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Technologies de l'information — Télécommunications et échange d'information entre systèmes — Réseaux locaux et métropolitains —

Partie 1AS: Temporisation et synchronisation pour les applications sensibles au temps des réseaux locaux pontés

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Abstract: Protocols, procedures, and managed objects for the transport of timing over local area networks are defined in this standard. It includes the transport of synchronized time, the selection of the timing source (i.e., best master), and the indication of the occurrence and magnitude of timing impairments (i.e., phase and frequency discontinuities).

Keywords: best master, frequency offset, Grandmaster Clock, Grandmaster PTP Instance, PTP End Instance, PTP Relay Instance, IEEE 802.1AS™, phase offset, synchronization, syntonization, time-aware system

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Introduction

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IEEE Standard for
Local and Metropolitan Area Networks—

Timing and Synchronization for Time-Sensitive Applications

1. Overview

1.1 Scope

This standard specifies protocols, procedures, and managed objects used to ensure that the synchronization requirements are met for time-sensitive applications, such as audio, video, and time-sensitive control, across networks, for example, IEEE 802 and similar media. This includes the maintenance of synchronized time during normal operation and following addition, removal, or failure of network components and network reconfiguration. It specifies the use of IEEE 1588™ specifications where applicable in the context of IEEE Std 802.1Q™-2018.[1] Synchronization to an externally provided timing signal [e.g., a recognized timing standard such as Coordinated Universal Time (UTC) or International Atomic Time (TAI)] is not part of this standard but is not precluded.

1.2 Purpose

This standard enables systems to meet the respective jitter, wander, and time-synchronization requirements for time-sensitive applications, including those that involve multiple streams delivered to multiple end stations. To facilitate the widespread use of packet networks for these applications, synchronization information is one of the components needed at each network element where time-sensitive application data are mapped or demapped or a time-sensitive function is performed. This standard leverages the work of the IEEE 1588 Working Group by developing the additional specifications needed to address these requirements.

[1] Information on references can be found in Clause 2.

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2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used; therefore, each referenced document is cited in text, and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 754™-2008, IEEE Standard for Floating-Point Arithmetic.[2, 3]

IEEE Std 802®-2014, IEEE Standard for Local and Metropolitan Area Networks—Overview and Architecture.

IEEE Std 802c™-2017, IEEE Standard for Local and Metropolitan Area Networks—Overview and Architecture—Amendment 2: Local Medium Access Control (MAC) Address Usage.

IEEE Std 802.1AC™-2016, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AX™-2014, IEEE Standard for Local and metropolitan area networks—Link Aggregation.

IEEE Std 802.1Q™-2018, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks.

IEEE Std 802.3™-2018, IEEE Standard for Ethernet.

IEEE Std 802.11™-2016, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

IEEE Std 1588™-2019, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

IERS Bulletin C (see https://www.iers.org/IERS/EN/Publications/Bulletins/bulletins.html).

IETF RFC 2863 (June 2000), The Interfaces Group MIB, K. McCloghrie and F. Kastenholz.[4]

IETF RFC 3410 (Dec. 2002), Introduction and Applicability Statements for Internet Standard Management Framework, J. Case, R. Mundy, D. Partain, and B. Stewart.

IETF RFC 3418 (Dec. 2002), Management Information Base (MIB) for the Simple Network Management Protocol (SNMP), R. Presuhn, ed.

ISO 80000-3:2006, Quantities and units — Part 3: Space and time.[5]

[2] IEEE publications are available from The Institute of Electrical and Electronics Engineers (https://standards.ieee.org).

[3] The IEEE standards or products referenced in this clause are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

[4] IETF Requests for Comments (RFCs) are available from the Internet Engineering Task Force (https://www.rfc-editor.org).

[5] ISO publications are available from the International Organization for Standardization (https://www.iso.org) and the American National Standards Institute (https://www.ansi.org).

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ITU-T Recommendation G.984.3, Amendment 2, Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence layer specification—Time-of-day distribution and maintenance updates and clarifications.[6]

ITU-T Recommendation G.9960, Unified high-speed wire-line based home networking transceivers—System architecture and physical layer specification [with ITU-T G.9961, commonly referred to as “G.hn”].

ITU-T Recommendation G.9961, Data link layer (DLL) for unified high-speed wire-line based home networking transceivers [with ITU-T G.9960, commonly referred to as “G.hn”].

MoCA® MAC/PHY Specification v2.0, MoCA-M/P-SPEC-V2.0-20100507, Multimedia over Coax Alliance (MoCA).[7]

[6] ITU-T publications are available from the International Telecommunications Union (https://www.itu.int).

[7] MoCA specifications are available from the Multimedia over Coax Alliance (http://www.mocalliance.org/specs).

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3. Definitions

For the purposes of this standard, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[8]

3.1 accuracy: The mean of the time or frequency error between the clock under test and a reference clock over an ensemble of measurements (see IEEE Std 1588-2019).

3.2 Bridge: Either a MAC Bridge or a VLAN-aware Bridge, as specified in Clause 5 of IEEE Std 802.1Q-2018.

3.3 clock: A physical device that is capable of providing a measurement of the passage of time since a defined epoch.

3.4 device: An entity implementing some functionality, e.g., a clock, a time-aware system, a port.

3.5 direct communication: A communication of IEEE 802.1AS information between two PTP Instances with no intervening PTP Instance.

3.6 end station: A device attached to a local area network (LAN) or metropolitan area network (MAN) that acts as a source of, and/or destination for, traffic carried on the LAN or MAN.

3.7 event message: A message that is timestamped on egress from a PTP Instance and ingress to a PTP Instance.

NOTE—See 8.4.3.[9]

3.8 fractional frequency offset: The fractional offset, *y*, between a measured clock and a reference clock as defined by the following:

$$y = \frac{f_m - f_r}{f_r}$$

where f_m is the frequency of the measured clock and f_r is the frequency of the reference clock. The measurement units of f_m and f_r are the same.

3.9 frequency offset: The offset between a measured frequency and a reference frequency as defined by $f_m - f_r$, where f_m is the frequency of the measured clock and f_r is the frequency of the reference clock. The measurement units of f_m and f_r are the same.

3.10 general message: A message that is not timestamped.

3.11 gPTP communication path: A segment of a generalized precision time protocol (gPTP) domain that enables direct communication between two PTP Instances.

NOTE—See 8.1.

3.12 grandmaster-capable PTP Instance: A PTP Instance that is capable of being a Grandmaster PTP Instance.

[8] *IEEE Standards Dictionary Online* is available at https://dictionary.ieee.org/.

[9] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement the standard.

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3.13 Grandmaster Clock: In the context of a single PTP domain, the synchronized time of a PTP Instance that is the source of time to which all other PTP Instances in the domain are synchronized.

3.14 Grandmaster PTP Instance: A PTP Instance containing the Grandmaster Clock.

3.15 local area network (LAN): A network of devices, whether indoors or outdoors, covering a limited geographic area, e.g., a building or campus.

3.16 local clock: A free-running clock, embedded in a respective entity (e.g., PTP Instance, CSN node), that provides a common time to that entity relative to an arbitrary epoch.

3.17 message timestamp point: A point within an event message serving as a reference point for when a timestamp is taken.

3.18 message type: The message type of a message is the name of the respective message, e.g., Sync, Announce, Timing Measurement Frame.

3.19 precision: A measure of the deviation from the mean of the time or frequency error between the clock under test and a reference clock (see IEEE Std 1588-2019).

3.20 primary reference: A source of time and/or frequency that is traceable to international standards. *See also:* **traceability.**

3.21 PTP End Instance: A PTP Instance that has exactly one PTP Port.

3.22 PTP Instance: An instance of the IEEE 802.1AS protocol, operating in a single time-aware system within exactly one domain. A PTP Instance implements the portions of IEEE Std 802.1AS indicated as applicable to either a PTP Relay Instance or a PTP End Instance.

NOTE—As used in IEEE Std 802.1AS, the term *PTP Instance* refers to an IEEE 1588 PTP Instance that conforms to the requirements of IEEE Std 802.1AS.

3.23 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of IEEE Std 802.1AS. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.11).

3.24 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one PTP Port to other PTP Ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

3.25 recognized timing standard: A recognized standard time source that is a source external to IEEE 1588 precision time protocol (PTP) and provides time that is traceable to the international standards laboratories maintaining clocks that form the basis for the International Atomic Time (TAI) and Coordinated Universal Time (UTC) timescales. Examples of these sources are National Institute of Standards and Technology (NIST) timeservers and global navigation satellite systems (GNSSs).

3.26 reference plane: The boundary between a PTP Port of a PTP Instance and the network physical medium. Timestamp events occur as frames cross this interface.

3.27 residence time: The duration of the time interval between the receipt of a time-synchronization event message by a PTP Instance and the sending of the next subsequent time-synchronization event message on another PTP Port of that PTP Instance. Residence time can be different for different PTP Ports. The term *residence time* applies only to the case where syncLocked is TRUE.

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NOTE 1—See 10.2.5.15 for the definition of the variable syncLocked.

NOTE 2—If a PTP Port of a PTP Instance sends a time-synchronization event message without having received a time-synchronization event message, e.g., if syncLocked is FALSE or if sync receipt timeout occurs (see 10.7.3.1), the duration of the interval between the most recently received time-synchronization event message and the sent time-synchronization event message is mathematically equivalent to residence time; however, this interval is not normally called a *residence time*.

3.28 stability (of a clock or clock signal): A measure of the variations over time of the frequency error (of the clock or clock signal). The frequency error typically varies with time due to aging and various environmental effects, e.g., temperature.

3.29 synchronized time: The time of an event relative to the Grandmaster Clock.

NOTE—If there is a change in the Grandmaster PTP Instance or its time base, the *synchronized time* can experience a phase and/or frequency step.

3.30 synchronized clocks: Absent relativistic effects, two clocks are synchronized to a specified uncertainty if they have the same epoch and their measurements of the time of a single event at an arbitrary time differ by no more than that uncertainty.

NOTE—See 8.2.2.

3.31 syntonized clocks: Absent relativistic effects, two clocks are syntonized to a specified uncertainty if the duration of a second is the same on both, which means the time as measured by each advances at the same rate within the specified uncertainty. The two clocks might or might not share the same epoch.

3.32 time-aware system: A device that contains one or more PTP Instances and/or PTP services (e.g., Common Mean Link Delay Service).

NOTE 1—See 11.2.17 for a description of the Common Mean Link Delay Service.

NOTE 2—A time-aware system can contain more than one PTP Instance in the same domain and/or different domains.

3.33 timestamp measurement plane: The plane at which timestamps are captured. If the timestamp measurement plane is different from the reference plane, the timestamp is corrected for ingressLatency and/or egressLatency. *See:* **reference plane**.

NOTE—For timestamping on egress and ingress, see 8.4.3.

3.34 traceability: See 3.1.81 in IEEE Std 1588-2019.

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