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Simple TWAMP (STAMP) Extensions for Segment Routing Networks
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Abstract

Segment Routing (SR) leverages the source routing paradigm. SR is applicable to both Multiprotocol Label Switching (SR-MPLS) and IPv6 (SRv6) forwarding planes. This document specifies RFC 8762 (Simple Two-Way Active Measurement Protocol (STAMP)) extensions for SR networks, for both SR-MPLS and SRv6 forwarding planes by augmenting the optional extensions defined in RFC 8972.

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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) forwarding planes [RFC8402]. 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] without the use of a control channel to pre-signal session parameters. [RFC8972] defines optional extensions for STAMP. Note that 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.

The STAMP test packets are transmitted along an IP path between a Session-Sender and a Session-Reflector to measure performance delay and packet loss along that IP path. It may be desired in SR networks that the same path (same set of links and nodes) between the Session-Sender and Session-Reflector is used for the STAMP test packets in both directions. This is achieved by using the STAMP [RFC8762] extensions for SR-MPLS and SRv6 networks specified in this document by augmenting the optional extensions defined in [RFC8972].

2. Conventions Used in This Document

2.1. Requirements Language

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] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2.2. Abbreviations

MPLS: Multiprotocol Label Switching.

PM: Performance Measurement.

SID: Segment ID.

SL: Segment List.

SR: Segment Routing.

SR-MPLS: Segment Routing with MPLS forwarding plane.

SRv6: Segment Routing with IPv6 forwarding plane.

SSID: STAMP Session Identifier.

STAMP: Simple Two-way Active Measurement Protocol.

2.3. 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 may be transmitted to the STAMP Session-Sender R1 on the same path (same set

of links and nodes) or a different path in the reverse direction from the path taken towards the Session-Reflector.

The nodes R1 and R3 may be connected via a link or 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. Destination Node Address TLV

The STAMP Session-Sender may need to transmit test packets to the STAMP Session-Reflector with a different destination address not matching an address on the Session-Reflector e.g. when the STAMP test packet is encapsulated by a tunneling protocol or an MPLS Segment List with IPv4 address from 127/8 range or Segment Routing Header (SRH) with an IPv6 address. Here, Session-Sender may select an IPv4 address from 127/8 range or select a Flow Label in case of IPv6 address ::1/128 for testing ECMPs. In an error condition, the STAMP test packet may not reach the intended STAMP Session-Reflector, an un-intended node may transmit reply test packets resulting in reporting of invalid measurement metrics.

[RFC8972] defines STAMP test packets that can include one or more optional TLVs. In this document, Destination Node Address TLV (Type TBA1) is defined for STAMP test packet [RFC8972] and has the following format shown in Figure 1:


```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|STAMP TLV Flags| Type=TBA1     |         Length                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                            Address                            .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: Destination Node Address TLV Format

The Length field is used to decide the Address Family of the Address.

The STAMP TLV Flags are set using the procedures described in [RFC8972].

The Destination Node Address TLV is optional. The Destination Node Address TLV indicates the address of the intended Session-Reflector node of the test packet.

The STAMP Session-Reflector that supports this TLV, MUST transmit reply test packet with Error D (Wrong Destination) in the STAMP TLV Flags field if it is not the intended destination of the received

Session-Sender test packet.

D (Wrong Destination): A one-bit flag. A Session-Sender MUST set the D flag to 0 before transmitting an extended STAMP test packet. A Session-Reflector MUST set the D flag to 1 if the Session-Reflector determined that it is not the intended Destination as identified in the Destination Node Address TLV. Otherwise, the Session-Reflector MUST set the D flag in the Reply test packet to 0.

Note that the Destination Node Address TLV is applicable to the P2P SR paths only.

4. Return Path TLV

For end-to-end SR paths, the STAMP Session-Reflector may need to transmit the reply test packet on a specific return path. The STAMP Session-Sender can request this in the test packet to the STAMP Session-Reflector using a Return Path TLV. With this TLV carried in the STAMP Session-Sender test packet, signaling and maintaining dynamic SR network state for the STAMP sessions on the Session-Reflector are avoided.

For links, the STAMP Session-Reflector may need to transmit the reply test packet on the same incoming link in the reverse direction. The STAMP Session-Sender can request this in the test packet to the STAMP Session-Reflector using a Return Path TLV.

[RFC8972] defines STAMP test packets that can include one or more optional TLVs. In this document, the TLV Type (value TBA2) is defined for the Return Path TLV that carries the return path for the STAMP Session-Sender test packet. The format of the Return Path TLV is shown in Figure 2:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|STAMP TLV Flags|   Type=TBA2   |         Length                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Return Path Sub-TLVs                        |
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: Return Path TLV

The STAMP TLV Flags are set using the procedures described in [RFC8972].

The Return Path TLV is optional. The STAMP Session-Sender MUST only insert one Return Path TLV in the STAMP test packet. The STAMP Session-Reflector that supports this TLV, MUST only process the first Return Path TLV in the test packet and ignore other Return Path TLVs if present, and it MUST NOT add Return Path TLV in the reply test packet. The Session-Reflector that supports this TLV MUST reply using the Return Path received in the Session-Sender test packet. Otherwise, the procedure defined in [RFC8762] is followed.

4.1. Return Path Sub-TLVs

The Return Path TLV contains one or more Sub-TLVs to carry the information for the requested return path. A Return Path Sub-TLV can carry Return Path Control Code, Return Path IP Address or Return Path Segment List.

The STAMP Sub-TLV Flags are set using the procedures described in [RFC8972].

When Return Path Sub-TLV is present in the Session-Sender test packet, the STAMP Session-Reflector that supports this TLV, MUST transmit reply test packet using the return path information specified in the Return Path Sub-TLV.

A Return Path TLV MUST NOT contain both Control Code Sub-TLV as well as Return Address or Return Segment List Sub-TLV.

4.1.1. Return Path Control Code Sub-TLV

The format of the Return Path Control Code Sub-TLV is shown in Figure 3. The Type of the Return Path Control Code Sub-TLV is defined as following:

o Type (value 1): Return Path Control Code. The STAMP Session-Sender can request the STAMP Session-Reflector to transmit the reply test packet based on the flags defined in the Control Code field.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|STAMP TLV Flags|    Type       |           Length              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Control Code                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: Control Code Sub-TLV in Return Path TLV

Control Code Flags (32-bit): Defined as follows.

0x0: No Reply Requested.

0x1: Reply Requested on the Same Link.

When Control Code flag is set to 0x0 in the STAMP Session-Sender test packet, the Session-Reflector does not transmit reply test packet to the Session-Sender and terminates the STAMP test packet. Optionally, the Session-Reflector may locally stream performance metrics via telemetry using the information from the received test packet. All other Return Path Sub-TLVs are ignored in this case.

When Control Code flag is set to 0x1 in the STAMP Session-Sender test packet, the Session-Reflector transmits the reply test packet over the same incoming link where the test packet is received in the reverse direction towards the Session-Sender.

4.1.2. Return Address Sub-TLV

The STAMP reply test packet may be transmitted to the Session-Sender to a different destination address on the Session-Sender using Return Path TLV. For this, the Session-Sender can specify in the test packet the receiving destination node address for the Session-Reflector reply test packet. When transmitting the STAMP test packet to a different destination address, the Session-Sender MUST follow the procedure defined in Section 4.3 of [RFC8762].

The format of the Return Address Sub-TLV is shown in Figure 4. The

Address Family field indicates the type of the address, and it SHALL be set to one of the assigned values in the "IANA Address Family Numbers" registry. The Type of the Return Address Sub-TLV is defined as following:

- o Type (value 2): Return Address. Destination node address of the STAMP Session-Reflector reply test packet different than the Source Address in the Session-Sender test packet.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|STAMP TLV Flags|     Type      |         Length                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Reserved                      | Address Family                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                            Address                            .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Return Address Sub-TLV in Return Path TLV

4.1.3. Return Segment List Sub-TLVs

The format of the Segment List Sub-TLVs in the Return Path TLV is shown in Figure 5. The segment entries MUST be in network order. The Segment List Sub-TLV can be one of the following Types:

- o Type (value 3): SR-MPLS Label Stack of the Return Path

- o Type (value 4): SRv6 Segment List of the Return Path

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|STAMP TLV Flags|      Type     |         Length                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Segment(1)                                 |
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Segment(n) (bottom of stack)               |
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Segment List Sub-TLV in Return Path TLV

An SR-MPLS Label Stack Sub-TLV may carry only Binding SID [I-D.ietf-pce-binding-label-sid] of the Return SR-MPLS Policy.

An SRv6 Segment List Sub-TLV may carry only Binding SID [I-D.ietf-pce-binding-label-sid] of the Return SRv6 Policy.

The STAMP Session-Sender MUST only insert one Segment List Return Path Sub-TLV in the test packet. The STAMP Session-Reflector MUST only process the first Segment List Return Path Sub-TLV in the test packet and ignore other Segment List Return Path Sub-TLVs if present.

Note that in addition to the P2P SR paths, the Return Segment List Sub-TLV is also applicable to the P2MP SR paths. For example, for P2MP SR paths, it may only carry the Node Segment Identifier of the Session-Sender in order for the reply test packet to follow an SR path to the Session-Sender.

5. 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 STAMP Session-Reflector.

If desired, attacks can be mitigated by performing basic validation and sanity checks, at the STAMP Session-Sender, of the timestamp fields in received 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 test packet to a single test cycle.

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

The STAMP extensions defined in this document may be used for potential "proxying" attacks. For example, a Session-Sender may specify a return path that has a destination different from that of the Session-Sender. But normally, such attacks will not happen in an SR domain where the Session-Senders and Session-Reflectors belong to the same domain. In order to prevent using the extension defined in this document for proxying any possible attacks, the return path has destination to the same node where the forward path is from. The Session-Reflector may drop the Session-Sender test packet when it cannot determine whether the Return Path has the destination to the Session-Sender. That means, when sending reply test packet, the Session-Sender should choose a proper source address according the specified Return Path to help the Session-Reflector to make the decision.

6. IANA Considerations

IANA will create a "STAMP TLV Type" registry for [RFC8972]. IANA is requested to allocate a value for the following Destination Address TLV Type from the IETF Review TLV range of this registry. This TLV is to be carried in the STAMP test packets.

- Type TBA1: Destination Node Address TLV

IANA is also requested to allocate a value for the following Return Path TLV Type from the IETF Review TLV range of the same registry. This TLV is to be carried in the STAMP test packets.

- Type TBA2: Return Path TLV

IANA is requested to create a sub-registry for "Return Path Sub-TLV Type". All code points in the range 1 through 175 in this registry shall be allocated according to the "IETF Review" procedure as specified in [RFC8126]. Code points in the range 176 through 239 in this registry shall be allocated according to the "First Come First Served" procedure as specified in [RFC8126]. Remaining code points are allocated according to Table 1:

Value	Description	Reference
0	Reserved	This document
1 - 175	Unassigned	This document
176 - 239	Unassigned	This document
240 - 251	Experimental	This document
252 - 254	Private Use	This document
255	Reserved	This document

Table 1: Return Path Sub-TLV Type Registry

IANA is requested to allocate the values for the following Sub-TLV Types from this registry.

- o Type (value 1): Return Path Control Code
- o Type (value 2): Return Address
- o Type (value 3): SR-MPLS Label Stack of the Return Path
- o Type (value 4): SRv6 Segment List of the Return Path

7. References

7.1. Normative References

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7.2. Informative References

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