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IEEE Std 1588™

Precision Clock Synchronization Protocol for Networked Measurement and Control Systems





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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

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

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

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

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
Annex R (informative) IEEE List of participants	498

PRECISION CLOCK SYNCHRONIZATION PROTOCOL FOR NETWORKED MEASUREMENT AND CONTROL SYSTEMS

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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.