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**Precision time protocol telecom profile for
phase/time synchronization with partial timing
support from the network**

Recommendation ITU-T G.8275.2/Y.1369.2



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Recommendation ITU-T G.8275.2/Y.1369.2

Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network

Summary

Recommendation ITU-T G.8275.2/Y.1369.2 contains the ITU-T precision time protocol (PTP) profile for phase/time distribution with partial timing support from the network (unicast mode). It provides the necessary details to utilize IEEE 1588 in a manner consistent with the architecture described in Recommendation ITU-T G. 8275/Y.1369. This Recommendation defines the PTP profile for unicast mode only. Future editions of this Recommendation may contain a separate profile for a mixed unicast/multicast case.

History

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Recommendation ITU-T G.8275.2/Y.1369.2

Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network

1 Scope

This Recommendation specifies a profile for telecommunication applications based on IEEE 1588 precision time protocol (PTP). The profile specifies the IEEE 1588 functions that are necessary to ensure network element interoperability for the delivery of accurate phase/time (and frequency) synchronization. The profile is based on the partial timing support (PTS) from the network architecture as described in [ITU-T G.8275] and definitions described in [ITU-T G.8260].

It is assumed that this profile will be used in well-planned cases where network behaviour and performance can be constrained within well-defined limits, including limits on static asymmetry. Control of static asymmetries can be achieved in case of assisted partial timing support. Use of this profile in non-assisted mode would require careful considerations on how to control static asymmetries.

This version of the profile specifies the high-level design requirements, modes of operation for the exchange of PTP messages, the PTP protocol mapping, the best master clock algorithm (BMCA) options, as well as the PTP protocol configuration parameters.

Further information on the setup of the protocol in the network is planned to be included in future versions of this Recommendation. In particular, this information will be related to architectures that imply rearrangements of the synchronization direction, and to architectures that include clocks with multiple PTP ports, especially when ports not in the MASTER state provide synchronization services.

At the time of publication of this profile, performance analysis, network limits, and clocks used in the profile, namely boundary and slave clocks, are for further study.

This Recommendation also specifies some aspects necessary for use in a telecom environment that are outside the scope of the PTP profile, but complement it.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T G.781] Recommendation ITU-T G.781 (2008), *Synchronization layer functions*.
- [ITU-T G.810] Recommendation ITU-T G.810 (1996), *Definitions and terminology for synchronization networks*.
- [ITU-T G.8260] Recommendation ITU-T G.8260 (2015), *Definitions and terminology for synchronization in packet networks*.
- [ITU-T G.8265.1] Recommendation ITU-T G.8265.1/Y.1365.1 (2014), *Precision time protocol telecom profile for frequency synchronization*.
- [ITU-T G.8271] Recommendation ITU-T G.8271/Y.1366 (2016), *Time and phase synchronization aspects of packet networks*.

- [ITU-T G.8272] Recommendation ITU-T G.8272/Y.1367 (2012), *Timing characteristics of primary reference time clocks.*
- [ITU-T G.8273] Recommendation ITU-T G.8273/Y.1368 (2013), *Framework of phase and time clocks.*
- [ITU-T G.8273.2] Recommendation ITU-T G.8273.2/Y.1368.2 (2014), *Timing characteristics of telecom boundary clocks and telecom time slave clocks.*
- [ITU-T G.8275] Recommendation ITU-T G.8275/Y.1369 (2013), *Time and phase distribution through packet networks.*
- [ITU-T G.8275.1] Recommendation ITU-T G.8275.1/Y.1369.1 (2016), *Precision time protocol telecom profile for phase/time synchronization with full timing support from the network.*
- [IEEE 1588] IEEE 1588 (2008), *IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

The terms and definitions used in this Recommendation are contained in [ITU-T G.810] and [ITU-T G.8260].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

APTS	Assisted Partial Timing Support
BC	Boundary Clock
BMCA	Best Master Clock Algorithm
ePRTC	Enhanced Primary Reference Time Clock
EUI	Extended Unique Identifier
GM	GrandMaster
GNSS	Global Navigation Satellite System
IP	Internet Protocol
OC	Ordinary Clock
ParentDS	Parent Data Set
PDV	Packet Delay Variation
PRC	Primary Reference Clock
PRS	Primary Reference Source
PRTC	Primary Reference Time Clock
PTP	Precision Time Protocol
PTPVAR	PTP Variance

PTS	Partial Timing Support
PTSF	Packet Timing Signal Fail
QL	Quality Level
SDH	Synchronous Digital Hierarchy
SF	Signal Fail
SSM	Synchronization Status Message
SSU	Synchronization Supply Unit
SSU-A	Primary level SSU
SSU-B	Secondary level SSU
ST2	Stratum 2
ST3E	Stratum 3 Enhanced
T-BC-P	Partial-Support Telecom Boundary Clock
TC	Transparent Clock
T-GM	Telecom Grandmaster
TLV	Type, Length, Value
T-TC-P	Partial-Support Telecom Transparent Clock
T-TSC-A	Assisted Partial-Support Telecom Time Slave Clock
T-TSC-P	Partial-Support Telecom Time Slave Clock
UDP	User Datagram Protocol
VLAN	Virtual Local Area Network

5 Conventions

Within this Recommendation, the following conventions are used: the term PTP refers to the PTP version 2 protocol defined in [IEEE 1588]. PTP messages used within this Recommendation are defined in [IEEE 1588] and are identified using italicized text.

The term telecom grandmaster (T-GM) refers to a device consisting of a grandmaster (GM) clock as defined in [IEEE 1588] and this Recommendation, with additional performance characteristics for further study.

The term partial-support telecom boundary clock (T-BC-P) refers to a device consisting of a boundary clock (BC) as defined in [IEEE 1588], with additional performance characteristics for further study. A T-BC-P may be assisted by having a primary reference time clock (PRTC) (e.g., global navigation satellite system (GNSS)) support.

The term partial-support telecom transparent clock (T-TC-P) refers to a device consisting of a transparent clock (TC) as defined in [IEEE 1588], with additional performance characteristics for further study.

The term partial-support telecom time slave clock (T-TSC-P) refers to a device consisting of either an ordinary clock (OC), with one PTP port, or a boundary clock (BC), with multiple PTP ports, as defined in [IEEE 1588] and this Recommendation, that does not support providing synchronization using PTP to other PTP clocks in the PTP domain, and with additional performance characteristics for further study. A T-TSC-P may be assisted by having PRTC (e.g., GNSS) support.

The term assisted partial-support telecom time slave clock (T-TSC-A) refers to a T-TSC-P that is assisted by having PRTC (e.g., GNSS) support as a primary source of time. Note: In the case of a T-TSC-A or T-TSC-P, with multiple PTP ports (BC), only one PTP port can be in PTP SLAVE state at any instant in time based on the BMCA. Other PTP ports not in the PTP SLAVE state may actively exchange synchronization messages with other PTP clocks populated in the unicast master table using unicast negotiation.

The term primary reference time clock (PRTC) refers to the clock defined in [ITU-T G.8272]. The term enhanced primary reference time clock (ePRTC) refers to an enhanced version of the PRTC, which is being studied.

6 Use of PTP for phase/time distribution

The 2002 version of the IEEE 1588 standard was developed by the IEEE initially to support the timing requirements of industrial automation and test and measurement, defining the precision time protocol (PTP) designed to enable accurate time transfer in this context.

The 2008 version of IEEE 1588 (defined in [IEEE 1588]) contains features useful to the transport of the protocol over a wide area network, and introduces the concept of "profile", whereby aspects of the protocol may be selected and specified for a particular use other than the originally intended industrial automation.

A PTP profile was defined by ITU-T in [ITU-T G.8265.1] to address applications requiring frequency synchronization only. An additional PTP profile was defined by ITU-T in [ITU-T G.8275.1] in order to allow the distribution of phase/time with full timing support from the network. This Recommendation defines another PTP profile to allow the distribution of phase and time with partial timing support (PTS) from the network.

The [IEEE 1588] telecom profile defined within this Recommendation is intended to be used by telecom applications requiring accurate phase and time synchronization. It covers applications where there is need for phase alignment and/or time of day. It supports the specific architecture described in [ITU-T G.8275] in order to allow the distribution of phase/time with PTS from the network, and is based on the 2008 version of PTP defined in [IEEE 1588]. This includes the case of assisted partial timing support (APTS).

This profile uses only the unicast mode.

In order to claim compliance with the telecom profile, the requirements of this Recommendation and the relevant requirements of [IEEE 1588], as referenced in Annex A, must be met.

The detailed aspects related to the telecom profile are described in the following clauses, while the profile itself is contained in Annex A. It follows the general rules for profile specification developed in [IEEE 1588].

This PTP telecom profile defines the [IEEE 1588] parameters to be used, in order to guarantee protocol interoperability between implementations and specifies the optional features, default values of configurable attributes and mechanisms that must be supported. However, it does not guarantee that the performance requirements of a given application will be met. Those performance aspects are currently under study, and imply additional elements beyond the content of the PTP profile itself. These are planned to be addressed in other ITU-T Recommendations.

6.1 High-level design requirements

Clause 19.3.1.1 of [IEEE 1588] states:

"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."

For operation in a telecom network, some additional criteria are also required to be consistent with standard telecom synchronization practices. With that in mind, the PTP profile for time and phase distribution must meet the following high-level requirements:

- 1) Mechanisms must be specified to allow interoperability between the various phase/time clocks belonging to the architecture defined in [ITU-T G.8275] and described in [ITU-T G.8273].
- 2) Mechanisms must permit consistent operation over managed wide area telecom networks.
- 3) Packet-based mechanisms must allow the synchronization network to be designed and configured in a fixed arrangement.
- 4) Protection schemes used by packet-based systems must be based on standard telecom operational practice and allow partial-support telecom time slave clocks (T-TSC-P and T-TSC-A) to have the ability to take phase and time from multiple geographically separate T-GM clocks.
- 5) Phase/time reference source selection based on received phase/time traceability and local priority, as well as automatic establishment of the phase/time synchronization network topology, should be permitted.

6.2 PTP modes and options

6.2.1 PTP Domains

A domain consists of a logical grouping of clocks communicating with each other using the PTP protocol.

PTP domains are used to partition a network within an administrative domain. The PTP messages and data sets are associated with a domain and therefore the PTP protocol is independent for different domains.

In this PTP telecom profile, the default PTP domain number is 44, and the range of applicable PTP domain numbers is {44 – 63}.

NOTE – This range has been selected from the user-defined PTP domain number range defined in [IEEE 1588]. Although non-overlapping ranges have been considered for the different PTP telecom profiles so that interactions between the profiles are prevented, nothing precludes another industry from using the same user-defined PTP domain number range when defining a non-telecom PTP profile. It is the responsibility of the network operator to identify if the risk of unintentional interactions between PTP profiles exists, and to take the necessary actions to prevent such behaviour.

6.2.2 PTP messages

[IEEE 1588] defines two categories of message types: event and general PTP messages. The two types differ in that event messages are timed messages and require or contain an accurate timestamp. General message types do not require accurate timestamps.

[IEEE 1588] defines the following message types: *Sync*, *Delay_Req* (i.e., "delay request"), *Announce*, *Follow_Up*, *Delay_Resp* (i.e., "delay response"), *Pdelay_Req*, *Pdelay_Resp*, and *Pdelay_Resp_Follow_Up*, *Management* and *Signalling*.

Sync, *Delay_Req*, *Announce*, *Follow_Up*, *Delay_Resp*, and *Signalling* messages are used in this profile.

Pdelay_Req, *Pdelay_Resp*, and *Pdelay_Resp_Follow_Up* messages are not used in this profile.

The use of *Management* messages is for further study.

6.2.3 Types of PTP clocks supported in the profile

The OC and BC according to [IEEE 1588] are used in this profile.

There are two types of OCs:

- 1) OC that can only be a grandmaster (T-GM according to the architecture defined in [ITU-T G.8275], and as included in [ITU-T G.8272]).
- 2) OC that can only be a slave, i.e., slave-only OC (T-TSC-P with only one port or T-TSC-A with only one port according to the architecture defined in [ITU-T G.8275]). The clock specifications for T-TSC-P and T-TSC-A are for further study.

There are three types of BCs:

- 1) BC that can only be a grandmaster (T-GM according to the architecture defined in [ITU-T G.8275], and as included in [ITU-T G.8272]).
- 2) BC that can become a grandmaster and can also be slaved to another PTP clock (T-BC-P according to architecture defined in [ITU-T G.8275]). The clock specifications for T-BC-P are for further study.
- 3) BC that can only be a slave (T-TSC-P with more than one port or T-TSC-A with more than one port according to the architecture defined in [ITU-T G.8275]). The clock specifications for T-TSC-P and T-TSC-A are for further study.

NOTE – T-GM and GM are different concepts; GM is a status defined in [IEEE 1588] that a PTP clock may obtain if it wins the BMCA, while T-GM is a type of clock defined in the [ITU-T G.8275] architecture.

The mapping between these PTP clock types and the phase/time clocks defined in the [ITU-T G.8275] architecture is described in Table 1.

Table 1 – Mapping between [ITU-T G.8275.2] and PTP clock types

Clock type from [ITU-T G.8275.2]	Description	Clock type from [IEEE 1588]
T-GM	Master-only ordinary clock (master with a single PTP port, cannot be slaved to another PTP clock)	OC
	Master-only boundary clock (master with multiple PTP ports, cannot be slaved to another PTP clock)	BC (Note)
T-BC-P	Boundary clock (may become a GM, or may be slaved to another PTP clock)	BC
T-TSC-P	Slave-only, single port, ordinary clock (always a slave)	OC
	PTP clock at the end of the PTP synchronization chain, multiple port clock	BC (Note)
T-TSC-A	Slave-only, single port, ordinary clock (always a slave) with local PRTC assistance	OC
	PTP clock at the end of the PTP synchronization chain, multiple port clock with local PRTC assistance	BC (Note)
NOTE – According to [IEEE 1588], a clock that has multiple PTP ports is by definition a boundary clock.		