INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8275.1/Y.1369.1

(07/2014)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Synchronization, quality and availability targets

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

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

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PREPUBLISHED RECOMMENDATION

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Recommendation ITU-T G.8275.1/Y.1369.1

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

Summary

Recommendation ITU-T G.8275.1/Y.1369.1 contains the ITU-T PTP profile for phase and time distribution with full timing support from the network. It provides the necessary details to utilize IEEE Std 1588™-2008 in a manner consistent with the architecture described in Recommendation ITU-T G.8275/Y.1369.

Keywords

IEEE Std 1588™-2008, PTP, phase and time synchronization, full timing support

Recommendation ITU-T G.8275.1/Y.1369.1

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

1 Scope

This Recommendation specifies a profile for telecommunication applications based on IEEE Std 1588™-2008 Precision Time Protocol (PTP). The profile specifies the IEEE Std 1588™-2008 functions that are necessary to ensure network element interoperability for the delivery of accurate phase/time synchronization. The profile is based on the full timing support from the network architecture as described in G.8275 and definitions described in G.8260. The first 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 options, as well as the PTP protocol configuration parameters.

NOTE – The parameters defined in the first version of the profile have been chosen based on the case where physical layer frequency support is provided.

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

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.810] Recommendation ITU-T G.810 (1996), *Definitions and terminology for synchronization networks*

[ITU-T G.781] Recommendation ITU-T G.781 (2008), *Synchronization layer functions*

[ITU-T G.8260] Recommendation ITU-T G.8260 (2012), *Definitions and terminology for synchronization in packet networks*

[ITU-T G.8265.1] Recommendation ITU-T G.8265.1 (2014), *Precision time protocol telecom profile for frequency synchronization*

[ITU-T G.8271.1] Recommendation ITU-T G.8271.1 (2013), *Network limits for time synchronization in packet networks*

[ITU-T G.8272] Recommendation ITU-T G.8272 (2012), *Timing characteristics of primary reference time clocks*

[ITU-T G.8273] Recommendation ITU-T G.8273 (2013), *Framework of phase and time clocks*

[ITU-T G.8273.2] Recommendation ITU-T G.8273.2 (2014), *Timing characteristics of telecom boundary clocks and telecom time slave clocks*

[ITU-T G.8275] Recommendation ITU-T G.8275 (2013), *Time and phase distribution through packet networks*

[IEEE 1588] IEEE Std 1588™-2008, *Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*

3 Definitions

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

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BC Boundary Clock

BMCA Best Master Clock Algorithm

EEC synchronous Ethernet Equipment Clock

EUI Extended Unique Identifier

GM Grandmaster

GNSS Global Navigation Satellite System

OC Ordinary Clock

ParentDS Parent Data Set (terminology used in [IEEE 1588])

PRC Primary Reference Clock

PRS Primary Reference Source

PRTC Primary Reference Time Clock

PTP Precision Time Protocol

QL Quality Level

SSU Synchronization Supply Unit

SSU-A primary level SSU

SSU-B secondary level SSU

SDH Synchronous Digital Hierarchy

SSM Synchronization Status Message

ST2 Stratum 2

ST3E Stratum 3 Enhanced

T-BC Telecom Boundary Clock

T-GM Telecom Grandmaster

T-TC Telecom Transparent Clock

T-TSC Telecom Time Slave Clock

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 Boundary Clock (T-BC) refers to a device consisting of a Boundary Clock as defined in [IEEE 1588] and this Recommendation, with additional performance characteristics defined in [ITU-T G.8273.2].

The term Telecom Transparent Clock (T-TC) refers to a device consisting of a Transparent Clock as defined in [IEEE 1588], with additional performance characteristics for further study.

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

The term Telecom Time Slave Clock (T-TSC) refers to a device consisting of a PTP Slave-only Ordinary Clock as defined in [IEEE 1588] and this Recommendation, with additional performance characteristics defined in the Annex C of [ITU-T G.8273.2].

6 Use of PTP for phase/time distribution

The first version of the IEEE 1588 standard has been developed by the IEEE initially to support the timing requirements of industrial automation, and defines the precision time protocol (PTP) designed to enable accurate time transfer in this context.

The second 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 has been defined by ITU-T in [ITU-T G.8265.1] to address applications requiring frequency synchronization only. This Recommendation defines another PTP profile, for telecom applications requiring accurate phase and time synchronization. It supports the specific architecture described in [ITU-T G.8275] in order to allow the distribution of phase/time with full timing support from the network, and is based on the second version of PTP defined in [IEEE 1588].

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 parameters from [IEEE 1588] 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 defined in other ITU-T Recommendations, and imply additional elements beyond the content of the PTP profile itself.

6.1 High-Level Design Requirements

[IEEE 1588] states in subclause 19.3.1.1:

"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 Telecom Time Slave Clocks (T-TSC) the ability to take phase and time from multiple geographically separate Telecom Grandmaster (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 entity. 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 24, and the range of applicable PTP domain numbers is {24 - 43}.

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 behavior.

6.2.2 PTP messages used in the profile

This PTP profile uses the messages: *Sync*, *Follow_Up*, *Announce*, *Delay_Req*, and *Delay_Resp*.

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

Pdelay_Req, *Pdelay_Resp*, and *Pdelay_Resp_Follow_Up* messages are not used.

6.2.3 Types of PTP clocks supported in the profile

The Ordinary Clock (OC) and Boundary Clock (BC) according to [IEEE 1588] are used in this profile.

There are two types of OCs:

- 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])
- OC that can only be a slave, i.e. Slave-only OC (T-TSC according to the architecture defined in [ITU-T G.8275], and compliant with Annex C of [ITU-T G.8273.2]).

There are two types of BCs:

- 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])
- BC that can become a grandmaster and can also be slaved to another PTP clock (T-BC according to architecture defined in [ITU-T G.8275], and compliant with [ITU-T G.8273.2])

NOTE – T-GM and grandmaster are different notions; grandmaster (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 G.8275 and PTP clock types

Clock Type from [ITU-T G.8275]	Description	Clock Type from [IEEE 1588]
T-GM	Master-only Ordinary Clock (master with a single PTP port, always a GM, cannot be slaved to another PTP clock)	OC
	Master-only Boundary Clock (master with multiple PTP ports, always a GM, cannot be slaved to another PTP clock)	BC
T-BC	Boundary Clock (may become a GM, or may be slaved to another PTP clock)	BC
T-TSC	Slave-only Ordinary Clock (always a slave, cannot become a GM)	OC

6.2.4 One-way versus two-way operation

PTP operation must be two-way in this profile in order to transport phase/time synchronization, because propagation delay must be measured. Therefore, only two-way mode is allowed in this profile.

6.2.5 One-step versus two-step clock mode

Both one-step and two-step clocks are supported in the profile. A clock compliant with the profile may use either a one-step clock or a two-step clock.

To be compliant with [IEEE 1588], a slave port must be capable of receiving and processing messages from both one-step clocks and two-step clocks, without any particular configuration.

6.2.6 Ethernet multicast addressing for PTP messages

This PTP telecom profile uses Ethernet multicast addressing for the transmission of all PTP messages.

For the PTP profile specified in this Recommendation, when using the PTP mapping defined in [IEEE 1588] Annex F, both the non-forwardable multicast address 01-80-C2-00-00-0E and forwardable multicast address 01-1B-19-00-00-00 are supported.

An equipment compliant with this profile must be capable to handle both the non-forwardable multicast address 01-80-C2-00-00-0E and the forwardable multicast address 01-1B-19-00-00-00 on all its PTP capable ports. The choice of the multicast address is done by configuration on a per-port basis; all the PTP messages of a port must use the configured address for transmitting PTP messages to the remote PTP port. In case the remote PTP port is configured with the other address, the local PTP port must accept and process the received messages.

The default address depends on the operator policy. See information in Appendix III.

6.2.7 PTP mapping

This PTP telecom profile is based on the PTP mapping defined in [IEEE 1588] Annex F, *Transport of PTP over IEEE 802.3/Ethernet*.

Therefore, a PTP clock compliant with the profile described in this Recommendation must be compliant with [IEEE 1588] Annex F.

The transportSpecific field is used in this profile and must be set to “0”.

In the scenarios currently considered, e.g. based on full timing support with T-BC only, the insertion of a VLAN tag in the frames carrying PTP messages is not allowed. In this profile, when receiving a PTP message within a frame containing a VLAN tag, this frame must be discarded.

Using VLAN tags in other scenarios is for further study.

6.2.8 Message rates

Within the scope of the profile, the following messages can be used and the corresponding indicated nominal rates must be respected:

- *Sync* messages (if used, *Follow_up* messages will have the same rate) - nominal rate: 16 packets-per-second
- *Delay_Req*/*Delay_Resp* messages - nominal rate: 16 packets-per-second
- *Announce* messages - nominal rate: 8 packets-per-second

The requirements of subclause 7.7.2.1 of [IEEE 1588] must also be respected for the transmission of *Sync* and *Announce* messages. In addition, the time between successive *Sync* messages must not exceed twice the mean *Sync* interval specified above, and the time between successive *Announce* messages must not exceed twice the mean *Announce* interval specified above.

The transmission of *Delay_Req* messages is specified in subclause 9.5.11.2 of [IEEE 1588].

In addition to sub-bullet 1 and sub-bullet 2 of subclause 9.5.11.2, a clock compliant to this profile must follow one of the following options:

- Transmission time requirements according to sub-bullet 3 of [IEEE 1588] subclause 9.5.11.2, using an implementation-specific distribution. In this case, the PTP node must, with 90% confidence, issue *Delay_Req* messages with inter-message intervals within ±30% of $2^{logMinDelayReqInterval}$ seconds.
- Transmission time requirements specified in sub-bullet 4 of [IEEE 1588] subclause 9.5.11.2.

In addition, the time between successive *Delay_Req* messages must not exceed $2^{logMinDelayReqInterval+1}$ seconds.

Additional background information concerning the *Delay_Req* message transmission specified in subclause 9.5.11.2 of [IEEE 1588] is included in Appendix II.

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

6.3 Protection aspects and Alternate BMCA

6.3.1 Alternate BMCA

The PTP profile specified in this Recommendation uses an Alternate BMCA, as described in subclause 9.3.1 of [IEEE 1588]. This Alternate BMCA differs from the default BMCA of [IEEE 1588] in the following:

a) The Alternate BMCA considers the per-port Boolean attribute notSlave. If notSlave is TRUE, the port is never placed in the SLAVE state, and will always go to the MASTER state. If notSlave is FALSE, the port can be placed in the SLAVE state. The notSlave attribute is set via the configurable port dataset member portDS.notSlave.

   The default value and range of values for this attribute, for the ports of a BC or OC that can only be a GM (i.e. T-GM), are TRUE and {TRUE}.

   The default value and range of values for this attribute, for the port of a slave-only OC (i.e. T-TSC) are FALSE and {FALSE}.

   The default value and range of values for this attribute, for the ports of a BC that may or may not be a GM (i.e. T-BC) are TRUE and {TRUE, FALSE}.

b) The Alternate BMCA allows for multiple clocks to be active grandmasters simultaneously (clocks with clockClass less than 128 cannot be a slave). If there are multiple active grandmasters, every clock that is not a grandmaster is synchronized by a single grandmaster in the PTP domain.

c) The per-port attribute localPriority is assigned to each port r of a clock and is used in the determination of E_{rbest} and E_{best}. Each parent clock or foreign master clock dataset, whose *Announce* information was received on the port r, is appended with the localPriority attribute of the local port r before the dataset comparison defined in Figure 2 and Figure 3 is invoked. The localPriority attribute is not transmitted in *Announce* messages. This attribute is used as a tie-breaker in the dataset comparison algorithm, in the event that all other previous attributes of the datasets being compared are equal. The localPriority attribute is set via the configurable, unsigned integer, port dataset member portDS.localPriority. The data type for this attribute is UInteger8. The range of values for this attribute is {1 - 255}. The default value for this attribute is 128. A clock compliant with this PTP profile is allowed to support a subset of the values defined in the range.

d) The attribute localPriority is assigned to the local clock, to be used if needed when the data associated with the local clock, D_0, is compared with data on another potential grandmaster received via an *Announce* message. The local clock localPriority attribute is set via the configurable, unsigned integer, default dataset member defaultDS.localPriority. The data type for this attribute is UInteger8. The range of values for this attribute is {1 - 255}. The default value for this attribute is 128. A clock compliant with this PTP profile is allowed to support a subset of the values defined in the range.

NOTE 1 – Because the value of the notSlave attribute is, per definition, always TRUE on all PTP ports of a T-GM, the localPriority attribute is, in practice, not used for a T-GM.

NOTE 2 – For a T-GM, the Alternate BMCA output is in practice static and provides a recommended state = BMC_MASTER, because the notSlave attribute = TRUE for all the PTP ports of a T-GM. The resulting decision code can be M1 or M2, depending on the status of the T-GM (locked or in holdover).

6.3.2 Considerations on the use of the localPriority attributes

The localPriority attributes provide a powerful tool in defining the synchronization network architecture.

The use of the default values for these attributes as defined by the Alternate BMCA results in a timing-loop free synchronization network.

Proper planning will be mandatory to avoid timing-loops when configuring values different from the default ones.

6.3.3 Static clock attribute priority1

In this PTP profile, the clock attribute priority1 is static. It is initialized to a default value equal to the midpoint value, 128, of its range, and this value must not be changed.

The priority1 parameter is not used in this version of the PTP telecom profile. Future versions may consider using this attribute, this is for further study.

6.3.4 Clock attribute priority2

In this PTP profile, the clock attribute priority2 is configurable.

It is initialized to a default value, equal for T-GM and T-BC clocks to the midpoint value, 128, of its range {0 - 255}. The default value for T-TSC clocks is 255, and the range is {255}.

A T-GM or T-BC clock compliant with this PTP profile must support all the values of priority2 defined in the range.

Appendix IV describes possible use cases for the priority2 attribute; other cases are for further study.

6.3.5 Other clock attributes

In this PTP profile, the clock attributes clockAccuracy and offsetScaledLogVariance must use the following values. The use of other values for these clock attributes is forbidden in this PTP profile.

defaultDS.clockQuality.clockAccuracy:

- 0x21 for a T-GM connected to a PRTC in locked-mode (i.e. PRTC traceable to GNSS)
- 0xFE for a T-GM not connected to a PRTC in locked-mode
- 0xFE for a T-BC, all the time

defaultDS.clockQuality.offsetScaledLogVariance:

- 0x4E5D for a T-GM connected to a PRTC in locked-mode (i.e. PRTC traceable to GNSS)
- 0xFFFF for a T-GM not connected to a PRTC in locked-mode
- 0xFFFF for a T-BC, all the time

6.3.6 State decision algorithm

The state decision algorithm applicable to the Alternate BMCA of the PTP profile specified in this Recommendation is given in Figure 1, clause 6.3.7. After a decision is reached by use of this algorithm, the data sets of the local clock are updated as specified in subclause 9.3.5 of [IEEE 1588]. Details on the use of the algorithm are given in subclause 9.3.3 of [IEEE 1588].

6.3.7 Dataset comparison algorithm

The dataset comparison algorithm for the Alternate BMCA of the PTP profile specified in this Recommendation is given in Figures 2 and 3 below. With this algorithm, one clock is compared with another using the datasets representing those clocks, appended with the localPriority attribute. Details on the use of the algorithm are given in subclause 9.3.4 of [IEEE 1588].

If either of the datasets A or B in Figures 2 and 3 contain the data of the parent clock or a foreign master clock, the corresponding localPriority for its dataset is the localPriority of the local port r on which the information from that parent clock or foreign master clock has been received (see item (c) of clause 6.3.1 of this Recommendation).

If either of the datasets A or B in Figures 2 and 3 contain the data of the local clock, D_0, the corresponding localPriority for that dataset is the localPriority of the local clock (see item (d) of clause 6.3.1 of this Recommendation).

NOTE – It is recommended that the entire dataset comparison algorithm described in Figures 2 and 3 be implemented even if some parameters are currently static, because they may be used in future versions of this Recommendation.

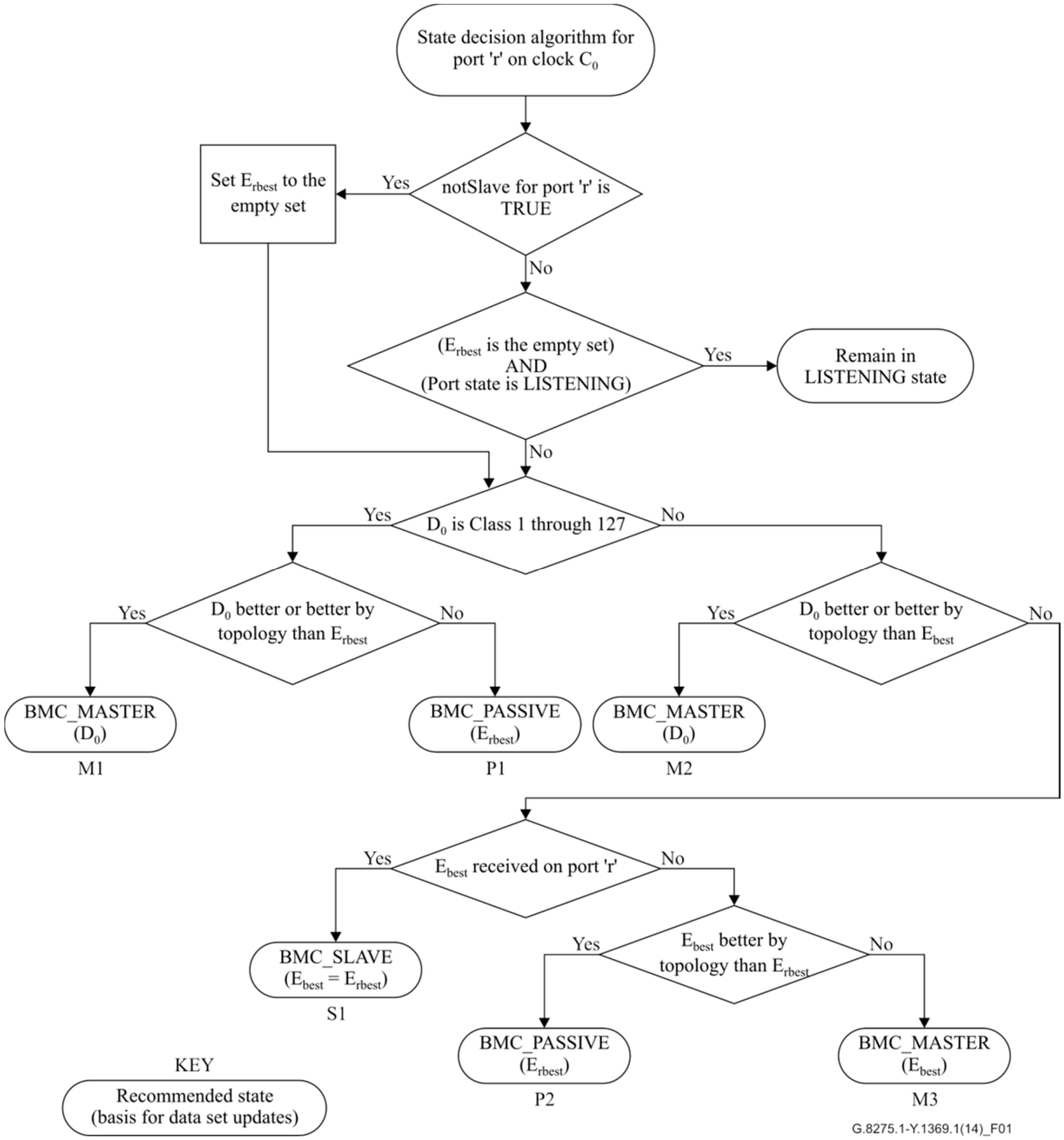

Figure 1 – State decision algorithm for Alternate BMCA

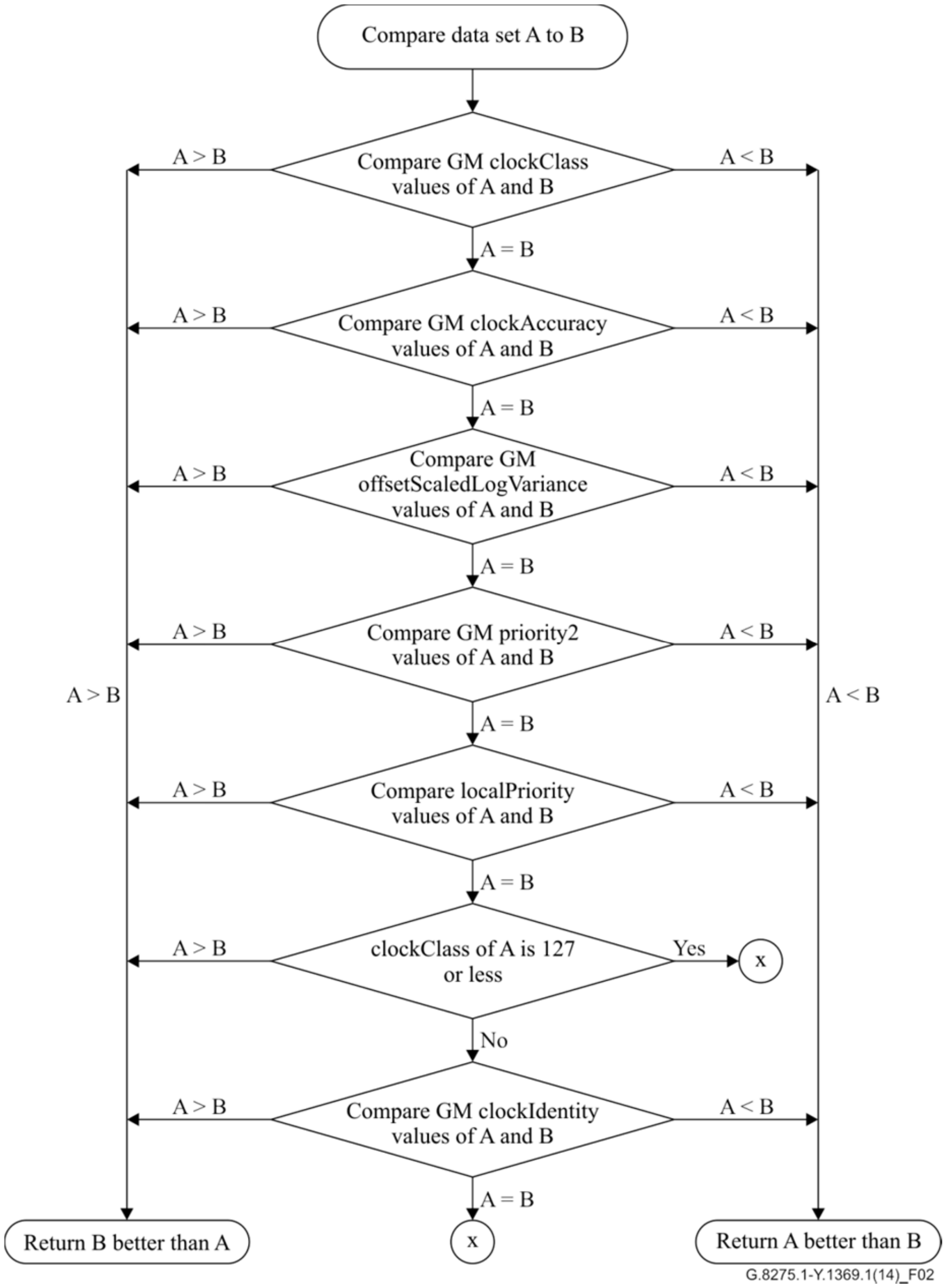

Figure 2 – Dataset comparison algorithm, part 1, for Alternate BMCA

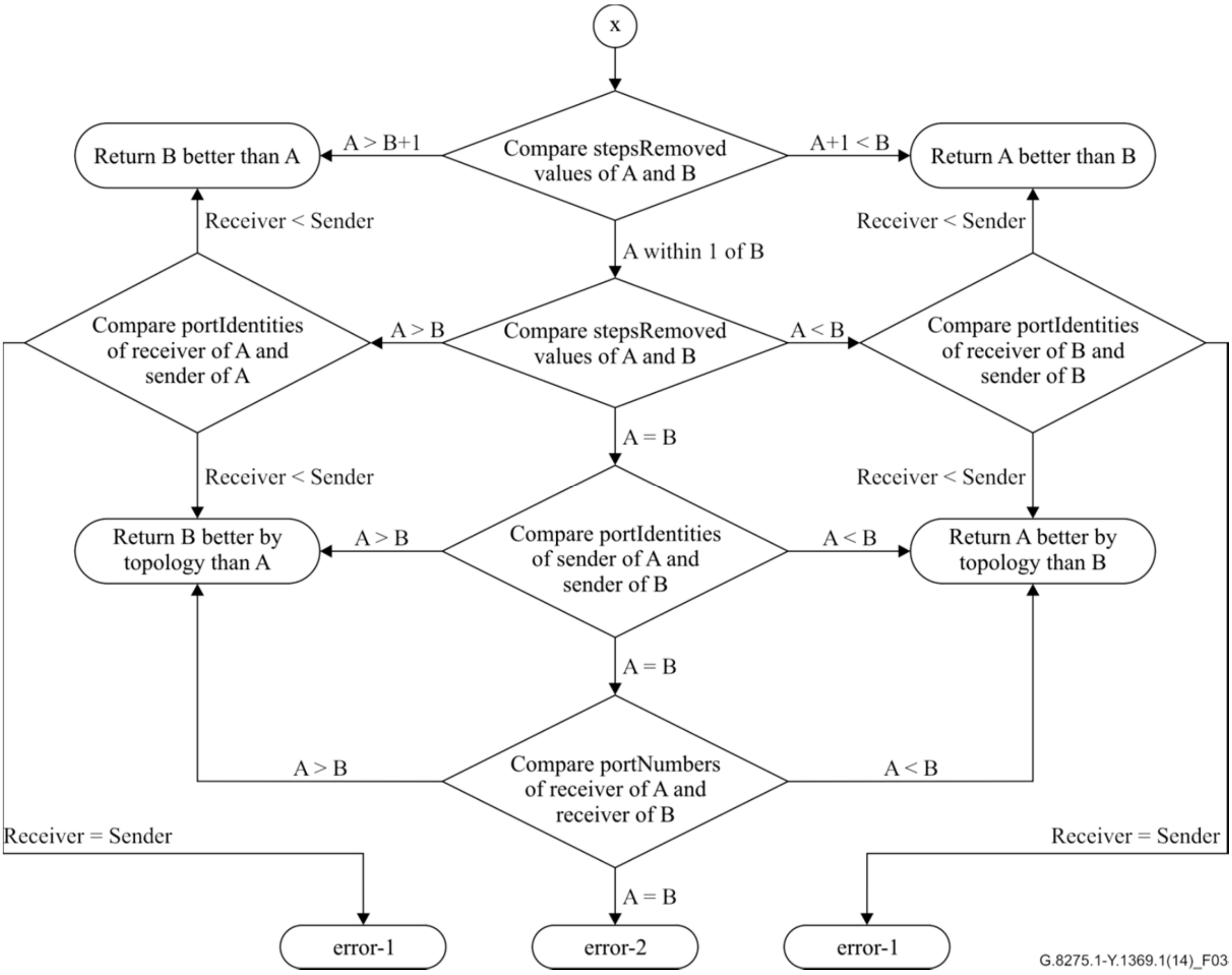

Figure 3 – Dataset comparison algorithm, part 2, for Alternate BMCA

6.3.8 Unused PTP fields

Some PTP fields are not used in this PTP profile. This clause defines the actions applicable to these unused PTP fields.

Table A.6 in clause A.10 of this Recommendation defines the PTP common header flag values, and whether or not each flag is used in this profile.

In addition, the following fields are not used in this profile:

- the “controlField” in the common header of PTP messages is not used in this profile. This field must be ignored by the receiver for all types of PTP messages.
- the “priority1” field in the *Announce* message is not used, and must be set to a fixed value specified in clause 6.3.3.

When a PTP clock receives a PTP message with a field, whose use is not specified in this PTP profile, containing a value outside the allowed range, then this field of the PTP message must be ignored, without discarding the PTP message.

As an example, a PTP clock compliant with this PTP profile must ignore on reception the field value for the following fields. A clock compliant with this PTP profile must not update its local data sets with the ingress value for these fields.

- flagField - alternateMasterFlag
- flagField - unicastFlag
- flagField - PTP profile Specific 1
- flagField - PTP profile Specific 2

When a PTP clock receives a PTP message with a field, whose use is specified in this PTP profile, containing a value outside the allowed range, then this entire PTP message must be discarded.

As an example, a compliant clock must discard on reception the ingress packet (General & Event messages) when any of the following fields are outside of the allowed range for the profile. The clocks local data set must not be updated with the ingress value.

- grandmasterClockQuality - clockClass
- grandmasterClockQuality - clockAccuracy
- domainNumber
- versionPTP

NOTE – If a clock receives an *Announce* message with the “priority1” field different than 128, and that the clock advertising this value is selected as the GM, then 128 must be re-advertised by the clock. The unused attribute priority1 is ignored by the receiving clock for the purpose of the Alternate BMCA.

6.4 Phase/time traceability information

In order to deliver phase/time traceability information, the clockClass values described in Table 2 below must be used in this PTP telecom profile. Additional information for interworking purposes is provided in Table 4.

The frequencyTraceable flag present in the header of the PTP messages is defined in this profile as follows: if the PTP clock is traceable to a PRTC in locked mode or to a PRC (e.g. using a PRC-traceable physical layer frequency input), then this parameter must be set to TRUE, otherwise it must be FALSE. This flag is not used in the Alternate BMCA defined in clause 6.3; the values provided for this flag in Table 2 are for information only, for usage by the network operator (e.g. as monitoring indication).

When a T-GM first enters holdover, it downgrades the clockClass value that it uses to 7. It then calculates if the time error at its output is still within the holdover specification. When the T-GM determines that the time error at its output has exceeded the holdover specification, it downgrades the clockClass value that it uses to 140, 150 or 160 depending on the quality of its frequency reference (internal oscillator or received physical layer frequency signal on an external interface).

When a T-BC first enters holdover, it downgrades the clockClass value that it uses to 135. It then calculates if the time error at its output is still within the holdover specification. When the T-BC determines that the time error at its output has exceeded the holdover specification, it downgrades the clockClass value that it uses to 165 (internal oscillator or received physical layer frequency signal on an external interface).

NOTE – The applicable holdover specification depends on the design and budgeting of the synchronization network. See Appendix V of [ITU-T G.8271.1] for examples of network budgeting.

Table 2– Applicable clockClass values

Phase/time traceability description	defaultDS clockClass	frequencyTraceable flag
T-GM connected to a PRTC in locked mode (e.g. PRTC traceable to GNSS)	6	TRUE
T-GM in holdover, within holdover specification, traceable to Category 1 frequency source (Note 1)	7	TRUE
T-GM in holdover, within holdover specification, non-traceable to Category 1 frequency source (Note 1)	7	FALSE
T-BC in holdover, within holdover specification, traceable to Category 1 frequency source (Note 1)	135	TRUE
T-BC in holdover, within holdover specification, non-traceable to Category 1 frequency source (Note 1)	135	FALSE
T-GM in holdover, out of holdover specification, traceable to Category 1 frequency source (Note 1)	140	TRUE
T-GM in holdover, out of holdover specification, traceable to Category 2 frequency source (Note 1)	150	FALSE
T-GM in holdover, out of holdover specification, traceable to Category 3 frequency source (Note 1)	160	FALSE
T-BC in holdover, out of holdover specification (Note 1)	165	Note 2
T-GM or T-BC without time reference since start-up	248	Note 2
Slave only OC (does not send *Announce* messages)	255	Note 2
NOTE 1 – The holdover specification threshold controlling the time spent advertising clockClass values 7 or 135 could be set to zero so that the T-GM or T-BC would advertise a degraded clockClass value directly after losing traceability to a PRTC. In this case, initially after advertising clockClass values 140, 150, 160, or 165, a clock may still be within the holdover specification. NOTE 2 – The frequencyTraceable flag may be TRUE or FALSE, depending on the availability of a PRC-traceable physical layer frequency input signal.		

Table 3 describes how the clock Quality Levels defined in [ITU-T G.781] are mapped to Category 1, 2, and 3 frequency sources used in Table 2.

Table 3 – Mapping of G.781 clock Quality Levels to Category 1, 2, 3 frequency sources

Category (in Table 2)	G.781 Option I Quality Levels	G.781 Option II Quality Levels
Category 1 frequency source	QL-PRC	QL-PRS
Category 2 frequency source	QL-SSU-A	QL-ST2
Category 3 frequency source	QL-SSU-B	QL-ST3E

NOTE – The case of a T-BC acting as a GM, with an external phase/time input coming from a PRTC, is handled by means of a virtual PTP port with associated E_{rbest} attributes as described in Annex C. The general case of T-BC with a phase/time external synchronization input different from PRTC is for further study.

Table 4 presents a subset of the clockClass values of Table 2 based on the quality of the frequency reference, and the mapping of the corresponding values used by some equipment deployed prior to this Recommendation.

NOTE – When interoperability with equipment deployed prior to this Recommendation is needed, both sets of clockClass values would need to be supported. Other aspects may be required for full interoperability.

Table 4 – clockClass values for equipment deployed prior to this Recommendation

Phase/time traceability description	Values defined in Table 2	Values prior to this Rec.
T-GM connected to a PRTC in locked mode (e.g. PRTC traceable to GNSS)	6	6
T-GM in holdover, out of holdover specification, traceable to Category 1 frequency source (Note 1)	140	7
T-GM in holdover, out of holdover specification, traceable to Category 2 frequency source (Note 1)	150	Note 2
T-GM in holdover, out of holdover specification, traceable to Category 3 frequency source (Note 1)	160	52
T-BC in holdover, out of holdover specification,	165	187

using unspecified frequency source (Note 1)		
Slave only OC (does not send *Announce* messages)	255	255
NOTE 1 – Initially after advertising clockClass values greater than 6, a clock may still be within the holdover specification. NOTE 2 – Refer to the applicable value specified for the equipment.		

7 ITU-T PTP profile for phase/time distribution with full timing support from the network

The PTP profile for phase/time distribution with full timing support from the network is contained in Annex A.

8 Security aspects

For further study.

Annex A

ITU-T PTP profile for phase/time distribution with full timing support from the network

(This annex forms an integral part of this Recommendation.)

This Annex contains the PTP telecom profile for phase/time distribution with full timing support from the network, as required by [IEEE 1588]. In order to claim compliance with this PTP telecom profile, the requirements in this Annex and in the body of this Recommendation must both be met.

A.1 Profile identification

profileName: ITU-T PTP profile for phase/time distribution with full timing support from the network

profileVersion: 1.0

profileIdentifier: 00-19-A7-01-01-00

This profile is specified by the ITU-T

A copy may be obtained from www.itu.int

A.2 PTP attribute values

The default values and ranges of the PTP attributes for use in this profile are contained in Tables A.1, A.2, A.3, A.4 and A.5.

Attributes not specified by this profile must use the default initialization values and ranges defined in [IEEE 1588].

These tables provide a default initialization value and range for each dataset member for:

- Telecom Grandmaster: Ordinary Clock or Boundary Clock that can only act as a GM (T-GM according to [ITU-T G.8275] – first PTP clock of the chain)
- Telecom Time Slave Clock: Ordinary Clock with a clockClass = 255 (T-TSC according to [ITU-T G.8275] – last PTP clock of the chain)
- Telecom Boundary Clock: Boundary Clock that may or may not be a GM; such a clock will be a GM if it is the best clock in the network (T-BC according to [ITU-T G.8275] – intermediate PTP clocks of the chain)

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, clause 6.2.3.

Table A.1 – defaultDS data set member specifications

Subclause from [IEEE 1588]	Members of the data set	Telecom Grandmaster requirements		Telecom Time Slave Clock requirements		Telecom Boundary Clock requirements	
		Default initialization value	**Range**	**Default initialization value**	**Range**	**Default initialization value**	**Range**
8.2.1.2.1	defaultDS.twoStepFlag (static)	As per PTP	{FALSE, TRUE}	As per PTP	{FALSE }	As per PTP	{FALSE, TRUE}
8.2.1.2.2	defaultDS.clockIdentity (static)	As per PTP, based on EUI-64 format	As per PTP	As per PTP, based on EUI-64 format	As per PTP	As per PTP, based on EUI-64 format	As per PTP
8.2.1.2.3	defaultDS.numberPorts (static)	1 for OC As per PTP for BC	{1} for OC As per PTP for BC	1	{1}	As per PTP	As per PTP
8.2.1.3.1.1	defaultDS.clockQuality. clockClass (dynamic)	248	{6, 7, 140, 150, 160, 248}	255	{255}	248	{135, 165, 248}
8.2.1.3.1.2	defaultDS.clockQuality. ClockAccuracy (dynamic)	0xFE	{0x21, 0xFE}	0xFE	{0xFE}	0xFE	{0xFE}
8.2.1.3.1.3	defaultDS.clockQuality. offsetScaledLogVariance (dynamic)	0xFFFF	{0x4E5D, 0xFFFF}	0xFFFF	{0xFFFF }	0xFFFF	{0xFFFF}
8.2.1.4.1	defaultDS.priority1 (configurable)	128	{128}	128	{128}	128	{128}
8.2.1.4.2	defaultDS.priority2 (configurable)	128	{0-255}	255	{255}	128	{0-255}
8.2.1.4.3	defaultDS.domainNumber (configurable)	24	{24-43}	24	{24-43}	24	{24-43}
8.2.1.4.4	defaultDS.slaveOnly (configurable)	FALSE	{FALSE}	TRUE	{TRUE}	FALSE	{FALSE}
New member	defaultDS.localPriority (configurable)	128	{1-255}	128	{1-255}	128	{1-255}

Table A.2 – currentDS data set member specifications

Subclause from [IEEE 1588]	Members of the data set	Telecom Grandmaster requirements		Telecom Time Slave Clock requirements		Telecom Boundary Clock requirements	
		Default initialization value	Range	Default initialization value	Range	Default initialization value	Range
8.2.2.2	currentDS.stepsRemoved (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.2.3	currentDS.offsetFromMaster (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.2.4	currentDS.meanPathDelay (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP

Table A.3 – parentDS data set member specifications

Subclause from [IEEE 1588]	Members of the data set	Telecom Grandmaster requirements		Telecom Time Slave Clock requirements		Telecom Boundary Clock requirements	
		Default initialization value	Range	Default initialization value	Range	Default initialization value	Range
8.2.3.2	parentDS.parentPortIdentity (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.3.3	parentDS.parentStats (dynamic)	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
8.2.3.4	parentDS.observedParentOffsetScaledLogVariance (dynamic)	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
8.2.3.5	parentDS.observedParentClockPhaseChangeRate (dynamic)	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
8.2.3.6	parentDS.grandmasterIdentity (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.3.7	parentDS.grandmasterClockQuality (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.3.8	parentDS.grandmasterPriority1 (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.3.9	parentDS.grandmasterPriority2 (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
NOTE 1 – As per PTP, not applicable for this profile							

Table A.4 – timePropertiesDS data set member specifications

Subclause from [IEEE 1588]	Members of the data set	Telecom Grandmaster requirements		Telecom Time Slave Clock requirements		Telecom Boundary Clock requirements	
		Default initialization value	Range	Default initialization value	Range	Default initialization value	Range
8.2.4.2	timePropertiesDS.currentUtcOffset (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.4.3	timePropertiesDS.currentUtcOffsetValid (dynamic)	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}
8.2.4.4	timePropertiesDS.leap59 (dynamic)	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}
8.2.4.5	timePropertiesDS.leap61 (dynamic)	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}
8.2.4.6	timePropertiesDS.timeTraceable (dynamic)	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}	FALSE	{FALSE, TRUE}
8.2.4.7	timePropertiesDS.frequencyTraceable (dynamic)	FALSE	{FALSE, TRUE} Note 1	FALSE	{FALSE, TRUE} Note 1	FALSE	{FALSE, TRUE} Note 1
8.2.4.8	timePropertiesDS.ptpTimescale (dynamic)	TRUE	{TRUE}	TRUE	{TRUE}	TRUE	{TRUE}
8.2.4.9	timePropertiesDS.timeSource (dynamic)	0xA0	As per PTP	0xA0	As per PTP	0xA0	As per PTP
Note 1 – If the clock is traceable to a PRTC in locked mode or a PRC (e.g. using a PRC-traceable physical layer frequency input), then this parameter must be set to TRUE, otherwise it must be FALSE.							

Table A.5 – portDS data set member specifications

Subclause from [IEEE 1588]	Members of the data set	Master port requirements of Telecom Grandmaster		Slave port requirements of Telecom Time Slave Clock		Telecom Boundary Clock requirements	
		Default initialization value	**Range**	**Default initialization value**	**Range**	**Default initialization value**	**Range**
8.2.5.2.1	portDS.portIdentity.clockIdentity (static)	As per PTP, based on EUI-64 format	As per PTP	As per PTP, based on EUI-64 format	As per PTP	As per PTP, based on EUI-64 format	As per PTP
8.2.5.2.1	portDS.portIdentity.portNumber (static)	1 for OC As per PTP for BC	{1} for OC As per PTP for BC	1	{1}	As per PTP	As per PTP
8.2.5.3.1	portDS.portState (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP	As per PTP
8.2.5.3.2	portDS.logMinDelayReqInterval (dynamic)	-4	{-4}	-4	{-4}	-4	{-4}
8.2.5.3.3	portDS.peerMeanPathDelay (dynamic)	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
8.2.5.4.1	portDS.logAnnounceInterval (configurable)	-3	{-3}	-3 Note 2	{-3} Note 2	-3	{-3}
8.2.5.4.2	portDS.announceReceiptTimeout (configurable)	3	{3 - z} z is FFS	3	{3 - z} z is FFS	3	{3 - z} z is FFS
8.2.5.4.3	portDS.logSyncInterval (configurable)	-4	{-4}	-4 Note 2	{-4} Note 2	-4	{-4}
8.2.5.4.4	portDS.delayMechanism (configurable)	01	{01}	01	{01}	01	{01}
8.2.5.4.5	portDS.logMinPdelayReqInterval (configurable)	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
8.2.5.4.6	portDS.versionNumber (configurable)	2	{2}	2	{2}	2	{2}
New member	portDS.notSlave (configurable)	TRUE	{TRUE}	FALSE	{FALSE}	TRUE	{TRUE, FALSE}
New member	portDS.localPriority (configurable)	128	{1-255}	128	{1-255}	128	{1-255}

NOTE 1 – As per PTP, not applicable for this profile

NOTE 2 – This type of message is not sent by a Slave-only Ordinary Clock

A.3 PTP options

A.3.1 Node types required, permitted, or prohibited

In this profile, the required node types are: ordinary clocks and boundary clocks.

In this version of the profile, the prohibited node types are: transparent clocks.

A.3.2 One-step versus two-step clock mode

Both one-step and two-step clocks are permitted. A clock must be capable of receiving and handling messages transmitted from both one-step and two-step clocks. A clock is not required to support both one-step and two-step mode for transmitting messages.

A.3.3 Transport mechanisms required, permitted, or prohibited

In this profile, the required transport mechanism is IEEE 802.3/Ethernet, as per Annex F of [IEEE 1588]. Both the non-forwardable multicast address, 01-80-C2-00-00-0E, and the forwardable multicast address, 01-1B-19-00-00-00, are required to be supported for compliance with this profile.

All other transport mechanisms are for further study within the scope of this profile.

A.3.4 Unicast messages

All messages are sent multicast, using one of the two multicast addresses in clause A.3.3. The unicast mode is not permitted in this version of the profile.

A.4 Best master clock algorithm (BMCA) options

This profile uses the Alternate BMCA described in clause 6.3 of this Recommendation.

A.5 Path delay measurement option (delay request/delay response)

The delay request/delay response mechanism is used in this profile. The peer delay mechanism must not be used in this profile.

A.6 Clock identity format

The use of IEEE EUI-64 to generate the clock identity must be supported as indicated in subclause 7.5.2.2.2 of [IEEE 1588]. Non-IEEE clockIdentity formats are not supported.

A.7 Configuration management options

Management aspects are for further study, and will be specified in a future version of this profile.

A.8 Security aspects

Security aspects are for further study. The experimental security protocol of Annex K of [IEEE 1588] is not used.

A.9 Other optional features of IEEE Std 1588™-2008

Other optional features of [IEEE 1588] are not used in this version of the profile. These include unicast message negotiation (16.1 of [IEEE 1588]), path trace (16.2), alternate timescales (16.3), grandmaster clusters (17.3), alternate master (17.4), unicast discovery (17.5), acceptable master table (17.6), and the experimental cumulative frequency scale factor offset (Annex L).

A.10 PTP common header flags

The PTP common header flag values, and whether or not each flag is used in this profile, are given in Table A.6.

NOTE – Some of these flags are used only in certain PTP messages, and not in all the PTP messages, see [IEEE 1588], subclause 13.3.2.6. The following rule defined in [IEEE 1588], subclause 13.3.2.6, must be respected: “For message types where the bit is not defined in Table 20, the values shall be FALSE.”

Table A.6 – PTP flags

Flag	Value to be sent	Behaviour for the receiving node
alternateMasterFlag	FALSE	Flag is ignored
twoStepFlag	As per PTP	Used
unicastFlag	FALSE	Flag is ignored
PTP profile Specific1	FALSE	Flag is ignored
PTP profile Specific2	FALSE	Flag is ignored
Reserved	FALSE	Reserved by PTP and flag is ignored
leap61	As per PTP	Used
leap59	As per PTP	Used
currentUtcOffsetValid	As per PTP	Used
ptpTimescale	TRUE	Used
timeTraceable	As per PTP	Used
frequencyTraceable	As per PTP	Used

Annex B

Options to establish the PTP topology with the Alternate BMCA

(This annex forms an integral part of this Recommendation.)

This PTP telecom profile defines an Alternate BMCA that allows using two main approaches to set up the topology of the phase/time synchronization network:

- Automatic topology establishment: when configuring the localPriority attributes defined in this Recommendation to their default value, the PTP topology is established automatically by the Alternate BMCA based on the *Announce* messages exchanged by the PTP clocks. A synchronization tree with shortest paths to the T-GMs is built after this operation. In this mode, during failure events and topology reconfiguration, the Alternate BMCA will be run again and result in a new synchronization tree. This Alternate BMCA operation ensures that no timing loop will be created without requiring manual intervention or prior analysis of the network. The convergence time to the new PTP topology depends on the size of the network, and on the specific configuration of the PTP parameters.
- Manual network planning: the use of the localPriority attributes defined in this Recommendation with different values than their default value allows building manually the synchronization network topology, in a similar way as SDH networks are typically operated based on the SSM. This option allows a full control on the actions during failure events and topology reconfiguration, based on the configured local priorities of the system. However, careful network planning is required prior to the deployment in order to avoid timing loops.

Annex C

Inclusion of an external phase/time input interface in a T-BC

(This annex forms an integral part of this Recommendation.)

This Annex describes the model for inclusion of an external phase/time input interface in a T-BC, so that this external port can participate in the source selection. The high-level principles are introduced in this Annex.

A virtual PTP port and a virtual E_{rbest} is associated to the external phase/time input (e.g. coming from a PRTC) of the T-BC, in order to allow this external interface to participate to the PTP protocol.

The following attributes are associated to the virtual PTP port:

- clockClass
- clockAccuracy
- offsetScaledLogVariance
- localPriority

stepsRemoved attribute must be set to zero in the case a PRTC is connected to the external phase/time interface.

The grandmasterIdentity assigned to the virtual PTP port is the clockIdentity of the T-BC itself. The portNumber assigned to the virtual PTP port is set to a value different from the portNumber values already assigned to the T-BC PTP ports.

The values assigned to the virtual PTP port for other parameters used in the dataset comparison algorithm are for further study.

NOTE – The general case of T-BC with a phase/time external synchronization input different from PRTC is for further study.

NOTE – If the external phase/time interface contains a Time-of-Day data channel for transmitting time and associated information, this information should be considered in deriving the values of the relevant PTP attributes of the virtual PTP port. The details of the time information to be transmitted are for further study. Initial descriptions can be found in Appendix III of [ITU-T G.8272].

Appendix I

Considerations on the use of Transparent Clock

(This appendix does not form an integral part of this Recommendation.)

The first version of this profile is based on a chain of Boundary Clocks defined in [IEEE 1588]. The integration of the Transparent Clock in this profile may be considered for future versions of this document. In particular, it is under consideration for applications such as 2-port type of devices, e.g. demarcation devices or microwave equipment.

NOTE – The mapping and addressing as defined in clauses 6.2.7 and 6.2.6 of this Recommendation would need to be considered in order to integrate Transparent Clock functionality in a chain of Boundary Clocks based on this profile.

Architectural and performance aspects need to be studied.

Appendix II

Considerations on the transmission of Delay_Req messages

(This appendix does not form an integral part of this Recommendation.)

This Appendix discusses the requirements defined in [IEEE 1588] for the transmission of *Delay_Req* messages when using the default uniform distribution defined in sub-bullet 3 of subclause 9.5.11.2 of [IEEE 1588]. Note that this uniform distribution is not used in the PTP telecom profile defined in this Recommendation; a profile-specific distribution has been defined in clause 6.2.8.

The second dashed item of the requirements defined in subclause 9.5.11.2 of [IEEE 1588] controls the variability of the times between successive *Delay_Req* messages. It is analogous to the corresponding requirement for the sending of *Sync* and *Announce* messages, given in subclause 7.7.2.1 of [IEEE 1588]. However, a key difference is that, while the requirement for *Sync* messages applies to the population of inter-message intervals, the requirement for *Delay_Req* messages applies only to the mean of the population.

To be more precise, assume that a population of N inter-message intervals has been measured, and let T_j be the measured values, $j = 1, 2, \ldots, N$. The sample mean, m, is just the numerical average, i.e.,

$$m = \frac{1}{N}\sum_{j=1}^{N} T_j \,. \qquad (1)$$

Let T_{min} be the minimum *Delay Request* interval; it is equal to $2^{\text{portDS.logMinDelayReqInterval}}$ s. The second dashed item above states that the mean of the distribution must be greater than or equal to T_{min} with 90% or greater statistical confidence.

The statistical test for this is well-known, and is based on the fact that the distribution of m approaches a normal distribution as N becomes large (i.e., it is based on the central limit theorem). Let σ be the standard deviation of the distribution of the inter-message times, i.e., the distribution of the T_j. Let $z_{0.90}$ be the 90th percentile of the standard normal distribution; it is given by $z_{0.90} = 1.281$. Then, the probability that the true mean of the distribution exceeds the quantity

$$q_{0.1} = m - z_{0.90}\sqrt{\frac{\sigma}{N}} \,, \qquad (2)$$

is 0.9, i.e., 90%. The probability that the mean of the distribution is less than this value is 0.1. In addition, if σ is not known, the sample standard deviation, s, may be used in Eq. (2) and the Normal distribution is replaced by the Student-t distribution with $N - 1$ degrees of freedom. The sample standard deviation is given by

$$s = \left[\frac{1}{N-1}\sum_{j=1}^{N}(T_j - m)^2\right]^{1/2} . \qquad (3)$$

To meet the requirement, the quantity $q_{0.1}$ must exceed T_{min}. It is seen from Eq. (2) that $q_{0.1}$ approaches m as N approaches infinity. Since m converges to the mean of the distribution of inter-message times as N approaches infinity, the requirement can be met for sufficiently large N as long as the mean of the distribution exceeds T_{min}. Note that the mean of the distribution must exceed T_{min};

the requirement cannot be met if the mean of the distribution is exactly equal to T_{min} or less than T_{min}.

If it is chosen to comply with the requirement of the third dashed item, one way of meeting this requirement is to increase the upper end of the probability distribution by 10%. If this is done, the transmission times are selected such that the interval between successive *Delay_Req* messages is taken from a uniform distribution over the interval between 0 and $2.2T_{min}$. A new random value for the transmission interval is computed for each message transmitted. When computing the mean *Delay_Req* interval from measured samples to check if it exceeds T_{min} with 90% or greater statistical confidence (if the third dashed item is used), the number of measured samples N must be at least 1000. The granularity of the distribution must be less than or equal to 1/16 *Sync* interval.

If it is chosen to meet the requirement of the fourth dashed item is met, a *Delay_Req* message is transmitted as soon as possible after receipt of a *Sync* message, subject to not violating the second dashed item.

Appendix III

Considerations on the default PTP Ethernet multicast address

(This appendix does not form an integral part of this Recommendation.)

This PTP profile supports both the non-forwardable multicast address 01-80-C2-00-00-0E and forwardable multicast address 01-1B-19-00-00-00 when the PTP mapping defined in Annex F of [IEEE 1588] is used.

The default Ethernet multicast address to be used depends on the operator policy; further considerations are provided hereafter.

<u>Option 1 – use of the non-forwardable multicast address 01-80-C2-00-00-0E as the default PTP address</u>

Some network operators consider that the PTP messages must never be forwarded through a PTP-unaware network equipment.

The use of the non-forwardable multicast address 01-80-C2-00-00-0E guarantees this property most of the time (exceptions exist for some old Ethernet equipment).

Therefore, in the case of network equipment misconfiguration (e.g. if the PTP functions are not enabled in PTP-aware network equipment), the use of this multicast address prevents incorrect distribution of synchronization, since the PTP messages will be blocked by the PTP-unaware network equipment.

<u>Option 2 – use of the forwardable multicast address 01-1B-19-00-00-00 as the default PTP address</u>

Some network operators consider that using forwardable multicast address is more flexible and that it is preferable to forward the PTP messages to keep the synchronization link running in case some equipment is misconfigured as non PTP nodes, although there are potentially risks of performance degradation. The Network Management System will easily find the misconfiguration and send alarms.

However, it is possible to block the PTP messages by properly provisioning this multicast address in the filtering database of each Ethernet equipment.

Appendix IV

Considerations on the use of priority2

(This appendix does not form an integral part of this Recommendation.)

The PTP attribute priority2 is configurable in this profile. In some special circumstances, the use of the priority2 attribute can simplify the network management. This Appendix describes two use cases; other possible cases are for further study.

Case 1:

Operators can configure the PTP attribute priority2 to make all of the T-BCs either traceable to one T-GM, or traceable to two different T-GMs at the same time.

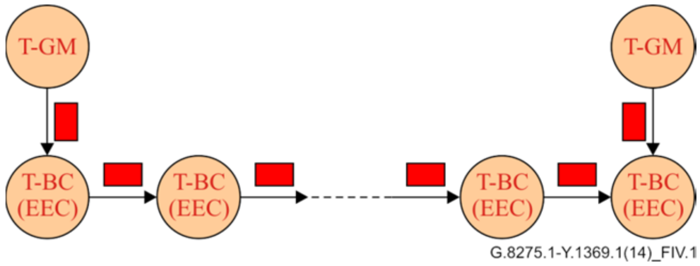

Figure IV.1 – Use of priority2 with two T-GMs in the network

For example, in Figure IV.1, if all other PTP attributes of the two T-GMs are the same, and the two T-GMs are configured with the same priority2 value, each T-BC will select the T-GM with the shortest path; if the two T-GMs are configured with different priority2 values, all of the T-BCs will synchronize to the T-GM with the smallest priority2 value.

Case 2:

Operators can configure the PTP attribute priority2 to prevent the T-BCs of an upstream network from synchronizing with the T-BCs of a downstream network when the T-GM becomes in failure.

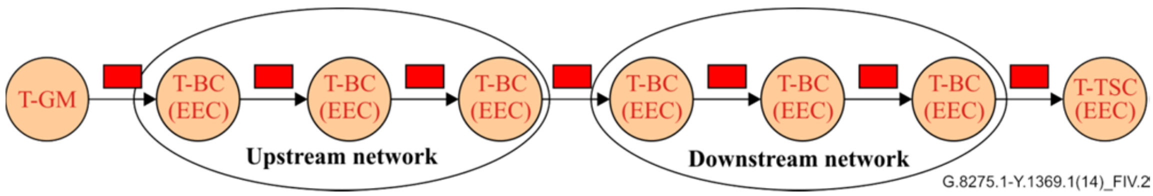

Figure IV.2 – Use of priority2 with T-BCs of different network layers

For example, in Figure IV.2, if all other PTP attributes of all of the T-BCs are the same, and the PTP attribute priority2 of all of T-BCs are configured with the same value, then when the T-GM becomes in failure, the T-BCs in the upstream network can synchronize with the T-BCs in the downstream network, depending on the clockIdentity values of all of the T-BCs. If the T-BCs in the upstream network are configured with a smaller priority2 value than the T-BCs in the downstream network then, when the T-GM is in failure, the T-BCs in the downstream network will synchronize to the T-BCs in the upstream network.

Appendix V

Description of PTP Clock States and associated contents of Announce messages

(This appendix does not form an integral part of this Recommendation.)

V.1 Purpose of the Appendix

This Appendix provides information related to possible T-GM and T-BC clock states. The intention of the clock state information is to provide a high-level indication of the operational status of the entire clock as opposed to just individual PTP ports. It provides a mapping between the clock states and PTP Port States as defined in [IEEE 1588]. In addition, it provides a table showing the contents of the *Announce* message fields that will occur in the various clock states.

The Acquiring clock state, if included in an implementation, allows a T-GM or a T-BC to delay the distribution of grandmaster information transmitted by the clock. The purpose of this Acquiring clock state is to allow a T-GM or a T-BC some time to establish a timescale with acceptable accuracy before using it for the clock's node time.

NOTE – The procedures defined within this Appendix for the Acquiring clock state are not compliant to the procedures of [IEEE 1588] and the delay introduced by this state can impact the overall settling time during PTP topology re-arrangements.

Inclusion of clocks using the procedures of this Appendix in a network is under operator responsibility.

V.2 Description of the states

- Free-Run State

The PTP clock has never been synchronized to a time source and is not in the process of synchronizing to a time source.

As it relates to the PTP port state defined in [IEEE 1588], a clock is in Free-Run state if there are no PTP ports in: MASTER, PRE-MASTER, PASSIVE, UNCALIBRATED, or SLAVE states.

- Acquiring State

The PTP clock is in process of synchronizing to a time source. The duration and functionality of this state is implementation specific. This state is not required in an implementation.

As it relates to the PTP port state defined in [IEEE 1588], a clock is in Acquiring state if there is a PTP port in UNCALIBRATED state.

- Locked State

The PTP clock is synchronized to a time source and is within some internal acceptable accuracy.

As it relates to the PTP port state defined in [IEEE 1588], a clock is in Locked state if there is a PTP port in SLAVE state.

- Holdover-In-Specification State

The PTP clock is no longer synchronized to a time source and is using information obtained while it was previously synchronized or other information sources were still available, to maintain performance within desired specification. The node may be relying solely on its own facilities for holdover or may use something like a frequency input from the network to achieve a holdover of time and/or phase.

As it relates to the PTP port state defined in [IEEE 1588], a clock is in Holdover-In-Specification state if there are no PTP ports in: INITIALIZING, LISTENING, UNCALIBRATED or SLAVE states, and performance is within desired specification.

- Holdover-Out-Of-Specification State

The PTP clock is no longer synchronized to a time source and, while it may be using information obtained while it was previously synchronized or other information sources were still available, it is unable to maintain performance within desired specification.

As it relates to the PTP port state defined in [IEEE 1588], a clock is in Holdover-Of- Out-Specification state if there are no PTP ports in: INITIALIZING, LISTENING, UNCALIBRATED or SLAVE states, and performance is not within desired specification.

V.3 Example of mapping between PTP Port States and PTP Clock States for a 3 ports Telecom Boundary Clock

Table V.1 – PTP Port State vs Clock State Mapping

Telecom Boundary Clock					
	Port State			**Clock State**	
Trigger event	**Port 1**	**Port 2**	**Port 3**		**Notes**
Power up of PTP	INITIALIZING	INITIALIZING	INITIALIZING	Free-Run	No port in MASTER, PASSIVE, UNCALIBRATE, nor SLAVE
Clock completes initialization	LISTENING	LISTENING	LISTENING	Free-Run	No port in MASTER, PASSIVE, UNCALIBRATE, nor SLAVE
Qualified *Announce* received from foreign master on port P1	UNCALIBRATED	LISTENING	LISTENING	Acquiring	A port is in UNCALIBRATED state
AnnounceReceiptTimeout event on ports P2 and P3	UNCALIBRATED	MASTER	MASTER	Acquiring	A port is in UNCALIBRATED state
Calibration finished port P1	SLAVE	MASTER	MASTER	Locked	A Slave port exists on the node
AnnounceReceiptTimeout event on port P1	MASTER	MASTER	MASTER	Holdover-In-Specification	Start HO timer No port in SLAVE, UNCALIBRATED, LISTENING, nor INITIALIZING
HO timer expires	MASTER	MASTER	MASTER	Holdover-Out-Of-Specification	HO timer expired and no port in SLAVE, UNCALIBRATED, LISTENING, nor INITIALIZING
Port P3 receives qualified *Announce* CC 7	MASTER	MASTER	UNCALIBRATED	Acquiring	A port is in UNCALIBRATED state
Calibration finished port P3	MASTER	MASTER	SLAVE	Locked	A Slave port exists on the node
Port P1 receives qualified *Announce* CC 6	UNCALIBRATED	MASTER	PRE-MASTER	Acquiring	A port is in UNCALIBRATED state
QUALIFICATION TIMEOUT EXPIRY on port P3	UNCALIBRATED	MASTER	MASTER	Acquiring	A port is in UNCALIBRATED state
Calibration finished port P1	SLAVE	MASTER	MASTER	Locked	A Slave port exists on the node

V.4 T-GM Announce message contents based on the internal PTP clock states

Table V.2 – T-GM Announce message contents

Announce Message Fields	Free-Run State	Acquiring State	Locked State	Holdover-In-Specification State	Holdover-Out-Of-Specification State
sourcePortIdentity (header.sourcePortIdentity)	Local clockId of the T-GM + Port Number	Local clockId of the T-GM + Port Number	Local clockId of the T-GM + Port Number	Local clockId of the T-GM + Port Number	Local clockId of the T-GM + Port Number
leap61 (header.flagField)	FALSE	From Time Source	From Time Source	FALSE	FALSE
leap59 (header.flagField)	FALSE	From Time Source	From Time Source	FALSE	FALSE
currentUtcOffsetValid (header.flagField)	FALSE	TRUE/FALSE [Implementation Specific]	TRUE	TRUE	TRUE/FALSE [Implementation Specific]
ptpTimescale (header.flagField)	TRUE	TRUE	TRUE	TRUE	TRUE
timeTraceable (header.flagField)	FALSE	TRUE	TRUE	TRUE	FALSE
frequencyTraceable (header.flagField)	FALSE	TRUE/FALSE based on Frequency Source lock	TRUE	TRUE/FALSE based on Frequency Source lock	TRUE/FALSE based on Frequency Source lock
currentUtcOffset	35	Based on input reference UTC Offset	Based on input reference UTC Offset	Last known UTC Offset	Last known UTC Offset
grandmasterPriority1	128 (default)	128 (default)	128 (default)	128 (default)	128 (default)
grandmasterClockQuality.clockClass	248	Implementation specific, generally previous state 7/140/150/160/248	6	7	140/150/160
grandmasterClockQuality.clockAccuracy	Unknown (0xFE)	Unknown (0xFE)	Time is accurate within 100ns (0x21)	Unknown (0xFE)	Unknown (0xFE)
grandmasterClockQuality.offsetScaledLogVariance	0xFFFF (default)	0xFFFF (default)	0x4E5D	0xFFFF (default)	0xFFFF (default)
grandmasterPriority2	Configured priority2 of the T-GM	Configured priority2 of the T-GM	Configured priority2 of the T-GM	Configured priority2 of the T-GM	Configured priority2 of the T-GM
grandmasterIdentity	Local clockId of the T-GM	Local clockId of the T-GM	Local clockId of the T-GM	Local clockId of the T-GM	Local clockId of the T-GM
stepsRemoved	0	0	0	0	0
timeSource	INT_OSC (0xA0)	INT_OSC (0xA0)	As per PTP	INT_OSC (0xA0)	INT_OSC (0xA0)

V.5 T-BC Announce message contents based on the internal PTP clock states

Table V.3 – T-BC Announce message contents

Announce Message Fields	**Free-Run State**	**Acquiring State**	**Locked State**	**Holdover-In-Specification State**	**Holdover-Out-Of-Specification State**
sourcePortIdentity (header.sourcePortIdentity)	Local clockId of the T-BC + Port Number	Local clockId of the T-BC + Port Number	Local clockId of the T-BC + Port Number	Local clockId of the T-BC + Port Number	Local clockId of the T-BC + Port Number
Leap61 (header.flagField)	FALSE	Note 1	Note 1	FALSE	FALSE
Leap59 (header.flagField)	FALSE	Note 1	Note 1	FALSE	FALSE
currentUtcOffsetValid (header.flagField)	FALSE	TRUE	Note 1	TRUE	TRUE/FALSE [Implementation Specific]
ptpTimescale (header.flagField)	TRUE	TRUE	Note 1	TRUE	TRUE
timeTraceable (header.flagField)	FALSE	TRUE	Note 1	TRUE	FALSE
frequencyTraceable (header.flagField)	FALSE	TRUE /FALSE based on Frequency Source lock	Note 1	TRUE /FALSE based on Frequency Source lock	TRUE /FALSE based on Frequency Source lock
currentUtcOffset	35	Last known UTC Offset	Note 1	Last known UTC Offset	Last known UTC Offset
grandmasterPriority1	128 (default)	128 (default)	Note 1	128 (default)	128 (default)
grandmasterClockQuality.clockClass	248	Implementation Specific. Generally previous state. 135/165/248	Note 1	135	165
grandmasterClockQuality.clockAccuracy	Unknown (0xFE)	Unknown (0xFE)	Note 1	Unknown (0xFE)	Unknown (0xFE)
grandmasterClockQuality.offsetScaledLogVariance	0xFFFF (default)	0xFFFF (default)	Note 1	0xFFFF (default)	0xFFFF (default)
grandmasterPriority2	Configured priority2 of the T-BC	Configured priority2 of the T-BC	Note 1	Configured priority2 of the T-BC	Configured priority2 of the T-BC
grandmasterIdentity	Local clockId of the T-BC	Local clockId of the T-BC	Note 1	Local clockId of the T-BC	Local clockId of the T-BC
stepsRemoved	0	0	Received stepsRemoved +1	0	0
timeSource	INT_OSC (0xA0)	INT_OSC (0xA0)	Note 1	INT_OSC (0xA0)	INT_OSC (0xA0)
NOTE 1 – The value sent in the *Announce* message corresponds to the value of the current grandmaster.					