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PRECISION CLOCK SYNCHRONIZATION PROTOCOL FOR NETWORKED MEASUREMENT AND CONTROL SYSTEMS

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IEEE Std	FDIS	Report on voting
1588 (2019)	65C/1084/FDIS	65C/1091/RVD

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Abstract: In this standard, a protocol is defined that provides precise synchronization of clocks in packet-based networked systems. Synchronization of clocks can be achieved in heterogeneous systems that include clocks of different inherent precision, resolution, and stability. The protocol supports synchronization accuracy and precision in the sub-microsecond range with minimal network and local computing resources. Customization is supported by means of profiles. The protocol includes default profiles that permit simple systems to be installed and operated without the need for user management. Sub-nanosecond time transfer accuracy can be achieved in a properly designed network.

Keywords: Boundary Clock, clock, Grandmaster Clock, IEEE 1588™, management, Ordinary Clock, security, synchronization, Transparent Clock

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Introduction

This introduction is not part of IEEE Std 1588-2019, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

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

IEEE Std 1588-2019 includes content that was not present in IEEE Std 1588-2008. Similarly some content that was present in the IEEE Std 1588-2008 is not in IEEE Std 1588-2019. The following Annexes in 1588-2008 are not present in IEEE Std 1588-2019:

— Annex C (informative) Examples of residence and asymmetry corrections

— Annex K (informative) Security protocol (experimental)

— Annex L (informative) Transport of cumulative frequency scale factor offset (experimental)

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IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

1. Scope

This standard defines a network protocol, the Precision Time Protocol (PTP), enabling accurate and precise synchronization of the real-time clocks of devices in networked distributed systems. The protocol is applicable to systems where devices communicate via networks, including Ethernet. The standard allows multicast communication, unicast communication or both. The standard specifies requirements for mapping the protocol to specific network implementations and defines such mappings, including User Datagram Protocol (UDP)/Internet Protocol (IP versions 4 and 6), and layer-2 IEEE 802.3 Ethernet.

The protocol enables heterogeneous systems that include clocks of various inherent precision, resolution, and stability to synchronize to a grandmaster clock. The protocol supports synchronization in the sub-microsecond range with minimal network bandwidth and local clock computing resources. The protocol enhances support for synchronization to better than 1 nanosecond. The protocol specifies how corrections for path asymmetry are made, if the asymmetry values are known. The grandmaster can be synchronized to a source of time external to the system, if time traceable to international standards or other source of time is required. The protocol provides information for devices to compute Coordinated Universal Time (UTC) from the protocol distributed time, if the grandmaster is traceable to international standards and is able to access pending leap-second changes. Options are also provided to allow end devices to compute other time scales from the protocol distributed time scale.

The protocol defines timing domains in which system timing is consistent. The protocol establishes the timing topology. The default behavior of the protocol allows simple systems to be installed and operated without requiring the administrative attention of users to determine the system timing topology.

The standard defines all needed data types, message formats, required computations, internal states, the behavior of devices with respect to transmitting, receiving, and processing protocol communications. The standard provides for the management of protocol artifacts in devices. The standard defines formal mechanisms for message extensions and the requirements for profiles that allow customization for specific application domains.

The standard defines conformance requirements. Optional specifications are provided for protocol security. This standard documents conditions under which this standard is backward compatible with IEEE 1588-2008.

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FIPS PUB 180-4:2015, Secure Hash Standard.[1]

FIPS PUB 198-1:2008, The Keyed-Hash Message Authentication Code (HMAC).

IEC 61158-5-10:2007, Industrial communication networks—Fieldbus specifications—Part 5-10: Application layer service definition—Type 10 elements.[2]

IEC 61158-6-10:2007, Industrial communication networks—Fieldbus specifications—Part 6-10: Application layer protocol specification—Type 10 elements.

IEC 61784-1:2007, Industrial communication networks—Profiles—Part 1: Fieldbus profiles.

IEC 61784-2:2007, Industrial communications networks—Profiles—Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3.

IEC 62026-3:2008, Low-voltage switchgear and controlgear—Controller-device interfaces (CDIs)—Part 3: DeviceNet.

IEEE Std 754™, IEEE Standard for Binary Floating-Point Arithmetic.[3, 4]

IEEE Std 802®, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.

IEEE Std 802.1AS™-2011, IEEE Standard for Local and Metropolitan Area Networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

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

IEEE Std 802.1Q™ -2014, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks.

IEEE Std 802.3™, IEEE Standard for Ethernet.

IEEE Std. 802.11™, 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.

IERS Bulletin C.[5]

IETF RFC 768 (1980), User Datagram Protocol, Postel, J., ed.[6]

IETF RFC 791 (1981), Internet Protocol, Postel, J., ed.

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IETF RFC 1624 (1994), Computation of the Internet Checksum via Incremental Update, Rijsinghani, A., ed.

IETF RFC 4868 (2007), Using HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 with IPsec, Kelly, S., and Frankel, S., eds.

IETF RFC 8200 (2017), Internet Protocol, Version 6 (IPv6) Specification, Deering, S., and Hinden, R., eds.

ISO/IEC 10646:2003, Information technology—Universal Multiple-Octet Coded Character Set (UCS)—Part 1: Architecture and Basic Multilingual Plane.[7]

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