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

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IEEE Instrumentation and Measurement Society

Developed by the
Technical Committee on Sensor Technology (TC-9)

IEEE Std 1588™-2019
(Revision of IEEE Std 1588-2008)

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Technical Committee on Sensor Technology (TC-9)
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IEEE Instrumentation and Measurement Society

Approved 7 November 2019

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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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Contents

1. Scope 14

2. Normative references 15

3. Definitions, acronyms, and abbreviations 16
   3.1 Definitions 16
   3.2 Acronyms and abbreviations 24

4. Conventions 26
   4.1 Descriptive lexical form syntax 26
   4.2 Word usage 27
   4.3 Behavioral specification notation 28

5. Data types and on-the-wire formats 30
   5.1 General 30
   5.2 Primitive data type specifications 30
   5.3 Derived data type specifications 31
   5.4 On-the-wire formats 35

6. Clock synchronization model 36
   6.1 General requirements on implementations 36
   6.2 Principal assumptions about the network and implementation recommendations 39
   6.3 PTP Networks 39
   6.4 PTP message classes 40
   6.5 PTP device types 41
   6.6 Synchronization overview 53
   6.7 PTP communications overview 65

7. Characterization of PTP entities 69
   7.1 Domains 69
   7.2 Timescales used in PTP 72
   7.3 PTP communications 74
   7.4 PTP communication media 81
   7.5 PTP Ports 84
   7.6 PTP Instance characterization 89
   7.7 PTP timing characterization 103

8. PTP data sets 105
   8.1 General specifications for data set members 105
   8.2 Data sets for PTP Instances 113
   8.3 Data sets for Transparent Clocks 141
   8.4 commonMeanLinkDelayService data sets 144

9. PTP for Ordinary Clocks and Boundary Clocks 144
   9.1 General protocol requirements for PTP Ordinary Clocks and Boundary Clocks 144
   9.2 State protocol 145
   9.3 Best master clock algorithms 154
   9.4 Grandmaster PTP Instance timePropertiesDS updates 164
   9.5 PTP message processing semantics 166
   9.6 Changes in the PTP Instance 182

10. PTP for Transparent Clocks 182
   10.1 Requirements for both end-to-end and peer-to-peer Transparent Clocks 182
   10.2 End-to-end Transparent Clock requirements 182
   10.3 Peer-to-peer Transparent Clock requirements 191

11. Clock offset, path delay, residence time, and asymmetry corrections 195

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11.1 General specifications 195
11.2 Computation of <offsetFromMaster> in Ordinary Clocks and Boundary Clocks 196
11.3 Delay request-response mechanism for Ordinary Clocks and Boundary Clocks 197
11.4 Peer-to-peer delay mechanism 199
11.5 MDMI interface and Special Ports 204

12. Synchronization and syntonization of clocks 214
12.1 Clock adjustments 214
12.2 Syntonization 214
12.3 Synchronization 215

13. PTP message formats 216
13.1 General 216
13.2 General PTP message format requirements 216
13.3 Header 216
13.4 Suffix 222
13.5 Announce message 222
13.6 Sync and Delay_Req messages 224
13.7 Follow_Up message 224
13.8 Delay_Resp message 225
13.9 Pdelay_Req message 225
13.10 Pdelay_Resp message 226
13.11 Pdelay_Resp_Follow_Up message 226
13.12 Signaling message 227
13.13 PTP management message 228

14. TLV entity specifications 228
14.1 General requirements 228
14.2 Propagation of TLVs through Boundary Clocks 230
14.3 Vendor and standard organization extension TLVs 231
14.4 PAD TLV (optional) 233

15. PTP management messages (optional) 234
15.1 General 234
15.2 PTP management mechanism 234
15.3 Processing of PTP management messages 234
15.4 PTP management message format 235
15.5 Management TLVs 238

16. General optional features 272
16.1 Unicast message negotiation (optional) 272
16.2 Path trace (optional) 280
16.3 Alternate timescale offsets (optional) 282
16.4 Holdover upgrade (optional) 289
16.5 Isolation of PTP Instances running under profiles specified by different standards organizations (optional) 290
16.6 Common Mean Link Delay Service (optional) 291
16.7 Configurable correction of timestamps (optional) 298
16.8 Calculation of the <delayAsymmetry> for certain media (optional) 299
16.9 Mixed multicast/unicast operation (optional) 301
16.10 Cumulative frequency transfer method for synchronizing clocks (optional) 304
16.11 Slave Event Monitoring (optional) 308
16.12 Enhanced synchronization accuracy metrics (optional) 317
16.13 Message Length Extension (optional) 323
16.14 PTP integrated security mechanism (optional) 324

17. State configuration options 338
17.1 General 338
17.2 Grandmaster clusters (optional) 338

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17.3 Alternate master (optional) 340
17.4 Unicast discovery (optional) 343
17.5 Acceptable master table (optional) 345
17.6 Mechanism for external configuration of a PTP Instance's PTP Port state (optional) 347
17.7 Reduced state sets and use of the <foreignMasterList> feature (optional) 353

18. Interactions between PTP Instances in different PTP domains 354
18.1 General specifications 354
18.2 Interfaces enabling interdomain interactions 355

19. Compatibility of this edition with earlier and future editions 355
19.1 General 355
19.2 Compatibility between version 2 and future versions 356
19.3 Compatibility with IEEE Std 1588-2002 356
19.4 Compatibility between the PTP Instance conformant to this edition and the implementations conformant to IEEE Std 1588-2008 356

20. Conformance 361
20.1 Conformance objective 361
20.2 PTP conformance requirements 361
20.3 PTP Profiles 362

Annex A (informative) Using the Precision Time Protocol (PTP) 365
A.1 Overview 365
A.2 Physical layout 366
A.3 Logical layout 366
A.4 Component issues 367
A.5 Local implementation issues 368
A.6 System implementation issues 370
A.7 Guidelines to achieve optimal performance 371
A.8 Recommendations to aid in conformance testing 371
A.9 Recommendation for implementations in unicast networks or networks with non-PTP bridges and routers 372

Annex B (informative) Timescales and epochs in PTP 375
B.1 General considerations 375
B.2 UTC, TAI and the PTP epoch and timescale updates 375
B.3 Standard time sources 378
B.4 Meaning and uses of the attributes of the timePropertiesDS data set 379

Annex C (normative) Transport of PTP over User Datagram Protocol over Internet Protocol Version 4 382
C.1 General 382
C.2 UDP port numbers 382
C.3 IPv4 multicast addresses 382
C.4 sdoId field values 383
C.5 Optional values 384
C.6 IPv4 Options 384
C.7 Protocol addresses 384

Annex D (normative) Transport of PTP over User Datagram Protocol over Internet Protocol Version 6 385
D.1 General 385
D.2 UDP port numbers 385
D.3 IPv6 multicast addresses 386
D.4 Optional values 386
D.5 Protocol addresses 386

Annex E (normative) Transport of PTP over IEEE 802.3 transports 387
E.1 General 387
E.2 Ethertype 387
E.3 Multicast media access control (MAC) addresses 387

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E.4 majorSdoId field values 388
E.5 Optional values....388
E.6 Protocol addresses....388

Annex F (normative) Transport of PTP over DeviceNET....389
F.1 Protocol....389
F.2 message timestamp point....389
F.3 clockIdentity....389
F.4 PTP message formats....389
F.5 DeviceNet addressing for PTP....390

Annex G (normative) Transport of PTP over ControlNET....391
G.1 Protocol....391
G.2 clockIdentity....391
G.3 PTP message formats....391
G.4 ControlNet addressing for PTP....391

Annex H (normative) Transport of PTP over IEC 61158 Type 10....392
H.1 Background....392
H.2 Message specification....393
H.3 DLPDU of the IEC 61158 TYPE10....394
H.4 Encoding specifications....395

Annex I (normative) Default PTP Profiles....398
I.1 General....398
I.2 General requirements....398
I.3 Delay Request-Response Default PTP Profile....398
I.4 Peer-to-Peer Default PTP Profile....400
I.5 High-Accuracy Delay Request-Response Default PTP Profile....401

Annex J (normative) Performance monitoring options (optional)....407
J.1 General....407
J.2 Timestamp monitoring....407
J.3 Additional parameters....410
J.4 Record data types....412
J.5 Data sets for performance monitoring....414

Annex K (informative) Suppression of rogue Announce messages....419
K.1 Example—Star topology....420
K.2 Example—PTP Network with a single loop with an odd number of PTP Instances in the loop....422
K.3 Example—More complex single loop PTP Network....423
K.4 Example—Linear chain....423

Annex L (normative) Layer-1 based synchronization performance enhancement (optional)....425
L.1 General....425
L.2 Basic terms....426
L.3 Link Reference Model....427
L.4 L1Sync port characteristics....429
L.5 L1Sync data sets....431
L.6 L1Sync message exchange....434
L.7 L1Sync port operation specification....437
L.8 Optional parameters (option within this option)....439
L.9 Link verification using Signaling messages (informative)....444

Annex M (informative) Sub-nanosecond synchronization using the High Accuracy Default PTP Profile....445
M.1 General....445
M.2 Frequency loopback....445
M.3 Timestamping precision....447
M.4 Timestamping accuracy....448

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M.5 Medium and its asymmetry 449
M.6 Timing characteristics 450

Annex N (informative) Calibration procedures 452
N.1 General 452
N.2 Theoretical background 455
N.3 Assumptions and requirements 457
N.4 Calibration procedures 459

Annex O (informative) Example inter-domain interactions 466
O.1 General 466
O.2 Sourcing timing to multiple domains 466
O.3 Providing timing to users (sinks) from multiple independent domains 467
O.4 Transferring time from PTP domain A to PTP domain B 468
O.5 Example use for external configuration of port state 473

Annex P (informative) Security 474
P.1 Overview, assumptions, and approach 474
P.2 Multipronged approach—detailed definition 474

Annex Q (informative) Bibliography 495

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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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