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Performance Measurement Using Simple TWAMP (STAMP) for Segment Routing Networks
draft-gandhi-spring-stamp-srpm-05

Abstract

Segment Routing (SR) leverages the source routing paradigm. SR is applicable to both Multiprotocol Label Switching (SR-MPLS) and IPv6 (SRv6) data planes. This document describes procedures for Performance Measurement in SR networks using the mechanisms defined in RFC 8762 (Simple Two-Way Active Measurement Protocol (STAMP)) and its optional extensions defined in RFC 8972 and draft-gandhi-ippm-stamp-srpm. The procedure described is applicable to SR-MPLS and SRv6 data planes and is used for both links and end-to-end SR paths including SR Policies.

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1. Introduction

Segment Routing (SR) leverages the source routing paradigm and greatly simplifies network operations for Software Defined Networks (SDNs). SR is applicable to both Multiprotocol Label Switching (SR-MPLS) and IPv6 (SRv6) data planes [RFC8402]. SR takes advantage of the Equal-Cost Multipaths (ECMPs) between source and transit nodes, between transit nodes and between transit and destination nodes. SR Policies as defined in [I-D.ietf-spring-segment-routing-policy] are used to steer traffic through a specific, user-defined paths using a stack of Segments. Built-in SR Performance Measurement (PM) is one of the essential requirements to provide Service Level Agreements (SLAs).

The Simple Two-way Active Measurement Protocol (STAMP) provides capabilities for the measurement of various performance metrics in IP networks [RFC8762]. It eliminates the need for control protocol by using configuration and management model to provision and manage test sessions. [RFC8972] defines optional extensions for STAMP. [I-D.gandhi-ippm-stamp-srpm] defines STAMP extensions for SR networks.

The STAMP supports two modes of STAMP Session-Reflector: Stateless and Stateful as described in Section 4 of [RFC8762]. In Stateless mode, maintenance of each STAMP test session on Session-Reflector is avoided. In SR networks, as the state is in the packet, the signaling of the parameters and creating extra states in the network are undesired. Hence, Stateless mode of Session-Reflector is preferred in SR networks.

This document describes procedures for Performance Measurement in SR networks using the mechanisms defined in STAMP [RFC8762] and its optional extensions defined in [RFC8972] and [I-D.gandhi-ippm-stamp-srpm]. The procedure described is applicable to SR-MPLS and SRv6 data planes and is used for both links and end-to-end SR paths including SR Policies [RFC8402].

2. Conventions Used in This Document

2.1. Abbreviations

BSID: Binding Segment ID.

DM: Delay Measurement.

ECMP: Equal Cost Multi-Path.

HMAC: Hashed Message Authentication Code.

LM: Loss Measurement.

MPLS: Multiprotocol Label Switching.

NTP: Network Time Protocol.

OWAMP: One-Way Active Measurement Protocol.

PM: Performance Measurement.

PSID: Path Segment Identifier.

PTP: Precision Time Protocol.

SHA: Secure Hash Algorithm.

SID: Segment ID.

SL: Segment List.

SR: Segment Routing.

SRH: Segment Routing Header.

SR-MPLS: Segment Routing with MPLS data plane.

SRv6: Segment Routing with IPv6 data plane.

SSID: STAMP Session Identifier.

STAMP: Simple Two-way Active Measurement Protocol.

TC: Traffic Class.

TTL: Time To Live.

2.2. Reference Topology

In the reference topology shown below, the STAMP Session-Sender R1 initiates a STAMP test packet and the STAMP Session-Reflector R3 transmits a reply test packet. The reply test packet is transmitted back to the STAMP Session-Sender R1 on the same path or a different path in the reverse direction.

The nodes R1 and R3 may be connected via a link or there exists an SR path [RFC8402]. The link may be a physical interface, virtual link, or Link Aggregation Group (LAG) [IEEE802.1AX], or LAG member link. The SR path may be an SR Policy

[I-D.ietf-spring-segment-routing-policy] on node R1 (called head-end) with destination to node R3 (called tail-end).

```
                        T1                T2
                       /                   \
              +-------+     Test Packet     +-------+
              |       | - - - - - - - - - ->|       |
              |   R1  |=====================|   R3  |
              |       |<- - - - - - - - - - |       |
              +-------+  Reply Test Packet  +-------+
                       \                   /
                        T4                T3

          STAMP Session-Sender        STAMP Session-Reflector

                        Reference Topology
```

3. Overview

For performance measurement in SR networks, the STAMP test packets defined in [RFC8762] and its optional extensions defined in [RFC8972] and [I-D.gandhi-ippm-stamp-srpm] are used as described in this document. The procedures are used to measure one-way, two-way and round-trip delay as well as packet loss metrics in an SR network.

For performance delay and packet loss measurement, STAMP Session-Sender test packets are transmitted in-band on the same path as the data traffic flow under measurement to measure the delay and packet loss experienced by the data traffic flow. It is also desired that Session-Reflector reply test packets are transmitted in-band on the same path in the reverse direction. This is achieved in SR networks by using the STAMP extensions defined in [I-D.gandhi-ippm-stamp-srpm].

A destination UDP port number is selected as described in [RFC8762]. The same destination UDP port is used for link and end-to-end SR path STAMP test sessions.

3.1. Example STAMP Reference Model

An example of a STAMP reference model and typical measurement parameters including the destination UDP port for STAMP test session is shown in the following Figure 1:

```
                              +------------+
                              | Controller |
                              +------------+
                                  /    \
     Destination UDP Port        /      \    Destination UDP port
     Authentication Mode & Key  /        \   Authentication Mode & Key
     Delay Measurement Mode    /          \
     Timestamp Format         /            \
     Packet Loss Type        /              \
                            /                \
                           v                  v
                       +-------+          +-------+
                       |       |          |       |
                       |   R1  |==========|   R3  |
                       |       |          |       |
                       +-------+          +-------+

                STAMP Session-Sender  STAMP Session-Reflector
```

Figure 1: Example STAMP Reference Model

Example of the Timestamp Format is PTPv2 [IEEE1588] and NTP. Example of Delay Measurement Mode is one-way, two-way and round-trip mode as described in this document. Example of Packet Loss Type is round-trip packet loss [RFC8762].

When using the authenticated mode for delay measurement, the matching Authentication Type (e.g. HMAC-SHA-256) and Key are user-configured on STAMP Session-Sender and STAMP Session-Reflector [RFC8762].

The STAMP Session-Reflector R3 uses the timestamp format from the received STAMP test packet. In addition, the STAMP Session-Reflector R3 uses the parameters of the return path for the reply test packet from the received STAMP test packet, as described in this document.

Note that the controller in the reference model is not intended for signaling the SR parameters for STAMP test sessions between the STAMP Session-Sender and STAMP Session-Reflector. In addition, maintenance of each STAMP test session on Session-Reflector and creating extra state are avoided in an SR network.

The YANG data model defined in [I-D.ietf-ippm-stamp-yang] can be used to provision the STAMP Session-Sender and STAMP Session-Reflector.

4. Delay Measurement for Links and SR Paths

4.1. Session-Sender Test Packet

The content of an example STAMP Session-Sender test packet using an UDP header [RFC0768] is shown in Figure 2. The payload contains the STAMP Session-Sender test packet defined in [RFC8762].

```
+---------------------------------------------------------------+
| IP Header                                                     |
.  Source IP Address = Session-Sender IPv4 or IPv6 Address      .
.  Destination IP Address=Session-Reflector IPv4 or IPv6 Address.
.  Protocol = UDP                                               .
.                                                               .
+---------------------------------------------------------------+
| UDP Header                                                    |
.  Source Port = As chosen by Session-Sender                    .
.  Destination Port = User-configured Port | 862                .
.                                                               .
+---------------------------------------------------------------+
| Payload = Test Packet as specified in Section 4.2 of RFC 8762 |
.                                                               .
+---------------------------------------------------------------+
```

Figure 2: Example Session-Sender Test Packet

4.1.1. Session-Sender Test Packet for Links

The STAMP Session-Sender test packet as shown in Figure 2 is transmitted over the link for delay measurement. The local and remote IP addresses of the link are used as Source and Destination Addresses.

4.1.2. Session-Sender Test Packet for SR Paths

The delay measurement for end-to-end SR path in SR network is applicable to both end-to-end SR-MPLS and SRv6 paths including SR Policies.

The STAMP Session-Sender IPv4 or IPv6 address is used as the Source Address. The SR Policy endpoint IPv4 or IPv6 address is used as the Destination Address.

In the case of Color-Only Destination Steering, with IPv4 endpoint of 0.0.0.0 or IPv6 endpoint of ::0 [I-D.ietf-spring-segment-routing-policy], the loopback address from the range 127/8 for IPv4, or the loopback address ::1/128 for IPv6 is used as the Destination Address, respectively.

4.1.2.1. Session-Sender Test Packet for SR-MPLS Policies

An SR-MPLS Policy may contain a number of Segment Lists. A STAMP Session-Sender test packet is transmitted for each Segment List of the SR-MPLS Policy. The content of an example STAMP Session-Sender test packet for an end-to-end SR-MPLS Policy is shown in Figure 3.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Segment(1)             | TC  |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Segment(n)             | TC  |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                PSID                   | TC  |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Test Packet as shown in Figure 2               |
.                                                               .
+---------------------------------------------------------------+
```

Figure 3: Example Session-Sender Test Packet for SR-MPLS Policy

The Segment List (SL) can be empty in case of a single-hop SR-MPLS Policy with Implicit NULL label.

The Path Segment Identifier (PSID) [I-D.ietf-spring-mpls-path-segment] of an SR-MPLS Policy can be carried in the MPLS header as shown in Figure 3, and can be used for direct measurement as described in Section 7.

4.1.2.2. Session-Sender Test Packet for SRv6 Policies

An SRv6 Policy may contain a number of Segment Lists. A STAMP Session-Sender test packet is transmitted for each Segment List of the SRv6 Policy. An SRv6 Policy can contain an SRv6 Segment Routing Header (SRH) carrying a Segment List as described in [RFC8754]. The content of an example STAMP Session-Sender test packet for an end-to-end SRv6 Policy is shown in Figure 4.

The SRv6 network programming is described in [I-D.ietf-spring-srv6-network-programming]. The procedure defined for upper-layer header processing for SRv6 SIDs in [I-D.ietf-spring-srv6-network-programming] is used to process the

IPv6/UDP header in the received test packets on the Session-Reflector.

```
+---------------------------------------------------------------+
| IP Header                                                     |
.  Source IP Address = Session-Sender IPv6 Address              .
.  Destination IP Address = Destination IPv6 Address            .
.                                                               .
+---------------------------------------------------------------+
| SRH as specified in RFC 8754                                  |
.  <PSID, Segment List>                                         .
.                                                               .
+---------------------------------------------------------------+
| IP Header                                                     |
.  Source IP Address = Session-Sender IPv6 Address              .
.  Destination IP Address = Session-Reflector IPv6 Address      .
.  Protocol = UDP                                               .
.                                                               .
+---------------------------------------------------------------+
| UDP Header                                                    |
.  Source Port = As chosen by Session-Sender                    .
.  Destination Port = User-configured Port | 862                .
.                                                               .
+---------------------------------------------------------------+
| Payload = Test Packet as specified in Section 4.2 of RFC 8762 |
.                                                               .
+---------------------------------------------------------------+
```

Figure 4: Example Session-Sender Test Packet for SRv6 Policy

The Segment List (SL) may be empty and no SRH may be carried.

The Path Segment Identifier (PSID) [I-D.ietf-spring-srv6-path-segment] of the SRV6 Policy can be carried in the SRH as shown in Figure 4 and can be used for direct measurement as described in Section 7.

4.2. Session-Reflector Test Packet

The STAMP Session-Reflector reply test packet is transmitted using the IP/UDP information from the received test packet. The content of an example STAMP Session-Reflector reply test packet is shown in Figure 5.

```
+-----------------------------------------------------------------+
| IP Header                                                       |
.  Source IP Address = Session-Reflector IPv4 or IPv6 Address     .
.  Destination IP Address                                         .
.              = Source IP Address from Received Test Packet      .
.  Protocol = UDP                                                 .
.                                                                 .
+-----------------------------------------------------------------+
| UDP Header                                                      |
.  Source Port = As chosen by Session-Reflector                   .
.  Destination Port = Source Port from Received Test Packet       .
.                                                                 .
+-----------------------------------------------------------------+
| Payload = Test Packet as specified in Section 4.3 of RFC 8762   |
.                                                                 .
+-----------------------------------------------------------------+
```

Figure 5: Example Session-Reflector Test Packet

4.2.1. One-way Delay Measurement Mode

In one-way delay measurement mode, a reply test packet as shown in Figure 5 is transmitted by the STAMP Session-Reflector, for both links and SR Policies. The reply test packet may be transmitted on the same path or a different path in the reverse direction.

The STAMP Session-Sender address may not be reachable via IP route from the STAMP Session-Reflector. The STAMP Session-Sender in this case can send its reachability path information to the STAMP Session-Reflector using the Return Path TLV defined in [I-D.gandhi-ippm-stamp-srpm].

In this mode, as per Reference Topology, all timestamps T1, T2, T3, and T4 are collected by the test packets. However, only timestamps T1 and T2 are used to measure one-way delay as (T2 - T1).

4.2.2. Two-way Delay Measurement Mode

In two-way delay measurement mode, a reply test packet as shown in Figure 5 is transmitted by the STAMP Session-Reflector in-band on the same path in the reverse direction, e.g. on the reverse direction link or associated reverse SR path [I-D.ietf-pce-sr-bidir-path].

For two-way delay measurement mode for links, the STAMP Session-Reflector needs to transmit the reply test packet in-band on the same link where the test packet is received. The STAMP Session-Sender can request in the test packet to the STAMP Session-Reflector to transmit the reply test packet back on the same link using the Control Code

Sub-TLV in the Return Path TLV defined in [I-D.gandhi-ippm-stamp-srpm].

For two-way delay measurement mode for end-to-end SR paths, the STAMP Session-Reflector needs to transmit the reply test packet in-band on a specific reverse path. The STAMP Session-Sender can request in the test packet to the STAMP Session-Reflector to transmit the reply test packet back on a given reverse path using a Segment List sub-TLV in the Return Path TLV defined in [I-D.gandhi-ippm-stamp-srpm].

In this mode, as per Reference Topology, all timestamps T1, T2, T3, and T4 are collected by the test packets. All four timestamps are used to measure two-way delay as ((T4 - T1) - (T3 - T2)).

4.2.2.1. Session-Reflector Test Packet for SR-MPLS Policies

The content of an example STAMP Session-Reflector reply test packet transmitted in-band on the same path as the data traffic flow under measurement for two-way delay measurement of an end-to-end SR-MPLS Policy is shown in Figure 6.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Segment(1)             | TC  |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Segment(n)             | TC  |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Test Packet as shown in Figure 5               |
.                                                               .
+---------------------------------------------------------------+
```

Figure 6: Example Session-Reflector Test Packet for SR-MPLS Policy

4.2.2.2. Session-Reflector Test Packet for SRv6 Policies

The content of an example STAMP Session-Reflector reply test packet transmitted in-band on the same path as the data traffic flow under measurement for two-way delay measurement of an end-to-end SRv6 Policy with SRH is shown in Figure 7.

The procedure defined for upper-layer header processing for SRv6 SIDs in [I-D.ietf-spring-srv6-network-programming] is also used to process

the IPv6/UDP header in the received reply test packets on the Session-Sender.

```
+---------------------------------------------------------------+
| IP Header                                                     |
.  Source IP Address = Session-Reflector IPv6 Address           .
.  Destination IP Address = Destination IPv6 Address            .
.                                                               .
+---------------------------------------------------------------+
| SRH as specified in RFC 8754                                  |
.  &lt;Segment List&gt;                                               .
.                                                               .
+---------------------------------------------------------------+
| IP Header                                                     |
.  Source IP Address = Session-Reflector IPv6 Address           .
.  Destination IP Address                                       .
.              = Source IPv6 Address from Received Test Packet  .
.  Protocol = UDP                                               .
.                                                               .
+---------------------------------------------------------------+
| UDP Header                                                    |
.  Source Port = As chosen by Session-Reflector                 .
.  Destination Port = Source Port from Received Test Packet     .
.                                                               .
+---------------------------------------------------------------+
| Payload = Test Packet as specified in Section 4.3 of RFC 8762 |
.                                                               .
+---------------------------------------------------------------+
```

Figure 7: Example Session-Reflector Test Packet for SRv6 Policy

4.2.3. Round-trip Delay Measurement Mode

The STAMP Session-Sender test packets are sent in loopback mode to measure round-trip delay of a bidirectional path. The IP header of the STAMP Session-Sender test packet contains the Destination Address equals to the STAMP Session-Sender address and the Source Address equals to the STAMP Session-Reflector address. Optionally, the STAMP Session-Sender test packet can carry the return path information (e.g. return path label stack for SR-MPLS) as part of the SR header. This way, the received Session-Sender test packets are not punted out of the fast path in forwarding (to slow path or control-plane) at the STAMP Session-Reflector. Also, the Session-Reflector does not process them and generate reply test packets.

As the reply test packet is not generated by the STAMP Session-Reflector, the STAMP Session-Sender ignores the 'Session-Sender

Sequence Number', 'Session-Sender Timestamp', 'Session-Sender Error Estimate', and 'Session-Sender TTL' in the received test packet.

In this mode, as per Reference Topology, the timestamps T1 and T4 are collected by the test packets. Both these timestamps are used to measure round-trip delay as (T4 - T1).

4.3. Delay Measurement for P2MP SR Policies

The Point-to-Multipoint (P2MP) SR path that originates from a root node terminates on multiple destinations called leaf nodes (e.g. P2MP SR Policy [I-D.ietf-pim-sr-p2mp-policy]).

The procedures for performance measurement described in this document for P2P SR Policies are used for the P2MP SR Policies as listed below.

- The STAMP Session-Sender root node transmits test packets using the Tree-SID defined in [I-D.ietf-pim-sr-p2mp-policy] for the P2MP SR-MPLS Policy as shown in Figure 8. The STAMP Session-Sender test packets may contain the replication SID as defined in [I-D.ietf-spring-sr-replication-segment].

- The Destination Address is set to the loopback address from the range 127/8 for IPv4, or the loopback address ::1/128 for IPv6.

- Each STAMP Session-Reflector leaf node transmits its node address in the Source Address of the reply test packets shown in Figure 5. This allows the STAMP Session-Sender root node to identify the STAMP Session-Reflector leaf nodes of the P2MP SR Policy.

- The P2MP root node measures the delay for each P2MP leaf node individually.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Tree-SID                 | TC  |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Test Packet as shown in Figure 2                            |
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8: Example Session-Sender Test Packet with Tree-SID for SR-MPLS Policy

The round-trip delay measurement for a P2MP SR-MPLS Policy can use the Node SID of the Session-Sender in the MPLS header of the Session-Sender test packet.

4.4. Additional STAMP Test Packet Processing Rules

The processing rules described in this section are applicable to the STAMP test packets for links and end-to-end SR paths including SR Policies.

4.4.1. TTL

The TTL field in the IPv4 and MPLS headers of the STAMP Session-Sender and STAMP Session-Reflector reply test packets is set to 255, except in the following cases.

When using the Destination IPv4 Address from the range 127/8, the TTL field in the IPv4 header is set to 1.

For link delay, the TTL field in the STAMP test packet is set to 1 in one-way and two-way delay measurement modes.

4.4.2. IPv6 Hop Limit

The Hop Limit field in the IPv6 and SRH headers of the STAMP Session-Sender and STAMP Session-Reflector reply test packets is set to 255, except in the following cases.

When using the Destination IPv6 Address of loopback address ::1/128, the Hop Limit field in the IPv6 header is set to 1.

For link delay, the Hop Limit field in the STAMP test packet is set to 1 in one-way and two-way delay measurement modes.

4.4.3. Router Alert Option

The Router Alert IP option (RAO) [RFC2113] is not set in the STAMP test packets for links and end-to-end SR paths.

5. Packet Loss Measurement for Links and SR Paths

The procedure described in Section 4 for delay measurement using STAMP test packets can be used to detect (test) packet loss for links and end-to-end SR paths. The Sequence Number field in the STAMP test packet is used as described in Section 4 "Theory of Operation" of [RFC8762], to detect forward, reverse and round-trip packet loss.

6. Direct Measurement for Links and SR Paths

The STAMP "Direct Measurement" TLV (Type 5) defined in [RFC8972] can be used in SR networks. The STAMP test packets with this TLV are transmitted using the procedures described in Section 4 to collect the transmit and receive counters of the data flow for the links and end-to-end SR paths. Note that in this case, the STAMP test packets may follow the same or a different path than the data flow under direct measurement.

The PSID carried in the received data packet for the traffic flow under measurement can be used to measure receive data packets for end-to-end SR path on the STAMP Session-Reflector. The PSID in the received Session-Sender test packet header can be used to associate the receive traffic counter on the Session-Reflector for the end-to-end SR path.

7. Session Status for Links and SR Paths

The STAMP test session status allows to know if the performance measurement is active on the links and end-to-end SR paths. The STAMP test session status initially is declared succeeded when one or more reply test packets are received at the STAMP Session-Sender. The STAMP test session status is declared failed when consecutive N number of reply test packets are not received at the STAMP Session-Sender, where N is locally provisioned value.

8. ECMP Support for SR Policies

An SR Policy can have ECMPs between the source and transit nodes, between transit nodes and between transit and destination nodes. Usage of Anycast SID [RFC8402] by an SR Policy can result in ECMP

paths via transit nodes part of that Anycast group. The test packets need to be transmitted to traverse different ECMP paths to measure delay of an SR Policy.

Forwarding plane has various hashing functions available to forward packets on specific ECMP paths. The mechanisms described in [RFC8029] and [RFC5884] for handling ECMPs are also applicable to the delay measurement.

In IPv4 header of the STAMP Session-Sender test packets, sweeping of Destination Address from the range 127/8 can be used to exercise particular ECMP paths. Note that in the loopback mode for round-trip delay measurement, both the forward and the return paths must be SR-MPLS paths in this case.

As specified in [RFC6437], Flow Label field in the outer IPv6 header can also be used for sweeping to exercise different IPv6 ECMP paths.

The "Destination Node Address" TLV [I-D.gandhi-ippm-stamp-srpm] can be carried in the STAMP Session-Sender test packet to identify the intended destination node, for example, when using IPv4 Destination Address from the range 127/8. The STAMP Session-Reflector must not transmit reply test packet if it is not the intended destination node in the "Destination Node Address" TLV [I-D.gandhi-ippm-stamp-srpm].

9. Security Considerations

The performance measurement is intended for deployment in well-managed private and service provider networks. As such, it assumes that a node involved in a measurement operation has previously verified the integrity of the path and the identity of the far-end STAMP Session-Reflector.

If desired, attacks can be mitigated by performing basic validation and sanity checks, at the STAMP Session-Sender, of the counter or timestamp fields in received measurement reply test packets. The minimal state associated with these protocols also limits the extent of measurement disruption that can be caused by a corrupt or invalid packet to a single test cycle.

Use of HMAC-SHA-256 in the authenticated mode protects the data integrity of the test packets. SRv6 has HMAC protection authentication defined for SRH [RFC8754]. Hence, test packets for SRv6 may not need authentication mode. Cryptographic measures may be enhanced by the correct configuration of access-control lists and firewalls.

The security considerations specified in [RFC8762] and [RFC8972] also apply to the procedures described in this document.

10. IANA Considerations

This document does not require any IANA action.

11. References

11.1. Normative References

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