Network Working Group
Internet-Draft
Updates: 8762 (if approved)
Intended status: Standards Track
Expires: May 19, 2021

G. Mirsky
X. Min
ZTE Corp.
H. Nydell
Accedian Networks
R. Foote
Nokia
A. Masputra
Apple Inc.
E. Ruffini
OutSys

November 15, 2020

Simple Two-way Active Measurement Protocol Optional Extensions
draft-ietf-ippm-stamp-option-tlv-10

Abstract

This document describes optional extensions to Simple Two-way Active Measurement Protocol (STAMP) that enable measurement of performance metrics. The document also defines a STAMP Test Session Identifier and thus updates RFC 8762.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on May 19, 2021.

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1. Introduction

Simple Two-way Active Measurement Protocol (STAMP) [RFC8762] defined the STAMP base functionalities. This document specifies the use of optional extensions that use Type-Length-Value (TLV) encoding. Such extensions enhance the STAMP base functions, such as measurement of one-way and round-trip delay, latency, packet loss, packet

duplication, and out-of-order delivery of test packets. This specification defines optional STAMP extensions, their formats, and the theory of operation. Also, a STAMP Test Session Identifier is defined as an update of the base STAMP specification [RFC8762].

2. Conventions Used in This Document

2.1. Acronyms

BDS BeiDou Navigation Satellite System

BITS Building Integrated Timing Supply

CoS Class of Service

DSCP Differentiated Services Code Point

ECN Explicit Congestion Notification

GLONASS Global Orbiting Navigation Satellite System

GPS Global Positioning System [GPS]

HMAC Hashed Message Authentication Code

LORAN-C Long Range Navigation System Version C

MBZ Must Be Zero

NTP Network Time Protocol [RFC5905]

PMF Performance Measurement Function

PTP Precision Time Protocol [IEEE.1588.2008]

TLV Type-Length-Value

SSID STAMP Session Identifier

SSU Synchronization Supply Unit

STAMP Simple Two-way Active Measurement Protocol

2.2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP

14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. STAMP Test Session Identifier

The STAMP Session-Sender transmits test packets to the STAMP Session-Reflector. The STAMP Session-Reflector receives the Session-Sender's packet and acts according to the configuration and optional control information communicated in the Session-Sender's test packet. STAMP defines two different test packet formats, one for packets transmitted by the STAMP Session-Sender and one for packets transmitted by the STAMP Session-Reflector. STAMP supports two modes: unauthenticated and authenticated. Unauthenticated STAMP test packets are compatible on the wire with unauthenticated TWAMP-Test [RFC5357] packets.

By default, STAMP uses symmetrical packets, i.e., the size of the packet transmitted by the Session-Reflector equals the size of the packet received by the Session-Reflector.

A STAMP Session is identified by the 4-tuple (source and destination IP addresses, source and destination UDP port numbers). A STAMP Session-Sender MAY generate a locally unique STAMP Session Identifier (SSID). The SSID is a two-octet-long non-zero unsigned integer. SSID generation policy is implementation-specific. [I-D.gont-numeric-ids-generation] thoroughly analyzes common algorithms for identifier generation and their vulnerabilities. For example, an implementation can use algorithms described in Section 7.1 of [I-D.gont-numeric-ids-generation]. An implementation

MUST NOT assign the same identifier to different STAMP test sessions. A Session-Sender MAY use the SSID to identify a STAMP test session. If the SSID is used, it MUST be present in each test packet of the given test session. In the unauthenticated mode, the SSID is located as displayed in Figure 1.

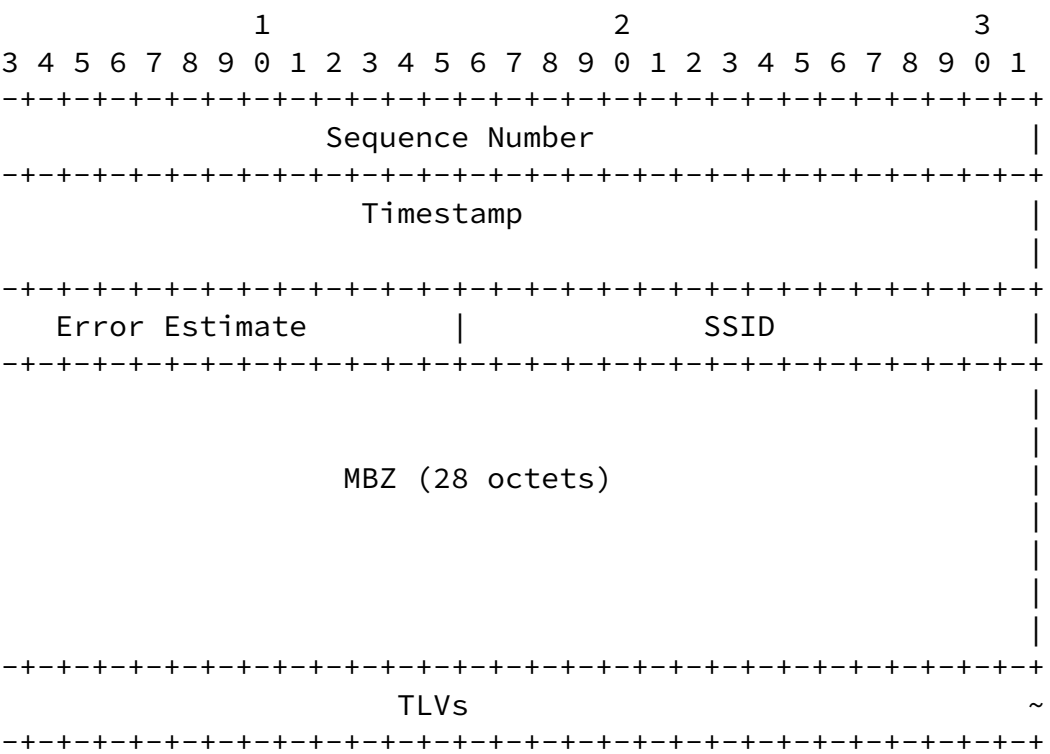
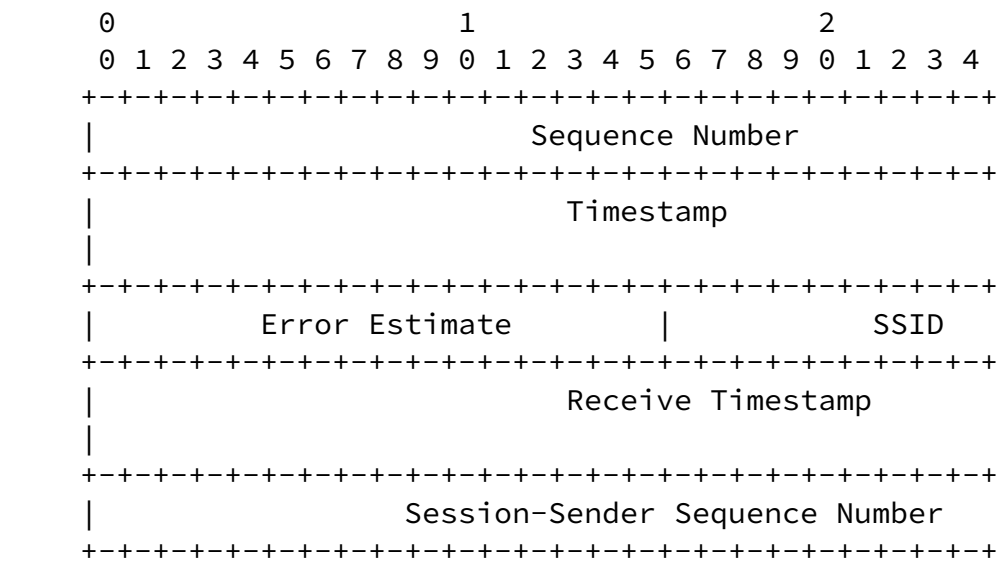


Figure 1: The format of an extended STAMP Session-Sender test packet

in unauthenticated mode

An implementation of the STAMP Session-Reflector that supports this specification MUST identify a STAMP Session using the SSID in combination with elements of the usual 4-tuple for the session. Before a test session commences, a Session-Reflector MUST be provisioned with all the elements that identify the STAMP Session. A STAMP Session-Reflector MUST discard non-matching STAMP test packet(s). The means of provisioning the STAMP Session identification is outside the scope of this specification. A conforming implementation of STAMP Session-Reflector MUST copy the SSID value from the received test packet and put it into the reflected packet, as displayed in Figure 2.



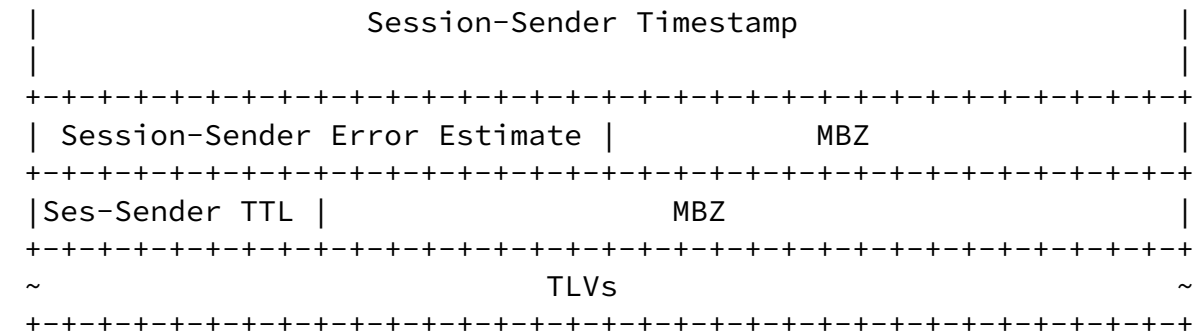
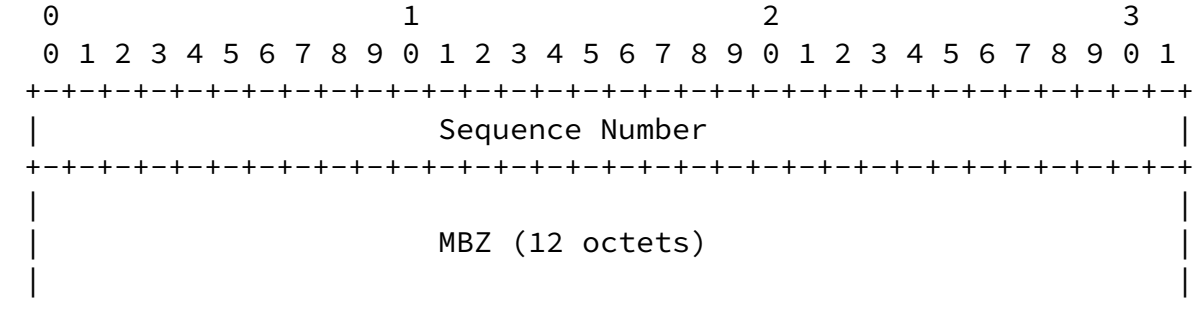


Figure 2: The format of an extended STAMP Session-Reflector test packet in unauthenticated mode

A STAMP Session-Reflector that does not support this specification will return the zeroed SSID field in the reflected STAMP test packet. The Session-Sender MAY stop the session if it receives a zeroed SSID field. An implementation of a Session-Sender MUST support control of its behavior in such a scenario. If the test session is not stopped, the Session-Sender, can, for example, send a base STAMP packet [RFC8762] or continue transmitting STAMP test packets with the SSID.

Location of the SSID field in the authenticated mode is shown in Figure 3 and Figure 4.



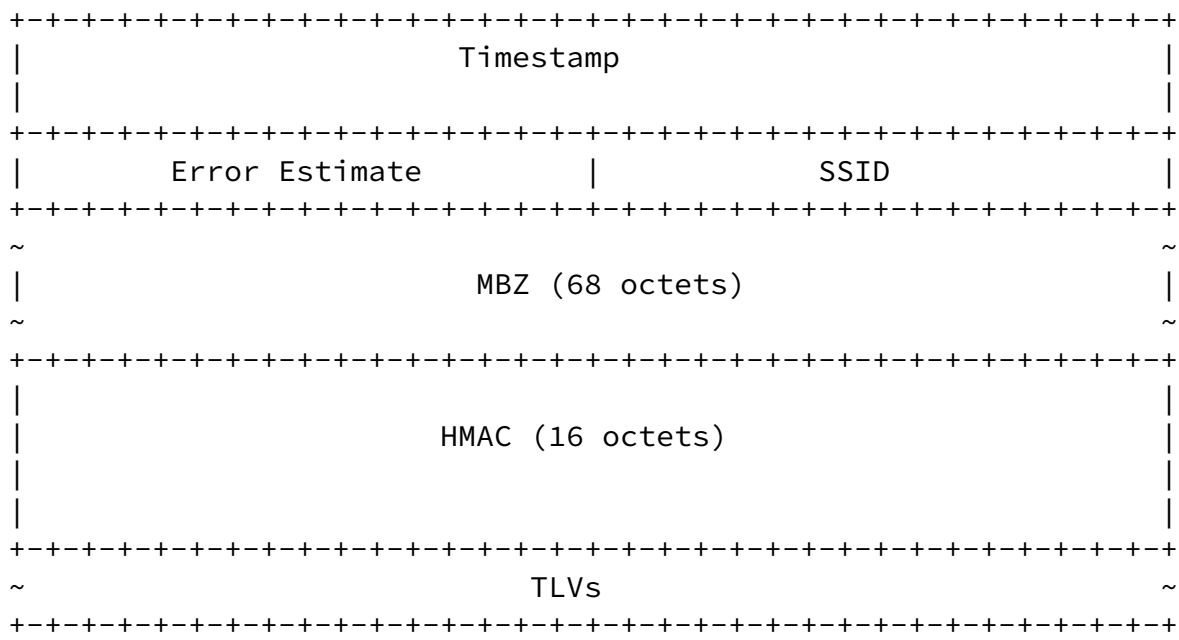
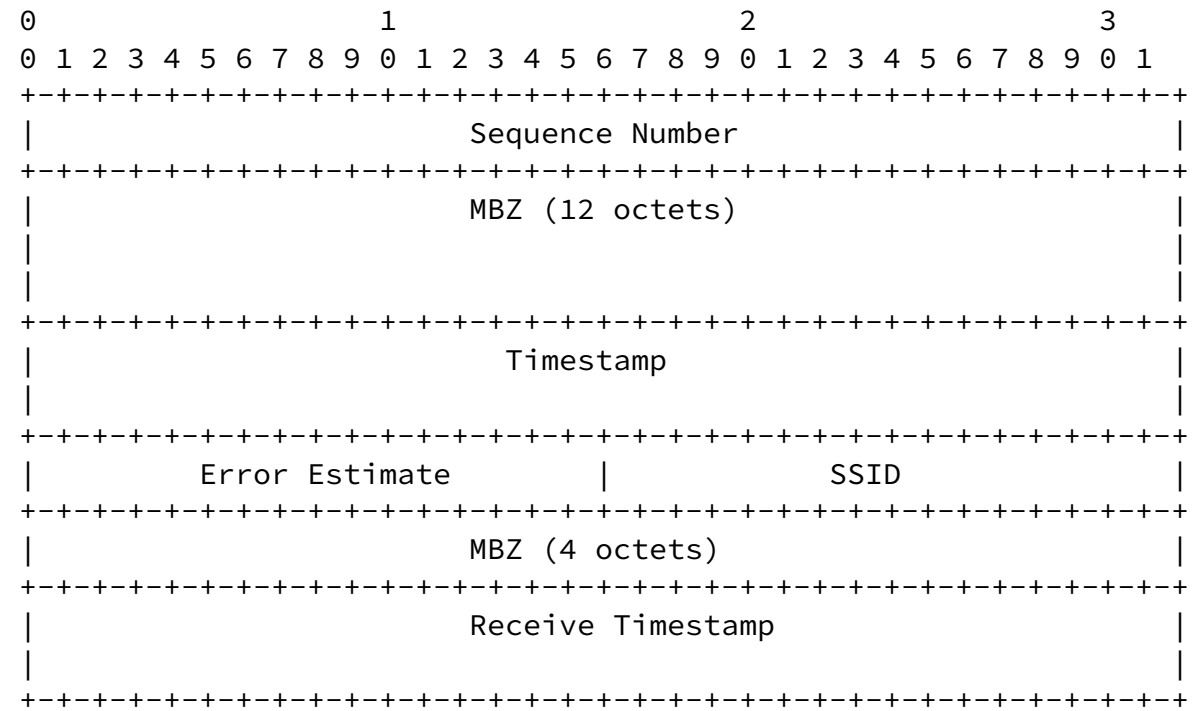
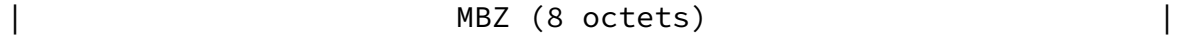


Figure 3: Base STAMP Session-Sender test packet format in authenticated mode





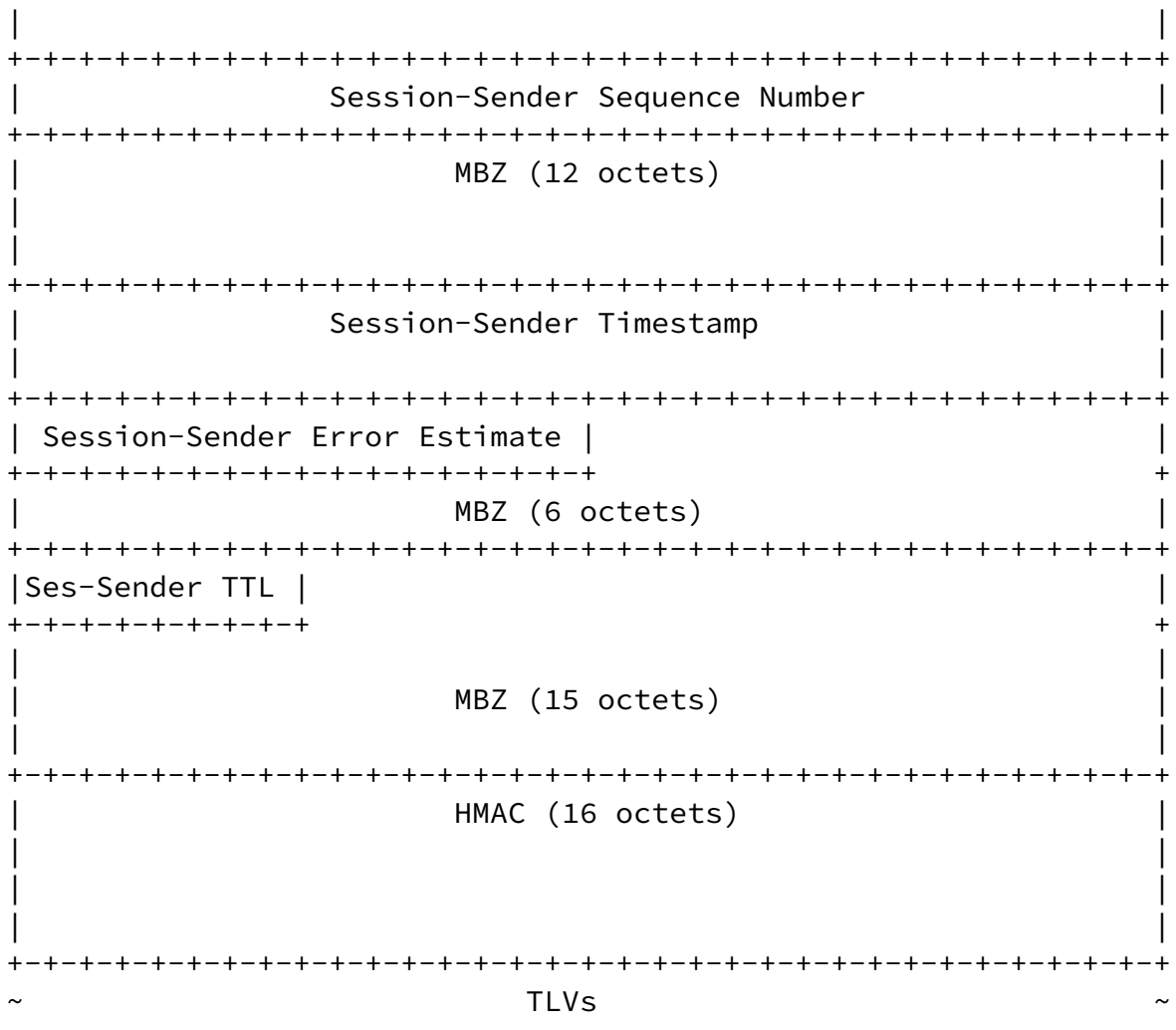


Figure 4: Base STAMP Session-Reflector test packet format in authenticated mode

4. TLV Extensions to STAMP

The Type-Length-Value (TLV) encoding scheme provides a flexible extension mechanism for optional informational elements. TLV is an optional field in the STAMP test packet. Multiple TLVs MAY be placed in a STAMP test packet. Additional TLVs may be enclosed within a given TLV, subject to the semantics of the (outer) TLV in question. TLVs have a one-octet-long STAMP TLV Flags field, a one-octet-long Type field, and a two-octet-long Length field that is equal to the length of the Value field in octets. If a Type value for TLV or sub-TLV is in the range for Vendor Private Use, the Length MUST be at least 4, and the first four octets MUST be that vendor's Structure of Management Information (SMI) Private Enterprise Code, as recorded in IANA's SMI Private Enterprise Codes sub-registry, in network octet

order. The rest of the Value field is private to the vendor. The following sections describe the use of TLVs for STAMP that extend the STAMP capability beyond its base specification.

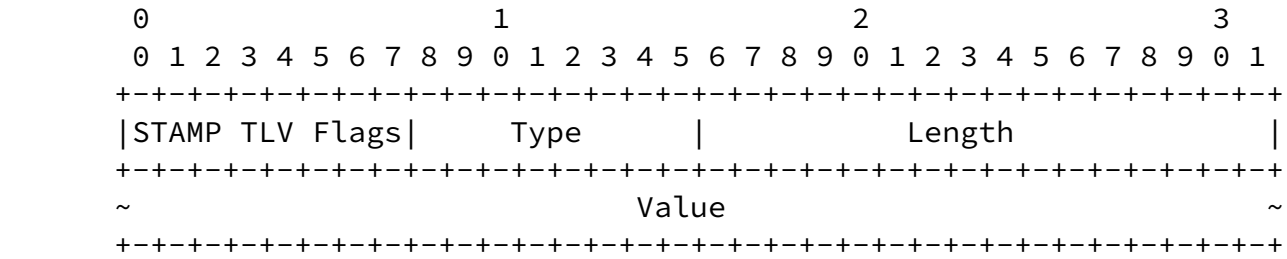


Figure 5: TLV Format in a STAMP Extended Packet

where fields are defined as the following:

- STAMP TLV Flags - eight-bit-long field. Detailed format and interpretation of flags defined in this specification is below.

- Type - one-octet-long field that characterizes the interpretation of the Value field. It is allocated by IANA, as specified in Section 5.1.

- Length - two-octet-long field equal to the length of the Value field in octets.

- Value - a variable-length field. Its interpretation and encoding is determined by the value of the Type field.

All multibyte fields in TLVs defined in this specification are in network byte order.

The format of the STAMP TLV Flags displayed in Figure 6 and the location of flags is according to Section 5.2.

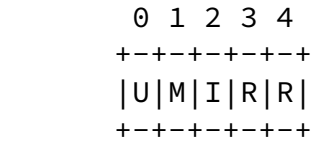


Figure 6: STAMP TLV Flags Format

where fields are defined as the following:

- U (Unrecognized) is a one-bit flag. A Session-Sender MUST set the U flag to 1 before transmitting an extended STAMP test packet. A

Session-Reflector MUST set the U flag to 1 if the Session-

Reflector has not understood the TLV. Otherwise, the Session-Reflector MUST set the U flag in the reflected packet to 0.

- M (Malformed) is a one-bit flag. A Session-Sender MUST set the M flag to 0 before transmitting an extended STAMP test packet. A Session-Reflector MUST set the M flag to 1 if the Session-Reflector determined the TLV is malformed, i.e., the Length field value is not valid for the particular type, or the remaining length of the extended STAMP packet is less than the size of the TLV. Otherwise, the Session-Reflector MUST set the M flag in the reflected packet to 0.

- I (Integrity) is a one-bit flag. A Session-Sender MUST set the I flag to 0 before transmitting an extended STAMP test packet. A Session-Reflector MUST set the I flag to 1 if the STAMP extensions have failed HMAC verification (Section 4.8). Otherwise, the Session-Reflector MUST set the I flag in the reflected packet to 0.

- R - reserved flags for future use. These flags MUST be zeroed on transmit and ignored on receipt.

A STAMP node, whether Session-Sender or Session-Reflector, receiving a test packet MUST determine whether the packet is a base STAMP packet or includes one or more TLVs. The node MUST compare the value in the Length field of the UDP header and the length of the base STAMP test packet in the mode, unauthenticated or authenticated based on the configuration of the particular STAMP test session. If the difference between the two values is larger than the length of the UDP header, then the test packet includes one or more STAMP TLVs that immediately follow the base STAMP test packet. A Session-Reflector that does not support STAMP extensions will not process but copy them into the reflected packet, as defined in Section 4.3 [RFC8762]. A Session-Reflector that supports TLVs will indicate specific TLVs that it did not process by setting the U flag to 1 in those TLVs.

A STAMP Session-Sender that has received a reflected STAMP test packet with extension TLVs MUST validate each TLV:

If the U flag is set, the STAMP system MUST skip the processing of the TLV.

If the M flag is set, the STAMP system MUST stop processing the remainder of the extended STAMP packet.

If the I flag is set, the STAMP system MUST discard all TLVs and MUST stop processing the remainder of the extended STAMP packet.

If an implementation of a Session-Reflector does not recognize the Type field value, it MUST include a copy of the TLV into the reflected STAMP packet. The Session-Reflector MUST set the U flag to 1. The Session-Reflector MUST skip the processing of the unrecognized TLV.

If a TLV is malformed, the processing of extension TLVs MUST be stopped. The Session-Reflector MUST copy the remainder of the received extended STAMP packet into the reflected STAMP packet. The Session-Reflector MUST set the M flag to 1.

4.1. Extra Padding TLV

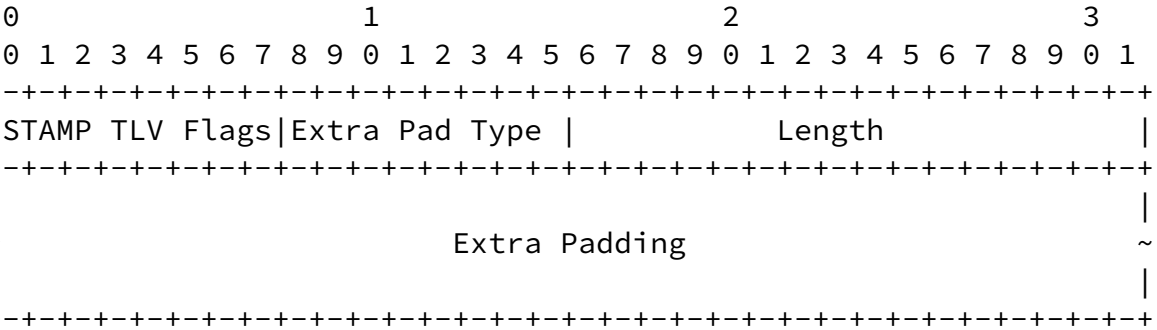


Figure 7: Extra Padding TLV

where fields are defined as the following:

- STAMP TLV Flags - is an eight-bit-long field. Its format is presented in Figure 6.
- Extra Padding Type - is a one-octet-long field, value TBA1 allocated by IANA Section 5.1.

- Length - two-octet-long field equal to the length of the Extra Padding field in octets.

- Extra Padding - SHOULD be filled by a sequence of a pseudo-random numbers. The field MAY be filled with all zeros. An implementation MUST control the type of filling of the Extra Padding field.

The Extra Padding TLV is similar to the Packet Padding field in a TWAMP-Test packet [RFC5357]. The use of the Extra Padding TLV is RECOMMENDED to perform a STAMP test using test packets of larger size than the base STAMP packet [RFC8762]. The length of the base STAMP packet is 44 octets in the unauthenticated mode or 112 octets in the authenticated mode. The Extra Padding TLV MAY be present more than one time in an extended STAMP test packet.

4.2. Location TLV

STAMP Session-Senders MAY include the variable-size Location TLV to query location information from the Session-Reflector. The Session-Sender MUST NOT fill any information fields except for STAMP TLV Flags, Type, and Length. The Session-Reflector MUST verify that the TLV is well-formed. If it is not, the Session-Reflector follows the procedure defined in Section 4 for a malformed TLV.

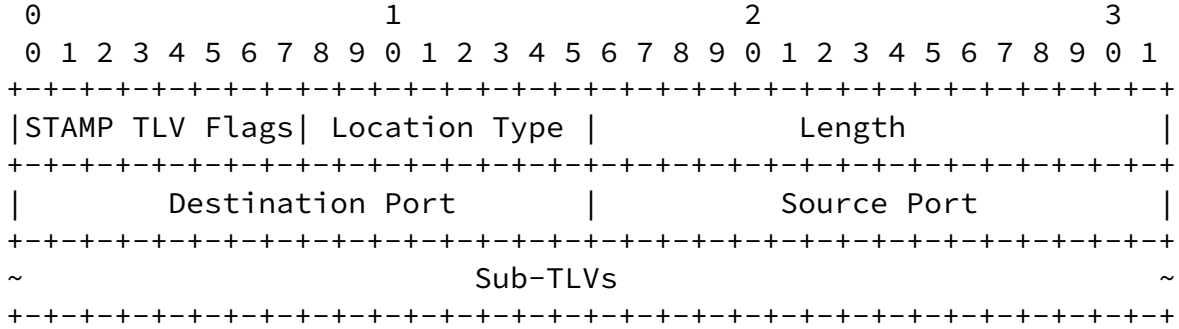


Figure 8: Location TLV

where fields are defined as the following:

- STAMP TLV Flags - is an eight-bit-long field. Its format is presented in Figure 6.

- Location Type - is a one-octet-long field, value TBA2 allocated by IANA Section 5.1.

- Length - two-octet-long field equal to the length of the Value field in octets.

- Destination Port - two-octet-long UDP destination port number of the received STAMP packet.

- Source Port - two-octet-long UDP source port number of the received STAMP packet.

- Sub-TLVs - a sequence of sub-TLVs, as defined further in this section. The sub-TLVs are used by the Session-Sender to request location information with generic sub-TLV types, and the Session-Reflector responds with the corresponding more-specific sub-TLVs for the type of address (e.g., IPv4 or IPv6) used at the Session-Reflector.

Note that all fields not filled by either a Session-Sender or Session-Reflector are transmitted with all bits set to zero.

4.2.1. Location Sub-TLVs

A sub-TLV in the Location TLV uses the format displayed in Figure 5. Handling of the U and M flags in the sub-TLV is as defined in Section 4. The I flag MUST be set by a Session-Sender and Session-Reflector to 0 before transmission and its value ignored on receipt. The following types of sub-TLV for the Location TLV are defined in this specification (type values are assigned according to Table 5):

- Source MAC Address sub-TLV - is a 12-octet-long sub-TLV. The Type value is TBA9. The value of the Length field MUST equal to 8. The Value field is an 8-octet-long MBZ field that MUST be zeroed on transmission and ignored on receipt.

- Source EUI-48 Address sub-TLV - is a 12-octet-long sub-TLV that includes the EUI-48 source MAC address. The Type value is TBA10. The value of the Length field MUST equal to 8.

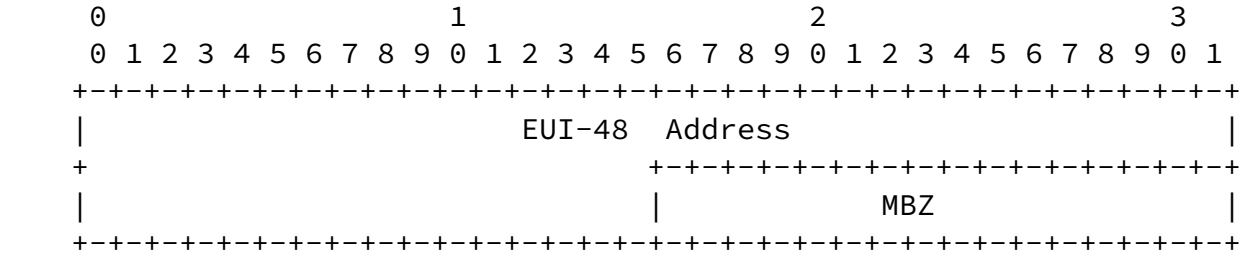


Figure 9: The Value Field of the Source EUI-48 Address sub-TLV

The Value field consists of the following fields (Figure 9):

* The EUI-48 is a six-octet-long field.

* Two-octet-ling MBZ field MUST be zeroed on transmission and ignored on receipt.

- Source EUI-64 Address sub-TLV - is a 12-octet-long sub-TLV that includes the EUI-64 source MAC address. The Type value is TBA11. The value of the Length field MUST equal to 8. The Value field consists of an eight-octet-long EUI-64 field.

- Destination IP Address sub-TLV - is a 20-octet-long sub-TLV. The Type value is TBA12. The value of the Length field MUST equal to 16. The Value field consists of a 16-octet-long MBZ field that MUST be zeroed on transmit and ignored on receipt

- Destination IPv4 Address sub-TLV - is a 20-octet-long sub-TLV that includes IPv4 destination address. The Type value is TBA13. The value of the Length field MUST equal to 16.

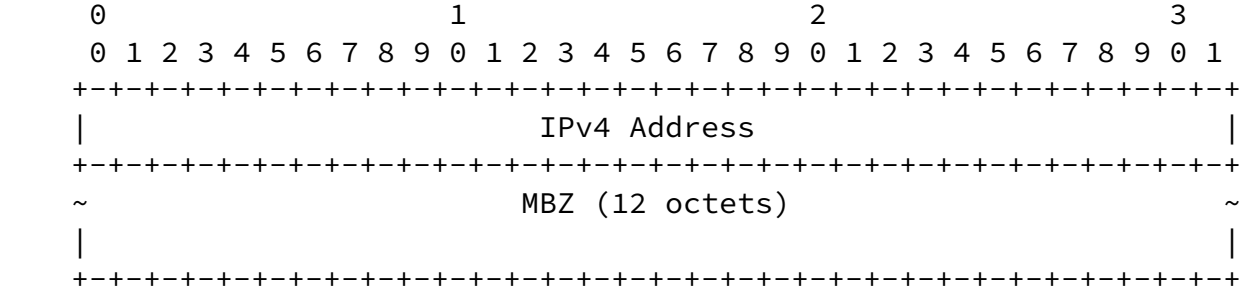


Figure 10: IPv4 Address in a Sub-TLV's Value Field

The Value field consists of the following fields (Figure 10):

* The IPv4 Address is a four-octet-long field.

* 12-octet-long MBZ field MUST be zeroed on transmit and ignored on receipt.

- Destination IPv6 Address sub-TLV - is a 20-octet-long sub-TLV that includes IPv6 destination address. The Type value is TBA14. The value of the Length field MUST equal to 16. The Value field is a 16-octet-long IP v6 Address field.

- Source IP Address sub-TLV - is a 20-octet-long sub-TLV. The Type value is TBA15. The value of the Length field MUST equal to 16. The Value field is a 16-octet-long MBZ field that MUST be zeroed on transmit and ignored on receipt

- Source IPv4 Address sub-TLV - is a 20-octet-long sub-TLV that includes IPv4 source address. The Type value is TBA16. The value of the Length field MUST equal to 16. The Value field consists of the following fields (Figure 10):

  * The IPv4 Address is a four-octet-long field.

  * 12-octet-long MBZ field that MUST be zeroed on transmit and ignored on receipt.

- Source IPv6 Address sub-TLV - is a 20-octet-long sub-TLV that includes IPv6 source address. The Type value is TBA17. The value of the Length field MUST equal to 16. The Value field is a 16-octet-long IPv6 Address field.

4.2.2. Theory of Operation of Location TLV

The Session-Reflector that received an extended STAMP packet with the Location TLV MUST include the Location TLV of the size equal to the size of Location TLV in the received packet in the reflected packet.

Based on the local policy, the Session-Reflector MAY leave some fields unreported by filling them with zeroes. An implementation of the stateful Session-Reflector MUST provide control for managing such policies.

A Session-Sender MAY include the Source MAC Address sub-TLV in the Location TLV. If the Session-Reflector receives the Location TLV that includes the Source MAC Address sub-TLV, it MUST include the Source EUI-48 Address sub-TLV if the source MAC address of the received extended test packet is in EUI-48 format. And the Session-Reflector MUST copy the value of the source MAC address in the EUI-48 field. Otherwise, the Session-Reflector MUST use the Source EUI-64 Address sub-TLV and MUST copy the value of the Source MAC address from the received packet into the EUI-64 field. If the received extended STAMP test packet does not have the Source MAC address, the Session-Reflector MUST zero the EUI-64 field before transmitting the reflected packet.

A Session-Sender MAY include the Destination IP Address sub-TLV in the Location TLV. If the Session-Reflector receives the Location TLV that includes the Destination IP Address sub-TLV, it MUST include the Destination IPv4 Address sub-TLV if the source IP address of the received extended test packet is of IPv4 address family. And the Session-Reflector MUST copy the value of the destination IP address in the IPv4 Address field. Otherwise, the Session-Reflector MUST use the Destination IPv6 Address sub-TLV and MUST copy the value of the destination IP address from the received packet into the IPv6 Address field.

A Session-Sender MAY include the Source IP Address sub-TLV in the Location TLV. If the Session-Reflector receives the Location TLV that includes the Source IP Address sub-TLV, it MUST include the Source IPv4 Address sub-TLV if the source IP address of the received extended test packet is of IPv4 address family. And the Session-Reflector MUST copy the value of the source IP address in the IPv4 Address field. Otherwise, the Session-Reflector MUST use the Source IPv6 Address sub-TLV and MUST copy the value of the source IP address from the received packet into the IPv6 Address field.

The Location TLV MAY be used to determine the last-hop IP addresses, ports, and last-hop MAC address for STAMP packets. The MAC address can indicate a path switch on the last hop. The IP addresses and UDP ports will indicate if there is a NAT router on the path. It allows the Session-Sender to identify the IP address of the Session-Reflector behind the NAT, and detect changes in the NAT mapping that could cause sending the STAMP packets to the wrong Session-Reflector.

4.3. Timestamp Information TLV

The STAMP Session-Sender MAY include the Timestamp Information TLV to request information from the Session-Reflector. The Session-Sender MUST NOT fill any information fields except for STAMP TLV Flags, Type, and Length. All other fields MUST be filled with zeroes. The Session-Reflector MUST validate the Length value of the TLV. If the value of the Length field is invalid, the Session-Reflector follows the procedure defined in Section 4 for a malformed TLV.

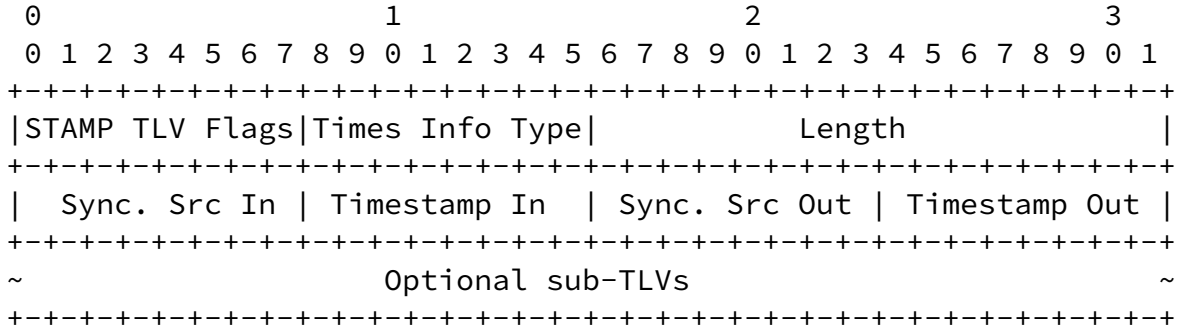


Figure 11: Timestamp Information TLV

where fields are defined as the following:

- STAMP TLV Flags - is an eight-bit-long field. Its format is presented in Figure 6.

- Timestamp Information Type - is a one-octet-long field, value TBA3 allocated by IANA Section 5.1.

- Length - two-octet-long field, set equal to the length of the Value field in octets (Figure 5).

- Sync Src In - one-octet-long field that characterizes the source of clock synchronization at the ingress of a Session-Reflector. There are several methods to synchronize the clock, e.g., Network Time Protocol (NTP) [RFC5905]. The value is one of those listed in Table 7.

- Timestamp In - one-octet-long field that characterizes the method by which the ingress of the Session-Reflector obtained the timestamp T2. A timestamp may be obtained with hardware assistance, via software API from a local wall clock, or from a remote clock (the latter is referred to as "control plane"). The value is one of those listed in Table 9.

- Sync Src Out - one-octet-long field that characterizes the source of clock synchronization at the egress of the Session-Reflector. The value is one of those listed in Table 7.

- Timestamp Out - one-octet-long field that characterizes the method by which the egress of the Session-Reflector obtained the timestamp T3. The value is one of those listed in Table 9.

- Optional sub-TLVs - optional variable-length field.

4.4. Class of Service TLV

The STAMP Session-Sender MAY include a Class of Service (CoS) TLV in the STAMP test packet. The format of the CoS TLV is presented in Figure 12.

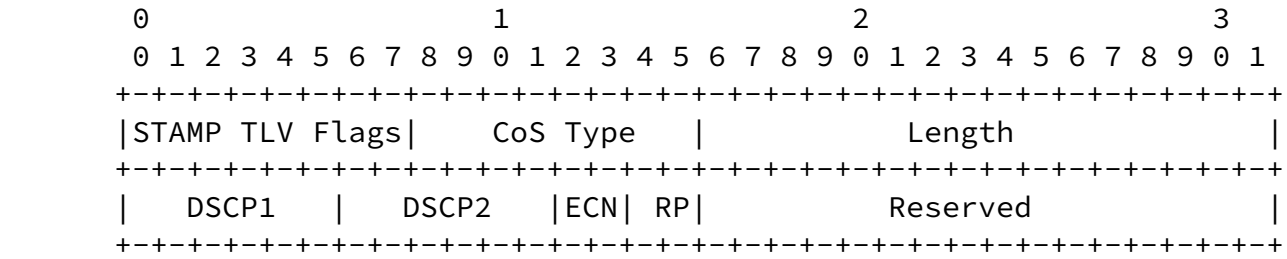


Figure 12: Class of Service TLV

where fields are defined as the following:

- STAMP TLV Flags - is an eight-bit-long field. Its format is presented in Figure 6.

- CoS (Class of Service) Type - is a one-octet-long field, value TBA4 allocated by IANA Section 5.1.

- Length - two-octet-long field, set equal to the value 4.

- DSCP1 - The Differentiated Services Code Point (DSCP) intended by the Session-Sender to be used as the DSCP value of the reflected test packet.

- DSCP2 - The received value in the DSCP field at the ingress of the Session-Reflector.

- ECN - The received value in the ECN field at the ingress of the Session-Reflector.

- RP (Reverse Path) - is a two-bit-long field. A Session-Sender MUST set the value of the RP field to 0 on transmission.

- Reserved - 16-bit-long field, MUST be zeroed on transmission and ignored on receipt.

A STAMP Session-Reflector that receives a test packet with the CoS TLV MUST include the CoS TLV in the reflected test packet. Also, the Session-Reflector MUST copy the value of the DSCP and ECN fields of the IP header of the received STAMP test packet into the DSCP2 field in the reflected test packet. Finally, the Session-Reflector MUST use the local policy to verify whether the CoS corresponding to the value of the DSCP1 field is permitted in the domain. If it is, the Session-Reflectorset MUST set the DSCP field's value in the IP header of the reflected test packet equal to the value of the DSCP1 field of the received test packet. Otherwise, the Session-Reflector MUST use the DSCP value of the received STAMP packet and set the value of the RP field to 1. Upon receiving the reflected packet, if the value of the RP field is 0, the Session-Sender will save the DSCP and ECN values for analysis of the CoS in the reverse direction. If the value of the RP field in the received reflected packet is 1, only CoS in the forward direction can be analyzed.

Re-mapping of CoS can be used to provide multiple services (e,g., 2G, 3G, LTE in mobile backhaul networks) over the same network. But if it is misconfigured, then it is often difficult to diagnose the root cause of excessive packet drops of higher-level service while packet drops for lower service packets are at a normal level. Using a CoS TLV in STAMP testing helps to troubleshoot the existing problem and also verify whether DiffServ policies are processing CoS as required by the configuration.

4.5. Direct Measurement TLV

The Direct Measurement TLV enables collection of the number of in-profile packets, i.e., packets that form a specific data flow, that

had been transmitted and received by the Session-Sender and Session-Reflector, respectively. The definition of "in-profile packet" is outside the scope of this document and is left to the test operators to determine.

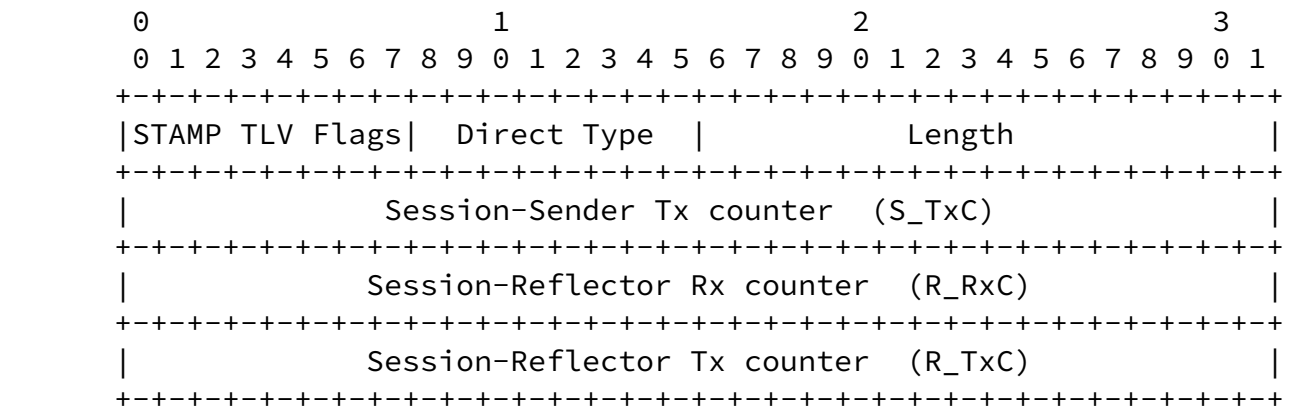


Figure 13: Direct Measurement TLV

where fields are defined as the following:

- STAMP TLV Flags - is an eight-bit-long field. Its format is presented in Figure 6.
- Direct (Measurement) Type - is a one-octet-long field, value TBA5 allocated by IANA Section 5.1.
- Length - two-octet-long field equals the length of the Value field in octets. The Length field value MUST equal 12 octets.
- Session-Sender Tx counter (S_TxC) is a four-octet-long field. The

Session-Sender MUST set its value equal to the number of the transmitted in-profile packets.

- Session-Reflector Rx counter (R_RxC) is a four-octet-long field. MUST be zeroed by the Session-Sender on transmit and ignored by the Session-Reflector on receipt. The Session-Reflector MUST fill it with the value of in-profile packets received.

- Session-Reflector Tx counter (R_TxC) is a four-octet-long field. MUST be zeroed by the Session-Sender and ignored by the Session-Reflector on receipt. The Session-Reflector MUST fill it with the value of the transmitted in-profile packets.

A Session-Sender MAY include the Direct Measurement TLV in a STAMP test packet. If the received STAMP test packet includes the Direct Measurement TLV, the Session-Reflector MUST include it in the reflected test packet. The Session-Reflector MUST copy the value from the S_TxC field of the received test packet into the same field of the reflected packet before its transmission.

4.6. Access Report TLV

A STAMP Session-Sender MAY include an Access Report TLV (Figure 14) to indicate changes to the access network status to the Session-Reflector. The definition of an access network is outside the scope of this document.

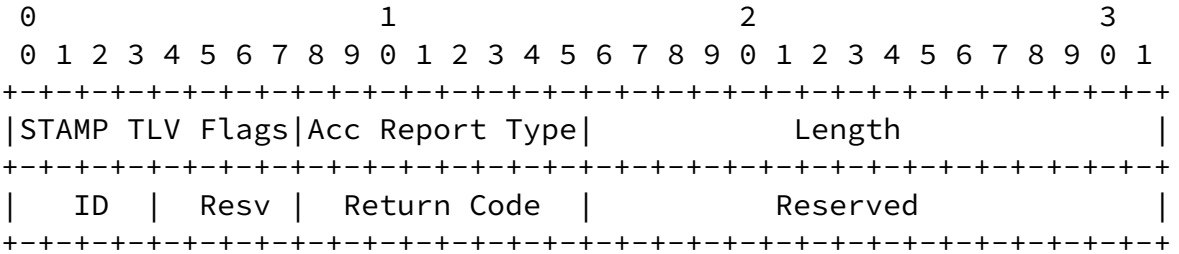


Figure 14: Access Report TLV

where fields are defined as follows:

- STAMP TLV Flags - is an eight-bit-long field. Its format presented in Figure 6.

- Access Report Type - is a one-octet-long field, value TBA6 allocated by IANA Section 5.1.

- Length - two-octet-long field, set equal to the value 4.

- ID (Access ID) - four-bit-long field that identifies the access network, e.g., 3GPP (Radio Access Technologies specified by 3GPP) or Non-3GPP (accesses that are not specified by 3GPP) [TS23501]. The value is one of those listed below:

  * 1 - 3GPP Network

  * 2 - Non-3GPP Network

  All other values are invalid and the TLV that contains it MUST be discarded.

- Resv - four-bit-long field, MUST be zeroed on transmission and ignored on receipt.

- Return Code - one-octet-long field that identifies the report signal, e.g., available or unavailable. The value is supplied to the STAMP end-point through some mechanism that is outside the scope of this document. The value is one of those listed in Section 5.6.

- Reserved - two-octet-long field, MUST be zeroed on transmission and ignored on receipt.

The STAMP Session-Sender that includes the Access Report TLV sets the value of the Access ID field according to the type of access network it reports on. Also, the Session-Sender sets the value of the Return Code field to reflect the operational state of the access network. The mechanism to determine the state of the access network is outside the scope of this specification. A STAMP Session-Reflector that received the test packet with the Access Report TLV MUST include the Access Report TLV in the reflected test packet. The Session-Reflector MUST set the value of the Access ID and Return Code fields

equal to the values of the corresponding fields from the test packet it has received.

The Session-Sender MUST also arm a retransmission timer after sending a test packet that includes the Access Report TLV. This timer MUST be disarmed upon reception of the reflected STAMP test packet that includes the Access Report TLV. In the event the timer expires before such a packet is received, the Session-Sender MUST retransmit the STAMP test packet that contains the Access Report TLV. This retransmission SHOULD be repeated up to four times before the procedure is aborted. Setting the value for the retransmission timer is based on local policies and network environment. The default value of the retransmission timer for the Access Report TLV SHOULD be three seconds. An implementation MUST provide control of the retransmission timer value and the number of retransmissions.

The Access Report TLV is used by the Performance Measurement Function (PMF) components of the Access Steering, Switching and Splitting feature for 5G networks [TS23501]. The PMF component in the User Equipment acts as the STAMP Session-Sender, and the PMF component in the User Plane Function acts as the STAMP Session-Reflector.

4.7. Follow-up Telemetry TLV

A Session-Reflector might be able to put in the Timestamp field only an "SW Local" (see Table 9) timestamp. But the hosting system might provide a timestamp closer to the start of the actual packet transmission even though it is not possible to deliver the information to the Session-Sender in time for the packet itself. This timestamp might nevertheless be important for the Session-Sender, as it improves the accuracy of measuring network delay by minimizing the impact of egress queuing delays on the measurement.

A STAMP Session-Sender MAY include the Follow-up Telemetry TLV to request information from the Session-Reflector. The Session-Sender MUST set the Follow-up Telemetry Type and Length fields to their

appropriate values. The Sequence Number and Timestamp fields MUST be zeroed on transmission by the Session-Sender and ignored by the Session-Reflector upon receipt of the STAMP test packet that includes the Follow-up Telemetry TLV. The Session-Reflector MUST validate the Length value of the STAMP test packet. If the value of the Length

field is invalid, the Session-Reflector MUST zero the Sequence Number and Timestamp fields and set the M flag in the STAMP TLV Flags field in the reflected packet. If the Session-Reflector is in stateless mode (defined in Section 4.2 [RFC8762]), it MUST zero the Sequence Number and Timestamp fields.

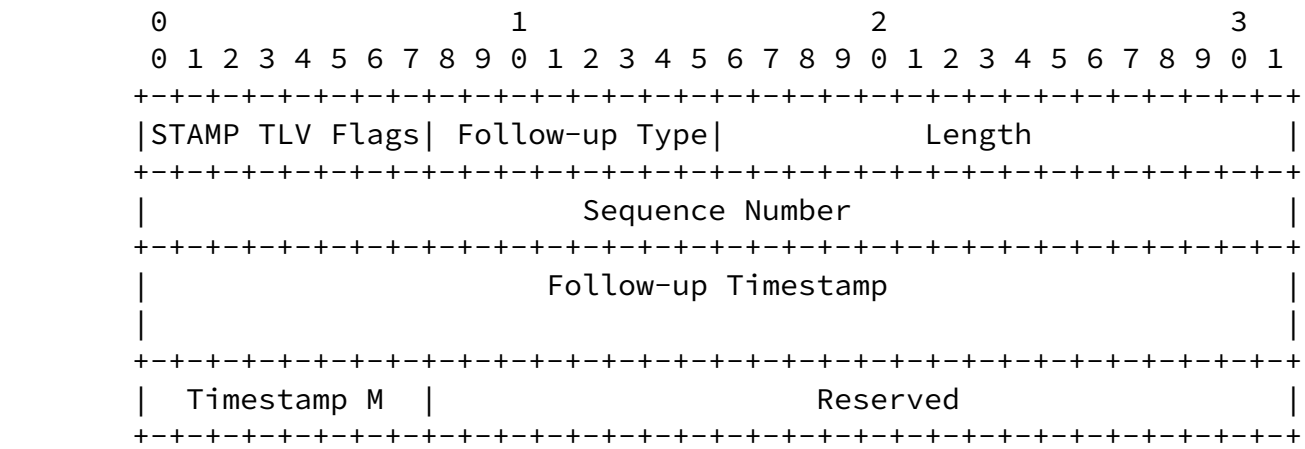


Figure 15: Follow-up Telemetry TLV

where fields are defined as follows:

- STAMP TLV Flags - is an eight-bit-long field. Its format presented in Figure 6.

- Follow-up (Telemetry) Type - is a one-octet-long field, value TBA7 allocated by IANA Section 5.1.

- Length - two-octet-long field, set equal to the value 16 octets.

- Sequence Number - four-octet-long field indicating the sequence number of the last packet reflected in the same STAMP-test session. Since the Session-Reflector runs in the stateful mode (defined in Section 4.2 [RFC8762]), it is the Session-Reflector's Sequence Number of the previous reflected packet.

- Follow-up Timestamp - eight-octet-long field, with the format indicated by the Z flag of the Error Estimate field of the STAMP base packet, which is contained in this reflected test packet transmitted by a Session-Reflector, as described in Section 4.2.1 [RFC8762]. It carries the timestamp when the reflected packet with the specified sequence number was sent.

- Timestamp M(ode) - one-octet-long field that characterizes the method by which the entity that transmits a reflected STAMP packet obtained the Follow-up Timestamp. The value is one of those listed in Table 9.

- Reserved - three-octet-long field. Its value MUST be zeroed on transmission and ignored on receipt.

4.8. HMAC TLV

The STAMP authenticated mode protects the integrity of data collected in the STAMP base packet. STAMP extensions are designed to provide valuable information about the condition of a network, and protecting the integrity of that data is also essential. All authenticated STAMP base packets (per Section 4.2.2 and Section 4.3.2 [RFC8762]) compatible with this specification MUST additionally authenticate the option TLVs by including the keyed Hashed Message Authentication Code (HMAC) TLV, with the sole exception of when there is only one TLV present, and it is the Extended Padding TLV. The HMAC TLV MUST follow all TLVs included in a STAMP test packet, except for the Extra Padding TLV. If the HMAC TLV appears in any other position in a STAMP extended test packet, then the situation MUST be processed as HMAC verification failure, as defined in this section, further below. The HMAC TLV MAY be used to protect the integrity of STAMP extensions in STAMP unauthenticated mode. An implementation of STAMP extensions MUST provide controls to enable the integrity protection of STAMP extensions in STAMP unauthenticated mode.

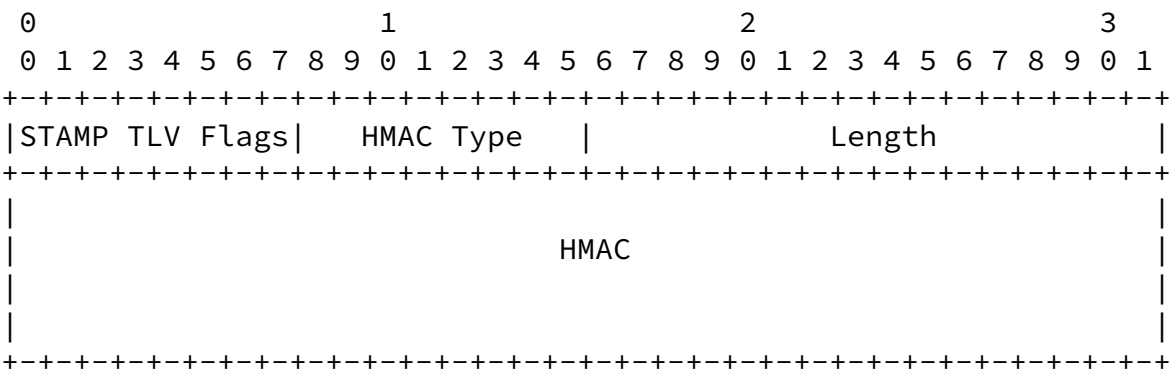


Figure 16: HMAC TLV

where fields are defined as follows:

- STAMP TLV Flags - is an eight-bit-long field. Its format is presented in Figure 6.

- HMAC Type - is a one-octet-long field, value TBA8 allocated by IANA Section 5.1.

- Length - two-octet-long field, set equal to 16 octets.

- HMAC - is a 16-octet-long field that carries HMAC digest of the text of all preceding TLVs.

As defined in [RFC8762], STAMP uses HMAC-SHA-256 truncated to 128 bits ([RFC4868]). All considerations regarding using the key listed in Section 4.4 of [RFC8762] are fully applicable to the use of the HMAC TLV. Key management and the mechanisms to distribute the HMAC key are outside the scope of this specification. HMAC TLV is anticipated to track updates in the base STAMP protocol [RFC8762], including the use of more advanced cryptographic algorithms. HMAC is calculated as defined in [RFC2104] over text as the concatenation of the Sequence Number field of the base STAMP packet and all preceding TLVs. The digest then MUST be truncated to 128 bits and written into the HMAC field. If the HMAC TLV is present in the extended STAMP test packet, e.g., in the authenticated mode, HMAC MUST be verified before using any data in the included STAMP TLVs. If HMAC verification by the Session-Reflector fails, then the Session-Reflector MUST stop processing the received extended STAMP test packet. The Session-Reflector MUST copy the TLVs from the received STAMP test packet into the reflected packet. The Session-Reflector MUST set the I flag in each TLV copied over into the reflected packet to 1 before transmitting the reflected test packet. If the Session-Sender receives the extended STAMP test packet with I flag set to 1, then the Session-Sender MUST stop processing TLVs in the reflected test packet. If HMAC verification by the Session-Sender fails, then the Session-Sender MUST stop processing TLVs in the reflected extended STAMP packet.

5. IANA Considerations

5.1. STAMP TLV Registry

IANA is requested to create the STAMP TLV Type registry. 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]. The 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: STAMP TLV Type Registry

This document defines the following new values in the IETF Review range of the STAMP TLV Type registry:

Value	Description	Reference
TBA1	Extra Padding	This document
TBA2	Location	This document
TBA3	Timestamp Information	This document
TBA4	Class of Service	This document
TBA5	Direct Measurement	This document
TBA6	Access Report	This document
TBA7	Follow-up Telemetry	This document
TBA8	HMAC	This document

Table 2: STAMP TLV Types

5.2. STAMP TLV Flags Sub-registry

IANA is requested to create the STAMP TLV Flags sub-registry as part of the STAMP TLV Type registry. The registration procedure is "IETF

Review" [RFC8126]. Flags are 8 bits. This document defines the following bit positions in the STAMP TLV Flags sub-registry:

Bit position	Symbol	Description	Reference
0	U	Unrecognized TLV	This document
1	M	Malformed TLV	This document
2	I	Integrity check failed	This document

Table 3: STAMP TLV Flags

5.3. Sub-TLV Type Sub-registry

IANA is requested to create the sub-TLV Type sub-registry as part of the STAMP TLV Type registry. 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]. The remaining code points are allocated according to Table 4:

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 4: Location Sub-TLV Type Sub-registry

This document defines the following new values in the IETF Review range of the Location sub-TLV Type sub-registry:

Value	Description	TLV Used	Reference

TBA9	Source MAC Address	Location	This document
TBA10	Source EUI-48 Address	Location	This document
TBA11	Source EUI-64 Address	Location	This document
TBA12	Destination IP Address	Location	This document
TBA13	Destination IPv4 Address	Location	This document
TBA14	Destination IPv6 Address	Location	This document
TBA15	Source IP Address	Location	This document
TBA16	Source IPv4 Address	Location	This document
TBA17	Source IPv6 Address	Location	This document

Table 5: STAMP sub-TLV Types

5.4. Synchronization Source Sub-registry

IANA is requested to create the Synchronization Source sub-registry as part of the STAMP TLV Type registry. All code points in the range 1 through 127 in this registry shall be allocated according to the "IETF Review" procedure as specified in [RFC8126]. Code points in

the range 128 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 6:

Value	Description	Reference
0	Reserved	This document
1- 127	Unassigned	This document
128 - 239	Unassigned	This document
240 - 249	Experimental	This document
250 - 254	Private Use	This document
255	Reserved	This document

Table 6: Synchronization Source Sub-registry

This document defines the following new values in the Synchronization Source sub-registry:

Value	Description	Reference
1	NTP	This document
2	PTP	This document
3	SSU/BITS	This document
4	GPS/GLONASS/LORAN-C/BDS/Galileo	This document
5	Local free-running	This document

Table 7: Synchronization Sources

5.5. Timestamping Method Sub-registry

IANA is requested to create the Timestamping Method sub-registry as part of the STAMP TLV Type registry. All code points in the range 1 through 127 in this registry shall be allocated according to the "IETF Review" procedure as specified in [RFC8126]. Code points in the range 128 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 8:

Value	Description	Reference
0	Reserved	This document
1- 127	Unassigned	This document
128 - 239	Unassigned	This document
240 - 249	Experimental	This document
250 - 254	Private Use	This document
255	Reserved	This document

Table 8: Timestamping Method Sub-registry

This document defines the following new values in the Timestamping

Methods sub-registry:

Value	Description	Reference
1	HW Assist	This document
2	SW local	This document
3	Control plane	This document

Table 9: Timestamping Methods

5.6. Return Code Sub-registry

IANA is requested to create the Return Code sub-registry as part of the STAMP TLV Type registry. All code points in the range 1 through 127 in this registry shall be allocated according to the "IETF Review" procedure as specified in [RFC8126]. Code points in the range 128 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 10:

Value	Description	Reference
0	Reserved	This document
1- 127	Unassigned	This document
128 - 239	Unassigned	This document
240 - 249	Experimental	This document
250 - 254	Private Use	This document
255	Reserved	This document

Table 10: Return Code Sub-registry

This document defines the following new values in the Return Code sub-registry:

Value	Description	Reference
1	Network available	This document

| 2 | Network unavailable | This document |
+-------+---------------------+---------------+

Table 11: Return Codes

6. Security Considerations

This document defines extensions to STAMP [RFC8762] and inherits all the security considerations applicable to the base protocol. Additionally, the HMAC TLV is defined in this document. Though the HMAC TLV protects the integrity of STAMP extensions; it does not protect against a replay attack. The use of HMAC TLV is discussed in detail in Section 4.8.

To protect against a malformed TLV an implementation of a Session-Sender and Session-Reflector MUST:

- check the setting of the M flag;
- validate the Length field value.

As this specification defined the mechanism to test DSCP mapping, this document inherits all the security considerations discussed in [RFC2474]. Monitoring and optional control of DSCP using the CoS TLV may be used across the Internet so that the Session-Sender and the Session-Reflector are located in domains that use different CoS profiles. Thus, it is essential that an operator verifies the set of CoS values that are used in the Session-Reflector's domain. Also, an implementation of a Session-Reflector SHOULD support a local policy to confirm whether the value sent by the Session-Sender can be used as the value of the DSCP field. Section 4.4 defines the use of that local policy.

7. Acknowledgments

Authors much appreciate the thorough review and thoughtful comments received from Tianran Zhou, Rakesh Gandhi, Yuezhong Song and Yali Wang. The authors express their gratitude to Al Morton for his comments and the most valuable suggestions. The authors greatly appreciate comments and thoughtful suggestions received from Martin Duke.

8. Contributors

The following people contributed text to this document:

Guo Jun
ZTE Corporation
68# Zijinghua Road
Nanjing, Jiangsu 210012
P.R.China

Phone: +86 18105183663
Email: guo.jun2@zte.com.cn

9. References

9.1. Normative References

[RFC2104] Krawczyk, H., Bellare, M., and R. Canetti, "HMAC: Keyed-Hashing for Message Authentication", RFC 2104, DOI 10.17487/RFC2104, February 1997, <https://www.rfc-editor.org/info/rfc2104>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 8126, DOI 10.17487/RFC8126, June 2017, <https://www.rfc-editor.org/info/rfc8126>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8762] Mirsky, G., Jun, G., Nydell, H., and R. Foote, "Simple Two-Way Active Measurement Protocol", RFC 8762, DOI 10.17487/RFC8762, March 2020, <https://www.rfc-editor.org/info/rfc8762>.

9.2. Informative References

[GPS] "Global Positioning System (GPS) Standard Positioning Service (SPS) Performance Standard", GPS SPS 5th Edition, April 2020.

[I-D.gont-numeric-ids-generation]
Gont, F. and I. Arce, "On the Generation of Transient Numeric Identifiers", draft-gont-numeric-ids-generation-04 (work in progress), July 2019.

[IEEE.1588.2008]
"Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems", IEEE Standard 1588, March 2008.

[RFC2474] Nichols, K., Blake, S., Baker, F., and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", RFC 2474, DOI 10.17487/RFC2474, December 1998, <https://www.rfc-editor.org/info/rfc2474>.

[RFC4868] Kelly, S. and S. Frankel, "Using HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 with IPsec", RFC 4868, DOI 10.17487/RFC4868, May 2007, <https://www.rfc-editor.org/info/rfc4868>.

[RFC5357] Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)", RFC 5357, DOI 10.17487/RFC5357, October 2008, <https://www.rfc-editor.org/info/rfc5357>.

[RFC5905] Mills, D., Martin, J., Ed., Burbank, J., and W. Kasch, "Network Time Protocol Version 4: Protocol and Algorithms Specification", RFC 5905, DOI 10.17487/RFC5905, June 2010, <https://www.rfc-editor.org/info/rfc5905>.

[TS23501] 3GPP (3rd Generation Partnership Project), "Technical Specification Group Services and System Aspects; System Architecture for the 5G System; Stage 2 (Release 16)", 3GPP TS23501, 2019.

Authors' Addresses

Greg Mirsky
ZTE Corp.

Email: gregimirsky@gmail.com

Xiao Min
ZTE Corp.

Email: xiao.min2@zte.com.cn

Henrik Nydell
Accedian Networks

Email: hnydell@accedian.com

Richard Foote
Nokia

Email: footer.foote@nokia.com

Adi Masputra
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
USA

Email: adi@apple.com

Ernesto Ruffini
OutSys
via Caracciolo, 65
Milano 20155
Italy

Email: eruffini@outsys.org