Simple TWAMP (STAMP) Extensions for Segment Routing Networks

draft-gandhi-ippm-stamp-srpm-02

Rakesh Gandhi - Cisco Systems (rgandhi@cisco.com) - Presenter
Clarence Filsfils - Cisco Systems (cfilsfil@cisco.com)
Daniel Voyer - Bell Canada (daniel.voyer@bell.ca)
Mach(Guoyi) Chen - Huawei (mach.chen@huawei.com)
Bart Janssens - Colt (Bart.Janssens@colt.net)
Agenda

- Requirements and Scope
- Summary of Extensions
- Next Steps
Requirements, Goals and Scope

Requirements:
- In-band Performance Measurement for links and SR paths

Goals:
- Avoid maintaining each test session on Session-Reflector
- Avoid control protocol for signaling dynamic parameters

Scope:
- STAMP [RFC 8762]
- STAMP Extensions [RFC 8972]
Updates Since Version-00

Updates:
- Updated terminology to align with STAMP
- Moved direct measurement messages to draft-gandhi-ippm-simple-direct-loss
- Moved Control Code to Return Path TLV
- Various editorial changes to address review comments

Open Items:
- None
STAMP Destination Node Address TLV

Destination Node Address TLV (value TBA1):

- Indicates the address of the intended destination of the Session-Sender test packet
- STAMP Session-Reflector that supports this TLV, **MUST NOT** send reply if it is not the intended destination of the Session-Sender test packet
- Useful when test packet is sent with 127/8 destination address (e.g. sweeping ECMP paths)
Return Path TLV (value TBA2) to carry Sub-TLV for return path:

Return Path Sub-TLVs Types:

- **Type (value 1):** Return Path Control Code. Reply test packet based on the control code flags
  - 0x0: No Reply Requested
  - 0x1: In-band Reply Requested
- **Type (value 2):** Return Address. Destination address for the reply; different than the Source Address in the Session-Sender test packet
- **Type (value 3):** SR-MPLS Label Stack of the Return SR Path
- **Type (value 4):** SR-MPLS Binding SID [draft-ietf-pce-binding-label-sid] of the Return SR Policy
- **Type (value 5):** SRv6 Segment List of the Return SR Path
- **Type (value 6):** SRv6 Binding SID [draft-ietf-pce-binding-label-sid] of the Return SR Policy

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**Figure: Return Path TLV**

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**Figure: Segment List Sub-TLV in Return Path TLV**
STAMP Return Path Control Code Sub-TLV - Usage

- Avoid maintaining each test session (session id, source-address) on Session-Reflector
- In-band Reply Requested:
  - For link delay measurement
    - STAMP Session-Reflector transmits test packet in-band on the same incoming link in the reverse direction
    - Link can be Virtual, LAG or LAG member
- No Reply Requested:
  - STAMP Session-Reflector does not transmit reply test packet to the STAMP Session-Sender and terminates the Session-Sender test packet
STAMP Return Address Sub-TLV - Usage

• Avoid maintaining each test session (session id, source-address) on Session-Reflector
• STAMP Session-Reflector reply test packet may be transmitted to a different node than the Session-Sender
• STAMP Session-Sender can specify in the test packet the receiving destination address for the STAMP Session-Reflector reply test packet
For an SR path, STAMP Session-Reflector reply test packet may need to be sent in-band on a specific return SR path.

Dynamically computed SR paths can change based on topology change, link/node failure, etc. in the network.

Avoid signaling and maintaining dynamic state on STAMP Session-Reflector for the return path for each STAMP test session (each session-id, source-address)
  - Can be order of 10K SR Policy (that can also have ECMPs)
Next Steps

- Welcome your comments and suggestions
- Requesting WG adoption
Thank you
Performance Measurement Using Simple TWAMP for Segment Routing Networks

draft-gandhi-spring-stamp-srpm-05

Rakesh Gandhi - Cisco Systems (rgandhi@cisco.com) - Presenter
Clarence Filsfils - Cisco Systems (cfilsfil@cisco.com)
Daniel Voyer - Bell Canada (daniel.voyer@bell.ca)
Mach(Guoyi) Chen - Huawei (mach.chen@huawei.com)
Bart Janssens - Colt (Bart.Janssens@colt.net)
Agenda

• Requirements and Scope
• Summary of Procedure
• Next Steps
Requirements, Goals and Scope

Requirements:

- In-band Performance Delay and Loss Measurement
  - Links and end-to-end P2P/P2MP SR paths
    - Links include physical, virtual, LAG, LAG member links
    - Applicable to SR-MPLS/SRv6 data planes
- One-way, two-way, round-trip delay and packet loss metrics

Goals:

- Avoid maintaining each test session on Session-Reflector
- Avoid control protocol for signaling dynamic parameters

Scope:

- STAMP [RFC 8762]
- STAMP Extensions [RFC 8972]
- STAMP Extensions for SR [draft-gandhi-ippm-stamp-srpm]
Updates Since Version-02

Updates:

✓ Draft status - Informational
✓ Updated terminology to align with STAMP
✓ Added (synthetic) packet loss section
✓ Removed stand-alone direct measurement messages
✓ Removed text for IPv6/UDP test packet with zero checksum
✓ Various editorial changes to address review comments

Open Items:

▪ None
Example STAMP Reference Model

+---------------+    +---------------+    +---------------+
| Controller    |    | Controller    |    | Controller    |

/       \                                      /       \                                      /       \
Destination UDP Port          \       \          Destination UDP port          \       \          Destination UDP port
/       \                                      /       \                                      /       \
Authentication Mode & Key     \       \          Authentication Mode & Key     \       \          Authentication Mode & Key
/       \                                      /       \                                      /       \
Delay Measurement Mode        \       \          Delay Measurement Mode        \       \          Delay Measurement Mode
/       \                                      /       \                                      /       \
Timestamp Format              \       \          Timestamp Format              \       \          Timestamp Format
/       \                                      /       \                                      /       \
Packet Loss Type              \       \          Packet Loss Type              \       \          Packet Loss Type
/       \                                      /       \                                      /       \

v                  v                                      v                  v

+---------------------+    +---------------------+    +---------------------+
|   R1                 |    |   =============     |    |   R3                 |

+---------------+    +---------------+
| STAMP Session-Sender |    | STAMP Session-Reflector |

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STAMP Session-Sender Test Packet for Links

- For links, STAMP Session-Sender test packets are transmitted over the links using local and remote link addresses
- User-configured destination UDP port is used for STAMP test packets (or port 862)
- IPv4 TTL /IPv6 Hop-limit is set to 1
- Applicable to physical, virtual, LAG, LAG member links

<table>
<thead>
<tr>
<th>IP Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source IP Address = Session-Sender IPv4 or IPv6 Address</td>
</tr>
<tr>
<td>Destination IP Address = Session-Reflector IPv4 or IPv6 Addr</td>
</tr>
<tr>
<td>Protocol = UDP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UDP Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Port = As chosen by Session-Sender</td>
</tr>
<tr>
<td>Destination Port = User-configured Port</td>
</tr>
</tbody>
</table>

| Payload = Test Packet specified in Section 4.2 of RFC 8762 |

Figure 1: STAMP Session-Sender Test Packet for links
STAMP Session-Sender Test Packet for SR-MPLS and SRv6 Policy

- For end-to-end SR Policy, STAMP Session-Sender test packets are transmitted with:
  1. MPLS label stack of SR-MPLS Policy
  2. SRv6 SRH [RFC 8754] with Segment List of SRv6 Policy
     - Using upper-layer processing (for UDP header) defined in SRv6 network programming
- User-configured destination UDP port is used for STAMP test packets (or port 862)
- IPv4 TTL/IPv6 Hop-limit is set to 255
- Color-Only Destination Steering:
  - IPv4
    - Destination Address in 127/8 range
    - TTL is set to 1
  - IPv6
    - Destination Address set to ::1/128
    - Hop Limit is set to 1

---

Figure 2: Example Session-Sender test packet for SR-MPLS Policy

```
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 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Test Packet including IP/UDP Header from Figure 1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

---

Figure 3: Example Session-Sender test packet for SRv6 Policy

```
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Source Port = As chosen by Session-Sender |
| Destination Port = User-configured Port | 862 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Payload = Test Packet specified in Section 4.2 of RFC 8762 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
### STAMP Session-Sender Test Packet for P2MP SR-MPLS Policy

- For end-to-end P2MP SR-MPLS Policy, STAMP Session-Sender test packets are transmitted with:
  - Tree-SID of the P2MP SR-MPLS Policy
  - IPv4 destination address selected from 127/8 range
  - IPv4 TTL is set to 1

![Example Session-Sender test packet for SR-MPLS Policy](image.png)

**Figure 4:** Example Session-Sender test packet for SR-MPLS Policy
STAMP Session-Reflector Test Packet

- STAMP Session-Reflector reply test packet is transmitted using the IP/UDP information from the received test packet.

+-----------------------------------------------+-----------------------------------------------+
| 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 specified in Section 4.3 of RFC 8762 |                                              |
+-----------------------------------------------+-----------------------------------------------+

Figure 5: STAMP Session-Reflector Test Packet
Performance Measurement Modes

• Need to measure in-band one-way, two-way and round-trip delay metrics in SR networks

• One-way Delay Measurement Mode
  – Existing (default) behavior

• Two-way Delay Measurement Mode
  – STAMP Session-Reflector test packet sent “in-band” on reverse path
  – Avoid per test session state on Session-Reflector
  – Link: Use Control Code Sub-TLV in the Return Path TLV from the received test packet.
  – E2E SR path: Use Segment List Sub-TLV in the Return Path TLV from the received test packet.

• Round-trip Delay Measurement Mode
  – STAMP Session-Sender test packet sent in loopback mode, carries the return path in the packet header
ECMP Support for SR Path

• SR Path can have ECMP between the ingress and transit nodes, between transit nodes and between transit and egress nodes
• Sending STAMP test packets that can take advantage of the hashing function in forwarding plane
• Existing forwarding mechanisms are applicable to test packets. Examples are:
  – For IPv4
    • Sweeping destination address in IPv4 header (e.g. 127/8)
    • Identify intended actual destination node in “Destination Node Address TLV”
  – For IPv6
    • Sweeping flow label in IPv6 header
Example PM Metrics

• Compute following example (one-way, two-way, round-trip) delay metrics:
  – Minimum delay
  – Maximum delay
  – Average delay
  – Delay variance

• Compute following example loss metrics:
  – Packet loss (i.e., synthetic packet loss)
  – Direct measurement packet counters
  – Session status succeeded/failed (i.e., measurement is active)
Next Steps

- Welcome your comments and suggestions
- Requesting WG adoption
Thank you
Simple Two-Way Direct Loss Measurement Procedure

draft-gandhi-ippm-simple-direct-loss-00

Rakesh Gandhi - Cisco Systems (rgandhi@cisco.com) - Presenter
Clarence Filsfils - Cisco Systems (cfilsfil@cisco.com)
Daniel Voyer - Bell Canada (daniel.voyer@bell.ca)
Mach(Guoyi) Chen - Huawei (mach.chen@huawei.com)
Bart Janssens - Colt (Bart.Janssens@colt.net)
Stefano Salsano - Universita di Roma "Tor Vergata" (stefano.salsano@uniroma2.it)
Agenda

• Requirements and Scope
• Summary
• Next Steps
Requirements and Scope

Requirements:
- Direct Loss Measurement (DLM) for accurate data packet loss
- Support Alternate-Marking Method (AMM) [RFC 8321]
- High scale for number of sessions and faster packet loss detection interval
  - Support hardware implementation

Goals:
- Avoid maintaining each test session on Session-Reflector
- Avoid control protocol for signaling dynamic parameters

Scope:
- Follow STAMP [RFC 8762] approach
Alternate Marking Method for Packet Loss

- RFC 8321 - Alternate-Marking Method for Passive and Hybrid Performance Monitoring
- RFC 8957 - Synonymous Flow Label Framework

Figure 2: Traffic Coloring
Case 1. STAMP Test Packets with Direct Measurement TLV

Figure: STAMP Session-Sender Test Packet Format

Figure: STAMP Session-Reflector Test Packet Format

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Case 2. Direct Loss Measurement Probe Packet for Data Packet Loss Detection

- Base Direct Loss Measurement probe packet defined
  - Hardware efficient counter updating
    - Well-known locations for traffic counters
  - Block number of the counters for alternate-marking method [RFC 8321]
  - Traffic class of the counters for per class packet loss
  - DLM probe packet is also defined for authenticated mode

- User-configured destination UDP Port is used for identifying DLM probe packets (different than port 862 and the one used by STAMP)

- Sequence Number allows to monitor DLM session status, out of order probe packets and probe packet drops

- Flags
  - X set to 1 for 64-Bit Counter, set to 0 for 32-Bit Counter
  - B set to 1 for Byte Counter, set to 0 for Packet Counter
  - T set to 1 for Sender-DSCP scoped Counter

```plaintext
<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP Header</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source IP Address = Session-Sender IPv4 or IPv6 Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination IP Address = Session-Reflector IPv4 or IPv6 Addr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol = UDP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDP Header</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source Port = As chosen by Session-Sender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination Port = User-configured Port</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmit Counter (C3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSCP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive Counter (C2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session-Sender Sequence Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session-Sender Counter (C1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flags</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ses-DSCP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ses-Block Num</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBZ (2 octets)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ses-Sender TTL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBZ</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

**Figure:** Session-Reflector Direct Loss Measurement Probe Packet
## Direct Measurement TLV vs. Direct Loss Measurement Probe Packet

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Need to write timestamp (clock sync needed for one-way delay)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Counter at fixed location in the probe packet for hardware-based counter update</td>
<td>No (TLV-based)</td>
<td>No (TLV-based)</td>
<td>Yes</td>
</tr>
<tr>
<td>Reply probe packets with counter at fixed location for hardware-based counter update</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Need to scan for DM TLV in each received probe packet on Session-Reflector in hardware (there can be multiple TLVs)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>32-bit and 64-bit Byte counters</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>64-bit packet counters</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Alternate-marking method packet loss - using block number for counters (out-of-order data packet support)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Per Traffic Class Counters</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Data Packet Loss Calculation

- Using the Counters $C_1$, $C_2$, $C_3$ and $C_4$ as per reference topology, from the $n^{th}$ and $(n-1)^{th}$ Direct Loss Measurement probe packets.
  - Transmit Loss $TxL[n-1, n] = (C_1[n] - C_1[n-1]) - (C_2[n] - C_2[n-1])$
  - Receive Loss $RxL[n-1, n] = (C_3[n] - C_3[n-1]) - (C_4[n] - C_4[n-1])$
- When using Alternate-Marking Method, all Counters used for the loss calculation belongs to the same Block Number, as described in Section 3.1 of [RFC8321].

Reference Topology
Next Steps

• Welcome your comments and suggestions
• Requesting WG adoption
• Define New STAMP Direct Measurement TLV2?
Thank you