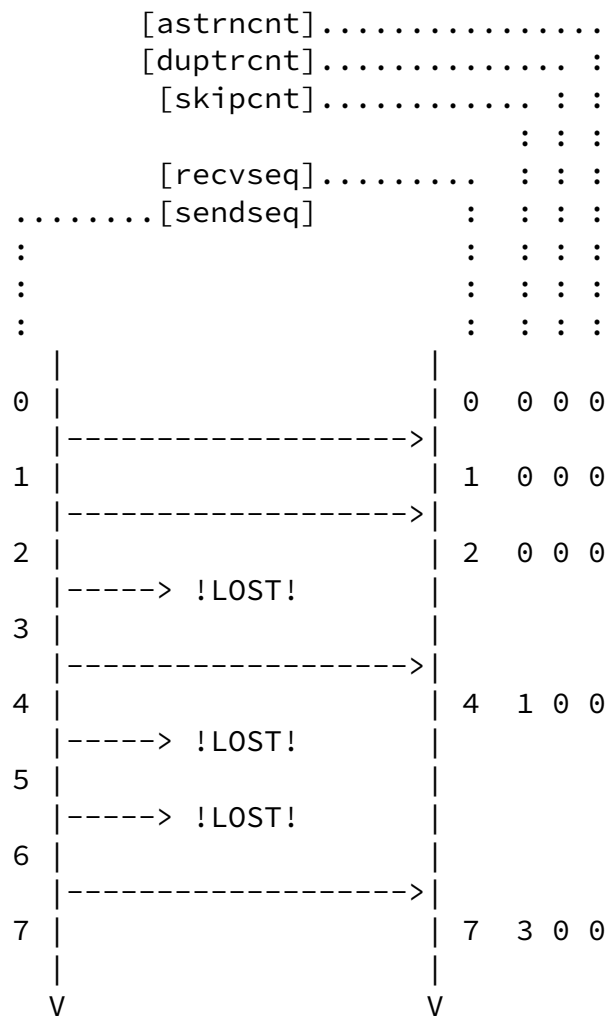


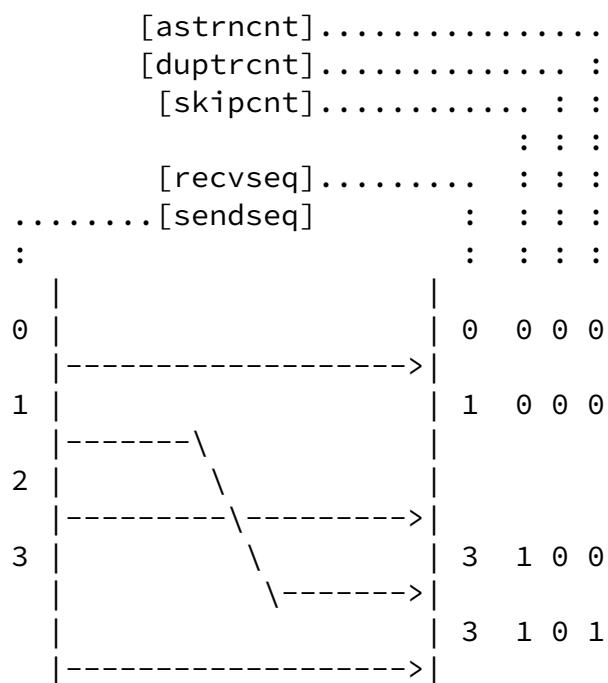
Figure 3

```

[astrncnt].....
[duptrcnt]..... :
[skipcnt]..... : :
               : : :
[recvseq]..... : : :
.....[sendseq] : : : :
:               : : : :
0 |               | 0 0 0 0
  |----->|
1 |               | 1 0 0 0
  |-----!DUP!----->|
  |               | 2 0 0 0
  |       \       |
  |        \----->|
2 |               | 2 0 1 0
  |----->|
3 |               | 3 0 1 0
  |-----!DUP!----->|
4 |               | 4 0 1 0
  |       \       |
  |        !DUP!----->|
  |       \       |
  |        \----->|
  |               | 4 1 2 0
  |               | 4 1 3 0
  |----->|
5 |               | 5 1 3 0
```

|  
V
|  
V

Figure 4



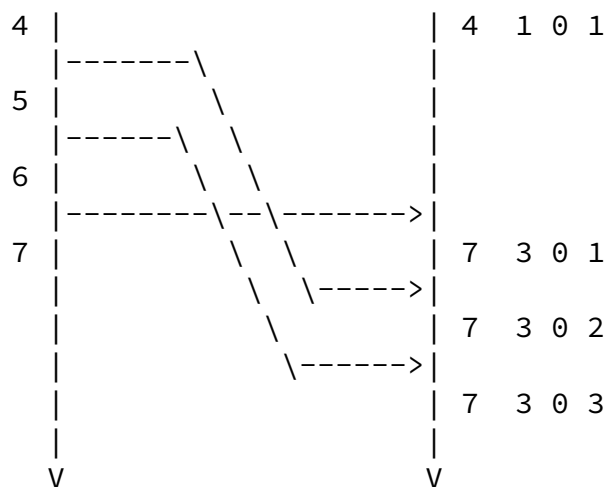
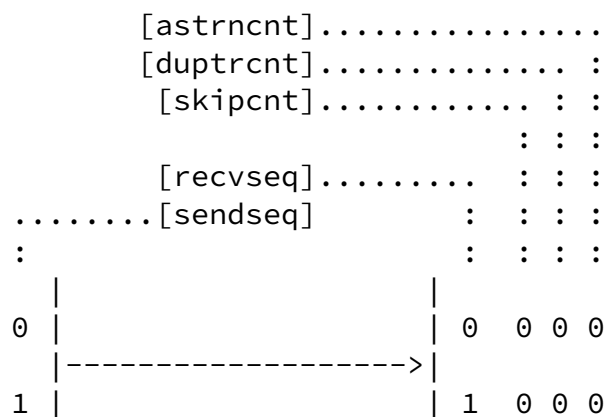


Figure 5

Figure 6 and Figure 7 show cases in a little bit complex situations. Figure 6 shows that the algorithm cannot distinguish a combination of duplication and loss from a reordering. Compare the flow to former of Figure 5.



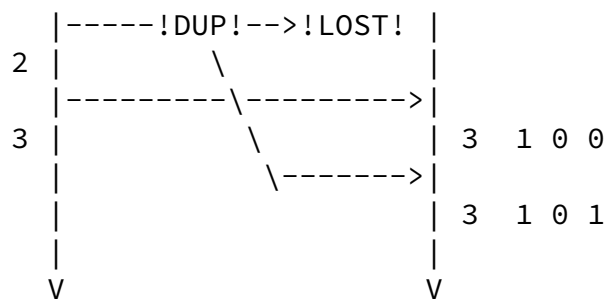


Figure 6

Figure 7 shows that the algorithm interprets duplication as reordering when a duplicated packet does not arrive in succession. It is not possible to hold all of the information contained in the arrival packets needed to measure accurately.

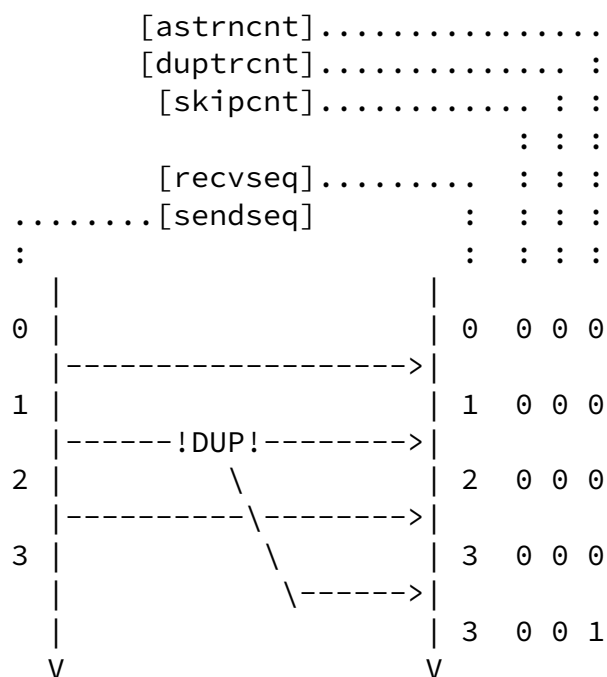


Figure 7

## 7. Security Considerations

The passive measurements do not use any additional packets and flows, so that most security considerations boil down to the issues of the



original protocols. For example, fraud sequence numbers cause the measurement process to become disorganized. This discussion boils down to the issues of the header protection.

## [Appendix A](#). Acknowledgements

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Internet-Draft     [draft-kikuchi-passive-measure-02.txt](#)

May 2008

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Kikuchi, et al.

Expires November 22, 2008

[Page 17]

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Internet-Draft     [draft-kikuchi-passive-measure-02.txt](#)

May 2008

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Kikuchi, et al.

Expires November 22, 2008

[Page 18]

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Internet-Draft [draft-kikuchi-passive-measure-02.txt](#)

May 2008

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