SMPTE PCD ST 2059-2:20xx
Revision of SMPTE ST 2059-2:2021

SMPTE Public Committee Draft

SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee TC-32NF Network/Facilities Architecture.

This revision harmonizes the SMPTE PTP Profile with IEEE 1588-2019 by attaching Synchronization Metadata (SM) TLV to Announce messages. Compatibility with IEEE 1588-2008 can be achieved by using 'SM TLV Method 1' legacy management messages that are identical to those of SMPTE ST 2059-2:2021. Corrections are made to remove text present in SMPTE ST 2059-2:2021 related to the peer delay mechanism which is not supported.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

IEEE 1588-2019 defines a protocol that provides precise synchronization of clocks in packet-based networked systems. The Precision Time Protocol (PTP) generates a hierarchical relationship among the PTP Instances in the system. The clocks in all PTP Instances ultimately derive their time from a clock known as the "Grandmaster Clock." In its basic form, this protocol is intended to be administration free.

IEEE 1588-2019 describes the concept of a PTP profile. The purpose is to specify particular combinations of options and attribute values to support a given application. The purpose of the profile is described in IEEE 1588-2019 subclause 20.3.1.1 'General':

"The purpose of a PTP profile is to allow organizations to specify specific selections of attribute values and optional features of PTP that, when using the same transport protocol, inter-work and achieve a performance that meets the requirements of a particular application.

A PTP profile is a set of required options, prohibited options, and the ranges and defaults of configurable attributes. Profiles specifications shall be consistent with the specifications in subclauses 20.2.1 and 20.2.2."

Subclause 20.3.1.2 'PTP profile recommendations' of IEEE 1588-2019 specifies what a PTP Profile should define:

- Which algorithm to implement to compare clocks to determine the best clock to use as a source of time.
- Which of the configuration management mechanisms is to be implemented.
- Which of the path delay mechanisms, delay request-response or peer delay is to be implemented.
- The range and default values of all PTP configurable attributes and data set members.
- The transport mechanisms required, permitted, or prohibited.
- The PTP Instance types required, permitted, or prohibited.
- The options required, permitted, or prohibited, and any parameter values associated with these options.

- Uncertainty specifications appropriate to the evaluation of whether traceability, to a primary reference is achieved for time and for frequency.
- The value of the observation interval (tau) used for variance measurement.

This Standard defines the SMPTE PTP Profile for time and frequency synchronization in a professional broadcast environment. It is intended to be used with SMPTE ST 2059-1 which defines a point in time, the SMPTE Epoch, which is used for alignment of real-time signals; formulae which specify the ongoing alignment of signals to time since the SMPTE Epoch; and formulae which specify the calculation of SMPTE ST 12-1 time address values and SMPTE ST 309 date values. A basic understanding of these concepts that are described in SMPTE ST 2059-1 will be helpful to readers of ST 2059-2.

This profile is designed with the following purposes in mind:

- To permit clocks to be synchronized quickly and accurately to enable professional media over IP applications.
- To convey Synchronization Metadata (SM) required for synchronization and time labeling of audio/video signals.

To achieve compatibility with IEEE 1588-2019, Synchronization Metadata is attached to Announce messages. In earlier versions of this standard, management messages were used to convey Synchronization Metadata.

For compatibility with devices conforming to IEEE 1588-2008, Synchronization Metadata TLV can continue to be provided using management messages in addition to being attached to Announce messages. Attaching Synchronization Metadata TLV to Announce Message is expected to allow the eventual introduction of new features not supported by IEEE 1588-2008.

It is highly desirable that future switches compliant with IEEE 1588-2019 maintain compatibility with Synchronization Metadata using management messages.

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

1 Scope

This standard specifies a Precision Time Protocol profile specifically for the synchronization of audio/video equipment in a professional broadcast environment.

The SMPTE PTP profile is based on IEEE 1588-2019 and includes a description of parameters, their default values, and permitted ranges.

To achieve harmonization with IEEE 1588-2019, Synchronization Metadata TLV is attached to Announce messages. For compatibility with devices conforming to earlier versions of this standard based on IEEE 1588-2008, Synchronization Metadata TLV conveyed using management messages is also defined.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any clause explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standard contains provisions that, through reference in this text, constitute provisions of this standard. Dated references require that the specific edition cited shall be used as the reference. Undated citations refer to the edition of the referenced document (including any amendments) current at the date of publication of this document. All standards are subject to revision, and users of this engineering document are encouraged to investigate the possibility of applying the most recent edition of any undated reference.

IEEE 1588-2019, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems[1]

IETF RFC 2236, Internet Group Management Protocol , Version 2 (IGMPv2)

IETF RFC 2710, Multicast Listener Discovery (MLD) for IPv6

IETF RFC 3376, Internet Group Management Protocol, Version 3 (IGMPv3)

IETF RFC 3810, Multicast Listener Discovery Version 2 (MLDv2) for Ipv6.

4 Terms and Definitions

For the purposes of this document, the terms and definitions given in IEEE 1588-2019 and the following apply:

3.1. big-endian

byte order where the bytes of a word are transmitted such that the most significant Byte is transmitted first

Note 1 to entry: This is commonly known as ‘network byte order’.

3.2. Daily Jam

optional daily procedure carried out within a facility that uses SMPTE ST 12-1 time code in which the time address value is adjusted to correspond to Local Time at the chosen time of the Daily Jam

Note 1 to entry: It is usually carried out in the early hours of the morning at a non-sensitive time as determined by the operator of the facility.

Note 2 to entry: The term "Daily Jam" is historical and used in that context. This standard does not constrain the jam to take place on a daily basis. In some systems it could occur only as required to accommodate discontinuities such as Leap Seconds or daylight saving time adjustment.

3.3. follower

clock in the context of a Precision Time Protocol (PTP) communication path that synchronizes to a source of time

Note 1 to entry: Referred to as ‘slave’ in IEEE 1588-2019

3.4. FOLLOW state

state of a clock port that synchronizes to the device on the path with the port that is in the LEAD state

Note 1 to entry: Equivalent to SLAVE state as defined in IEEE 1588-2019 subclauses 6.6.2.2 and 9.2.5.

3.5. grandmaster clock

clock within a PTP domain that is the ultimate source of time for clock synchronization using the Precision Time Protocol as defined in IEEE 1588-2019

[1] IEEE 1588 is a registered trademark of the Institute of Electrical and Electronics Engineers, Inc.

3.6. leader

clock in the context of a single Precision Time Protocol (PTP) communication path, that is the source of time to which all other clocks on that path synchronize

Note 1 to entry: Referred to as master in IEEE 1588-2008

3.7. LEAD state

state of a clock port that is the source of time on the path served by the port

Note 1 to entry: Equivalent to MASTER state as defined in IEEE 1588-2019 subclauses 6.6.2.2.and 9.2.5

3.8. Local Time

time (and date) as chosen by the facility's system administrator and implemented by the system

Note 1 to entry: This is typically the calendar date and time-of-day in common use in the locality. It usually includes an offset from UTC including the time zone, accumulated Leap Seconds by the rules of UTC, and, where observed, daylight saving time (summer time) by the rules of the responsible authority.

3.9. octet

byte

ordered sequence of 8 bits

Note 1 to entry: usage of byte is retained in this document where applicable reference is made to IEEE 1588-2019 in which both usages occur.

3.10. Precision Time Protocol

PTP

time communication protocol as defined in IEEE 1588-2019

3.11. PTP Domain

a logical grouping of PTP Instances using PTP to ensure that all Local PTP Clocks in the grouping are synchronized to the Grandmaster Clock of the domain, but are not necessarily synchronized to the Local PTP Clocks in another domain.

Note 1 to entry: See IEEE 1588-2019, subclause 7.1

3.12. PTP epoch

origin of the timescale of a domain as defined in IEEE 1588-2019 (subclause 7.2.3)

Note 1 to entry: This PTP epoch is the same as the SMPTE epoch defined in SMPTE ST 2059-1

3.13. PTP time

time elapsed since the PTP epoch as conveyed by the Precision Time Protocol as defined in IEEE 1588-2019 (subclause 7.2)

Note 1 to entry: The PTP epoch as defined above is 63072010 seconds before 1972-01-01T00:00:00Z (UTC).

3.14. Synchronization Metadata

SM

metadata required for the synchronization of audio/video signals

3.15. Synchronization signal

reference signal used for the synchronization of audio/video equipment in a professional broadcast environment, for which a phase relationship with respect to the SMPTE Epoch has been defined

Note 1 to entry: see SMPTE ST 2059-1.

3.16. Time Jump

discontinuity in Local Time that is known in advance, caused typically by an adjustment to the number of accumulated leap seconds or a change in daylight saving time

3.17. SM TLV Method 1

synchronization metadata conveyed using legacy management messages

3.18. SM TLV Method 2

synchronization metadata attached to Announce messages

5 Byte Order

This document follows the byte and bit endianness presentation conventions used in IEEE 1588-2019 conventions.

All SM TLV numeric data types shall be encoded in big-endian format and the LSB (least significant bit) shall be bit 0. Other data types are as described in IEEE 1588-2019.

6 PTP Profile

6.1. Profile Identification

The PTP Profile shall be identified as follows:

PTP Profile:

SMPTE profile for synchronization in a professional broadcast environment

Version 2.0

Profile identifier: 68-97-E8-00-01-00

This profile is specified by Society of Motion Picture and Television Engineers (SMPTE)

6.2. Common PTP message header

The common header for all PTP messages shall be as specified in Table 35 of IEEE 1588-2019 with the attributes listed below set as indicated:

minorVersionPTP shall be set to value 1.

majorSdoId shall be set to value 0

minorSdoId shall be set to value 0.

NOTE 1 The attributes minorVersionPTP and minorSdoId did not exist in IEEE 1588-2008 and their locations in the common PTP message header were reserved fields with value of 0.

NOTE 2 In IEEE 1588-2008 the attribute majorSdoId was named transportSpecific which was set to value 0 for UDP transport over IPv4.

6.3. Options present in IEEE 1588-2019

Options present in IEEE 1588-2019 shall be prohibited unless explicitly permitted in this profile.

See subclause 6.13 for permitted options.

6.4. BMCA

The default algorithm defined in IEEE 1588-2019 subclause 9.3.2 (BMCA) shall be used.

6.5. Management Mechanism

This profile does not mandate any specific management mechanism for configuration purposes.

Management messages are used when sending the SM dataset using legacy SM TLV Method 1, see subclause 6.14.2. This mechanism is not compliant with IEEE 1588-2019.

6.6. Path Delay Measurement Mechanism

The delay request-response mechanism shall be the path delay measurement mechanism.

6.7. PTP Attribute Values

6.7.1. General

Attributes not specified by this profile shall use the default initialization values and ranges specified in IEEE 1588-2019. The following attributes are specified by this profile:

6.7.2. Configurable data set members

defaultDS.priority1	Default value:	128
	Configurable range:	0 to 255
defaultDS.priority2	Default value:	128
	Configurable range:	0 to 255

defaultDS.priority1 specifies the priority to be used in the execution of the BMCA. defaultDS.priority2 specifies the secondary priority to be used in the execution of the BMCA.

The above default initialization values are the same as those specified in the Delay Request-Response Default PTP Profile in Annex I.3 of IEEE 1588-2019.

defaultDS.domainNumber	Default value:	127
	Configurable range:	0 to 127

A domain consists of one or more PTP devices communicating with each other as defined by the protocol. The domain is identified by an integer, the domainNumber, in the configurable range of 0 to 127.

defaultDS.slaveOnly	The default value of a PTP Instance that is a follower-only PTP Instance:	TRUE
	Otherwise:	FALSE

All devices with PTP Instances that are not explicitly intended to enter the LEAD state should set this attribute as TRUE.

portDS.logAnnounceInterval: Default value: 0

Configurable range: -3 to +1

The portDS.logAnnounceInterval specifies the mean time interval between successive Announce messages, i.e., the announceInterval. This interval in concert with announceReceiptTimeout governs how quickly the BMCA re-configures the system in the event of a failure.

The portDS.logAnnounceInterval shall be chosen to be uniform throughout a domain.

NOTE The value of the parameter is the logarithm to base 2 of the time interval in seconds. (For example, an interval of 0.25 s gives a value of -2, and an interval of 2 s gives a value of +1.)

In order to facilitate quick synchronization, the default value, or a shorter interval than the default, is recommended.

portDS.announceReceiptTimeout: Default value: 3

Configurable range: 2 to 10

The value of portDS.announceReceiptTimeout specifies the number of announceIntervals that have to pass without receipt of an Announce message before the occurrence of the event ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES.

The above default initialization value and configurable range is as specified in the Delay Request-Response Default PTP profile in Annex I.3 of IEEE 1588-2019.

portDS.logSyncInterval: Default value: -3

Configurable range: -7 to -1

The portDS.logSyncInterval specifies the mean time interval between successive Sync messages. The value of the parameter is the logarithm to base 2 of the time interval in seconds.

This interval is set to a low value (i.e. high message rate) to allow clocks to synchronize quickly. In order to facilitate quick synchronization, the default value, or a shorter interval than the default, is recommended.

portDS.delayMechanism: Delay request-response: 01h

The portDS.delayMechanism specifies the propagation delay measuring option used by the port, as per subclause 6.6 of this profile.

transparentClockDefaultDS.delayMechanism End-to-end transparent clock: 01h

The transparentClockDefaultDS.delayMechanism specifies the delay measuring option used by the transparent clock.

transparentClockDefaultDS.primaryDomain Default value: same as defaultDS.domainNumber

The transparentClockDefaultDS.primaryDomain specifies the primary syntonization domain of the transparent clock.

6.7.3. Dynamic data set members

portDS.logMinDelayReqInterval: Default initialization value: portDS.logSyncInterval

Permitted range:

portDS.logSyncInterval to portDS.logSyncInterval + 5

portDS.logMinDelayReqInterval is a dynamic attribute determined and advertised by a leader based on the ability of the leader to process the Delay_Req message traffic. (See subclause 7.7.2.4 ‘Delay_Req message transmission interval’ of IEEE 1588-2019).

The default initialization value should be as above. Optionally, a different initialization value may be configured within the permitted range. The leader should not increase the value of portDS.logMinDelayReqInterval with respect to the initialized value (decrease the message rate) unless the number of followers exceeds the number that the leader is able to support at the initialized rate.

6.7.4. Other attributes

τ: Default value: 1.0 s

This parameter τ (Greek letter tau) is the sample period between measurements in the variance algorithm, as described in subclause 7.6.3.2 ‘Variance algorithm’ of IEEE 1588-2019.

The above default initialization value is as specified in the Delay Request-Response Default PTP Profile in Annex I.3 of IEEE 1588-2019.

clockClass

The characteristics applicable to this profile shall be those defined in Table 5 of IEEE 1588-2019.

timePropertiesDS.timeTraceable

The value of this flag shall be as specified in subclauses 8.2.4.6 and 9.4 of IEEE 1588-2019.

NOTE 1 This flag, in conjunction with other clock parameters, can be used to determine whether independent grandmasters are providing an equivalent time reference.

NOTE 2 The use of timePropertiesDS.timeTraceable in this profile is not intended to indicate legal traceability.

parentDS.grandmasterClockQuality

The value of this attribute shall be as specified in subclauses 8.2.3.7, 7.6.2.5, 7.6.2.6 and 7.6.2.7 of IEEE 1588-2019. The clockAccuracy member should not be set to "Unknown".

NOTE This attribute, in conjunction with other clock parameters, can be used to determine whether independent grandmasters are providing an equivalent time reference.

6.7.5. Additional enumerated Values

The value of timeSource provides information about the source of time used by the grandmaster and shall be as enumerated in subclause 7.6.2.8 of IEEE 1588-2019 or one of the following two additional enumerated values defined in this profile:

timeSource = F0h	Time in the grandmaster is derived from the periodicity of a synchronization signal where the time value is undefined and is not related to real time and the timescale is ARB.
timeSource = F1h	Time in the grandmaster is derived from the periodicity of a synchronization signal where the time value was initialized using the timescale PTP. Subsequent time accuracy in relation to real time will depend on the frequency accuracy of the synchronization signal.

6.8. One-step and two-step PTP ports

Follower PTP Instances shall support both one-step and two-step PTP port semantics (see IEEE 1588-2019 subclauses 3.1.39 and 3.1.87 respectively).

Leaders and switch ports in the lead state may choose to support one-step or two-step PTP port semantics.

6.9. Clock Physical Requirements

6.9.1. Frequency accuracy

For application as the reference for a facility synchronization system, the PTP grandmaster clock shall maintain a frequency such that the value of the second as measured by the Grandmaster Clock deviates by no more than ± 5 parts per million (ppm) from the SI second.

This accuracy might not be appropriate for all applications; requirements for precision and stability of oscillators for both leaders and followers are application dependent, and appropriate choices should be made during system design.

6.9.2. Frequency adjustment range

Any clock in the FOLLOW state shall be able to correct its frequency to match any clock meeting the requirement above.

6.10. Node Types Required, Permitted or Prohibited

Required node types:	Ordinary Clocks
Permitted node types:	Boundary Clocks, End-to-end Transparent Clocks, Management node
Prohibited node types:	Peer to peer Transparent Clocks

6.11. Transport Mechanisms Permitted

Permitted transport mechanisms: UDP over IPv4 as specified in in Annex C of IEEE 1588-2019
UDP over IPv6 as specified in in Annex D of IEEE 1588-2019

At least one of the two permitted transport mechanisms shall be supported.

Boundary clocks supporting both transports simultaneously shall be permitted.

Transparent Clocks shall forward IPv4 messages using IPv4 and shall forward IPv6 messages using IPv6.

Annex C.5 of IEEE 1588-2019 states that for PTP event messages in the case of IPv4, the value of the differentiated service (DS) field in the Type of Service (ToS) field should be set to the highest traffic class selector code point available. The highest available codepoint typically corresponds to Expedited Forwarding (EF) as defined in RFC 3246. If the network supports Expedited Forwarding, PTP event messages should be marked with the corresponding codepoint. The recommended codepoint for EF is 46 decimal. If the forwarding behaviors and codepoints supported by the network are unknown, PTP event messages should be marked with the codepoint 46 decimal. PTP general messages should be marked with the same or lower DSCP value as event messages.

6.12. Communication Model

6.12.1. General

For IPv4 multicast messages, IGMPv2 shall be supported. For IPv6 multicast messages, MLDv2 shall be supported and MLDv1 may be supported.

Within a given PTP Domain, Announce, Sync and Follow_Up messages shall use the same transport mode, and shall be either all multicast or all unicast.

If a Follow_Up message is associated with an optional unicast Sync message then the Follow_Up message shall also be transmitted as a unicast message to the same unicast address as the associated Sync message in accordance with IEEE 1588-2019 subclause 9.5.10.

For any Delay_Req messages received in either multicast or unicast, the PTP leader shall respond with a Delay_Resp message in the same mode in accordance with IEEE 1588-2019 subclause 9.5.12.

Management messages may be multicast or unicast.

Within a PTP Domain, SM TLV management messages shall use the same transport mode as the Announce, Sync and Follow_Up messages.

Replies to SM TLV management messages shall be unicast. However, to avoid packet burst in large PTP networks a device should not reply to SM TLV management messages.

The only valid transport modes shall be multicast, mixed, and unicast as defined below. Multicast and mixed transport modes may coexist within a given PTP Domain while unicast transport mode shall not coexist with other transport modes.

Leaders shall support multicast transport mode and mixed transport mode simultaneously and may support unicast transport mode. Followers shall support multicast transport mode. Followers may support mixed transport mode and may support unicast transport mode.

6.12.2. Multicast transport mode

In this mode, leaders shall send Announce, Sync, SMPTE SM TLV Method 1 messages and, if applicable, Follow_Up messages as multicast and followers shall send Delay_Req messages as multicast. Delay_Resp messages are sent as multicast.

The logMessageInterval field of the delay response message is used to carry the portDS.logMinDelayReqInterval. Followers should use this as the portDS.logMinDelayReqInterval value. If the value is outside the range defined in ST 2059-2 subclause 5.7.3, then the value shall be set within the legal range defined in subclause 5.7.3 and if no specific value is indicated by the follower then it should be set equal to portDS.logSyncInterval.

6.12.3. Mixed transport mode

In this mode which is optional for followers to support, leaders shall send Announce, Sync, SMPTE SM TLV Method 1 and, if applicable, Follow_Up messages as multicast and followers shall send Delay_Req messages as unicast. Delay_Resp messages are sent as unicast. Unicast negotiation shall not be used for Delay_Resp messages.

The logMessageInterval field of the delay response message is used to carry the portDS.logMinDelayReqInterval. Followers should use this as the portDS.logMinDelayReqInterval value. If the value is outside the range defined in ST 2059-2 subclause 5.7.3, then the value shall be set within the legal range defined in subclause 5.7.3 and if no specific value is indicated by the follower then it should be set equal to portDS.logSyncInterval.

NOTE In Mixed mode, an IEEE 1588:2008 compliant leader sends a value of 0x7f in the delay response logMessageInterval field.

In this mode, followers shall send unicast Delay_Req messages to the IP source address in the Announce message from the leader. The IP source addresses of Sync and Follow_Up messages cannot be relied upon because they might have been replaced by the source address of a Transparent Clock. The Sync and Follow_Up messages can be correlated with the Announce message using the sourcePortIdentity field in the common message header, which is not altered by Transparent Clocks.

If mixed mode is implemented, then devices conform to IEEE 1588:2019 subclause 16.9. The optional Port Property TLV of IEEE 1588-2019 subclause 16.9.2 shall not be permitted.

6.12.4. Unicast transport mode

In this optional mode, leaders shall send Announce, Sync, SMPTE TLV Method 1 messages and, if applicable, Follow_Up messages as unicast and followers shall send Delay_Req messages as unicast. Unicast negotiation shall be used.

All applicable follower ports are configured with a set of potential leaders. Each follower uses the unicast negotiation option to request that the potential leaders transmit unicast Announce, Sync, and Delay_Resp messages to it. In this mode, leaders grant unicast transmission of Announce, Sync, and Delay_Resp messages and followers send unicast Delay_Req messages.

The unicast discovery option specified in IEEE 1588-2019 subclause 17.4 may be used to implement this set of leaders. If more than one leader grants unicast Announce messages, the follower shall select the best leader according to the BMCA as specified in IEEE 1588-2019 subclause 9.3.2.

NOTE The number of potential leaders configured in each follower port is implementation specific. In most cases all the followers in a system would be configured with the same set of potential leaders to facilitate all followers choosing the same best leader.

6.13. Permitted PTP options and features

6.13.1. Path trace

See IEEE 1588-2019 subclause 16.2.

6.13.2. Unicast message negotiation

See IEEE 1588-2019 subclause 16.1.

6.13.3. Unicast discovery

See IEEE 1588-2019 subclause 17.4.

6.13.4. Alternate timescales

See IEEE 1588-2019 subclause 16.3.

6.13.5. Acceptable master table

See IEEE 1588-2019 subclause 17.5.

6.13.6. Mixed multicast/unicast operation

See IEEE 1588-2019 subclause 16.9.

See also subclause 6.12.3 in this profile.

6.13.7. PTP integrated security mechanism

See IEEE 1588-2019 subclause 16.14. AUTHENTICATION TLVs may be appended to PTP messages.

See also IEEE 1588d-2023 which adds guidelines on the application and operation of GDOI (Group Domain of Interpretation) key management to Annex P and corrects errors and clarifies statements in subclause 16.4 and Annex P.

6.13.8. Performance monitoring

See IEEE 1588-2019 Annex J.

6.14. Synchronization Metadata TLV

6.14.1. General

Every port in LEAD state in a grandmaster clock shall provide Synchronization Metadata (SM) TLV Method 2 as specified in subclause 6.14.3.

When compatibility with earlier versions of this standard is required, SM TLV Method 1 shall be provided as defined in subclause 6.14.2.

The structure of the SM TLV is defined in subclause 6.15.

Follower implementations should be capable of receiving both SM TLV Method 1 and SM TLV Method 2.

6.14.2. SM TLV Method 1 (legacy IEEE 1588-2008 compliant)

When compatibility with legacy versions of this standard is required, once every second and also when its locking status is changed, every port in LEAD state in a grandmaster clock shall send a management message with Synchronization Metadata (SM) TLV appended. If followers have negotiated unicast Announce/Sync messages then the SM TLV shall be sent as unicast to these destinations.

SM TLV Method 1 is not compliant with IEEE 1588-2019.

The Management Message (COMMAND) shall be as defined in Table 1 and the SM TLV shall be set as defined in Table 2.

NOTE 1 The Legacy SM TLV is an organization-specific TLV. Its structure is not the same as that of the management TLV specified in subclause 15.5 of IEEE 1588-2019 for use with PTP management messages. Processing of PTP management messages according to IEEE 1588-2019 uses the value of the managementId present in the 5th and 6th octets of management TLVs. This SM TLV is of ORGANIZATION_EXTENSION tlvType in which the 5th and 6th octets instead contain part of the organizationId, 0x6897. While not an issue with implementations that follow this standard, it is possible that devices that do not support the SMPTE Profile might respond with an error message, either because the tlvType is ORGANIZATION_EXTENSION and not MANAGEMENT or because an expected managementId appears as 0x6897, which is in a reserved range.

NOTE 2 Messages related to synchronization, establishing the clock hierarchy, and signaling terminate in the protocol engine of a boundary clock and are not forwarded. Management messages are forwarded by other ports on the boundary clock subject to restrictions to limit the propagation of these messages within the system.

Table 1 — Structure of Management Message (COMMAND)

Bits								Octets (Bytes)	Offset	Description
7	6	5	4	3	2	1	0			
Header								34	0	See IEEE 1588-2008, subclause 13.3
targetPortIdentity								10	34	All ones
startingBoundaryHops								1	44	See IEEE 1588-2008 subclause 15.4.1.4 NOTE The value of startingBoundaryHops is chosen to take into account the maximum number of boundary clocks through which the message is expected to propagate.
boundaryHops								1	45	See IEEE 1588-2008 subclause 15.4.1.5
Reserved				actionField				1	46	actionField = COMMAND
Reserved								1	47	
SM TLV (see Table 2)								52	48	

6.14.3. SM TLV Method 2 (IEEE 1588-2019 compliant)

Every device in LEAD state shall append the SM TLV (see Table 2) to every Announce message.

If followers have negotiated unicast Announce messages then the SM TLV shall be appended to the unicast Announce messages as specified in IEEE 1588-2019 subclause 13.5. A follower shall use the TLV only from the leader that it has chosen as active according to the BMCA.

6.15. Structure of SM TLV

In Table 2, each reference to ‘subclause’ is to a subclause within this document unless specified otherwise.

Table 2 — Structure of SM TLV

Item	Octets (Bytes)	Offset	Description
tlvType	2	0	SM TLV Method 1: ORGANIZATION_EXTENSION, which has the value of 00 03.
			SM TLV Method 2: ORGANIZATION_EXTENSION_PROPAGATE, which has the value of 40 00.
lengthField	2 (uint16)	2	The length of the SM TLV data structure excluding tlvType and lengthField. The value of the lengthField shall be 48.
organizationId	3	4	68 97 E8 (SMPTE Organizationally Unique Identifier (OUI))
organizationSubType	3	7	SM TLV Method 1: Used to indicate the SM TLV version for management of forward / backward compatibility. 00 00 01 for this version.
			SM TLV Method 2: Used to indicate the SM TLV version for management of forward / backward compatibility. 00 00 02 for this version.
defaultSystemFrameRate	8	10	Default video frame rate of the system as a lowest term rational. The data type shall be composed of a pair of unsigned Int32 values coded in big-endian form where the first shall be the numerator and the second shall be the denominator. The denominator shall be the smallest value that represents the frame rate denominator[2].

[2] For example, for a video frame rate of 30000/1001 Hz (i.e., 30/1.001 Hz or nominally “29.97” Hz), the number would appear as 00 00 75 30 00 00 03 e9 in hexadecimal format.

Item	Octets (Bytes)	Offset	Description
gmLockingStatus	1	18	Complementary information to clockClass[3] 0: Unavailable All information about the grandmaster clock is conveyed in the Announce Message. 1: Internal Grandmaster is using a stable internal reference clock but is not synchronized to an external reference time source. Applies if time was set manually or if was previously locked to an external source. Followers would be expected to initiate (or maintain) synchronization with the grandmaster. 2: Cold Locking In response to a disturbance, the grandmaster is re-locking quickly. In this situation, a rapid phase adjustment with a time discontinuity can be expected. 3: Warm Locking In response to a disturbance, the grandmaster is re-locking slowly by means of a frequency adjustment, with no phase discontinuity. Time continuity is maintained. 4: Externally locked (i.e., in normal operation and stable) The grandmaster is locked to an external reference. Frequency stability and phase are determined by the external reference. Followers would be expected to initiate (or maintain) synchronization with the grandmaster.

[3] The Announce Message has a parameter named clockClass which can convey similar information. Because the clockClass parameter indicates only whether the grandmaster is locked or unlocked, complementary information about the behavior of the grandmaster in the event of a disturbance can be set using this field.

Item	Octets (Bytes)	Offset	Description
timeAddressFlags	1	19	Indicates the intended SMPTE ST 12-1 flags. Bit 0: Drop frame 0: Non-drop-frame 1: Drop-frame Bit 1: Color Frame Identification 0: Not in use 1: In use Bits 2 to 7: Reserved
currentLocalOffset	4 (int32)	20	Offset in seconds of Local Time from grandmaster PTP time[4]. See subclause 6.16.
jumpSeconds	4 (int32)	24	The size of the next discontinuity, in seconds, of Local Time. A value of zero indicates that no discontinuity is expected. A positive value indicates that the discontinuity will cause the currentLocalOffset to increase.
timeOfNextJump	6 (uint48)	28	The value of the seconds portion of the grandmaster PTP time at the time that the next discontinuity of the currentLocalOffset will occur. The discontinuity occurs at the start of the second indicated. See subclause 6.16.
timeOfNextJam	6 (uint48)	34	The value of the seconds portion of the PTP time corresponding to the next scheduled occurrence of the Daily Jam. If no Daily Jam is scheduled, the value of timeOfNextJam shall be zero. See subclause 6.16.
timeOfPreviousJam	6 (uint48)	40	The value of the seconds portion of the PTP time corresponding to the previous occurrence of the Daily Jam. See subclause 6.16.

[4] For example, if Local Time is Eastern Standard Time (North America) UTC−5, the date is 2014-01-01, and the time difference between TAI and UTC taking into account the number of leap seconds is -35, the value will be -18035 (decimal). If Daylight Saving is in effect (Eastern Daylight Time) UTC−4, the date is 2014-07-01, and the time difference between TAI and UTC taking into account the number of leap seconds is -35, the value will be -14435 (decimal).

Item	Octets (Bytes)	Offset	Description
previousJamLocalOffset	4 (int32)	46	The value of currentLocalOffset at the time of the previous Daily Jam event. If a discontinuity of Local Time occurs at the jam time, this parameter reflects the offset after the discontinuity. The default value shall be the current value of currentLocalOffset. See subclause 6.16.
daylightSaving	1	50	Bit 0: Current Daylight Saving 0: Not in effect 1: In effect Bit 1: Daylight Saving at next discontinuity 0: Not in effect 1: In effect Bit 2: Daylight Saving at previous Daily Jam event 0: Not in effect 1: In effect Bits 3 to 7: Reserved See subclause 6.16.
leapSecondJump	1	51	The reason for the forthcoming discontinuity of currentLocalOffset indicated by timeOfNextJump Bit 0: 0: Other than a change in the number of leap seconds (default) 1: A change in number of leap seconds Bits 1 to 7: Reserved See subclause 6.16.2.

NOTE SM TLV messages can experience slight delays from network transit times and internal processing in the follower before being ready for use. jumpSeconds and timeOfNextJump are designed to compensate for these delays by informing the follower in advance when changes signaled by the Synchronization Metadata are to be applied to time address calculations. Use of this mechanism in the follower is detailed in SMPTE ST 2059-1.

To determine Local Time, the follower shall add the signed 32-bit seconds field currentLocalOffset to the reconstructed PTP time.

6.16. Setting dynamic SM TLV Values

6.16.1. General

A Time Jump event is signaled in advance to indicate the future occurrence of a discontinuity in Local Time. This might arise from an adjustment to the number of accumulated leap seconds or daylight saving time.

The occurrence of the Daily Jam event, used to adjust the SMPTE ST 12-1 time address value generated in followers to Local Time, is also signaled in advance. This is signaled separately to a Time Jump event.

The SMPTE ST 12-1 time address discontinuity arising from the Time Jump event might not be immediately reflected in the time address value generated in followers. Rather, the adjustment to the SMPTE ST 12-1 time address value is made at the next Daily Jam event (see SMPTE ST 2059-1).

The values of several of the SM TLV items listed in Table 2 are dynamic in nature: currentLocalOffset, jumpSeconds, timeOfNextJump, timeOfNextJam, timeOfPreviousJam, previousJamLocalOffset, leapSecondJump and daylightSaving.

The values of some of these items are influenced by local operational policies and requirements. These include the Local Time zone, the time of the Daily Jam (if applicable), the dates and times when daylight saving time will take effect or end, and when leap-second changes occur.

Care needs to be taken on days when daylight saving time starts or ends to ensure that time-related SM TLV items signaled using PTP time achieve the required results at the intended Local Time.

Subclause 6.16.2 in this document specifies how SM TLV items are set in order to signal a Time Jump event.

Subclause 6.16.3 in this document specifies how SM TLV items are set in order to signal the Daily Jam event.

6.16.2. Signaling a Time Jump event

If the time of the next Time Jump event is not yet known, jumpSeconds and timeOfNextJump shall be set to 0.

To signal a Time Jump event, timeOfNextJump should be changed to the required value at least one day in advance of the event. In the same Management Message as the aforementioned change in value of timeOfNextJump and in subsequent Management messages, jumpSeconds shall be set to the value of the required time discontinuity of the Time Jump event and leapSecondJump shall be set to the appropriate value for the forthcoming discontinuity.

If the reason for the Time Jump event is the insertion or deletion of a leap second, Bit 0 of leapSecondJump shall be set to 1. In the case of an inserted (positive) leap second, jumpSeconds shall be set to −1 and timeOfNextJump shall be set to the PTP time of the second following the inserted second. In the case of a deleted (negative) leap second, jumpSeconds shall be set to +1 and timeOfNextJump shall be set to the PTP time of the second following the deleted second.

When the grandmaster PTP time seconds becomes greater than the unsigned 48-bit timeOfNextJump field (i.e., when the time of the event has been passed), the values of the following SM TLV items shall be changed as indicated:

- currentLocalOffset shall be adjusted to take into account the time discontinuity occurring at the Time Jump event.
- jumpSeconds and timeOfNextJump shall be set to 0 if no further Time Jump event is to be signaled and these values shall be maintained in subsequent Management Messages until the next Time Jump event is known.
- daylightSaving shall be set to an updated value in accordance with its usage as described in Table 2 and this value shall be maintained in subsequent Management Messages until the next Time Jump event related to a daylight saving change has taken place.
- if the value of Bit 0 of leapSecondJump had been set to 1, it shall be restored to its default value of 0.

6.16.3. Signaling the Daily Jam event

If Daily Jam is not in use, timeOfNextJam shall be set to zero, and timeOfPreviousJam and previousJamLocalOffset shall be set to achieve the required initialization of followers.

NOTE 1 In integer frame rate environments, setting timeOfPreviousJam to any time in the past, such as zero, and previousJamLocalOffset to currentLocalOffset will result in generated time addresses being aligned with Local Time.

If Daily Jam is in use, timeOfNextJam shall be initialized to the value corresponding to the next scheduled occurrence of the Daily Jam event in accordance with the steps described in Annex A. timeOfPreviousJam shall be initialized to the value corresponding to when the previous Daily Jam event would have been and previousJamLocalOffset shall be initialized to the value of currentLocalOffset that would have been applicable at the time of the previous jam.

NOTE 2 Initailization in the way described above takes into account any adjustments to Local Time caused by changes in daylight saving or the number of leap seconds.

Following initialization of timeOfPreviousJam and previousJamLocalOffset, their values should not be changed until after a jam has taken place.

The following procedure shall then be followed.

When the grandmaster PTP time seconds becomes greater than the value of timeOfNextJam (i.e., when the time of the Daily Jam has been passed, the values of the following SM TLV items shall be changed as indicated:

- previousJamLocalOffset shall be set to the value of currentLocalOffset at the time of the Daily Jam event that has just passed and this value of previousJamLocalOffset shall be maintained in subsequent Management Messages until the next Daily Jam event.
- timeOfPreviousJam shall be set to the value of timeOfNextJam and this value of timeOfPreviousJam shall be maintained in subsequent Management Messages until the next Daily Jam event.
- timeOfNextJam shall be set to the value corresponding to the next scheduled Daily Jam event or zero if no forthcoming jam event is scheduled.

Annex A (normative) Calculation of timeOfNextJam

timeOfNextJam shall correspond to a Local Time that is an integer multiple of 600 seconds (i.e., in units of 10 minutes).

There should not be more than one Daily Jam event between two successive midnights (Local Time).

The following steps shall be used to calculate timeOfNextJam:

Where the jam is required to take place on a daily basis at a user-selected time of day on the Local Time scale and where the hours and minutes are userDailyJamTimeHH and userDailyJamTimeMM respectively:

t is the elapsed time from the PTP Epoch in seconds

floor(*a*) is the greatest integer less than or equal to the real number *a*

t_mlocal and t_pdjamLocal are local scope temporary variables

1. Calculate time of midnight on Local Time scale (t_mlocal)

   t_mlocal = floor ((t + currentLocalOffset)/(24×60×60))×24×60×60

2. Calculate next Time of Daily Jam on Local Time scale (t_pdjamLocal)

   t_pdjamLocal = t_mlocal + (userDailyJamTimeHH×60×60) + (userDailyJamTimeMM×60)

3. Calculate time of next Daily Jam on the PTP scale

   timeOfNextJam = t_pdjamLocal - currentLocalOffset

4. Ensure timeOfNextJam is in the future

   If t is greater than or equal to timeOfNextJam then

   timeOfNextJam = timeOfNextJam + (24×60×60)

   endif

If currentLocalOffset is scheduled to change (as signaled by timeOfNextJump) in advance of the next planned occurrence of the Daily Jam, the value of timeOfNextJam shall be adjusted by the same amount to ensure that timeOfNextJam corresponds to the correct Local Time of the intended jam.

When the jam is required to take place at the time of the next discontinuity in Local Time (for example, to coincide with a change in daylight saving time), the following equation shall be used to generate timeOfNextJam.

timeOfNextJam = timeOfNextJump

NOTE The above provision is also needed when implementing a single jam event in facilities that do not use Daily Jam

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