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Amendment 1

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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, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet protocol aspects – Transport

Precision time protocol telecom profile for frequency synchronization

Amendment 1

Recommendation ITU-T G.8265.1/Y.1365.1 (2021) – Amendment 1

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
Ethernet over Transport aspects	G.8000–G.8099
MPLS over Transport aspects	G.8100–G.8199
Synchronization, quality and availability targets	**G.8200–G.8299**
Mobile network transport aspects	G.8300–G.8399
Service Management	G.8600–G.8699
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.8265.1/Y.1365.1

Precision time protocol telecom profile for frequency synchronization

Amendment 1

Summary

Recommendation ITU-T G.8265/Y.1365 describes the architecture and requirements for packet-based frequency distribution in telecom networks. Examples of packet-based frequency distribution include the network time protocol (NTP), IEEE-1588-2008 and IEEE 1588-2019 and are briefly described here. Details necessary to utilize IEEE-1588-2008 and IEEE 588-2019 in a manner consistent with the architecture are defined in other Recommendations.

Amendment 1 includes the following changes:

– IPv6 mapping, in addition to IPv4, is now mandatory;

– Clarifying notes have been added to the tables in Annex A which contains the PTP profile.

– Provides carifications to PTP attribute values.

History

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1.0	ITU-T G.8265.1/Y.1365.1	2010-10-07	15	11.1002/1000/10911
1.1	ITU-T G.8265.1/Y.1365.1 (2010) Amd. 1	2011-04-13	15	11.1002/1000/11143
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2.1	ITU-T G.8265.1/Y.1365.1 (2014) Cor. 1	2016-04-13	15	11.1002/1000/12811
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Keywords

IEEE 1588, frequency, packet-based synchronization.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

NOTE

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Table of Contents

Recommendation ITU-T G.8265.1/Y.1365.1

Precision time protocol telecom profile for frequency synchronization

Amendment 1

Editorial note: This is a complete-text publication. Modifications introduced by this amendment are shown in revision marks relative to Recommendation ITU-T G.8265.1/Y.1365.1 (2021).

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 frequency only. The profile is based on the architecture described in [ITU-T G.8265] and definitions described in [ITU-T 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 use of unicast transmission and negotiation, an alternate best master clock algorithm (BMCA), as well as the PTP protocol configuration parameters. The support for mixed unicast/multicast or static unicast modes is for further study.

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

An implementation compliant with this profile can claim compliance with either IEEE Std 1588-2008 [IEEE 1588-2008] or IEEE Std 1588-2019 [IEEE 1588-2019]. Considerations on the use of one or the other profile are provided in Appendix III. Compliance for a specific implementation with either the [IEEE 1588-2008] or [IEEE 1588-2019] versions of the standard should be stated when referring to this 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.781] Recommendation ITU-T G.781 (2020), *Synchronization layer functions for frequency synchronization based on the physical layer*.

[ITU-T G.8260] Recommendation ITU-T G.8260 (2020), *Definitions and terminology for synchronization in packet networks*.

[ITU-T G.8265] Recommendation ITU-T G.8265/Y.1365 (2010), *Architecture and requirements for packet-based frequency delivery*.

[IEEE 1588] Either [IEEE 1588-2008] or [IEEE 1588-2019] depending on the specific implementation. See clause 5 Conventions for more details.

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

[IEEE 1588-2019] IEEE 1588-2019, *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:

3.1.1 packet master clock [ITU-T G.8260]

3.1.2 packet slave clock [ITU-T G.8260]

3.1.3 packet timing signal [ITU-T G.8260]

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BMC	Best Master Clock
BMCA	Best Master Clock Algorithm
EUI	Extended Unique Identifier
GM	Grand Master
NTP	Network Time Protocol
OC	Ordinary Clock
ParentDS	Parent Data Set (terminology used in [IEEE 1588])
LSP	Label Switched Path
MA-L	MAC Address – Large
MA-M	MAC Address – Medium
MA-S	MAC Address – Small
MPLS	Multi-Protocol Label Switching
OUI	Organizationally Unique Identifier
PDV	Packet Delay Variation
PTP	Precision Time Protocol
PTSF	Packet Timing Signal Fail
QL	Quality Level
SDH	Synchronous Digital Hierarchy
SOOC	Slave-Only Ordinary Clock
SSM	Synchronization Status Message
SyncE	Synchronous Ethernet
TLV	Type Length Value
UDP	User Datagram Protocol
VLAN	Virtual Local Area Network

5 Conventions

Within this Recommendation, the following conventions are used: the term precision time protocol (PTP) refers to the PTP defined in [IEEE 1588]. The term "slave" or "slave clock" refers to a "slave-only ordinary clock" (SOOC) as defined in [IEEE 1588]. A "Telecom Slave" is a device consisting of one or more SOOCs. The term "master" or "packet master" or "packet master clock" refers to a grand master as defined in [IEEE 1588]. PTP messages used within this Recommendation are defined in [IEEE-1588] and are identified using italicized text.

Within this Recommendation, some requirements are stated as requiring compliance to [IEEE 1588]. For implementations compliant to [IEEE 1588-2008], the reference to [IEEE 1588] means compliance to [IEEE 1588-2008]. For implementations compliant to [IEEE 1588-2019], the reference to [IEEE 1588] means compliance to [IEEE 1588-2019]. Some of these references to [IEEE 1588] include a specific clause number. In these cases, the clause number is the same in both [IEEE 1588-2008] and [IEEE 1588-2019]. If the requirements are in different clauses in the two versions of IEEE 1588, then the text of this Recommendation shall include the specific clause for [IEEE 1588-2008] and the specific cause for [IEEE 1588-2019].

6 Use of PTP for frequency distribution

The [IEEE 1588] standard contains the precision time protocol (PTP) that was designed to enable accurate time transfer. It introduces the concept of the "profile", whereby aspects of the protocol may be selected and specified for a particular application. This Recommendation defines the "profile for telecom" applications in order to support the specific architectures described in [ITU-T G.8265].

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].

The [IEEE 1588] telecom profile defined within this Recommendation is intended to be used by applications that need frequency synchronization only. It does not cover applications where there is need for phase alignment and/or time of the day. This profile addresses the case where the PTP masters and slaves will be used in networks where there is no support for the PTP protocol in any intermediate node between the PTP master and the PTP slave.

It is also important to note that the default PTP protocol is based on multicast. This profile uses only the negotiated unicast mode. The use of mixed unicast/multicast operation or static unicast mode is for further study.

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.

6.1 High-level design requirements

[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 the telecom network, some additional criteria are also required to be consistent with standard telecom synchronization practices. With that in mind, high-level objectives for the PTP profile for frequency distribution are:

1) To allow interoperability between PTP master clocks and PTP slave clocks compliant with the profile.

   This means that PTP master clocks compliant with the profile must have the ability to serve multiple PTP slave clocks from different vendors, and slaves require the ability to derive synchronization from one or more masters from different vendors.

2) To permit operation over managed, wide-area packet-based telecom networks.

   This may include networks based on protocols such as Ethernet, IP and multi-protocol label switching (MPLS), and combinations thereof.

3) To define message rates and parameter values consistent with frequency distribution to the required performance for telecom applications.

   Note that the profile does not guarantee meeting performance criteria by itself, but should permit the desired performance, given competently designed equipment operating over a suitably designed and managed packet network.

4) To allow interoperability with existing synchronization networks (such as synchronous Ethernet (SyncE) and synchronous digital hierarchy (SDH)).

   In particular, this means that the profile must define the means to support the transmission of the [ITU-T G.781] quality level (QL) values from packet master clock to packet slave clock, providing full traceability back to a primary reference.

   The QL levels transmitted must be consistent with the existing synchronization practice, and the performance of clocks in the synchronization chain.

5) To allow the synchronization network to be designed and configured in a fixed arrangement.

   Masters should always remain masters, and slaves should always remain slaves. Autonomous re-configuration of the synchronization network (e.g., by use of an automatic process such as the best master clock algorithm described in [IEEE 1588]) should be prevented.

6) To enable protection schemes to be constructed in accordance with standard telecom network practices.

   This should include the following:

   – physical protection, using redundant hardware and master at the same location;
   – geographical protection, using a separate master at a different location. This should include the ability to construct both 1:1 and N:1 protection schemes for packet master clocks.

7) To define the criteria under which slaves switch from one packet master clock to an alternate packet master clock.

   These should be based on standard telecom criteria, i.e., QL value first, then priority values.

8) To permit the operation of existing, standard-based security techniques to help ensure the integrity of the synchronization.

   Examples may include encryption and/or authentication techniques, or network techniques for separating traffic, such as virtual local area networks (VLANs) or label switched paths (LSPs). Note that the profile does not have to define these techniques, but nothing in the profile should prevent the use of them.

– Slaves should be prevented from connecting to rogue masters (this could be either by an authentication process, or by using network separation to prevent rogue masters from accessing slaves).
– Masters should be prevented from providing service to unauthorized slaves.

Note that it may not be possible to implement some of these requirements without actually degrading the overall level of system performance.

6.2 General description

[IEEE 1588] defines several clock types with varying degrees of PTP message processing. This Recommendation only addresses ordinary clocks as defined in [IEEE 1588]. Boundary and transparent clocks as defined in [IEEE 1588] are out-of-scope for this edition of the Recommendation.

The performance achievable at the slave clock is dependent on several factors. Key issues include the packet delay variation and the stability of the slave clock's internal oscillator. These aspects are out-of-scope for this edition of the Recommendation.

6.2.1 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.

For the purpose of this profile, PTP domains are established by using unicast messaging to ensure isolation of grandmaster clocks. A clock (slave or master) must not take any information from a PTP domain and use it to influence the behaviour of a clock in another PTP domain.

NOTE – There is only a single packet master clock per PTP domain. Within a PTP domain, the domain number will be the same for all clocks.

For example, in Figure 2, there are *N* PTP domains. Each master is utilizing the same PTP domain number. Domain separation is provided by unicast messages.

6.2.2 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"), *Management* and *Signaling.*

6.3 PTP modes

[IEEE 1588] describes several modes of operation between a master and a slave. This clause describes these modes with respect to functionality needed to be compliant with this profile.

6.3.1 One-way versus two-way operation

PTP is a protocol designed to deliver time synchronization. In order to compensate for the propagation delay of messages through the network, messages are sent in each direction allowing the round-trip delay to be measured. The one-way delay is then estimated as being half the round-trip delay. This is known as two-way operation. However, when PTP is used to deliver frequency only, two-way operation is not required, since the propagation delay of the synchronization messages does not need to be compensated. For frequency distribution, the use of a one-way operation is therefore possible.

Nevertheless, some clock recovery implementations do use two-way mode, even if the application only requires frequency distribution. Indeed, the "reverse" path (i.e., the *Delay_Req* messages) may be used by the clock recovery algorithm. Conversely, a one-way-only scheme may be used in order to reduce the bandwidth consumed by the PTP messages.

A PTP master compliant with the profile must be capable of supporting one-way and two-way timing transfer. A slave however may only utilize one-way, or may utilize two-way, but is not required to support both methods.

6.3.2 One-step versus two-step clock mode

PTP defines two types of clock behaviours: the "one-step clock" and the "two-step clock". In a one-step clock, the precise timestamp is transported directly in the *Sync* message. In a two-step clock, a *Follow_Up* message is used to carry the precise timestamp of the corresponding *Sync* message. The use of *Follow_Up* messages is optional in the PTP protocol.

It has to be noted that the one-step clock approach enables to reduce significantly the number of PTP messages sent by the master, and relax the master capacities.

However, there might be situations where the two-step clock approach might be required (e.g., when some security features are required). These situations are for further study.

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

NOTE – The performances of the PTP timing flow generated by the master with those two approaches are for further study.

To be compliant with [IEEE 1588], a slave must be capable of handling both one-step clock and two-step clock, without any particular configuration.

As per [IEEE 1588], when a two-step clock is used, the value of the flag "twoStepFlag" shall be TRUE to indicate that a *Follow_up* message will follow the *Sync* message, and that the slave must not consider the timestamp embedded in the *Sync* message. When a one-step clock is used, the value of the flag "twoStepFlag" shall be FALSE, and the slave must consider the timestamp embedded in the *Sync* message in this case.

6.3.3 Unicast versus multicast mode

PTP allows the use of unicast and multicast modes for the transmission of the PTP messages.
For the PTP profile specified in Annex A, negotiated unicast mode is used for all the PTP messages.

The use of multicast mode for some or all of the PTP messages is for further study.

Appendix I provides information related to this aspect.

A master or a slave compliant with the PTP profile specified in Annex A must support negotiated unicast mode. Support for mixed unicast/multicast or static unicast modes is for further study.

6.4 PTP mapping

This PTP telecom profile is based on the PTP mapping *Transport of PTP over User Datagram Protocol over Internet Protocol Version 4* [IEEE 1588] and *Transport of PTP over User Datagram Protocol over Internet Protocol Version 6* [IEEE 1588].

A master or a slave compliant with the profile described in this Recommendation must be compliant with *Transport of PTP over User Datagram Protocol over Internet Protocol Version 4* [IEEE 1588] and ~~may be compliant~~ with *Transport of PTP over User Datagram Protocol over Internet Protocol Version 6* [IEEE 1588].

NOTE – The use of the IP/UDP mapping is to facilitate the use of IP addressing. It does not imply that the PTP flow can be carried over an unmanaged packet network. It is assumed that a well-controlled packet network will be used to control and minimize packet delay variation.

NOTE – Based on expected network evolution, the support for IPv4 may be made optional or dropped in future versions of this Recommendation.

6.5 Message rates

The message rate values are only defined for protocol interoperability purposes. It is not expected that any slave clock shall meet the relevant target performance requirements at all packet rates within the given range, specifically at the lower packet rate. The appropriate value depends on the clock characteristics and on the target performance requirements. Different packet rate needs may also apply during the stabilization period.

NOTE – A specific slave implementation, in order to meet its target performance requirements, may support a subset of the message rates within the ranges noted below. A master, on the other hand, is required to support the full range of message transmission rates. Unless an implementation specifies otherwise, the default value listed below is assumed to be used.

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

– *Sync* messages (if used, *Follow_up* messages will have the same rate) – minimum rate: one packet every 16 seconds, maximum rate: 128 packets-per-second.

– *Delay_Req*/*Delay_Resp* messages – minimum rate: one packet every 16 seconds, maximum rate: 128 packets-per-second.

– *Announce* messages – minimum rate: one packet every 16 seconds, maximum rate: eight packets-per-second (A default rate is given as one packet every two seconds).

– *Signaling* messages – no rate is specified.

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

6.6 Unicast message negotiation

Within a telecommunication network, there are benefits to allowing PTP slave devices to request the synchronization service from PTP masters. [IEEE 1588] defines a unicast message negotiation mechanism to allow slaves to request this service within a unicast environment. This profile supports the unicast message negotiation in accordance with [IEEE 1588] and is described below.

Packet master clocks and slave-only clocks compliant with the profile must support the unicast message negotiation mechanism as per clause 16.1 of [IEEE 1588] and as described in this clause.

Only slave-only clocks are allowed to make a request for unicast service from the master.

When using the unicast mode, PTP slaves request synchronization service by sending a PTP *Signaling* message in unicast, containing the REQUEST_UNICAST_TRANSMISSION TLV, to the IP address of the selected PTP master.

NOTE 1 – In this telecom profile, unicast connection establishment without negotiation is for further study.

The *Signaling* message containing the REQUEST_UNICAST_TRANSMISSION TLV is periodically renewed.

When initiating unicast negotiation with a master, a slave can use all 1's as the initial value for the targetPortIdentity field of the *Signaling* message. Based on the response from the master, the slave can then learn the clockIdentity and portNumber of the Master and may use this in any subsequent *Signaling* message. The slave may also continue to use all 1's. Similarly, the master may either learn and use the clockIdentity and portNumber of the slave, or use all 1's value for the targetPortIdentity field of the *Signaling* messages that it sends. Both master and slave must be prepared to handle both situations in reception, i.e., receive PTP *Signaling* messages with either their own clockIdentity and portNumber or with all 1's values for the targetPortIdentity field.

The logInterMessagePeriod can be configured to adjust the requested transmission rate of *Sync*, *Announce* and *Delay_Resp* messages.

The configurable range for the logInterMessagePeriod is given in Annex A for all the relevant messages.

The durationField value in each REQUEST_UNICAST_TRANSMISSION TLV has a default initialization value of 300 seconds and a configurable range of 60 to 1000 seconds.

In the event that a PTP master is unable to meet a given slave request, it should deny the request entirely rather than offer the slave less than it originally requested.

In the event of being denied service by a master, or receiving no response to the service request:

– A slave should wait a minimum of one second (after denial or no response received) before issuing a new unicast service request for that message type to the same master.
– If a slave has issued three service requests for the same message type with either no response or a "grant denied" response, it should either:
  - cancel any granted unicast service it may have for other message types, and request service from a different master, or
  - wait a further 60 s before re-issuing the request to the same master.

An example of the message exchange to initiate the unicast synchronization service is shown in Figure 1. The timing diagram example represents the exchange of unicast messages for a one-step clock (i.e., no *Follow_up* messages) using one-way mode (i.e., no *Delay_Req* or *Delay_Resp*).

The example shows a unicast negotiation phase for a packet slave sending *Signaling* messages for *Announce* and *Sync* requests; a packet master granting the packet slave the requested message rates; a packet master transmitting the requested *Announce* and *Sync* message rates and the renewal of *Announce* and *Sync* before the expiration of durationField.

Note that several timing diagrams could be represented based on various exchanges of message types, the use of single or concatenated type length values (TLVs) in *Signaling* messages, the use of different durationFields for each message type, etc. Figure 1 provides an example of message interaction; it is for illustrative purposes only and does not represent a particular implementation.

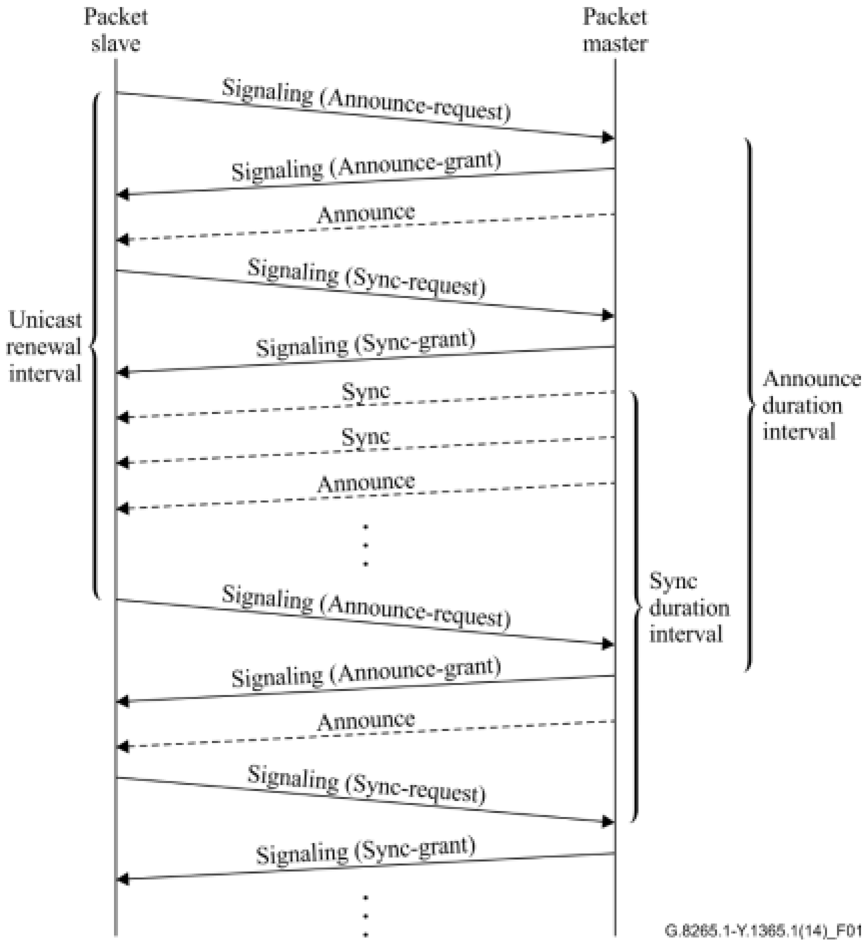

Figure 1 – Unicast negotiation example

PTP slaves may request several types of PTP messages from a PTP master (e.g., slave working in two-way mode, which may request *Sync* and *Delay_Resp* messages, or slave requesting *Announce* and *Sync* messages from the same master). To request unicast transmission of different PTP message types, and to respond to such requests, [IEEE 1588] allows the use of a single *Signaling* message containing multiple TLVs or the use of multiple *Signaling* messages. Masters and slaves compliant with this profile must be prepared to handle those two situations. The expected behaviour during the initial negotiation and during the consecutive unicast service renewals is described in the paragraphs that follow.

Each request for unicast transmission from a specific slave to a master should start by issuing an *Announce* service type request first for that specific master. Only after the slave has been granted unicast service for the *Announce* message and received the first unicast *Announce* message from the specified master, can the rest of the service type request take place. Such practice would ensure that the attributes (e.g., QL) and capabilities of the specified master are acceptable from the slave's perspective before the rest of the services are contracted.

Upon receiving the first *Announce* message from the master, the first *Signaling* message containing a REQUEST_UNICAST_TRANSMISSION TLV issued by the slave should include all the service types the specific slave requires from the master using multiple REQUEST_UNICAST_TRANSMISSION TLVs. Such practice will reduce the chance that the master will only grant part of the requested services in case it has been over-subscribed (due to simultaneous requests from other slaves). The master is allowed to respond to this request either with a single *Signaling* message containing multiple TLVs, or with multiple *Signaling* messages (e.g., each containing a single TLV).

When renewing the unicast services, the slave, in sending *Signaling* messages (for 'keep-alive' purposes), may either continue to request all service types with a single *Signaling* message containing multiple TLVs, or with multiple independent *Signaling* messages (e.g., each containing a single TLV). The master is allowed to respond to requests either with a single *Signaling* message containing multiple TLVs, or with multiple *Signaling* messages (e.g., each containing a single TLV).

As defined in [IEEE 1588], in order to receive continuous service, a requester should reissue a request in advance of the end of the grant period. The recommended advance should include sufficient margin for reissuing the request at least two more times if no grant is received.

In case the unicast transmission sessions are cancelled as defined in [IEEE 1588], a PTP clock cancelling several types of PTP messages may use a single *Signaling* message containing multiple TLVs or multiple *Signaling* messages. Masters and slaves compliant with this profile must be prepared to handle those two situations.

The PTP clock cancelling the session may either cancel the multiple service types with a single *Signaling* message containing multiple CANCEL_UNICAST_TRANSMISSION TLVs or with multiple independent *Signaling* messages (e.g., each containing a single CANCEL_UNICAST_TRANSMISSION TLV). The other PTP clock receiving the cancellation is allowed to respond to these requests either with a single *Signaling* message containing multiple ACKNOWLEDGE_CANCEL_UNICAST_TRANSMISSION TLVs or with multiple independent *Signaling* messages (e.g., each containing a single ACKNOWLEDGE_CANCEL_UNICAST_TRANSMISSION TLV).

NOTE 2 – The "Renewal Invited" flag described in [IEEE 1588] is not used in this profile.

6.7 Alternate BMCA, telecom slave model and master selection process

This clause describes the alternate best master clock (BMC) algorithm, the telecom slave model and the associated master selection process. These are described in the following clauses.

6.7.1 Alternate BMCA

As part of this telecom profile, an alternate best master clock algorithm (BMCA) is defined.

The following clauses specify this alternate BMCA for the masters and for the slaves.

6.7.1.1 Alternate BMCA for packet master clock

A packet master clock in this telecom profile is defined as a grandmaster ordinary clock according to clause 9.4 of [IEEE 1588].

The different masters that can be deployed in the network must be considered as being each in a different PTP domain (each master is considered as alone in its PTP domain).

Therefore, for a packet master clock, the alternate BMCA output is static and provides a recommended state = BMC_MASTER and a state decision code = M1.

As noted in clause 6.2.1 (domains), in unicast, this PTP domain separation between the masters is ensured by the network, which isolates each master in a separate PTP domain; this PTP domain separation does not need to be ensured by means of different PTP domain numbers, in order to avoid that an operator would have to ensure that each PTP master would be configured with a different PTP domain number:

– hence, there is only one active master in each domain, and all the masters are active;
– the PTP masters do not exchange *Announce* messages in unicast.

In multicast, this PTP domain separation between the masters is for further study.

Figure 2 illustrates the above specification from the masters' point of view. In this example, there are "*N*" domains.

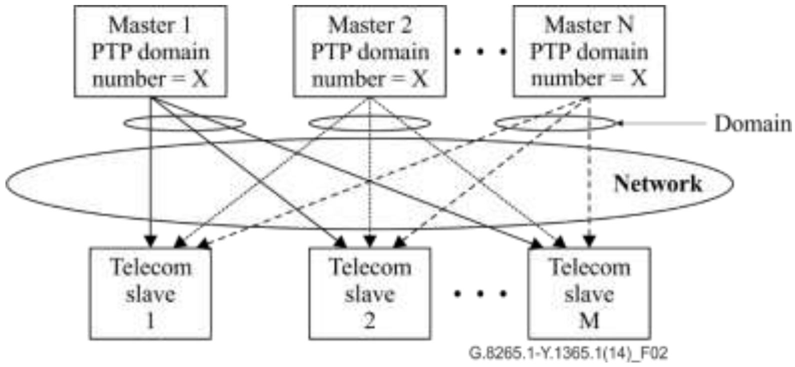

Figure 2 – Each master is active and considered isolated in a different PTP domain by the network

6.7.1.2 Alternate BMCA for slave only clock

As explained in the previous clause, each master is in a different PTP domain. Therefore, a telecom slave is participating in multiple PTP domains when listening to several masters.

In order to enable this participation to multiple PTP domains, a telecom slave may be composed of several PTP slave-only ordinary clock (SOOC) instances, as described in clause 6.7.2. Within a telecom slave, all the SOOC have the same PTP domain number.

For each instance of PTP slave-only ordinary clock in a telecom slave, the alternate BMCA output is static and provides a recommended state = BMC_SLAVE and a state decision code = S1.

6.7.2 Telecom slave model for master selection

The telecom slave model includes functions that are part of the packet slave clock required to support this telecom profile including the master selection process defined in clause 6.7.3.

NOTE 1 – Processing of timestamps and generation of necessary clock signals are for further study.

The telecom slave model consists of several independent PTP slave-only ordinary clock instances. Each PTP slave-only ordinary clock is participating in a single PTP domain and is communicating with a single master, and any PTP message received from another master must be discarded by the SOOC.

NOTE 2 – The behaviour of the telecom slave is described in terms of an example of a slave clock that implements several instances of the PTP protocol; other models are possible provided that the overall behaviour is maintained. These multiple PTP slave-only ordinary clock instances are a "logical separation", and do not imply any specific implementation (for instance, there is no need for a dedicated hardware per clock instance). The main purpose is to maintain several data sets (one per ordinary clock (OC) instance). Most of the attributes of the data sets of the different OC may be common in an implementation; the main one which needs to differ is the parentDS, providing the information about the packet master clock.

NOTE 3 – The use of this telecom slave model in the mixed unicast/multicast mode or in static unicast mode is for further study.

Figure 3 provides an example model of a telecom slave clock with *N* instances of the PTP protocol. No implementation requirements should be inferred from this figure.

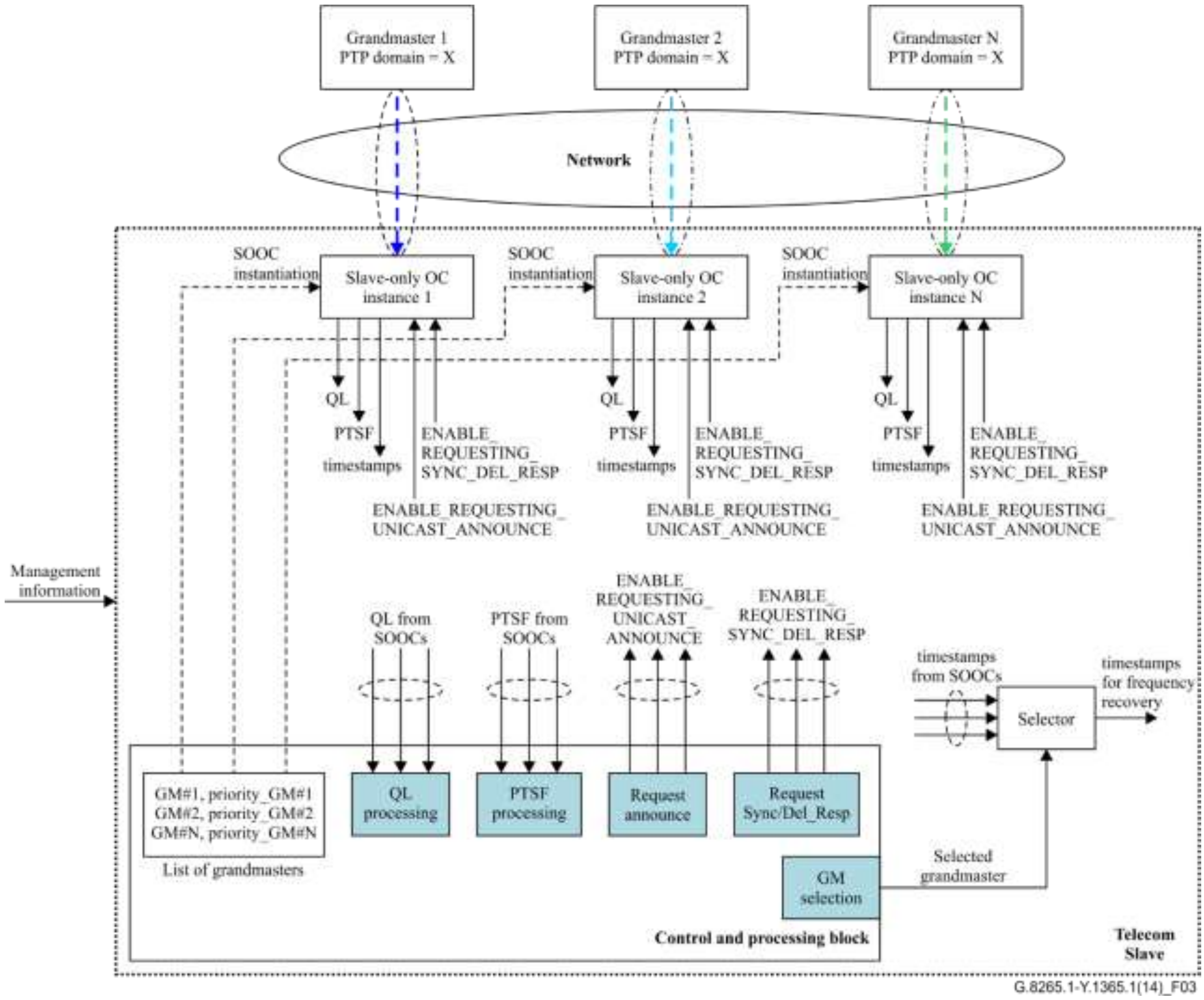

Figure 3 – Telecom slave model

The telecom slave model consists of several functions that are depicted below. It has to be noted that the SOOC instances are the only functions that are part of the PTP protocol. All other functions are outside the PTP protocol. Management of the functions in this model and overall PTP management is for further study.

List of grandmasters: A list containing the grandmasters that a telecom slave has been provisioned to communicate with. The list contains a number of *N* entries which are used to instantiate the slave-only OC instances (each entry of the list corresponds to a specific SOOC). Each entry of the list is associated a local priority of that grandmaster. The local priorities are used for master selection. Provisioning of the list of grandmasters and their priorities is via management control.

SOOC instance: A slave-only OC instance is used to communicate with its associated grandmaster. The SOOC provides as output: the QL and packet timing signal fail (PTSF) (see clause 6.7.3.2) to the control & processing block for the master selection, and the timestamps to the selector. The SOOC also maintains appropriate data set (e.g., the parentDS of the grandmaster). The SOOC receives as input the signals ENABLE_REQUESTING_UNICAST_ANNOUNCE and ENABLE_REQUESTING_UNICAST_SYNC/DEL_RESP from the control & processing block. These signals are used to enable the sending of *Signaling* messages to the grandmaster for requesting unicast transmission of *Announce* and *Sync*/*Delay_Resp* messages.

NOTE 4 – The signals ENABLE_REQUESTING_UNICAST_ANNOUNCE and ENABLE_REQUESTING_UNICAST_SYNC/DEL_RESP are internal signals used for the purpose of explaining the telecom slave behaviour.

Control & processing block: This block is used to process the inputs QL, PTSF and priority. The block is also used to control the selector and to deliver to the SOOC instances the output signals ENABLE_REQUESTING_UNICAST_ANNOUNCE and ENABLE_REQUESTING_UNICAST_SYNC/DEL_RESP.

The inputs QL, PTSF and priority are used to determine the grandmaster that will be used for frequency recovery, according to the master selection process specified in clause 6.7.3. The selected grandmaster is indicated to the selector.

The output signal ENABLE_REQUESTING_UNICAST_ANNOUNCE is sent to the SOOC instances to enable the request of *Announce* messages to obtain the QL value from the grandmasters. The output signal ENABLE_REQUESTING_UNICAST_SYNC/DEL_RESP is sent to the SOOC instances to enable the request of *Sync* messages (and *Delay_Resp* messages for a two-way slave). The enabling of these signals is implementation specific.

Selector block: The selector block is used to pass the timestamps of the selected "grandmaster" used for the frequency recovery.

6.7.3 Master selection process

The clock master selection process is outside of the scope of the [IEEE 1588] PTP protocol. The master is chosen from a locally-provisioned list of grandmasters and their respective priorities, as described in clause 6.7.2.

The following parameters contribute to the master selection process:

– quality level;

– packet timing signal fail (PTSF-lossSync, PTSF-lossAnnounce, PTSF-unusable);

– priority;

where the quality level is carried in the clockClass attribute by the *Announce* messages of the candidate master (see clause 6.7.3.1 for details on the correspondence between the quality level and the clockClass attribute), the packet timing signal fail conditions are described in clause 6.7.3.2, and the priority is locally maintained in the slave.

The algorithm selects the reference with the highest quality level that is not experiencing the signal fail conditions PTSF-lossSync or PTSF-lossAnnounce.

NOTE 1 – PTSF-unusable condition is for further study; it may also trigger the selection of a new master in some cases or a switch in holdover.

If multiple inputs have the same highest quality level, the input with the highest priority is selected. For the case where multiple inputs have the same highest priority and quality level, the current existing selected reference is maintained if it belongs to this group, otherwise an arbitrary reference from this group is selected.

NOTE 2 – The selection algorithm noted above describes selection of packet timing signals. The comparison of the recovered frequency with that of the local equipment clock is outside of the scope of this Recommendation. The equipment clock may not select an external reference and go into holdover (for example in the case where the quality of the local equipment clock is higher than the highest quality level received from the masters).

NOTE 3 – If no input could be selected, for example when all masters are in the PTSF condition, the normal behaviour of a clock will be to either enter holdover in the case of loss of the incoming signal, or remain in free-run, in the case where no signal has been present. These are outside the scope of this Recommendation.

The default behaviour for switching between masters (e.g., due to loss of signal or temporary reduction in QL) is revertive. When the signal or QL is restored, the telecom slave should revert to the highest priority master.

6.7.3.1 Mapping of SSM quality levels to PTP clock class

Table 1 provides the mapping values of synchronization status message (SSM) quality levels to the PTP clockClass attribute. The clockClass attribute is used to transmit the SSM QL from the packet master to the packet slave.

NOTE 1 – Table 1 contains the three options currently specified in [ITU-T G.781]. In a specific network deployment, both the packet masters and the telecom slaves must be configured to use the same option.

Table 1 – Mapping of quality levels to PTP clockClass values

SSM QL	ITU-T G.781			PTP clockClass
	Option I	**Option II**	**Option III**	
0001		QL-PRS		80
0000		QL-STU	QL-UNK	82
0010	QL-PRC			84
0111		QL-ST2		86
0011				88
0100	QL-SSU-A	QL-TNC		90
0101				92
0110				94
1000	QL-SSU-B			96
1001				98
1101		QL-ST3E		100
1010		QL-ST3/ QL-EEC2		102
1011	QL-SEC/ QL-EEC1		QL-SEC	104
1100		QL-SMC		106
1110		QL-PROV		108
1111	QL-DNU	QL-DUS		110

NOTE 2 – The order of quality levels in this table is specified in clause 5.4.2 of [ITU-T G.781] for each of the options.

NOTE 3 – Any received clockClass not specified in the Table should be mapped to QL-INV as per clause 5.4.2 of [ITU-T G.781]

6.7.3.2 Packet timing signal fail

This clause defines the notion of packet timing signal fail (PTSF), which corresponds to a signal indicating a failure of the PTP packet timing signal received by the slave.

Three types of PTSF may be raised in a slave implementation:

– [PTSF-lossSync], lack of reception of PTP timing messages from a master (loss of the packet timing signal): if the slave does not receive anymore the timing messages sent by a master (i.e., *Sync* and eventually *Follow_up* and *Delay_Resp* messages), then a PTSF-lossSync associated to this master must occur. A timeout period (i.e.., "syncReceiptTimeout" and "delayRespReceiptTimeout") for these timing messages must be implemented in the slave before triggering the PTSF-lossSync (the range and default value of this timeout parameter are defined in Table A.5 of this Recommendation.).

The value of syncReceiptTimeout shall specify the number of syncInterval time periods that have to pass without receipt of a Sync or Follow_Up message before the triggering the PTSF-lossSync event.

The value of delayRespReceiptTimeout shall specify the number of minDelayReqInterval time periods that have to pass without receipt of a Delay_Resp message before the triggering of the PTSF-lossSync event.

– [PTSF-lossAnnounce], lack of reception of PTP *Announce* messages from a master (loss of the channel carrying the traceability information): if the slave does not receive anymore the *Announce* messages sent by a master, then a PTSF-lossAnnounce associated to this master must occur. A timeout period for these *Announce* messages must be implemented in the slave before triggering the PTSF-lossAnnounce (the range and default value of this timeout parameter are as per [IEEE 1588]). This timeout corresponds to the "announceReceiptTimeout" attribute specified in [IEEE 1588].
– [PTSF-unusable], unusable PTP packet timing signal received by the slave, exceeding the input tolerance of the slave (noisy packet timing signal): if the PTP packet timing signal is not usable for the slave to achieve the performance target (e.g., violates the slave input tolerance because of excessive packet delay variation (PDV) noise), then a PTSF-unusable associated to this master must occur. The criteria used to determine that the packet timing signal is not suitable to be used is for further study (An example of criteria to be studied may relate to the PDV experienced by the packet timing signal as it traverses the network from the master to the slave).

The following actions must be triggered following a PTSF:

– When a PTSF occurs (PTSF-lossSync, PTSF-lossAnnounce or PTSF-unusable), the master associated to the PTP packet timing signal in failure is considered as not reachable, in failure, or the quality has deteriorated due to e.g., excessive PDV.
– In case PTSF-lossSync or PTSF-lossAnnounce occurs: the slave must select an alternate master as the new timing source if possible or must switch into holdover otherwise.
– In case PTSF-unusable occurs: the consequent actions to be performed are implementation specific and are for further study.

6.8 Additional protection functions

The following architectural functions are specified in [ITU-T G.8265].

6.8.1 Temporary master exclusion – Lock-out function

It must be possible in the telecom slave to exclude temporarily a master from the list of grandmasters (lock-out functionality).

6.8.2 Slave wait-to-restore time function

A wait-to-restore time must be implemented in the telecom slave.

The range associated to wait-to-restore time is for further study.

6.8.3 Slave non-reversion function

As part of the master selection process, a non-revertive mode may optionally be implemented in the telecom slave.

6.8.4 Forced traceability of master function

It must be possible to force the SSM QL value at the input of the grandmaster by configuration.

When no SSM is delivered by the timing signal used as a reference by the grandmaster (e.g., 2 MHz signal), the SSM QL value may be forced to a certain value before being mapped in the clockClass attribute and sent in the *Announce* messages by the grandmaster.

These network implementations and scenarios will need to be defined by the operator on a case by case basis. It shall be highly dependent on the operator's architecture.

6.8.5 Packet slave clock QL hold off function

In the case where sufficient holdover performance exists within the telecom slave, it must be possible to delay the transition of the QL value at the output of the slaves. This will allow the operator to limit downstream switching of the architecture under certain network implementations when traceability to the packet master is lost.

These network implementations and scenarios will need to be defined by the operator on a case by case basis. It shall be highly dependent on the operator's architecture.

The quality of the holdover oscillator is for further study.

The time maintained is for further study.

6.8.6 Slave output squelch function

In case the telecom slave provides an external output synchronization interface (e.g., 2 MHz), a squelch function must be implemented.

It must be possible to configure the telecom slave so that when all the grandmasters it can communicate with are in failure conditions (e.g., the QLs received are all going under a certain threshold, or PTSF conditions are raised), the output timing signal could be cut off.

These network implementations and scenarios will need to be defined by the operator on a case by case basis.

All aspects of this function are for further study.

7 ITU-T PTP profile for frequency distribution without timing support from the network

The [IEEE 1588] profile that supports frequency distribution in unicast mode is contained in Annex A.

8 Security aspects

Security aspects are for further study. See also [ITU-T G.8265].

Annex A

ITU-T PTP profile for frequency distribution without timing support from the network (unicast mode)

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

This annex contains the telecom profile for frequency distribution as required by [IEEE 1588]. In order to claim compliance with the 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 frequency distribution without timing support from the network (unicast mode)

profileVersion: 2.01.2 (for an implementation based on IEEE Std 1588-2008 [IEEE 1588-2008])

profileVersion: 2.11.3 (for an implementation based on IEEE Std 1588-201908 [IEEE 1588-2019])

NOTE 1 – Versions 2.0 and 2.1 are backward compatible with versions 1.2 and 1.3, respectively. 1.3 is backward compatible with version 1.2. Equipment with version 1.3 may be deployed in the same network as equipment with version 1.2. Version 1.3 indicates an implementation compliant with [IEEE 1588-2019].

NOTE 2 – Versions 2.01.2 and 2.11.3 are both valid versions of this Recommendation. Version 1.32.1, based on [IEEE 1588-2019], does not supersede Version 2.0,1.2 based on [IEEE 1588-2008].

profileIdentifier: 00-19-A7-00-0201-002 (for an implementation based on IEEE Std 1588-2008 [IEEE 1588-2008]).

profileIdentifier: 00-19-A7-00-0201-013 (for an implementation based on IEEE Std 1588-2019 [IEEE 1588-2019]).

This profile is specified by 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 shall use the [IEEE 1588] default initialization values and ranges.

Table A.1 – defaultDS data set member specifications

Clause from [IEEE 1588-2008]	Clause from [IEEE 1588-2019]	Members of the data set	Packet master requirements		Slave only clock requirements	
			Default value (Note 6)	Range	Default value (Note 6)	Range
8.2.1.2.1	Note 4	defaultDS.twoStepFlag (static) Note 4	As per PTP	{FALSE, TRUE}	As per PTP	{FALSE, TRUE}
8.2.1.2.2	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
8.2.1.2.3	8.2.1.2.3	defaultDS.numberPorts (static)	1	{1}	1	{1}
8.2.1.3.1.1	8.2.1.3.1.2	defaultDS.clockQuality. clockClass (dynamic)	Note 2	{80-110}	255	{255}
8.2.1.3.1.2	8.2.1.3.1.3	defaultDS.clockQuality. ClockAccuracy (dynamic)	As per PTP Note 3	As per PTP Note 3	Note 1	Note 1
8.2.1.3.1.3	8.2.1.3.1.4	defaultDS.clockQuality. offsetScaledLogVariance (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.1.4.1	8.2.1.4.1	defaultDS.priority1 (configurable)	Note 1	Note 1	Note 1	Note 1
8.2.1.4.2	8.2.1.4.2	defaultDS.priority2 (configurable)	Note 1	Note 1	Note 1	Note 1
8.2.1.4.3	8.2.1.4.3	defaultDS.domain Number (configurable)	4	{4-23}	4	{4-23}
8.2.1.4.4	8.2.1.4.4	defaultDS.slaveOnly (configurable)	FALSE	{FALSE}	TRUE	{TRUE}
Note 5	8.2.1.4.5	defaultDS.sdoId (configurable)	0	0	0	0

NOTE 1 – It is not used in this profile, and therefore equipment is not required to support it ~~As per PTP, not applicable for this profile.~~

NOTE 2 – The default value should correspond to the holdover quality of the master. The holdover of the master is outside the scope of this Recommendation. The clock class values are provided in Table 1.

NOTE 3 – For the case where the PTP grandmaster is syntonized to a PRC for frequency, but not synchronized to a reference source of time, the grandmaster should set defaultDS.clockQuality.clockAccuracy to 0xFE, "UNKNOWN".

NOTE 4 – In case of an IEEE 1588-2019 implementation, this data set member is deprecated.

NOTE 5 – Applicable to [IEEE 1588-2019] based implementations; This data set member does not exist in [IEEE 1588-2008].

NOTE 6 – If a default value is not provided by this recommendation, then it is implementation specific.

Table A.2 – currentDS data set member specifications

Clause from [IEEE 1588-2008]	Clause from [IEEE 1588-2019]	Members of the data set	Master requirements		Slave requirements	
			Default value (Note 4)	Range	Default value (Note 4)	Range
8.2.2.2	8.2.2.2	currentDS.stepsRemoved (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP
8.2.2.3	8.2.2.3	currentDS.offsetFrom Master (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.2.4	Note 2	currentDS.meanPath Delay (dynamic)	Note 1	Note 1	Note 1	Note 1
Note 3	8.2.2.4	currentDS.mean Delay (dynamic)	Note 1	Note 1	Note 1	Note 1

NOTE 1 – It is not used in this profile, and therefore equipment is not required to support it
As per PTP, not applicable for this profileNOTE 2 – In case of [IEEE 1588-2019] based implementations this data set member is deprecated.
NOTE 3 – Applicable to [IEEE 1588-2019] based implementations; this data set member does not exist in [IEEE 1588-2008].
NOTE 4 – If a default value is not provided by this recommendation, then it is implementation specific.

Table A.3 – parentDS data set member specifications

Clause from [IEEE 1588-2008]	Clause from [IEEE 1588-2019]	Members of the data set	Master requirements		Slave requirements	
			Default value (Note 3)	Range	Default value (Note 3)	Range
8.2.3.2	8.2.3.2	parentDS.parentPort Identity (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP
8.2.3.3	8.2.3.3	parentDS.parentStats (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.3.4	8.2.3.4	parentDS.observed ParentOffsetScaledLog Variance (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.3.5	8.2.3.5	parentDS.observedParentClock PhaseChangeRate (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.3.6	8.2.3.6	parentDS.grandmaster Identity (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP
8.2.3.7	8.2.3.7	parentDS.grandmaster ClockQuality (dynamic)	As per PTP. Note 2	As per PTP. Note 2	As per PTP. Note 2	As per PTP. Note 2
8.2.3.8	8.2.3.8	parentDS.grandmaster Priority1 (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.3.9	8.2.3.9	parentDS.grandmaster Priority2 (dynamic)	Note 1	Note 1	Note 1	Note 1

NOTE 1 – It is not used in this profile, and therefore equipment is not required to support it
As per PTP, not applicable for this profile.
NOTE 2 – Within this profile, only the clockClass attribute in this structure is used for the master selection, as per clause 6.7.3.
NOTE 3 – If a default value is not provided by this Recommendation, then it is implementation specific.

Table A.4 – timePropertiesDS data set member specifications

Clause from [IEEE 1588-2008]	Clause from [IEEE 1588-2019]	Members of the data set	Master requirements		Slave requirements	
			Default value (Note 4)	Range	Default value (Note 4)	Range
8.2.4.2	8.2.4.2	timePropertiesDS.current UtcOffset (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.4.3	8.2.4.3	timePropertiesDS.current UtcOffsetValid (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.4.4	8.2.4.4	timePropertiesDS.leap59 (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.4.5	8.2.4.5	timePropertiesDS.leap61 (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.4.6	8.2.4.6	timePropertiesDS.time Traceable (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.4.7	8.2.4.7	timePropertiesDS. frequencyTraceable (dynamic)	FALSE	{FALSE, TRUE} Note 2	FALSE	{FALSE, TRUE} Note 2
8.2.4.8	8.2.4.8	timePropertiesDS.ptp Timescale (dynamic)	As per PTP Note 3	As per PTP Note 3	As per PTP	As per PTP
8.2.4.9	8.2.4.9	timePropertiesDS.time Source (dynamic)	Note 1	Note 1	Note 1	Note 1

NOTE 1 – It is not used in this profile, and therefore equipment is not required to support it ~~As per PTP, not applicable for this profile~~.

NOTE 2 – If the clock is traceable to a PRC, then this parameter must be set to TRUE, otherwise it shall be FALSE. This parameter is not used by the alternate BMCA. This flag is for information only, e.g., for usage by the network operator.

NOTE 3 – For the case where the PTP grandmaster is syntonized to a PRC for frequency, but not synchronized to a reference source of time, the grandmaster should set timePropertiesDS.ptpTimescale = FALSE. This indicates the use of the ARB timescale.

In normal operation, a grand master (GM) compliant to this Recommendation will not reset the epoch or introduce discontinuities in the overall timescale during operation.

The use of the ARB timescale, in the situation where each GM does not have access to phase input to align their time of day to a common reference, may result in different active GMs that have vastly different timestamp values inserted in their Sync or Follow_Up packets (T1) and/or Delay_Resp packets (T4). A single telecom slave may receive information from these different GMs with different timestamp values.

NOTE 4 – If a default value is not provided by this recommendation, then it is implementation specific.

Table A.5 – portDS data set member specifications

[IEEE 1588-2008]		[IEEE 1588-2019]		Members of the data set	Master requirements		Slave requirements	
Clause	Data type	Clause	Data type		Default value (Note 7)	Range	Default value (Note 7)	Range
8.2.5.2.1	As per PTP	8.2.15.2.1	As per PTP	portDS.portIdentity.clock Identity (static)	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	As per PTP	8.2.15.2.1	As per PTP	portDS.portIdentity.port Number (static)	1	{1}	1	{1}
8.2.5.3.1	As per PTP	8.2.15.3.1	As per PTP	portDS.portState (dynamic)	As per PTP	As per PTP	As per PTP	As per PTP

Table A.5 – portDS data set member specifications

[IEEE 1588-2008]		[IEEE 1588-2019]		Members of the data set	Master requirements		Slave requirements	
Clause	Data type	Clause	Data type		Default value (Note 7)	Range	Default value (Note 7)	Range
8.2.5.3.2	As per PTP	8.2.15.3.2	As per PTP	portDS.logMinDelayReq Interval (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.5.3.3	As per PTP	Note 5	Note 5	portDS.peerMeanPath Delay (dynamic)	Note 1	Note 1	Note 1	Note 1
8.2.5.4.1	As per PTP	8.2.15.4.1	As per PTP	portDS.logAnnounce Interval (configurable)	Note 1	Note 1	Note 1	Note 1
8.2.5.4.2	As per PTP	8.2.15.4.2	As per PTP	portDS.announceReceiptTime out (configurable)	2	{2}	As per PTP	As per PTP
8.2.5.4.3	As per PTP	8.2.15.4.3	As per PTP	portDS.logSyncInterval (configurable)	Note 1	Note 1	Note 1	Note 1
8.2.5.4.4	As per PTP	8.2.15.4.4	As per PTP	portDS.delayMechanism (configurable)	01 Note 2	{01} Note 2	'01' for a two-way slave, and 'FE' for a one-way slave	{01, FE}
8.2.5.4.5	As per PTP	8.2.15.4.5	As per PTP	portDS.logMinPdelay ReqInterval (configurable)	Note 1	Note 1	Note 1	Note 1
8.2.5.4.6	As per PTP	8.2.15.4.6	As per PTP	portDS.versionNumber (configurable)	2	{2}	2	{2}
Note 6	Note 6	8.2.15.4.7	As per PTP	portDS.minorVersionNumber (configurable)	1	{1}	1	{1}
New member	UInte ger16	New member	UInteg er16	portDS.syncReceiptTimeout (configurable)	NA	NA	Note 3	{3–65535}, Note 4
New member	UInte ger16	New member	UInteg er16	portDS.delayRespReceiptTim eout (configurable)	NA	NA	Note 3	{3–65535}, Note 4

NOTE 1 – It is not used in this profile, and therefore equipment is not required to support.As per PTP, not applicable for this profile.

NOTE 2 – The master must support two-way operation.

NOTE 3 – An implementation can choose a fixed value or base it on negotiated message rate (e.g., a value proportional to the message rate). See Appendix II for further details.

NOTE 4 – The full range is not expected to be supported by an implementation, as the receipt timeout value typically depends on the message rate and the ability of the PTP clock implementation to maintain frequency and time during loss of Sync and/or Delay_Resp messages. An implementation should be verified only over the expected operating conditions. See Appendix II for further details.

NOTE 5 – In case of [IEEE 1588-2019] based implementations this data set member is deprecated.

NOTE 6 – Applicable to [IEEE 1588-2019] based implementations. This data set member does not exist in [IEEE 1588-2008]

NOTE 7 – If a default value is not provided by this Recommendation, then it is implementation specific.

A.3 PTP options

A.3.1 Node types required, permitted or prohibited

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

In this profile, the prohibited node types are: boundary and transparent clocks.

A.3.2 Transport mechanisms required, permitted or prohibited

In this profile, the required transport mechanism is *Transport of PTP over User Datagram Protocol over Internet Protocol Version 4* *and Transport of PTP over User Datagram Protocol over Internet Protocol Version 6* as per [IEEE 1588]. In the case of transport over IPv4, b~~B~~it 0 of the transportSpecific field defined in [IEEE 1588-2008] must be set to "0"; that field does not exist in [IEEE 1588-2019].

~~In this profile, a permitted transport mechanism is *Transport of PTP over User Datagram Protocol over Internet Protocol Version 6* as per [IEEE 1588].~~

A.3.3 Unicast messages

All messages are sent in unicast.

NOTE – In this telecom profile, unicast negotiation is enabled per default.

The slave will initiate the session by following the unicast message negotiation procedure defined in clause 16.1 of [IEEE 1588].

A.3.4 REQUEST_UNICAST_TRANSMISSION TLV

The value of logInterMessagePeriod is the logarithm, to base 2, of the requested mean period, in seconds, between the requested unicast messages.

For requesting unicast *Announce* messages: The configurable range is one message per 16 seconds to eight messages per second. The default initialization value of logInterMessagePeriod is -1 (one message every two seconds).

For requesting unicast *Sync* messages: The configurable range is one message every 16 seconds to 128 messages per second. No default rate is specified.

For requesting unicast *Delay_Resp* messages: The configurable range is one message every 16 seconds to 128 messages per second. No default rate is specified.

The durationField value in each REQUEST_UNICAST_TRANSMISSION TLV has a default initialization value of 300 seconds. The configurable range is 60 seconds to 1000 seconds.

NOTE 1 – A specific slave implementation, in order to meet its target performance requirements, as normal operation, may support a subset of the message rates within the ranges noted above. A master, on the other hand, is required to support the full range of message transmission rates. Unless an implementation specifies otherwise, the default value listed above is assumed to be used.

NOTE 2 – A specific slave implementation may support a subset of the durationField values within the range noted above. A master, on the other hand, is required to support the full range of durationField values. Unless an implementation specifies otherwise, the default value listed above is assumed to be used.

The maintenance and configuration of these default and configuration range values is implementation specific.

A.3.5 GRANT_UNICAST_TRANSMISSION TLV

In implementing the GRANT_UNICAST_TRANSMISSION TLV mechanism, the granted values shall be the same as requested in the received REQUEST_UNICAST_TRANSMISSION TLV as long as the requests are in the configurable range.

A.4 Best master clock algorithm (BMCA) options

This profile does not use the default BMCA as described in [IEEE 1588]. Clock selection is described in clause 6.7.

For a grandmaster clock, the alternate BMCA output is static and provides a recommended state = BMC_MASTER and a state decision code = M1.

For a slave-only ordinary clock, the alternate BMCA output is static and provides a recommended state = BMC_SLAVE and a state decision code = S1.

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

The delay request/delay response mechanism can be used in this profile. The peer delay mechanism shall not be used in this profile.

A.6 Configuration management options

Management aspects will be specified in a future version of this profile.

A.7 Clock identity format

For implementations based on [IEEE 1588-2008], the procedures to use an EUI-48 to create the EUI-64 clockIdentity as described in clause 7.5.2.2.2 of [IEEE 1588-2008] are no longer recommended. If a clockIdentity is formed by mapping an EUI-48 to an EUI-64, and if the EUI-48 was assigned from a MAC address – medium (MA-M) or a MAC address – small (MA-S), it is possible that the clockIdentity will be a duplicate of a clockIdentity formed directly from a different MA-M or MA-S (i.e., by appending bits to the end of that different MA-M or MA-S). Only if the EUI-48 was formed from an organizationally unique identifier (OUI), such as a MAC address – large (MA-L), is the uniqueness ensured. For new implementations based on [IEEE 1588-2008], the clockIdentity shall be constructed as per clause 7.5.2.2.2 of [IEEE 1588-2019]. Non-IEEE extended unique identifier (EUI) formats are not supported.

For implementations based on [IEEE 1588-2019], the clockIdentity shall be constructed as per clause 7.5.2.2.2 of [IEEE 1588-2019].

A.8 Flags used by this profile

The flags used by this profile are listed in Table A.6.

Table A.6 – PTP flags

Flag	Value
alternateMasterFlag	FALSE
unicastFlag	TRUE
PTP profile Specific1	FALSE
PTP profile Specific2	FALSE
Reserved	FALSE

NOTE – The "Renewal Invited" flag described in [IEEE 1588] is not used in this profile and is set to FALSE.

A.9 Control field (controlField)

The controlField in the common PTP header is not used in this profile. This field must be ignored by the receiver.

Appendix I

Use of mixed unicast/multicast mode for PTP messages

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

The profile in Annex A covers unicast operation for frequency distribution without timing support from the network. PTP was primarily designed for multicast operation. This appendix provides information on the possible use of multicast for PTP in a telecom environment.

Depending on the way multicast is used in a network, the use of the multicast mode for the PTP *Delay_Req* and *Delay_Resp* messages may not be appropriate in a telecom environment. In some cases, it could lead to a situation where the *Delay_Req* and *Delay_Resp* messages would be replicated and potentially distributed to multiple nodes, consuming network resources. It other cases, this issue may not occur.

Moreover, multicast may not always be supported in all the parts of a telecom network. Multicast may also generate additional PDV when compared to unicast.

The unicast mode solves those issues, but has some drawbacks for the *Sync*, *Follow_Up* and *Announce* messages; instead of having a unique flow for those messages that is sent to all slaves, one dedicated flow per slave has to be sent by the master.

Therefore, depending on the network environment, the use of multicast for *Sync*, *Follow_Up* and *Announce* messages may sometimes be a better option in order to reduce the traffic load on the master. However, the use of multicast messages for *Delay_Req* and *Delay_Resp* messages requires further study in a telecom environment, in order to avoid the replication issues described above.

Therefore, if the multicast mode is used for the *Sync*, *Follow_up* and *Announce* messages that are sent to a slave using two-way operation, then it implies a mix of unicast and multicast modes, since *Delay_Req* and *Delay_Resp* messages are sent in unicast. This situation can be a valid option in some network scenarios in order to reduce the traffic flow between master and slaves.

The mix of multicast and unicast generally creates delay asymmetry, but this asymmetry is not an issue for frequency delivery, which is targeted in the profile described in this Recommendation. It is only the potential additional PDV in one direction created by the multicast mode that may be an issue.

Two modes may be suitable for transporting the PTP timing messages in a telecom environment:

– unicast mode: where the PTP *Sync, Follow_Up*, *Delay_Req*, *Delay_Resp*, *Announce* and *Signaling* messages are sent in unicast;

– mix of unicast and multicast modes: where the *Sync*, *Follow_Up* and *Announce* messages are sent in multicast, and the *Delay_Req*, *Delay_Resp* and *Signaling* messages are sent in unicast.

NOTE – Not all timing messages are always used, as it depends on the behaviour of the slave (e.g., one-way or two-way) or of the master (e.g., one-step clock/two-step clock). Therefore, some situations may exist where only multicast mode is used (e.g., a slave working in one-way where *Delay_Req* and *Delay_Resp* messages are not used).

The development of the mixed multicast/unicast mode for use in a telecom environment is for further study.

Appendix II

Considerations on selecting timeout values

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

Careful consideration should be used when configuring syncReceiptTimeout and delayReqReceiptTimeout in a partially aware deployment. In a partially aware deployment there is a higher probability of loss of packets (or a burst of loss of packets) compared with fully aware networks. This leads to the desire to choose a good value for how many successive packet losses a PTP clock may tolerate before declaration of a receipt timeout, which may lead to raising a PTSF alarm, which in turn may lead to disqualification of the PTP connection from consideration for selection by the BMCA.

Typically, the length of the time a PTP clock can tolerate loss of Sync and Delay_Resp messages is related to the target performance requirements and also the design implementation of the PTP clock (such as the stability of the PTP clock's local oscillator to maintain the performance in-between the reception of PTP synchronization messages). The performance requirements and design implementation are known prior to PTP connection establishment.

The PTP clock receipt timeout properties are therefore configured by considering two additional related parameters

- Negotiated PTP message rate
- Duration of PTP message loss before entering a holdover state (whether holdover in-spec or holdover out-of-spec)

Note that the PTP clock that acts as the receiver of the PTP information is the one that initiates the contract negotiation with a request for a specific PTP message rate (per message type). With that negotiated PTP message information, combined with the known performance target and equipment design, it is then possible to determine the receipt timeout property for the connection.

II.1 Example of receipt timeout calculation (dynamic message rate)

A PTP clock may use the following formulas for setting values on the portDS.syncReciptTimeout and portDS.delayRespReceiptTimeout data set members to achieve desired performance, based on the message rate granted by unicast negotiation. Here, the tolerated consecutive synchronization message loss time (TLT) must be known in advance, based on the performance target and the equipment design. The TLT is defined as the time period the PTP clock can be without Sync and/or Delay_Resp messages and not enter the holdover state (whether holdover in-spec or holdover out-of-spec). In addition, for a proper error report management, there should also be a reasonable upper time limit to the receipt timeout; as described in clause II.3 this is assumed to be 15 minutes. Using the 15 minutes as a reasonable time limit to the receipt timeout, the maximum TLT should be 900s.

TLT = Tolerated consecutive synchronization message loss time [s]

NRS = Negotiated message rate PTP Sync messages [messages/s]

NRD = Negotiated message rate PTP Delay_Resp messages [messages/s]

portDS.syncReceiptTimeout = The minimum of {TLT × NRS, 65535}

portDS.delayRespReceiptTimeout = The minimum of {TLT × NRD, 65535}

Example ~**5** minutes TLT and **64** messages/s:

portDS.syncReceiptTimeout = The minimum of {5×60×64, 65535}

portDS.syncReceiptTimeout = 19200

Example ~**100** seconds TLT and **16** messages/s:

portDS.syncReceiptTimeout = The minimum of {100×16, 65535}

portDS.syncReceiptTimeout = 1600

II.2 Example of receipt timeout calculation (fixed message rate)

PTP clocks that operate only at one specific PTP message rate may use fixed values of the portDS.syncReciptTimeout and portDS.delayRespReceiptTimeout data set members that are implementation specific.

portDS.syncReceiptTimeout = fixed value by design

portDS.delayRespReceiptTimeout = fixed value by design

II.3 Range of receipt timeout

In some deployments that reference [b-ITU-T G.7710] on common equipment management function requirements, it may be desirable to report on loss of Sync or Delay_Resp messages within 15 minutes of the failure event. This may be a reasonable upper limit to the receipt timeout configurable range in a partially aware network deployment. When operating at 128 messages per second, with a receipt timeout of 65535, yields are about 8.5 minutes. When operating at lower message rates, care should be taken not to set the receipt timeout to the maximum allowed within the receipt timeout range to avoid unreasonably large timeout values in units of seconds.

Appendix III

Considerations on the use of IEEE1588-2019

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

Considerations on the use of IEEE1588-2019 is discussed in Appendix IX of [b-ITU-T G.8275].

Bibliography

[b-ITU-T G.7710] Recommendation ITU-T G.7710/Y.1701 (2020), *Common equipment management function requirements*.

[b-ITU-T G.8275] Recommendation ITU-T G.8275/Y.1369 (2020), *Architecture and requirements for packet-based time and phase distribution*.

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